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Drayton South Coal Project

Equine Health Impact Assessment

Prepared for Hansen Bailey on behalf of Anglo American Coal

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EXECUTIVE SUMMARY

A comprehensive review of the scientific literature was undertaken to evaluate the potential effects of dust, noise, vibration and lighting on equine health. This review found that horses are subjected to high levels of dust, noise, vibration and lighting as part of their normal progression from stud farm to racing stable. It was determined that the composition of the dust is crucial to the development of any adverse effects in horses, and that in the absence of endotoxins, moulds, bacteria and allergens attached to the dust, then crustal dust alone would be very unlikely to trigger any adverse effects in horses. These findings enabled accurate interpretation of the potential effects of the Project on the adjacent horse studs livestock.

Dust

Exposure to endotoxins, moulds, bacteria and allergens attached to dust was found to be very high during the normal course of a racing horse's life. This occurs primarily when horses are stabled for example, during race training, yearling preparation, education and hospitalisation of horses. Despite this type of dust exposure potentially having an adverse impact on equine health, horses are able to perform to an acceptable standard.

In contrast, the dust generated by the Project will be almost exclusively crustal in origin and have little to no attached endotoxins, moulds, bacteria and allergens. It is predicted that the Project will result in no increases in the annual average PM_{10} levels at Woodlands Stud receivers and less than 2 µg/m³ at Coolmore Stud receivers. From the equine literature review it is noted that a maximum recommended level of respirable dust in stables should be 230 µg/m³, while levels of 80-170 µg/m³ are considered normal for a paddock. Therefore, an increase of less than 2 µg/m³ would be considered negligible and have no detectable effect on horse health.

Even based on the worst case scenario for the northern most paddocks at Coolmore and Woodlands Studs, there may be a maximum 24-hour PM_{10} increase from the Project of between 10 and 25 µg/m³ on some days. Based on this assessment there will be no risk to stabled or pastured horses from combined mine and background PM_{10} levels, even if the worst case scenario occurred on a regular or even daily basis (which is not predicted to be the case).

Worth noting is that even when worst case operating conditions are modelled, the Project will not lead to any exceedances of the cumulative annual average PM_{10} levels over Coolmore and Woodlands Studs. The cumulative levels are also predicted to remain comparable to or better than those recorded in Kentucky, USA, which is renowned as the premier area for horse breeding in the world.

It is also noted that Coolmore Stud is currently in the process of assisting in the setting up of a breeding and racing project in Tianjin on the outskirts of Beijing, China. This involves the provision of over 100 thoroughbred horses by Coolmore to Tianjin. At this location, PM_{10} levels range from 165 to 377 µg/m³ which is far in exceedance of any levels that might be experienced on horse studs near the Project.

It is claimed that once established that the operations at Tianjin will be “*compared to centres of excellence in the NSW Hunter Valley, Kentucky in the US, Deauville in France and the Hokkaido breeding and training centres of Japan*” (http://www.racingandsports.com.au/en/racing/coolmore-partners-massive-china-racing-project-story-274878*)*.

If this is the case, then clearly potential impacts from air pollution (or perceptions of potential impacts) are not a concern to the international horse racing and breeding industry.

Noise

Horses are regularly exposed to high noise levels during the course of their life. This has been documented in several studies, including assessing noise levels on race days. An extensive review of the veterinary literature also indicates that it is appropriate to recommend noise level criteria suggested for human exposure. Based on this and the available data it is expected that noise from the Project will have no impact on the local horse population.

Given that the noise levels are not predicted to exceed the existing background levels at any locations on Coolmore or Darley owned land, noise levels from the Project will not have any impact on the equine population. Further, it has been determined that even under a worst case scenario, overpressure associated with blasting will be below regulatory limits at 105 dBL at those locations. To provide context, this would be perceived as a distant rumbling (similar to thunder) and would last for less than 1 second.

Overpressure from blasting will remain far below that of frequent helicopter landings at both horse studs and well below that of thunder associated with the lightning strikes that occur during frequent storms in the Hunter Valley.

Based on the case study of Edinglassie Stud, which is located less than 130 m from blasting at Mt Arthur Coal Mine and subject to overpressure levels much higher than proposed by the Project (commonly in the 120 – 124 dBL range), there is no evidence to suggest that overpressure generated from blasting causes any adverse impacts to horse health.

Given that the Project is located 1 km from either horse studs boundary and over 2 km from both horse studs primary areas of operations (including paddocks where horse are kept), it is considered that overpressure will not have any adverse effects on horse health.

As a result, there should be no concern that noise or overpressure from blasting or mine operations will induce a flight response in horses on the studs or have any impact on their behaviour (as indicated by the Edinglassie Stud example). Horses are far more likely to react to lightning strikes and thunder, helicopter landings and farm machinery such as tractors and lawnmowers rather than to distant mine noise. Further it is noted that future planned increases to the capacity of traffic on the Golden Highway (a major state road connecting central western NSW to the Hunter Valley and Newcastle) would be the most likely source of additional noise outside of the studs boundaries.

Vibration

Vibration, in particular that associated with road or air transport, is regularly encountered by horses and there has been no demonstrated adverse effects. It is anticipated that no vibration will be discernible from mine blasting to the majority of horses adjacent to the Project. Any vibration that may be felt will be at an extremely low level and of very short duration and should not elicit a flight response nor have any other adverse effects.

The EIS Acoustic Assessment undertaken by Bridges Acoustic confirms that the worst case vibration from blasting associated with the Project is predicted to be between 0.4 mm/s and 1.2 mm/s.

Based on the case study of Edinglassie Stud, which is located less than 130 m from blasting at Mt Arthur Coal Mine and subject to vibration levels up to 6 mm/s, there is no evidence to suggest that vibration generated from blasting causes any adverse impacts to horse health.

Given that the Project is located 1 km from horse studs boundary and over 2 km from both horse studs primary areas of operations (including paddocks where horses are kept) it is considered that vibration will not have any adverse effects on horse health.

Light

Due to the mine design and location there will be no direct light encroaching on horse stud livestock. In order to manipulate breeding cycles in mares, artificial lighting needs to be of a certain intensity and prolonged exposure. The lighting used at Drayton South will not be directly visible from the studs and any indirect light will not be of sufficient brightness to have any negative effect on breeding cycles.

Conclusion

Comparison with data generated in the EIS Air Quality Assessment, EIS Acoustics Assessment and EIS Visual Assessment indicated that the levels of dust, noise, vibration and light that the horses at both Coolmore and Woodlands Studs would be exposed to as a result of the Project would be far less than that which they are exposed to in a breeding and racing career. Based on the literature review and evaluation of data generated in the EIS assessments it is concluded that, in terms of dust, noise, vibration and lighting, the Project will have no adverse effects on the health of horses on the Coolmore and Woodlands Studs.

Based on this conclusion few specific recommendations are required. In particular, monitoring of horses responses to mining is not required to address uncertainty as sufficient evidence has been provided by the assessments completed as part of the EIS and the Edinglassie Stud example of how horses respond to mining. The Edinglassie Stud example is considered far more extreme when compared to the Project (as it is located much closer to two active mines) and as such provides certainty to the findings and conclusions of this assessment.

Specific recommendations in regard to ongoing assessment of any impact on horse health include continuous monitoring of dust levels throughout the duration of the Project and potentially periodic assessment of blasting to confirm that levels remain below those predicted in the EIS assessments.

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1 INTRODUCTION

Kannegieter Equine Specialists was commissioned by Hansen Bailey Environmental Consultants (Hansen Bailey) on behalf of Anglo American Coal (Anglo American) to complete an equine health impact assessment for the Drayton South Coal Project (the Project).

This report provides an assessment as to whether the predicted air quality, noise, light and vibration impacts from the Project are likely to have a detrimental effect on the health of horses on neighbouring properties.

The purpose of the assessment is to form part of an Environmental Impact Statement (EIS) being prepared by Hansen Bailey to support an application for Development Consent under Division 4.1 of Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) to facilitate the continuation of the existing Drayton Mine by the development of two open cut mining areas and associated infrastructure within the Drayton South area.

1.1 PROJECT DESCRIPTION

Drayton Mine is located approximately 13 km south of the township of Muswellbrook in the Upper Hunter Valley of New South Wales (NSW) (see **Figure 1**). Drayton Mine has been operating in the Muswellbrook community for over 30 years and runs out of coal in 2015.

The Project will allow for the continuation of the existing Drayton Mine for up to 15 years, by developing an open cut mining area within EL 5460. The Project will extract up to 6.4 Mtpa of export quality thermal coal by utilising existing Drayton Mine assets and infrastructure.

The Drayton South Coal Project addresses the reasons provided by the NSW Planning Assessment Commission (PAC) for the refusal of the previous application. The mine plan and Project Boundary is defined by ridgelines nominated in the 'Drayton South Coal Project PAC Review Report' for the previous application issued in December 2013. The Project will remain behind the ridgelines nominated by the PAC. Significantly, this at least doubles the buffer setback distance from the Coolmore and Woodlands thoroughbred horse studs (Coolmore and Woodlands Studs) and is at least 2 km from the horse stud operational areas.

The conceptual layout of the Project is shown in **Figure 2**.

1.2 PREVIOUS APPLICATION PAC FINDINGS

One of the key requirements of this report is to assess the Project as proposed against the relevant findings of the PAC on the previous application. The two PAC findings from the previous application most relevant to the equine health impact assessment are:

- The Project (previous application) has not demonstrated that it will not adversely impact on equine health and the operations of Coolmore and Darley horse studs; and

- The approach of monitoring the responses of thoroughbred horses to the mines operation to address uncertainty is not acceptable because once the damage to the operations of the studs occurs, it is irreversible.

The PAC's findings on the previous application have been addressed by this assessment (see **Sections 10** and **11**).

1.3 SECRETARIES ENVIRONMENTAL ASSESSMENT REQUIREMENTS

All applications for Development Consent under Division 4.1 of Part 4 of the EP&A Act must be accompanied by an EIS prepared in accordance with the NSW Department of Planning and Environment's Secretary Environmental Assessment Requirements (SEARs). This equine health impact assessment, which forms part of the EIS, addresses the SEARs concerning equine health. **Table 1** lists the SEARs that are relevant to, and are addressed by, this assessment.

Table 1
Secretaries Environmental Assessment Requirements

Key Issue	Requirement
Agriculture	- a detailed assessment of the likely impacts of the development on the Upper Hunter Equine and Viticulture Critical Industry Clusters, paying particular attention to the nearby Coolmore and Darley thoroughbred horse stud; - a detailed assessment of the likely impacts of the development on horse health
Noise & Blasting	a detailed assessment of the likely blasting impacts of the development (including noise, vibrations, overpressure, visual and odour) on horse health

This assessment only addresses these SEARs to the extent that they apply to horse health. The impacts on humans and property are not addressed in this report.

1.4 RELATED STUDIES

The studies which are to be read in conjunction with this assessment include the following:

- The EIS Air Quality Assessment;
- The EIS Acoustic Assessment;
- The EIS Visual Assessment; and
- The EIS Agricultural Impact Statement.

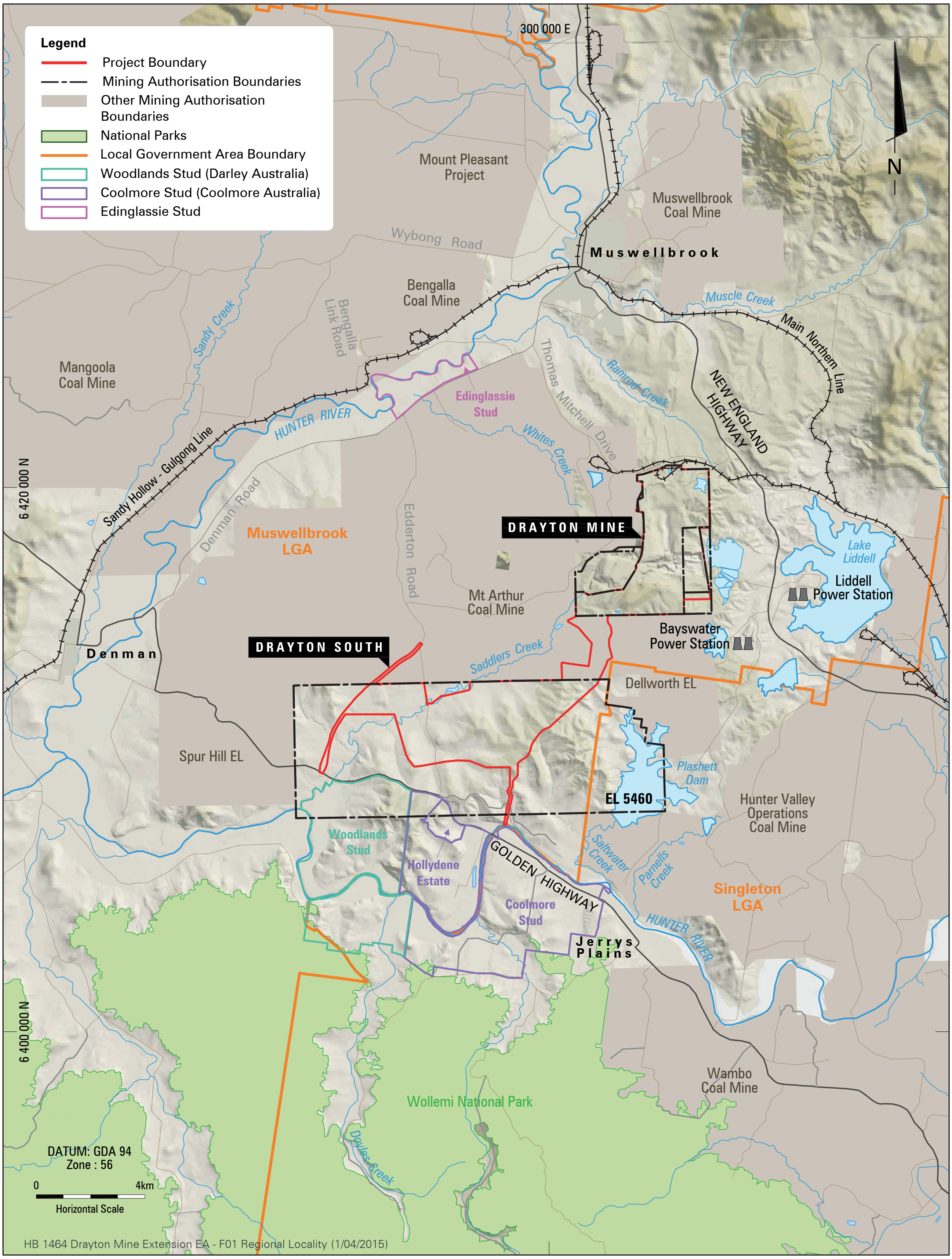
1.5 REPORT STRUCTURE

The report is structured as follows:

- **Section 1** is the introduction;
- **Section 2** describes the assessment approach;
- **Section 3** outlines the key findings of the literature review;
- **Section 4** provides background information of equine industries closest to the project
- **Section 5** discusses the potential for health issues resulting from dust generated by the Project;
- **Section 6** discusses the potential for health issues resulting from noise generated by the Project;
- **Section 7** discusses the potential for health issues resulting from vibration generated by the Project;
- **Section 8** discusses the potential for health issues resulting from light generated by the Project;
- **Section 9** discusses the potential effects on the equine critical Industry clusters;
- **Section 10** provides recommendations;
- **Section 11** provides conclusions; and
- **Section 12** lists relevant references.

The report also includes the following appendices:

- **Appendix 1** Horse Health Literature Review – The effects of dust on the equine lower respiratory tract;
- **Appendix 2** Comparative review of air quality backgrounds near horse breeding and racing areas; and
- **Appendix 3** Results of Endotoxin Laboratory Analysis.

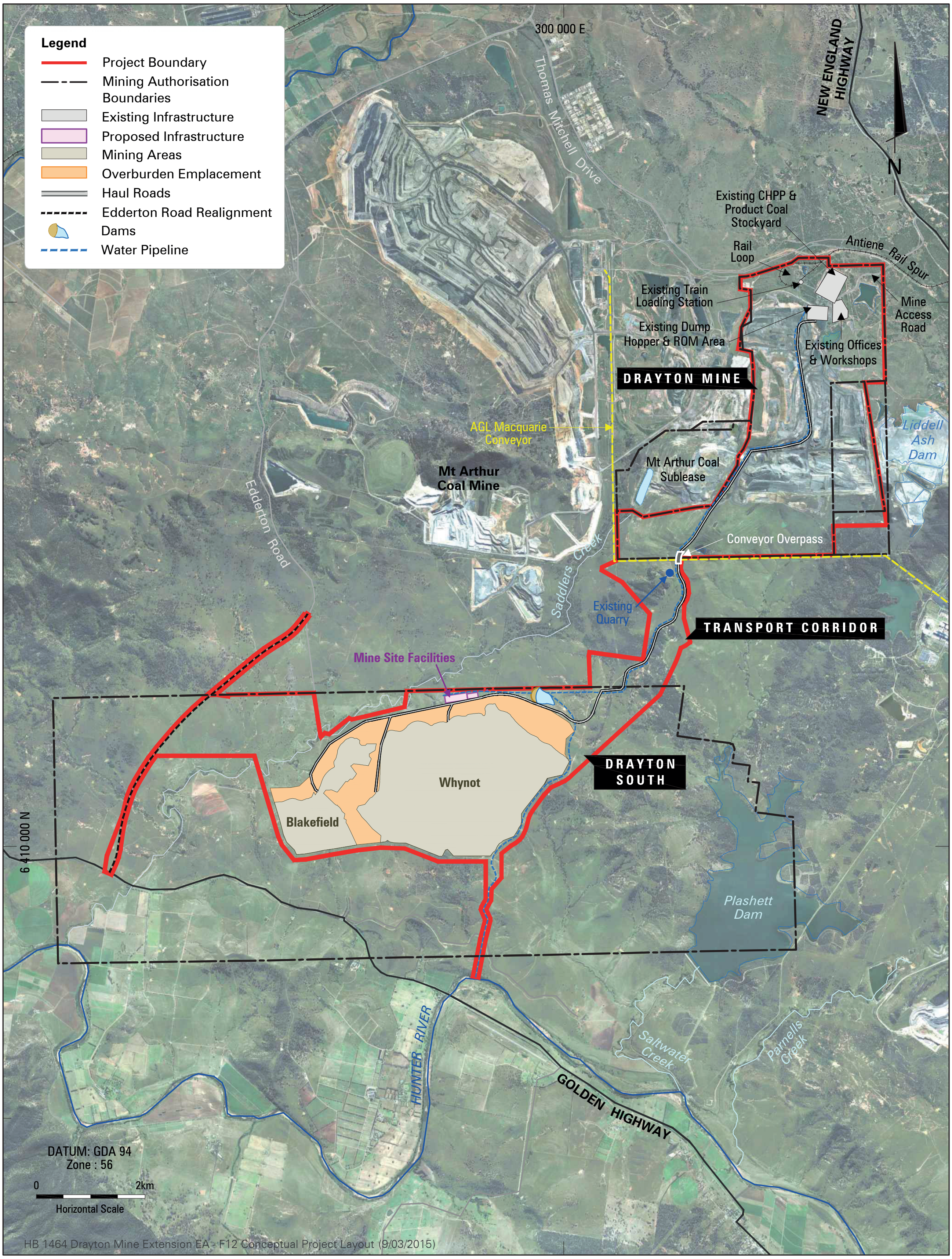


HB 1464 Drayton Mine Extension EA - F01 Regional Locality (1/04/2015)

DRAYTON SOUTH COAL PROJECT

Regional Locality

FIGURE 1



DRAYTON SOUTH COAL PROJECT

Conceptual Project Layout

FIGURE 2

2 ASSESSMENT APPROACH

The objective of the equine health impact assessment was to establish an understanding of the levels of dust that horses may be exposed to during the various stages of their life cycle in order to understand their level of sensitivity. Comparisons were then drawn to the predicted dust levels for the Project to determine whether there is likely to be any potential health impacts for horses being bred on the neighbouring thoroughbred breeding operations at Coolmore and Woodlands Studs.

As part of the assessment, the sensitivity of horses to noise and vibration impacts from blasting was also assessed as well as the potential effects of light. This involved a literature search regarding the hearing ability of horses and their response to noise as well as an evaluation of the effect of ground vibration on horses and the effects that indirect light from the project may have on the reproductive ability of horses. Predicted data from the Project could then be evaluated for any potential impact on horse health.

The scope of this assessment included the following:

- Address the SEARs concerning horse health;
- Conduct a review of relevant literature and veterinarian databases with regard to the effects of dust, noise, light and vibration on horse health;
- Conduct a review of the existing air quality of the region and a comparative review of this with other well-known racing and breeding locations in Australia and around the world;
- Undertake soil and dust sampling and analysis to evaluate endotoxin levels likely to be present in dust generated from the Project;
- Analyse the results of the air quality modelling to determine whether the predicted levels of dust are likely to have an impact on horse health;
- Analyse the results of the noise and vibration assessment to determine whether the predicted noise and vibration levels are likely to have an impact on horse health;
- Analyse the results of the visual impact assessment to determine whether the predicted light levels are likely to have an impact on reproduction ability;
- Consider the peer review comment received from Dr Deborah Jane Racklyeft BVSc, MVCS, PhD, FANZCVS and Prof Kristopher Hughes BVSc, FANZCVSc, DipECEIM, Registered Specialist in Equine Medicine, on the equine health impact assessment prepared for the previous application;
- Consider the comments received on the previous project application including that from the NSW Gateway Panel and the PAC; and
- Provide recommendations and management measures as relevant.

3 LITERATURE REVIEW

3.1 OVERVIEW

A targeted literature review was undertaken in four main areas to determine the sensitivity of horses to dust, noise, vibration and light. The findings of each are provided in the sections below.

3.2 DUST LITERATURE REVIEW

A comprehensive literature review was undertaken to determine the levels of dust and endotoxin that horses may be exposed to during rearing and during a racing career. The reason for this was to establish baseline levels of dust exposure in the environment of these horses. While dust is recognised as a potential irritant to the respiratory tract, the response to dust is mostly the result of endotoxins as well as other material such as bacteria or fungi attached to the dust. This is a particular problem in stabled horses, as occurs during race training or yearling preparation.

The following databases were searched in compiling the literature review:

- CAB abstracts (1990 to present); produced by CABI PUBMED; produced by US National Library of Medicine National Institutes of Health;
- Science Direct database;
- Wiley Online Library;
- Medline (1950 to present);
- Personal data base N Kannegieter;
- Web of Science; and
- Cambridge Journal Online.

The review found that there is very little published scientific information which evaluates the effects of dust of topsoil or crustal origin dust on the health of pastured horses. In contrast there is a large amount of data that examines the effects of dust from bedding, feed and the environment on stabled horses. The review evaluated the available data in both areas. There is also a vast amount of information regarding the effects of dust and pollution on human health. As this was not the focus of the study and there are sufficient differences between horse and human responses to dust exposure, this area was not reviewed as reliable conclusions cannot be made from the human literature in regard to equine respiratory tract health and disease.

The primary aim of the review was to provide information on known sources of dust as well as the composition and effect of this dust on the equine lower respiratory tract (LRT). Considerable data has been presented in regards to dust in a stabled environment even though this may not seem totally applicable to the situation in pastured horses as generally exists in the horse studs immediately adjacent the Project. This has been done for two reasons. Firstly to provide data on “occupational” background dust levels experienced by horses that undertake any athletic career and secondly to examine the effects that different levels and types of dust may have on the LRT.

The full literature review regarding the effects of dust on horse health is attached in Appendix 1.

Definitions

For the purposes of this report some definitions are presented below.

There is considerable imprecision in use of the term (dust) in both the human and veterinary literature. Many articles describe studies evaluating “dust”; however the composition of this dust can vary widely. This makes comparison between reports and evaluation of data very difficult. In many papers the composition of the dust is not defined at all.

The report of Reed et al (2006) provides full details of regulatory standards in relation to human health and dust in agricultural industries from an Australian perspective and can be referred to human health guidelines if required.

Inspirable Dust - Inspirable (inhalable) dust is defined as a material that may be deposited anywhere along the respiratory tract, where the aerodynamic diameter of the dust may range from 0 to 100 µm (ACGIH, 2005).

Respirable Dust - Respirable dust is defined as the proportion of airborne dust levels that when inhaled may penetrate to the unciliated airways of the lung. The median diameter of the dust particles is 4.25 µm. Respirable dust fraction is defined by ISO 7708 (AS2985, 2004) (Reed et al 2006).

Particulate matter is derived from several sources:

- *Background crustal dust from local and distant areas.*
- *Biologically derived;*
  - *‘hay dust’ at the horse stud infrastructure, and*
  - *pollen, plant and insect fragments in ambient air blown from local and distant areas.*
- *Combustion derived particulates (e.g. automobile exhaust, emissions from industrial boilers and other processes, smoke from domestic and grass/bush fires).*
- *Dust associated with the Project (e.g. overburden and coal dust).*

Dust may often be a combination of several of the above sources.

3.2.1 Key Findings

The literature review identified a number of research studies that provided good data with which to compare the potential effects of the Project. The key points from this research are summarised below:

- There is limited correlation between humans and horses in regards to the adverse effects of dust pollution on health;
- Horses are exposed to a large amount of dust in their lives particularly when performing as athletes. The primary sources of dust are bedding, hay and feed;
- The major causes of adverse effects from dust exposure on horses in any environment is not the particulate matter as such but rather the endotoxins, bacteria and fungi that are attached to the particulate matter;
- Horses have a highly refined respiratory tract that greatly protects against contamination of the upper and lower respiratory tracts. They also have excellent mucocillary clearance mechanisms which when combined with the advantages of postural drainage provide a very efficient and effective means of clearing the lower respiratory tract of particulate matter or foreign material;
- Despite exposure to high levels of dust in a stable environment, horses can perform well and be highly competitive; and
- Dust such as that generated by the Project, that does not have high levels of endotoxin associated with it, (e.g. nuisance or crustal dust) does not appear to increase the incidence of Inflammatory Airway Disease (IAD) in horses.

Following the literature review, it was concluded that the very high amount of dust that horses are exposed to, both as a result of being fed hay and in particular being kept in a stabled environment, is an “occupational hazard”. There are undoubtedly effects of this “dust” on the respiratory tract, particularly IAD. However, it is well documented that the effects of dust are primarily a result of endotoxins attached to the dust particle, rather than the inorganic dust component itself.

3.2.2 Key Data from Literature Review

The literature review also identified a number of research studies that provided good data with which to compare the potential effects of the Project. The key points from this data are summarised below:

- The minimal total airborne endotoxin concentration likely to cause lower respiratory tract disease in normal horses most likely exceeds 20 ng/m^3 (0.02 µg/m³) (McGorum et al, 1998);
- Total dust concentration in normal pasture environment for horses has been measured at 0.17 mg/m^3 (170 µg/m³), respirable dust at 80 µg/m³ and endotoxin levels of 0.00129 µg/m³ in total airborne dust (McGorum et al, 1998);
- The recommended maximum value for inhalable dust in a stable is estimated to be in the order of 2.5 to 3.0 mg/m^3 (2500-3000 µg/m³). Concentrations of respirable dust in stables ranges from 0.15 to 9.28 mg/m^3 (150–9280 µg/m³) with a recommended maximum value of 0.23 mg/m^3 (230 µg/m³) (Cargill 1999);
- Racehorses spend most of their time (up to 22 hours) in looseboxes and are exposed to aerosolised foreign dusts and gases almost continuously and any effects these agents have would likely be cumulative. There can be peaks of dust exposure up to

50 times greater than background levels depending on type of bedding, feed, activity of the horse and stable management (Malakides and Hodgson 2003);

- Forty percent of horses develop IAD within the first two weeks of entering racetrack stables for training. This represents a very high percentage of affected horses that are clinically well and preparing for the high stresses of racing (Malakides and Hodgson 2003);
- More than a third of horses entering racetrack stables had some form of airway inflammation prior to transport to racetrack stables but these horses were not necessarily at greater risk of continuation of inflammation or further respiratory disease (Malakides and Hodgson 2003); and
- Contrary to expectation, many dust-generating activities and sources are not associated with IAD (Malakides and Hodgson 2003).

3.2.3 Inflammatory Airway Disease

The most common disease of the lower respiratory tract of horses in Australia is IAD. This is a relatively recently categorised condition that covers most LRT diseases of horses apart from Chronic Obstructive Pulmonary Disease (COPD). In Australia, well over 20-55% of horses in any form of athletic endeavour may have IAD. The incidence in pastured horses is much lower. IAD is a very general response to a wide variety of stimuli. Causes include viruses, bacteria, fungi, and stable dust. The effects that IAD have on horse health and performance vary greatly from no effect through to death in cases that become complicated. IAD is primarily a disease of stabled horses. IAD is considered to be more a response to the presence of irritant material in the lower airways, rather than the more severe allergic response seen in COPD. No doubt the precise definition of both these diseases will evolve with future research and as the links between IAD and COPD, if any, are further evaluated.

As IAD is a non-specific response to general irritants, this is potentially a disease that can have an increased incidence directly as a result of increased exposure to dust. The concentration and composition of dust that the horses might be exposed to in a paddock situation needs to be evaluated before any conclusion can be drawn as to the potential risk of IAD in pastured horses.

The report of Malakides and Hodgson (2003) provides comprehensive information on IAD in horses. They found that endotoxin was primarily responsible for IAD. The source of endotoxin is from degenerate g*ram-negative bacteria and as such endotoxin is ubiquitous in nature and is commonly present on surfaces of plants and animals. Variable concentrations of endotoxins are found in agricultural environments such as housing for pigs, chickens, cows and horses, as well as sources such as bedding, hay, grains, straw, and bird droppings. Most environments in which horses have contact potentially can be contaminated with dusts with adherent bacteria and their cell-wall fragments, which subsequently may become aerosolised and inhaled. Endotoxin from dust sources (such as feed, bedding and sources outside boxes) in stables is associated with IAD in thoroughbred racehorses in Australia.*

Malikides and Hodgson (2003) also performed a number of experiments and concluded that 40.3% (range 30-50%) developed IAD within the first 2 weeks of entering racetrack stables for training. This represents a very high percentage of affected horses that are clinically well and preparing for the high stresses of racing. In half these horses the problem persists and may develop into clinical disease as a result of training and management stresses. More than a third of horses entering racetrack stables for training had some form of airway inflammation prior to transport to racetrack stables. The conditions that young racehorses are placed in and their health management (particularly with regard to regular anthelmintic treatment) prior to transport to racetrack stables may influence whether or not horses arrive with some form of IAD. However, the high proportion of young racehorses that develop IAD prior to arrival at racetrack stables are not necessarily at greater risk of continuation of inflammation or further respiratory disease.

A further key conclusion was that contrary to expectation, many dust-generating activities and sources were not associated with IAD.

3.2.4 Role of Dust in IAD - Summary

There are a large number of potential causes of LRT disease in horses.

The following table from Spendlove et al (2008) summarises these causes.

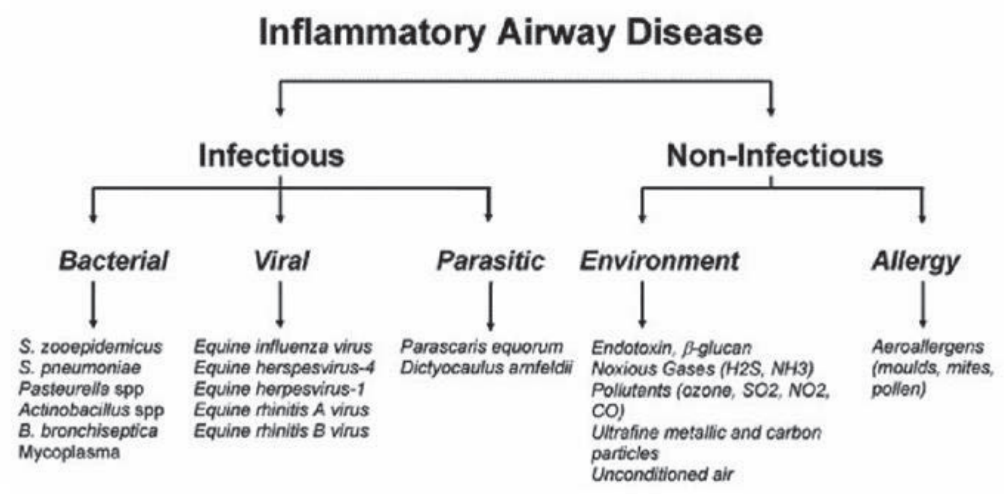


Figure 2: *Potential causes of lower airway inflammation in horses.*

(RIRDC Publication No 08/051)

It should be noted from this table that crustal dust alone is not cited as a cause of IAD.

Buechner-Maxwell (1993 a,b) found that airway hyper responsiveness in horses was due to many factors, but dust alone not cited as a major cause. A later report by the same author (Buechner-Maxwell et al, 1996) found that short term exposure (4 weeks) to a stabled environment did not increase any inflammatory mediators in normal horses, although there were some limitations to this study.

The report of Malakides and Hodgson (2003) provides comprehensive information on IAD in horses. They concluded there was a strong association between endotoxin and IAD. The source of endotoxin is from degenerate gram-negative bacteria and as such endotoxin is ubiquitous in nature and is commonly present on surfaces of plants and animals. Variable concentrations of endotoxins are found in agricultural environments such as housing for pigs, chickens, cows and horses, as well as sources such as bedding, hay, grain, straw, and bird droppings. Endotoxins are also present in industrial processing and storage of organic materials such as cotton and flax, wood chips, timber, fibreglass, wastes, potatoes and paper, as well as in animal slaughter and processing facilities, domestic water, house dust contaminated by pets and vermin, and cigarette smoke. Most environments in which horses have contact potentially can be contaminated with dusts with adherent bacteria and their cell-wall fragments, which subsequently may become aerosolised and inhaled. In addition, endotoxins are present in the oral, pharyngeal and nasal cavities as well as the intestinal tracts of humans and animals. Aspiration of secretions from the mouth and nasopharynx may lead to bronchial contamination by endotoxins although horses are more likely to be exposed to endotoxin-contaminated dusts via inhalation.

It was found that a significant linear (or exposure-response) relationship existed between the average percentage of neutrophils in lower airways and exposure to high (>4-5 ng/m3) respirable endotoxin concentrations in breathing zone dust. In addition, young racehorses that became cases (as defined) and developed neutrophilic IAD were approximately four times more likely to have been exposed to either low (<1.2 ng/m3) or high (>4.2 ng/m3) concentrations of endotoxin. These associations controlled for the possible confounding effects of many other variables, highlighting the importance of endotoxin alone in the genesis of neutrophilic lower airway inflammation.

In summary, results of this study indicate that endotoxin from dust sources (such as feed, bedding and sources outside boxes) in stables is associated with neutrophilic IAD in two and three year old thoroughbred racehorses in Australia. As in humans, the severity of this airway inflammation is related to the endotoxin concentration of the inhaled dust. Ventilation quality and meteorological conditions, particularly evaporation level, in looseboxes and stables also were significant risk factors for IAD.

3.2.5 Respiratory Defense Mechanisms in the Horse

Malikides and Hodgson (2003) reported that under normal outdoor circumstances low concentrations of endotoxin are inhaled, however the respiratory tract has efficient defense mechanisms to counteract this airborne endotoxin. It is only when high concentrations of dusts containing endotoxin is inhaled and deposited within the airways that inflammation develops.

Votion et al (1997) reported only particles having a diameter less than 5 μm potentially reach the lower respiratory tract. Factors affecting the deposition of droplets into the lungs include droplet size and respiratory conditions, such as the inhalation and exhalation flow rates and the tidal volume, and anatomical peculiarities. Since characteristics relating to physiological and anatomical factors have a significant influence on aerodynamic behaviour and hence the deposition of the inhaled particles, extrapolation of results obtained in human medicine to horses is not appropriate. These authors documented that the majority (92.6%) of the particles produced by nebulisation of a 0.9% saline solution will have a MMAD smaller than 5 μm. Aerosol deposition in the lungs expressed as percentage of the activity released from the nebuliser were mean +/- s.d. 5.09 +/- 0.66% and 7.35+/- 1.96%, respectively, meaning that only a fraction of that released at the nostrils actually reaches the lungs. The percentage of aerosol reaching the lungs was smaller than the average 10% of aerosol deposition achieved in human medicine.

Malikides and Hodgson (2003) provided a very detailed report regarding dust and IAD in horses. They reported that during normal breathing more than 95% of inhaled particles greater than 5 μm (e.g. small hay and straw fibres, fine wood shaving fibres, sand, pollens, plant spores, and larger bacteria, such as Streptococci) are filtered in the nasal passages, pharynx and tracheal bifurcation as a result of collision and impaction between high velocity particles within the airflow and changing airway anatomy. In the nasal passages, soluble noxious gases are concomitantly removed and neutralised via buffering by fluid and protein found in nasal mucus, and the air is humidified and warmed before entering the smaller lower airways. Once a particle impacts upon the moist nasal respiratory epithelium, it is trapped by mucus and removed by ciliary transport. It is important to note that few particles larger than 5 to 15 μm enter the trachea and more distal airways. When air reaches the level of the respiratory bronchioles and alveoli, most particles <0.5 μm do not contact the respiratory epithelium and are expelled in exhaled air. However, because air velocity is very low in the gas exchanging structures, particles with a diameter <0.1 μm (e.g. gas molecules, endotoxin molecules, viruses, proteins, combustion nuclei, ultra-fine particles) are subject to random thermal kinetic buffeting (Brownian motion/diffusion) and have time to diffuse to the walls of surrounding air surfaces.

Species difference in histamine release from lungs in response to cotton dust were found both between species as well as intra-species by Evans and Nicholls (1974). In this study horses were less reactive to dust while human and pig lungs were most sensitive. Reactivity was also found to increase with age. These authors cited earlier works by Nicholls et al (1967) and. Douglas et al (1970) that failed to detect any histamine release in response to dust in cattle, sheep and horses.

Sweeney et al (1989) confirmed there was good tracheal mucus clearance rates in horses with a tracheal mucus velocity of approximately 20 mm/min, as had been shown in many studies. These authors considered there were considerable differences between species in structure and function of the respiratory tract.

3.2.6 Equine Exposure to Dust

Horses are exposed to large amounts of dust from many sources. These are well reviewed in the report of Malikides and Hodgson (2003) as follows:

> *Factors Contributing to Dust Exposure - In order to be inhaled and cause an effect, dusts must be aerosolised such that solid particles (dusts or smoke) or liquid droplets (mists) of sufficiently small diameter maintain stability as a suspension in air. In racehorse environments this is achieved by machinery (eg., mechanical walkers), ventilation air, or movement of humans and horses in and around stables. Particles that are aerosolised (eg., large viruses, fungal spores and small to medium sized bacteria, fine feed or bedding dust, smoke and motorised pollution) usually range between 0.1 to 10 µm in diameter. They are cleared from air via direct removal by ventilatory airflow (particularly small fungal spores), removal of pathogenic potential while airborne (eg, death of infectious agent) or by reaching an equilibrium and subsequently falling out of the air. Although aerosolised bacteria and viruses may die within seconds, viruses being particularly sensitive to changes in relative humidity, many species still maintain their pathogenicity, antigenicity and ability to induce airway inflammation. This is an important mechanism for certain bacteria, which after death release endotoxin and (1→3)-β-D-glucan, potent pro-inflammatory agents when inhaled into airways. In general, clearance of airborne dusts takes many hours whereas gases such as ammonia or ozone diffuse through air and can remain airborne in still air for much longer. Racehorses, who spend most of their time (up to 22 hours) in looseboxes, are therefore exposed to aerosolised foreign dusts and gases almost continuously and any effects these agents have would likely be cumulative. However, it is important to note that these "steady state" dust levels do not reflect the true levels to which racehorses are exposed due to large variation induced by horse behaviour in loose boxes, horse and human activity in and outside looseboxes, and stable ventilation, bedding type and management. This large variation in concentrations of dusts can occur within horse looseboxes, between looseboxes in the same stable and particularly around the horse's head. Airborne concentrations of dusts in looseboxes, (mostly small fungal and actinomycete spores), regardless of quality of ventilation, can be 2-50 times higher when bedding in looseboxes is being changed and cleaned. On average, this increase in concentration is higher when horses are bedded on straw rather than wood shavings or paper. As well, short periods lying and resting on dust rich bedding exposes horses to massive quantities of infectious and non-infectious particles. Sweeping laneways or stable corridors, catching and moving horses, delivery of feed and bedding to stables, and proximity to roads and urban environments also contribute to increasing exposure of horses to airborne dusts.*

Work by McGorum et al (1998) gives a good indication of base line levels for dust in a pasture management system for horses, although the pasture setting was in Edinburgh (UK) so dust levels may be low compared with general Australian conditions. It was found that total airborne endotoxin concentrations exceeded 20 ng/m^3 (0.02 µg/m^3) in half the stables examined, and that even healthy horses in these environments, may be exposed to sufficient endotoxin to cause airway inflammation and bronchial hyper-responsiveness. However, as normal horses do not develop detectable pulmonary inflammation or hyper-responsiveness when housed in conventional stables (Derksen et al, 1985; McGorum et al, 1993), it is likely that that the minimal total airborne endotoxin concentration causing LRT disease in normal horses exceeds 20 ng/m^3 (0.02 µg/m^3).

Malikides and Hodgson (2003) reported that under normal outdoor circumstances low concentrations of endotoxin are inhaled. However, the respiratory tract has efficient defence mechanisms to counteract this airborne endotoxin. It is only when high concentrations of dusts containing endotoxin are inhaled and deposited within the airways that inflammation develops.

3.2.7 Effect of Dust on Foals

Foals, like adult horses, are susceptible to respiratory disease, which is mostly of bacterial or viral origin. Respiratory disease is very common on all horse farms, often at very high levels. While dust may facilitate the spread of infections between foals this generally occurs when there are increased concentrations of foals close together, sharing the same breathing zone, such as might occur in when foals are herded together in yards or dusty laneways, rather than in paddocks where dust levels are much lower.

An increase in dust levels is unlikely to have any detectable detrimental effect on foals in a paddock environment.

Hoffman et al (1993) examined the incidence of respiratory tract disease in thoroughbred foals in breeding farms in Canada. The study found that 82% (+/- 5%) of foals were affected at one time by lower respiratory tract disease over a 7 month period with bacterial infection the most common inciting factor.

Hoffman et al (1993b) considered that respiratory tract infection in young foals was regarded as enzootic on horse breeding farms. Bacteria, in particular strep zooepidemicus, were primarily responsible. Dust may also be involved in the spread of infections within stables, and it was suggested that stables need to be at least 100 to 150 metres apart to prevent dust-driven disease spread between buildings (Collins and Algers, 1986).

The disease known as “Rattles” is the most common disease of foals in the Hunter Valley that may be transmitted by dust. Rattles (which is caused by *Rhodococcus equi*) is a common LRT disease in foals and is particularly prevalent in the Hunter Valley. There is an increased incidence of the disease associated with dry dusty conditions and dust particles may carry the *R Equi* bacteria considerable distances. The most common source of *R Equi* is considered to be the manure from “carrier” mares, which is then compacted into soil and in dry dust conditions can be inhaled by foals when they are in close proximity, such as in stock yards.

A comprehensive review of this disease, which has included studs in the Hunter Valley, has been published by Muscatello et al (2006). They found the most dangerous areas on studs for foals are likely to be laneways and holding pens and that control may be aided by minimising the time that foals spend in these environments. In addition, areas on farms that had low pasture cover, sandy, dry and acidic soils seemed to be a greater risk.

While there is a potential risk to foals as a result of short term increased exposure to dust, in reality it is extremely unlikely to be a problem unless *R Equi* bacteria is present in considerable numbers in the topsoil over the areas proposed to be mined by the Project. Similarly, the likely absence of any pathogenic bacteria in the dust arising from the Project would indicate any dust from this source is unlikely to compromise the health of foals.

3.3 COMPARATIVE AIR QUALITY IN RACING AND BREEDING LOCATIONS WORLDWIDE

In all environments that horses are raised or raced there is a background level of dust. This is inevitable due to the agricultural nature of raising horse stock as well as the necessity to provide food, bedding and protection from the elements for horses in race training. Information on background dust levels experienced by horses as part of their normal environment was documented in the literature review.

To date there has been no comprehensive evaluation of dust levels at different geographic locations around the world. Therefore an evaluation of dust levels at various established and well recognised racing and breeding locations was undertaken and the report entitled “Comparative review of air quality backgrounds near horse breeding and racing areas” prepared by PAEHolmes, 2012, which is attached as Appendix 2. It was considered important to determine dust levels from other horse racing and breeding sites to enable comparison on a wider basis and to understand how they compared to the existing climate of the Hunter Valley and that of the Project being assessed.

The review evaluated established and well recognised racing and breeding locations within Australia and internationally. Locations identified as fitting the criteria included:

- Australia;
  - Hunter Valley, NSW;
  - Randwick, NSW; and
  - Flemington, Victoria.
- United States of America;
  - Louisville, Kentucky; and
  - Lexington, Kentucky.
- Ireland;
  - Kildare;
  - Tipperary; and
  - Meath.
- United Kingdom;
  - Newmarket.
- Saudi Arabia; and
- Hong Kong.
  - Sha Tin; and
  - Happy Valley.

Based on this information, background data for particulate matter finer than 10 microns (PM_{10}) was determined at monitoring stations close to these sites and are reproduced in **Table 2**.

Table 2
PM_{10} Annual Average Concentrations

Location		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
		PM^{10} Annual Average Concentration (µg/m^3)										
Saudi Arabia	Saudi Arabia	148	143	137	128	118	112	107	104	-	-	-
Hong Kong	Sha Tin	-	-	-	-	53	53	51	50	45	45	-
	Eastern	-	-	-	-	49	47	49	46	43	43	-
Australia	Footscray	-	-	-	-	21	22	20	21	22	-	-
	Singleton	-	-	-	-	-	-	-	-	-	20	19
	Muswellbrook	-	-	-	-	-	-	-	-	-	20	19
	Tamworth	-	-	-	-	-	18	16	16	18	12	13
	Randwick	-	-	-	-	-	22	18	17	20	16	15
United States of America	Louisville	-	-	25	23	26	23	25	22	-	-	-
	Louisville 2	-	-	23	21	24	22	24	21	-	-	-
	Lexington-Fayette	-	-	23	21	24	21	23	19	-	-	-
	Elizabethtown	-	-	19	18	21	17	-	-	-	-	-
	Richmond	-	-	20	18	21	18	-	-	-	-	-
Ireland	Cork, Old Station Road	-	24	26	22	19	16	15	16	18	22	-
	Cork, Heatherton Park	-	21	20	19	17	18	17	15	15	18	-
	Dublin, Dun Laoghraine	-	-	-	-	-	-	-	15	15	15	-
	Tipperary, Clonmel	-	-	-	20	19	-	-	-	-	-	-
	Kildare, Naas	-	-	17	17	-	-	-	-	-	-	-
	Kildare, Newbridge	-	-	-	-	-	-	-	-	14	20	-
	Meath, Navan	-	-	-	-	-	-	23	-	-	-	-
United Kingdom	Newmarket Racecourse	-	-	-	21	20	17	17	16	16	16	16

This review concluded that the majority of horse breeding and racing businesses within Australia and internationally operate in similar and comparable PM_{10} air quality backgrounds, typically ranging between 15 and 26 µg/m³. As might be expected, Saudi Arabia and Hong Kong had higher concentrations of between 104 and 148 µg/m^3 and 53 and 43 µg/m^3, respectively.

This data is important in that it provides a background level of dust that horses currently experience during racing and breeding. As noted in the literature review, the level of endotoxins attached to the dust is of more importance to equine health. To date, there is no data on endotoxin levels from soil in association with potential mining projects. Research in this regard is presented in **Section 5.2**.

3.4 ATHLETIC PERFORMANCE AND AIR QUALITY

Garlipp et al (2011) stated that in many reports respiratory diseases are considered to be “occupational diseases” in horses.

In Australia well over 20-55% of horses in any form of athletic endeavour may have IAD. The incidence in pastured horses is much lower. IAD is a very general response to a wide variety of stimuli. Causes include viruses, bacteria, fungi, and stable dust. The effects that IAD have on horse health and performance varies considerably depending on the seriousness of the response and the expected athletic performance of the horse. IAD is primarily a disease of stabled horses. Racing horses at the elite level are all stabled, some for up to 22 hours per day. It is well recognized and documented that these horses are able to win races often despite the presence of some degree of IAD.

Table 2 clearly shows that very high environmental dust levels are present in some of the major racing areas of the world. Some of the best horses in the world are found in the Saudi Arabia and in Hong Kong. These horses are able to compete on the international stage despite high levels of dust as well as airborne pollutants. Further, the high dust levels experienced, particularly in Hong Kong and Saudi Arabia, has not been seen as a reason not to train horses in those locations.

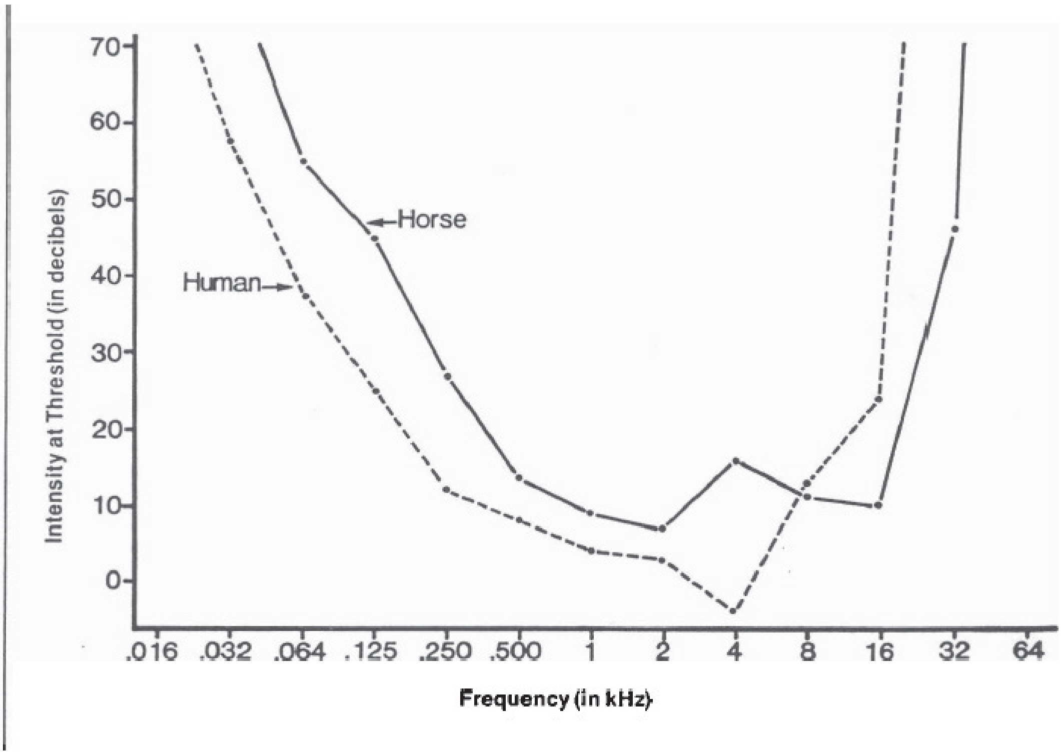
3.5 NOISE LITERATURE REVIEW

There are a small number of articles that have evaluated the hearing ability of horses and their response to noise. Anecdotal information suggest that horses are very adverse to sudden increases in noise and that they are prone to a “flight” response which may result in injury to themselves.

One of the more comprehensive studies on hearing in horses was undertaken by Heffner and Heffner (1983). These authors found that when comparing horses with humans, it can be seen that while most sounds audible to horses are also audible to humans and vice versa, several differences do exist (see **Figure 3**).

Firstly, horses are less sensitive to low-frequency sounds than humans, whose low-frequency range extends down to 29 Hz (at 60 dBA). Secondly, this difference extends into the mid-frequency range from 500 Hz to 8 kHz where it can be seen that humans' lowest threshold of -4 dBA at 4 kHz is significantly lower than the horse's lowest threshold of 7 dBA at 2 kHz. However, above 8 kHz horses are clearly more sensitive than humans, whose 60 dBA high-frequency hearing limit is 19 kHz.

Figure 3
Comparative hearing ability of horses and humans



A review of research into the relative hearing ability of a wide variety of animals (in *Comparative Psychology: A Handbook* by Greenberg and Haraway) found that the hearing threshold of horses was 5-15 dBA higher than humans – that is, horses are somewhat deaf compared to humans.

A more detailed report of hearing in cattle and horses was documented by Heffner and Heffner (1983a). They found that horses' hearing ranged from 55 Hz to 33.5 kHz, with a region of best sensitivity from 1 kHz to 16 kHz, with a lowest threshold of 7 dBA. Audiograms showed a gradual increase in sensitivity as frequency increased to about 500 Hz. At this point the audiogram levels off, with a range of best sensitivity extending from 1 kHz to 16 kHz, with a dip in sensitivity at 4 kHz. Above 16 kHz, sensitivity decreases rapidly until the upper limit of audibility is reached. Overall, at an intensity of 60 dB, the horses' range of hearing extends from 55 Hz to 33.5 kHz.

In low-frequency hearing ability, horses are more sensitive than most other mammals. At an intensity of 60 dBA, the highest frequencies audible were 30 kHz, 38 kHz, and 32 kHz for Horses A, B, and C, respectively. These results give the horse an average high-frequency hearing limit of 33.5 kHz, a value lower than that of most other mammals.

In summary, horses, cattle, and sheep are more sensitive to low frequencies and less sensitive to high frequencies than most other mammals. However, unlike the horse, both cattle and sheep possess well-defined best frequencies at which points they are 13-18 dBA more sensitive than the horse.

Whether these differences are related to the fact that horses are members of a different mammalian order remains to be determined. Both horses and cattle do not hear as high as most mammals, an observation that coincides with their larger than average interaural distance.

The response of horses to loud, unexpected noise, as well as sights and smell, was investigated by Christensen et al (2005). During the auditory test, a novel sound (white noise, 10–20,000 Hz, 60 dBA) was played as horses approached the feeder. Exposure to the novel visual and auditory stimuli elicited significantly increased heart rate (HR) responses in the horses, whereas there was no increase in HR to the olfactory stimulus. The average HR responses to the different test situations gave a similar picture (control: 52+/-2, visual: 57+/-2, olfactory: 51+/-2.72, auditory: 62+/- 2.28)

Time spent eating was negatively correlated with all other variables, i.e. the more time a horse spent eating, the less it responded to the test stimulus.

The test stimuli elicited different behavioural responses in the horses and the heart rate increased in response to the visual and auditory stimuli, but not to the olfactory stimulus. Apart from a significantly reduced eating time in all test situations compared to the control situation, it is noteworthy that the behavioural responses to the novel visual and auditory stimuli were similar, whereas the responses towards the novel olfactory stimulus differed. The horses in the study showed very little adverse locomotion activity in the tests.

The United States National Park Service's 2004 Sheep Report provides a comprehensive review of the likely effects of aircraft fly-over noise on animals, with particular emphasis on wildlife. The report differentiates between chronic exposure, for which the major concerns are related to the animals' energy conservation, and acute exposure, such as startle and panic behaviour. The report advised that *acute responses… occur in most wildlife species evaluated at noise levels greater than 95 dBA.*

One other factor to consider is habituation. If the noise is familiar and not associated with danger, the animals' response will become moderated. This is most evident in the (often ineffectual) use of scare guns to remove pest species such as cockatoos from crops or seagulls from airports. Habituation in horses is commonly seen, for example in horses used in large scale performance events and shows as well as police horses. One of the best examples was the use of army and cavalry horses in many wars up until the early part of last century where horses became accustomed to explosions.

When Flemington Racecourse became the proposed venue for Australia's largest music festival – the Big Day Out – there was concern expressed by the owners of the thoroughbred race horses stabled at the racecourse that the horses may react badly to the potentially excessive music noise. In order to evaluate the potential impact of this concert on horses stabled at the site, a comprehensive noise impact study was undertaken (Huybregts 2008). The noise exposure (LAeq,15 minutes) of horses during major race events was measured at

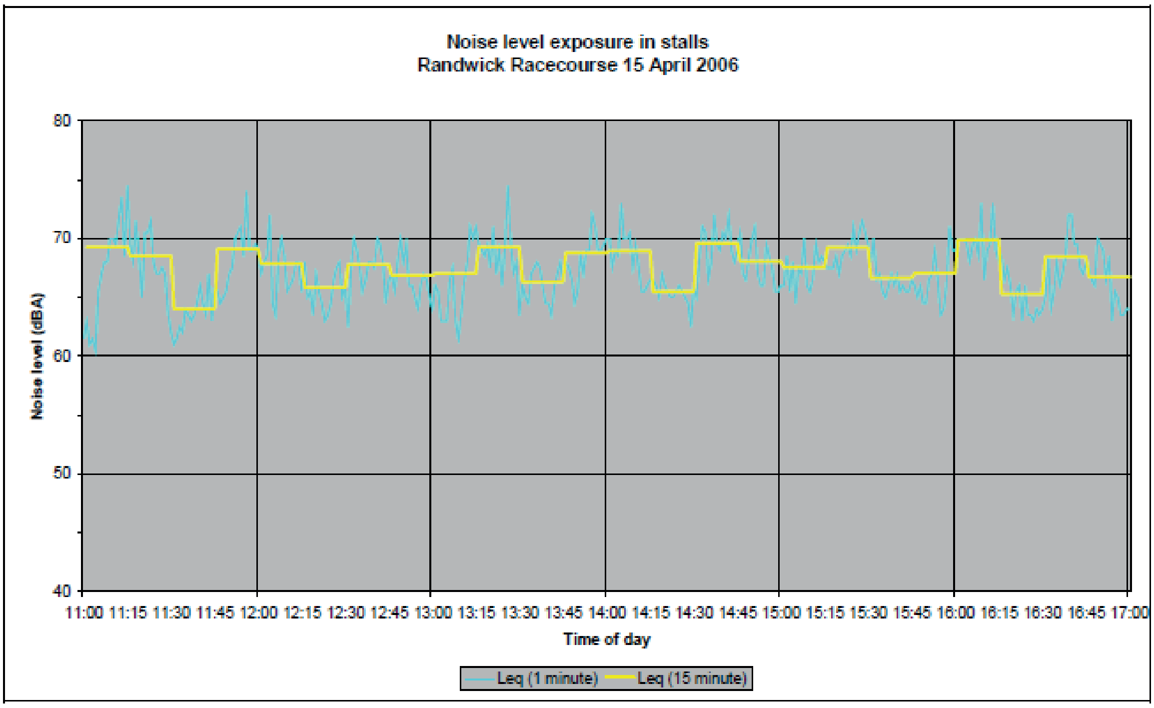
58-62 dBA in the stables (rising to 66-68 dBA during helicopter flyovers), and 65-70 dBA in the stalls. The Clerk of the Course's horse was exposed to 76 dBA LAeq, 6h at Randwick Racecourse during the New Easter Carnival and 85 dBA LAeq, 6h at Flemington during the Melbourne Cup. Results of the noise monitoring near the stables showed that on non-race days, the LAeq, 15 minutes noise levels were in the range 50-65 dBA during the day. On race days, noise levels were about 51-68 dBA.

During the Big Day Out, the noise exposure (LAeq, 15 minutes) of horses in the stables was measured at 54-70 dBA. The horses generally showed little response to the music noise except when the noise was associated with visible stimuli, or when the noise was of an alarming character such as short bursts of high-pitched singing.

The figures below show the noise levels experienced in the stalls and by the Clerk of the Course's horse. These show many sudden changes in noise levels, peaking at 100 dBA.

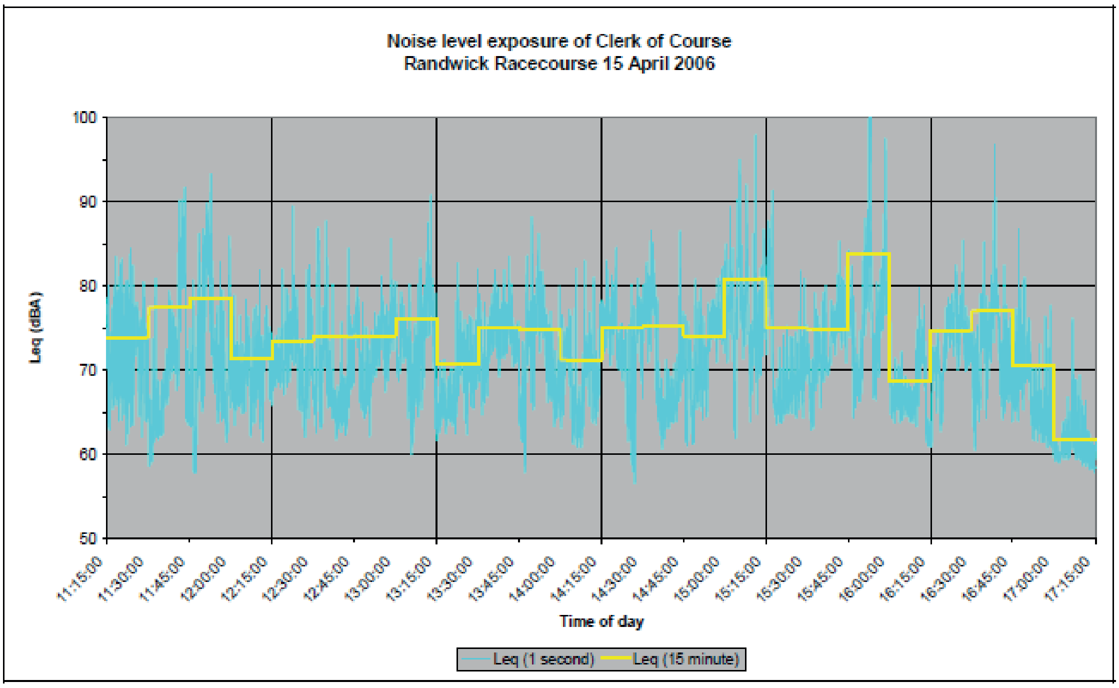
Figure 4 shows the measured noise levels in the stalls. Noise levels (LAeq, 15 minutes) were in the range 64-70 dBA. **Figure 5** shows the noise exposure of Yotis, the Clerk of Course's horse, moving between stalls, the pre-mounting yard, the mounting yard and the race track for the whole event. Noise levels (LAeq,15 minutes) were in the range 69-84 dBA. The LAeq,6h noise level for the whole of the measurement period was 76 dBA.

Figure 4
Measured Noise Levels in the Stalls



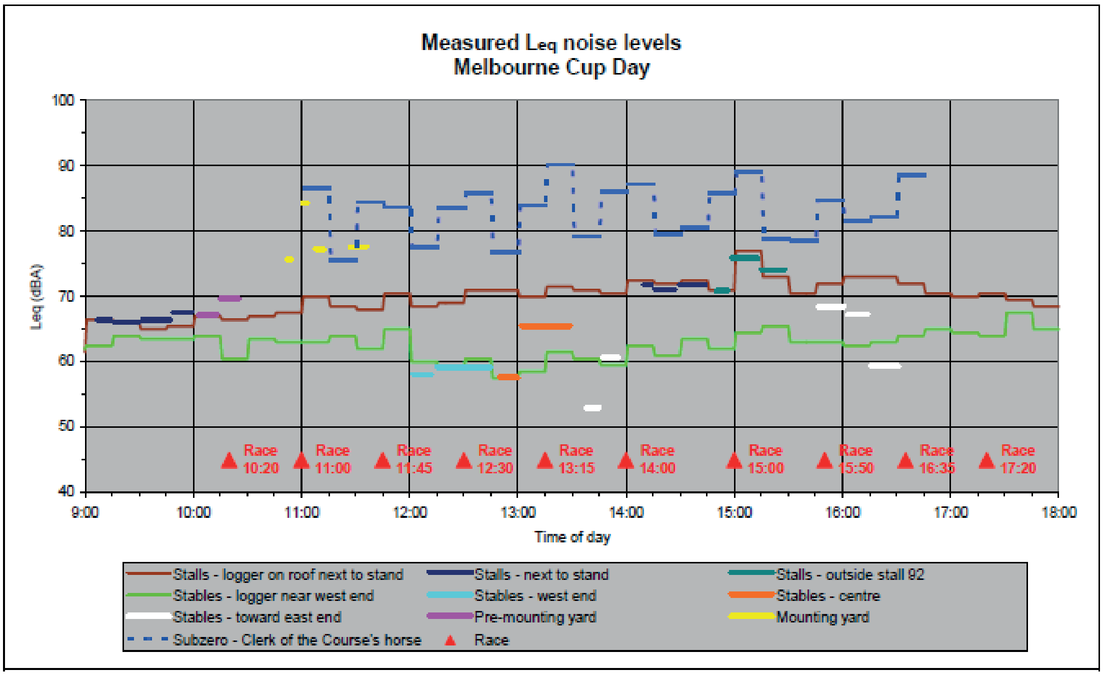
(Huybregts 2008)

Figure 5
Noise Exposure of Yotis, a Clerk of the Course's horse



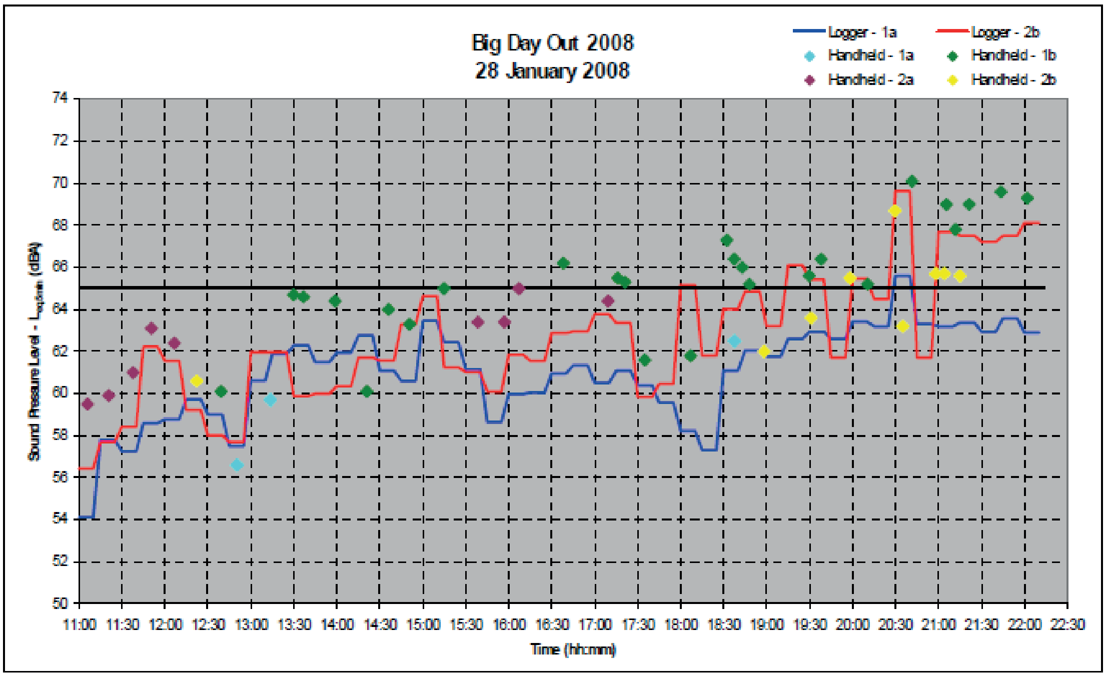
(Huybregts 2008)

Figure 6
Measured Noise Levels Melbourne Cup Day



(Huybregts 2008)

Figure 7
Noise levels in stables during the Big Day Out



(Huybregts 2008)

The Huybregts report (2008) considered:

- That the circumstances of the exposure to concert noise would be somewhat unfamiliar;
- That the noise would not be associated with any danger and if there is any initial startle responses, habituation may occur quickly; and
- That the horses at the two race events investigated were exposed to “average” noise levels of 65-70 dBA in the stalls and 70-90 dBA when moving in and out of the stalls.

They concluded that while definite recommendations regarding criteria for the exposure of thoroughbred horses to noise could not be provided, it was felt that some kind of threshold level would be useful. In summary they advised that “*it appears that use of Flemington Racecourse as a concert venue would be acceptable provided that the LAeq noise level in the stables did not exceed 65 dBA.*

This was combined with recommendations that:

- Fireworks or other activities causing loud bangs should not be permitted; and
- Noise levels should be monitored in the stables to confirm that the LAeq noise levels do not generally exceed 65 dBA.

A report from New Zealand documented further studies evaluating the effect of noise on animals. (Proposed Mining And Related Activities - Mt William North Assessment of Noise & Vibration Effects, 2011).

The report concluded as follows;

> *<u>Effects of Noise on Animals</u>*
> *We have conducted an extensive literature review of the potential noise effects on livestock and wildlife the results of which are succinctly summarised by one research paper, Warren et al (2006), which states that there is a "surprising dearth of research on the behavioural responses of animals to altered acoustic environments".*
>
> *A discussion of the available research knowledge is provided and summarised as follows:*
>
> > *1. Once animals become habituated to noise, especially when it is steady and associated with clearly non-threatening activity, they demonstrate little adverse response. This is particularly true with cattle, horses and other livestock.*
> > *2. Similarly, birds appear to readily adapt to noise and whilst very loud events can startle birds, noise events that meet applicable criteria for human exposure, are extremely unlikely to cause startle or similar effects.*
> > *3. The response of birds, animals and livestock to noise will also depend on the character and duration of the sound and observations suggest that steady broad band noise will create less negative response than transient, intermittent or tonal sounds.*
>
> *<u>Horses</u>*
> *A case study by Huybregts from Marshall Day Acoustics observes that horses in stables exposed to LAeq,15min of 54-70 dB generally show little response to music noise unless the noise is particularly impulsive. A noise criterion of 65 dB LAeq is recommended by Huybregts (2008). Le Blanc et al (1991) found that birth success of pregnant mares was not affected byF-14 jet aircraft noise. While the 'fright-flight' reaction was initially observed, the mares did adapt to the noise.*
>
> *Race horses are known for being high-strung. However, Marshall Day Acoustics have observed horses grazing in paddocks directly under the main approach path of the Christchurch International Airport where noise levels are in excess of 90 dB (LAmax) during an aircraft flyover. Although these horses are arguably "used to" the noise, there was generally little recognition by them of an aircraft passing, let alone any sign of disturbance. This tends to support the conclusions by Le Blanc et al (1991).*
>
> *From the above information, we recommend a noise level criteria suggested for human exposure.*

3.5.1 Environmental Noise in Other Horse Populations

Horses are subject to high noise levels in a number of different environments. One of the most extreme locations is at Clarendon, NSW, which is the location of a large Royal Australian Air Force (RAAF) base. Planes land and take off at irregular intervals and the noise and vibration is excessive. The Hawkesbury Equine Veterinary Centre is directly across the road from the base. Despite the loud noise and vibration even horses that are recently introduced to the clinic environment display no ill effects. Hawkesbury race course is also in very close proximity and horses stabled in this location, and those arriving to race at the track, also cope without any adverse effects.

3.6 VIBRATION LITERATURE REVIEW

There is little scientific data regarding the effect of ground vibration on horse health. While little is known of the effects of ground vibration, there have been many studies evaluating the effects of low level whole body vibration (WBV) in people and animal models (Crewther et al 2004) and no adverse effects have been detected.

The amount of vibration associated with intermittent blasting that might be experienced by horses close to the Project would seem to be less than that which may be experienced by animals during transport. Given that horses are regularly transported long distances in both planes and motor vehicles without any ill effects or concern, it is likely that vibration from blasting will also cause no concern to horses in the area.

Due to its irregular and intermittent nature, it is not envisaged that any detrimental effects of vibration will be encountered.

3.7 SONIC BOOM LITERATURE REVIEW

The most likely effect of a sudden increase in noise associated with blasting is a short term “flight or fight response”. An individual animal may become startled but in the absence of ongoing noise it is very unlikely to run from the noise or harm itself. A further factor is that horses do have some difficulty in initially determining the direction from which noise has arisen so that they are unlikely to immediately run in the opposite direction.

While it is acknowledged there is very little scientific information regarding the effects of noise, vibration and over pressure from blasting there has been considerable study done on the effects of sonic booms from jet aircraft on animals. The effect of a sonic boom might be considered similar, although of potentially much greater magnitude, to that of blasting. The studies evaluating the effect of sonic booms from aircraft engines invariably find there is no adverse effect in horses. Those that are regularly on the property will rapidly become habituated to any excess noise while those newly introduced may temporarily be startled but will be calmed by other horses and will quickly habituate.

The Caval Ridge Coal Mine Project EIS states that (originally reported in Noise Basics and the Effect of Aviation Noise on the Environment Wyle):

> *An analysis of data from 42 herds did not show any evidence that flyovers or proximity to the ends of the active runways had an effect on the milk production of the herds. Animal installations were selected for observations on animal behaviour under sonic boom conditions. Numbers of animals observed in this study were about 10,000 commercial feedlot beef cattle, 100 horses, 150 sheep and 320 lactating dairy cattle. Booms during the test period were scheduled at varying intervals during the morning hours Monday to Friday of each week.*
>
> *Results of the study showed that the reactions of the sheep and horses to sonic booms were slight. Dairy cattle were little affected by sonic booms (125 dB to 136 dB). Only 19 of 104 booms produced even a mild reaction, as evidenced by a temporary cessation of eating, rising of heads, or slight startle effects in a few of those being milked. Milk production was not affected during the test period, as evidenced by total and individual milk yield.*
>
> *Horses*
> *Horses have also been observed to react to over flights of jet aircraft. Several of the studies reviewed reported a varied response of horses to low-altitude aircraft over flights.*
>
> *Although horses were observed noticing the over flights, it did not appear to affect either survivability or reproductive success. There was also some indication that habituation to these types of disturbances was occurring. (U.S. Air Force 1994b).*
> *LeBlanc, et al. (1991), studied the effects of F-14 jet aircraft noise on pregnant mares. They specifically focused on any changes in pregnancy success, behavior, cardiac function, hormonal production, and rate of habituation. Their findings reported observations of “flight-fright” reactions, which caused increases in heart rates and serum cortisol concentrations. The mares, however, did habituate to the noise. Levels of anxiety and mass body movements were the highest after initial exposure, with intensities of responses decreasing thereafter. There were no differences in pregnancy success when compared to a control group.*
>
> *The literature does suggest that common responses include the “startle” or “fright” response and, ultimately, habituation. It has been reported that the intensities and durations of the startle response decrease with the numbers and frequencies of exposures, suggesting no long-term adverse effects.*
>
> *The majority of the literature suggests that domestic animal species (cows, horses, chickens) and wildlife species exhibit adaptation, acclimation, and habituation after repeated exposure to jet aircraft noise and sonic booms. Animal responses to aircraft noise appear to be somewhat dependent on, or influenced by, the size, shape, speed, proximity (vertical and horizontal), engine noise, color, and flight profile of*

> *planes. Helicopters also appear to induce greater intensities and durations of disturbance behavior as compared to fixed-wing aircraft. Some studies showed that animals that had been previously exposed to jet aircraft noise exhibited greater degrees of alarm and disturbance to other objects creating noise, such as boats, people, and objects blowing across the landscape. Other factors influencing response to jet aircraft noise may include wind direction, speed, and local air turbulence; landscape structures (i.e., amount and type of vegetative cover); and, in the case of bird species, whether the animals are in the incubation/nesting phase.*
>
> *The response to sonic booms or other sudden disturbances is similar among many species (Moller 1978). Sudden and unfamiliar sounds usually act as an alarm and trigger a "fight or flight" startle reaction. However, sonic booms are not expected to cause more than a temporary startle-response because the "pursuit" would not be present.*

Other studies, summarized below, have also demonstrated no adverse effects of sonic booms:

> *Eight ponies, 2 open cows, 6 cows with calves, and 24 steers were used in a series of trials to study the effects of simulated sonic booms (overpressure of 200 N/m2) on eating patterns, feed intake, and behavioral activity. All animals clearly showed a startle response after each boom. Eating patterns and feed intake were not affected by sonic booms* (Bond et al 1974).
>
> *The effects of sonic booms on farm animal behavior and reproduction were investigated at Edwards Air Force Base in California. All animals had experienced sonic booms prior to the study. Observed behavioral reactions of animals to the booms were minimal except for avian species. Reactions were more pronounced from low-flying subsonic aircraft noise than from booms* (Casady and Lehmann, 1967).

The lack of adverse effects of blasting on horses is further evidenced by testimony from Dr Deborah Jane Racklyeft BVSc, MVCS,PhD, FANZCVS. She has confirmed that in her 23 years' experience as a registered Specialist in Equine Medicine at Satur Veterinary Clinic in the Upper Hunter Valley and in doing so attending numerous horses with traumatic injuries, often as a result of their flight response her personal experience has been that there has never been an occasion where an injury has been due to mine blasting or other mine-associated activities.

Given there is a comparable impact level on the flight instinct of horses for sonic booms and mine blasting activities, multiple independent studies have concluded there is sufficient data to suggest that there will be no adverse impact on equine health from blasting. This evidence has been further supported by the opinion of Dr Racklyeft who has advised that she has not attended any injuries in horses that may have been caused by a flight response subsequent to blasting.

3.8 LIGHT LITERATURE REVIEW

By way of background the use of artificial light is commonly used in equine breeding to alter the normal breeding season. During winter mares do not cycle and they require approximately 60 days of increasing light periods, which mimic longer day light hours which would occur naturally, before they begin cycling again.

Typically 16 hours of light per day are required before mares will start cycling. They visually involve an extra hour of artificial lighting at dawn with lights switched off at midnight. Usually about 70 – 100 lux is recommended. An alternative suggestion has been to expose the mares to 1 hour of extra lighting at approximately 9.5 – 10 hours after onset of darkness.

Increased light periods in Australia commence about the winter equinox (late June) and must continue until they start to cycle in September.

Given that as little as 10 lux of light exposure may have some effect in some mares it is possible that light from any source may potentially effect the breeding cycle of mares.

The effects of photoperiod on reproductive activity and hair changes in pony mares were studied by Kooistra and Ginther (1975). The effect of a fixed daily photoperiod on the onset of the breeding season was studied in four treatment groups: daily photoperiod equivalent to the normal day length (control group); constant light 24 hours a day with no dark (L24:D0 group); 16-hour daily photoperiod with 8 hours of dark (L16:D8 group); and 9-hour daily photoperiod with 15 hours of dark (L9:D15 group). A fixed daily photoperiod of 16 or 24 hours induced early onset of the breeding season and early shedding of hair, with development of a smooth coat. A photoperiod of 9 hours retarded the onset of the breeding season. Mares induced to begin the breeding season earlier than normal did not become anestrous earlier than normal. Mares kept on a long daily photoperiod in the fall became anestrous later than normal.

This would indicate that exposure to light may result in earlier onset of the breeding season, which might be seen as an advantage rather than a disadvantage in the thoroughbred breeding industry.

Interestingly, the reproductive performance of Icelandic horses, which are exposed to long hours of daylight for much of the year, is comparable, or better, than horses with less daylight hours (Dýrmundsson, 1994).

Based on the study report findings it is concluded that increased exposure to light is unlikely to have any detrimental effect on the breeding cycle of mares.

3.9 COMMENTS ON ADDITIONAL LITERATURE REVIEW DATA

A literature review was also produced by Mr Terry Short from La Tierra in advice provided to the Review PAC.

However the conclusion reached in that report being that "*noise, blasting, lighting and maybe even air emission could have the potential to disrupt or impact the breeding operations of studs"* is contrary to the scientific evidence presented in the EA Equine Health Impact Assessment and is not supported by the data or literature cited in the Short report.

This conclusion appears to be based largely on the unsupported personal opinion of Mr Short (based apparently on misleading information obtained as a result of a literature search) and to a lesser extent public submissions (also unsupported by any scientific documentation) to the PAC. To the best of my knowledge no public submission presented any scientific claims to support the opinion that the mine would have an adverse impact on horse health or breeding.

The report claims to "*have conducted its own review of available and relevant literature which is cited throughout."* There are just three references cited in regard to equine health, compared to well over 100 scientific veterinary documents reviewed and included in the EA Equine Health Assessment submitted as part of the previous application. Of even greater concern is that the three scientific articles quoted in regard to equine health are not relevant to the Project and are actually highly misleading.

The Short report advises (p17) that *"this review has observed other studies that do correlate the equine and human response to particulate matter from dust (Martin and Harwood, 2002)".* The article cited compares human asthma with recurrent airway obstruction (RAO) in horses and explores similarities in the genetic makeup of horses and people in regards to the allergenic response in the lungs. In this article RAO is specifically defined as COPD or heaves. The article specifically states that *"equine RAO is a hypersensitivity reaction to mould spores present in hay and straw dust and / or other allergens*". It is likely there is a strong genetic basis with a complex mode of inheritance for RAO (Racine et al 2011) however people with no mutations predisposing them to asthma would not develop the disease under any environmental conditions (Hall 2000, cited by Marti & Harwood 2002). Further RAO (or COPD) is purely a disease of stabled horses. It is extremely rare in the Southern Hemisphere, while being very common in the Northern Hemisphere.

There is no suggestion or indication that there will be mould or allergens in any dust generated by the Project so that the citation of this article is highly misleading and should have been refuted by the PAC. This reference actually supports the approach in the Equine Health Impact Assessment Report which advised that dust in stables was a good benchmark for occupational dust exposure by racing horses and posed far higher risks to horses than any potential increase in dust from the mine.

This article was also used as the basis for the statement in the Short report that *"unfounded assumption in the AIS and Equine Impact Assessment that the equine response would differ* *to the human response to dust exceedances. Further analysis is required*". Horses do respond differently in many respects, yet as both are mammalian species there are many physiological features in common. The conclusions from evaluating the large amount of existing scientific data regarding equine dust exposure is that human safety levels would be more than adequate for horses. Although precise safe levels for dust exposure in horses have not been defined, given there are anatomical and physiological differences in the way each species respond (for example humans being upright, are far more likely to inhale dust into the lungs and keep it there as their nostrils are well above the height of their lungs - in contrast horses nostrils and windpipe are lower than the bulk of their lungs, which naturally favours easier removal of any dust and irritants) then it is highly probable the safe levels would be much higher. Despite this the Project has accepted human safety guidelines as a level to use for horses to provide even greater certainty about the safety of the Project in regards to horse health.

The other two equine health articles quoted by Short are those by Schwart et al (1981) and Arenz et al (2001). Both these articles relate to a very specific disease, namely "silicate pneumoconiosis" or "pulmonary silicosis". This is an extremely rare condition with both these reports being the only reported cases and which documented similar animals affected by the disease from the Montesey-Carmel Peninsula in California USA. The authors advise this disease is found in arid or desert areas where the soils are rich in silicates. There is no indication of how the horses acquired the disease or any discussion of dust inhalation. Quoting these reports is very misleading as there is no indication that any soil disturbed by the Project is rich in silicates. Pulmonary silicosis will not be an issue in this case. Therefore the claim in the Short report that "*other studies indicate that there are impacts from equine exposure to environmental inorganic particulate matter*" is highly misleading and must not be relied upon by the PAC.

It is unfortunate that the Short report chose to select only three out of over 100 scientific articles to cite from, and those three articles were irrelevant to the Project. As noted above, one report referred to the effects of mould and allergens on horse health, specifically in relation to COPD, which is a problem of stabled horses and not actually widely recognised in Australia nor will there be mould or allergens attached to the crustal dust, while both the other reports referred to pulmonary silicosis which has only been reported once ever and is associated with unusual soil composition which does not exist in the Hunter Valley,

The Short report also claims to have undertaken "*additional analysis of potential impacts of noise, dust and lighting to equine breeding" under the heading "unstated impacts*" (p14). There is no indication of what this analysis is or what facts or scientific information this statement is based on. The Short report states (p38) that *"no information does not equal no impact and precautionary principle must apply*." This statement ignores the large amount of scientific data and documentation which has been provided and which clearly demonstrates there will be no impact on equine health as a result of dust, noise, vibration or changes in lighting.

4 BACKGROUND OF EQUINE INDUSTRIES IN THE REGION

4.1 COOLMORE AUSTRALIA

Coolmore is a multi-national thoroughbred breeding operation with headquarters in Tipperary, Ireland and supported by operations in Kentucky, USA, and the Hunter Valley. Coolmore Stud in the Hunter Valley is Coolmore's only operation in Australia. Coolmore acquired this property from the Arrowfield Group in 1991.

Coolmore is a thoroughbred breeding operation with revenue generated primarily through standing fees for its stallions. The Coolmore website identifies the property as the best in Australia with three main reasons for success being stallions; Danehill, Encosta de Lago and Fastnet Rock. Many of the premium Coolmore stallions are shuttled between Australia and Ireland to enable full year breeding across both hemispheres. Coolmore also generates revenue through agistment of clients' broodmares and rearing of foals. Coolmore generally does not breed its own horses for racing. Also, Coolmore does not normally stand stallions other than their own.

4.2 DARLEY AUSTRALIA

Darley is a multi-national thoroughbred breeding operation standing stallions in six countries. The Darley business model is quite different to Coolmore with a focus on breeding and raising thoroughbreds for the Darley racing operation. Darley Australia operates studs in both NSW and Victoria. In NSW, Darley operates the Kelvinside Stud at Aberdeen, Woodlands Stud at Jerrys Plains and Twin Hills Stud at Cootamundra. Within the Hunter Valley, Darley purchased the Kelvinside Stud from Hilton Cope in 2003 and the Woodlands Stud from Ingham Brothers in 2008.

Darley's business model incorporates a number of revenue streams including:

- Standing fees for its stallions;
- Fees for agistment of clients broodmares;
- Sales of horses produced by its own bloodstock; and
- Prize money earned through racing.

Darley offers the services of its stallions to its clients exclusively at the Kelvinside Stud. Many stallions are shuttled between the northern and southern hemisphere operations to enable breeding operations throughout the year. Darley also agists clients' broodmares at Kelvinside Stud.

The Woodlands Stud is used exclusively for the agistment of Darley's own broodmares. The offspring of Darley's internal breeding operations are either offered for sale at local and international sales or retained for participation in Darley's racing operations.

4.3 EDINGLASSIE STUD

The Edinglassie Stud is a highly regarded Australian thoroughbred stud farm located 7 km south west of Muswellbrook. The Edinglassie stud produces elite thoroughbred racehorses and yearlings for sale (Edinglassie website, 2015) and offers services that include mare (and progeny) agistment, foaling facilities and a hospital. The Edinglassie Stud is equipped with modern yearling preparation facilities, including walking machine, round yards and day yards.

The Edinglassie Stud is located less than 130 m from operations at the neighbouring BHP Billiton Mt Arthur Coal Mine, 850 m from Coal & Allied’s Bengalla rail loop, 1300 m from the coal preparation plant and 1100 m from active mining (see **Figure 8**).

Mt Arthur Coal Mine is the largest operating coal mine in the Hunter Valley, with saleable production from the open cut complexes totalling over 18 million tonnes in the 2013 financial year.

DRAYTON SOUTH COAL PROJECT

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Edinglassie Horse Stud Proximity to Mining Activities

FIGURE 8

5 ASSESSMENT AGAINST PREDICTED PROJECT DUST

5.1 EIS AIR QUALITY ASSESSMENT

As part of the EIS for the Project, Pacific Environment Limited (PEL) completed an Air Quality and Greenhouse Gas Impact Assessment (the EIS Air Quality Assessment) which characterised the existing baseline air quality for the project site and surrounding areas and undertook regulatory dispersion modelling to predict future ambient air quality during the Project life. As part of this EIS Equine Health Impact Assessment, the findings of the EIS Air Quality Assessment have been reviewed and included in this report for discussion where relevant.

5.1.1 Existing Baseline Air Quality

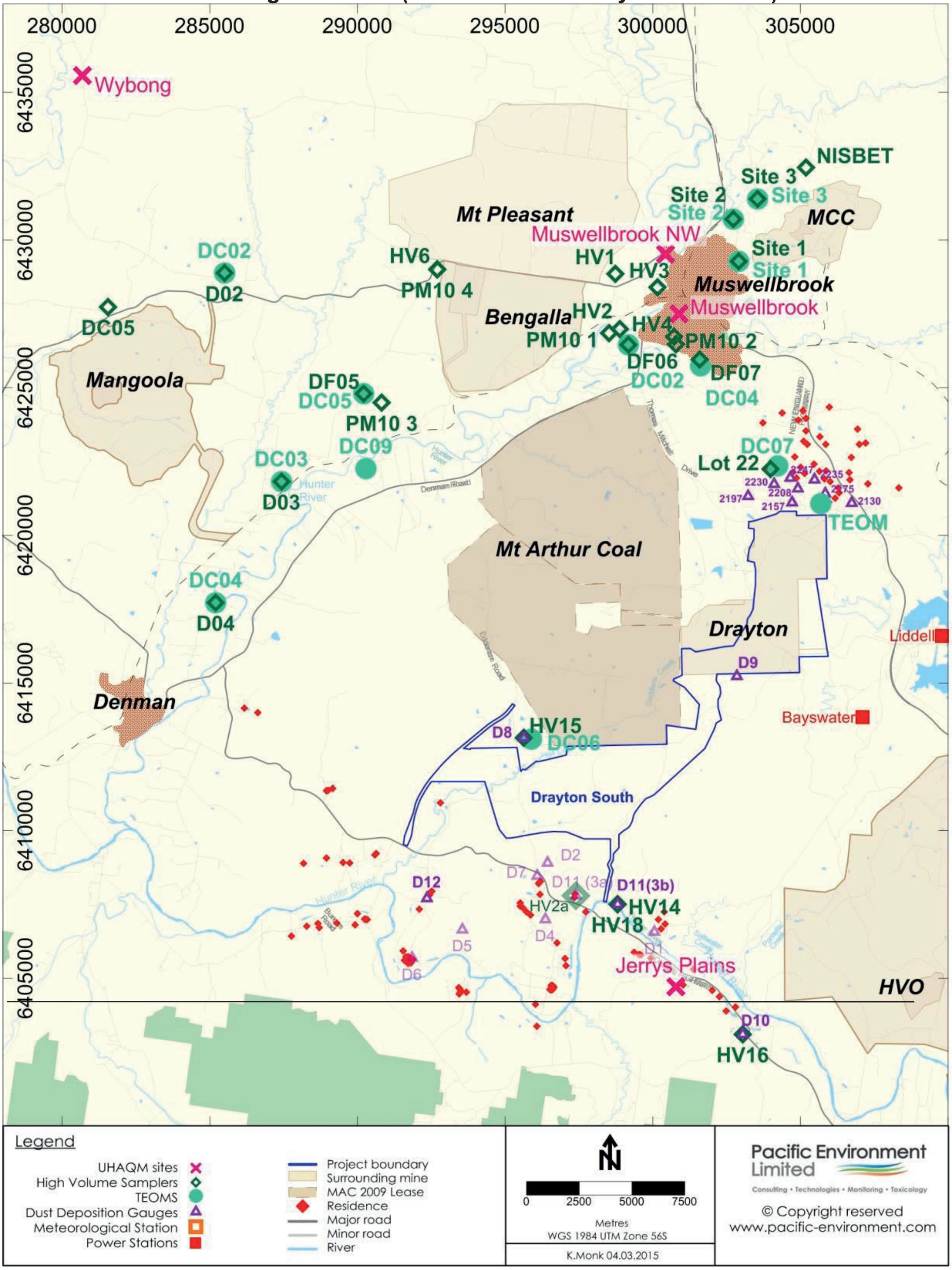
As part of the EIS Air Quality Assessment, background air monitoring data was reviewed and incorporated into the report for the purpose of characterising the existing baseline air quality for the area. The locations of the monitoring sites are shown on **Figure 9** with the results presented in **Table 3**. From the results in **Table 3** it can be seen that the Llanillo site (HV2a), which is closest to the horse studs, recorded an average PM_{10} concentration of 25 µg/m^3 over the monitoring period from 2000 to 2011. During this time the measured level ranged from 12 to 42 µg/m^3.

Table 3
TSP and PM_{10} annual average concentrations (µg/m^3)

Year	Edderton (HV4)	Llanillo (HV2a)		Plashett (HV18)		Jerrys Plains School (HV16)		LOT 9	
	TSP	TSP	PM_{10}	TSP	PM_{10}	TSP	PM_{10}	PM_{10}	TSP
1998	31	-	-			-	-	-	-
1999	32	-	-			-	-	-	-
2000	30	38	17			-	-	-	-
2001	35	44	15			32	19	-	-
2002	44	53	**39**			49	22	-	-
2003	46	58	**31**			42	**31**	-	-
2004	42	43	**32**			38	25	-	-
2005	45	46	**37**			42	14	21	50
2006	61	59	**42**			52	15	27	-
2007	43	51	20			49	18	31	68
2008	50	43	16			58	17	23	52
2009	47	51	20			58	18	26	63
2010	37	35	14			41	15	-	50
2011	36	32	12			39	14	-	44
2012	39			37	14	40	12		
2013	47			38	14	60	19		
2014	56			49	19				
Average all data	**42**	**46**	**25**	**41**	**16**	**46**	**18**	**26**	**54**

Red numbers represent background results that exceed criteria

Figure 9
Monitoring Locations (From EIS Air Quality Assessment)



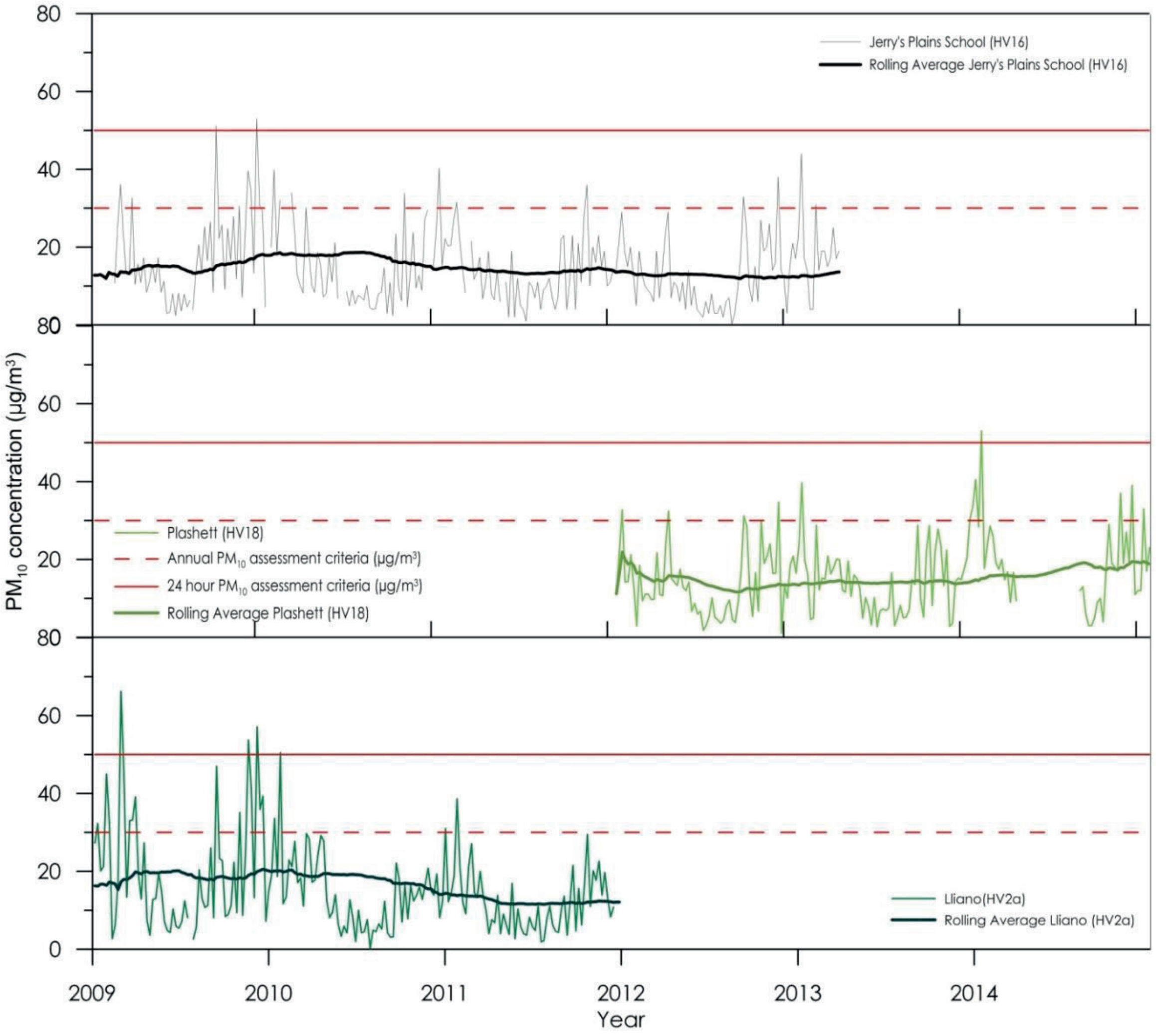
The annual average Total Suspended Particulates (TSP) and PM_{10} values from 2001 to 2014 at Llanillo and Jerrys Plains School, both of which are relevant to the studs, indicate there have been a number of readings that were above the relevant criteria. The data recorded during this period suggests that higher concentrations were generally recorded at Llanillo (HV2a). The Llanillo (HV2a) monitor was located near a cultivated site and was relocated in 2011 to a more representative location, when it was renamed HV18. The PM_{10} levels recorded at HV2a are probably representative of the conditions currently experienced by horses in the district where paddocks are regularly cultivated. **Plate 1** shows cultivated paddocks at Coolmore Stud.

Figure 10 presents a graphical representation of 24hr average PM_{10} monitoring data at High Volume Air Sampler (HVAS) sites HV2a, HV18 and HV16 respectively (from 2009), all of which are relevant to the studs. The graphs show that at HV2a and HV16 there were a number of exceedances of the 24-hour average criterion during 2009, which are likely the large dust storms that swept across NSW during these periods (PEL, 2015). HV18 had an exceedance of the 24-hour criterion during January 2014 when there were bushfires in the Muswellbrook area at this time.

The rolling average for each monitor in **Figure 10** illustrated the annual PM_{10} criterion was not exceeded during this period.

Plate 1
Cultivated Paddocks on Coolmore Stud

Figure 10
PM_{10} Concentration measured from HVAS at Llanillo (HV2a), Plashett (HV18) and Jerry's Plains School (HV16) 2009-2014



5.1.2 EIS Air Quality Assessment Predictions

The EIS Air Quality Assessment predicts that the Project will result in no increases in the annual average PM_{10} levels at Woodlands Stud receivers and less than 2 $\mu g/m^3$ at Coolmore Stud receivers. Representative receivers and monitoring locations are shown on **Figure 12**.

The worst affected receiver in the location of the studs is receiver 217A (Coolmore) with a maximum predicted 24hr PM_{10} Project concentration of 12 $\mu g/m^3$. From the equine literature review it is noted that a maximum recommended level of respirable dust in stables should be 230 $\mu g/m^3$, while levels of 80-170 $\mu g/m^3$ are considered normal for a paddock. There are no receivers at the Woodlands or Coolmore Studs that are predicted to experience annual average PM_{10} concentrations above the assessment criteria of 30 $\mu g/m^3$ due to emissions from the Project plus background concentrations or cumulative sources.

Modelling indicates that cumulative 24-hour PM_{10} levels above the assessment criterion of 50 $\mu g/m^3$ (project plus all other sources) are predicted to occur at the worst affected receiver (217A) for up to three days of the year in Year 4. On these potential three occasions when the cumulative prediction exceeds the assessment criterion, the Project contribution is low at 3 $\mu g/m^3$. In Year 6 there are between three or four days that may potentially exceed the criterion. The contribution of the measured background concentrations are around 44.4 to 47.7 $\mu g/m^3$ and again the Project alone contributes a small fraction of the total cumulative concentration. There are two days predicted to exceed the criterion in Year 12. Accordingly the assessment indicates that the predicted exceedances are a factor of the conservative background monitoring data that has been used and not as a direct result of the Project contribution.

The worst case scenario for the northern most paddocks at Coolmore and Woodlands Studs would seem most likely to occur around Year 6 of the Project, as seen in **Figure 11** below. This indicates that there may be a maximum PM_{10} (24-hour) increase from the Project of between 10 and 25 $\mu g/m^3$ on some days. Based on this assessment there will be no risk to pastured horses from combined mine and background PM_{10} even if the worst case scenario occurred on a regular or even daily basis. The annual average results show that the cumulative dust levels will generally be below 25 $\mu g/m^3$ at all locations on Coolmore and Woodlands Studs. It is proposed that the worst case impacts would be managed on a day to day basis using a network of real-time monitoring stations, which will enable mine personnel to respond to high dust levels prior to reaching worst case predicted levels by modifying activities and / or increasing controls as required.

Figure 11
Maximum Predicted 24-hour average PM_{10} concentrations due to emissions from Drayton South only - Year 6 (From EIS Air Quality Assessment)

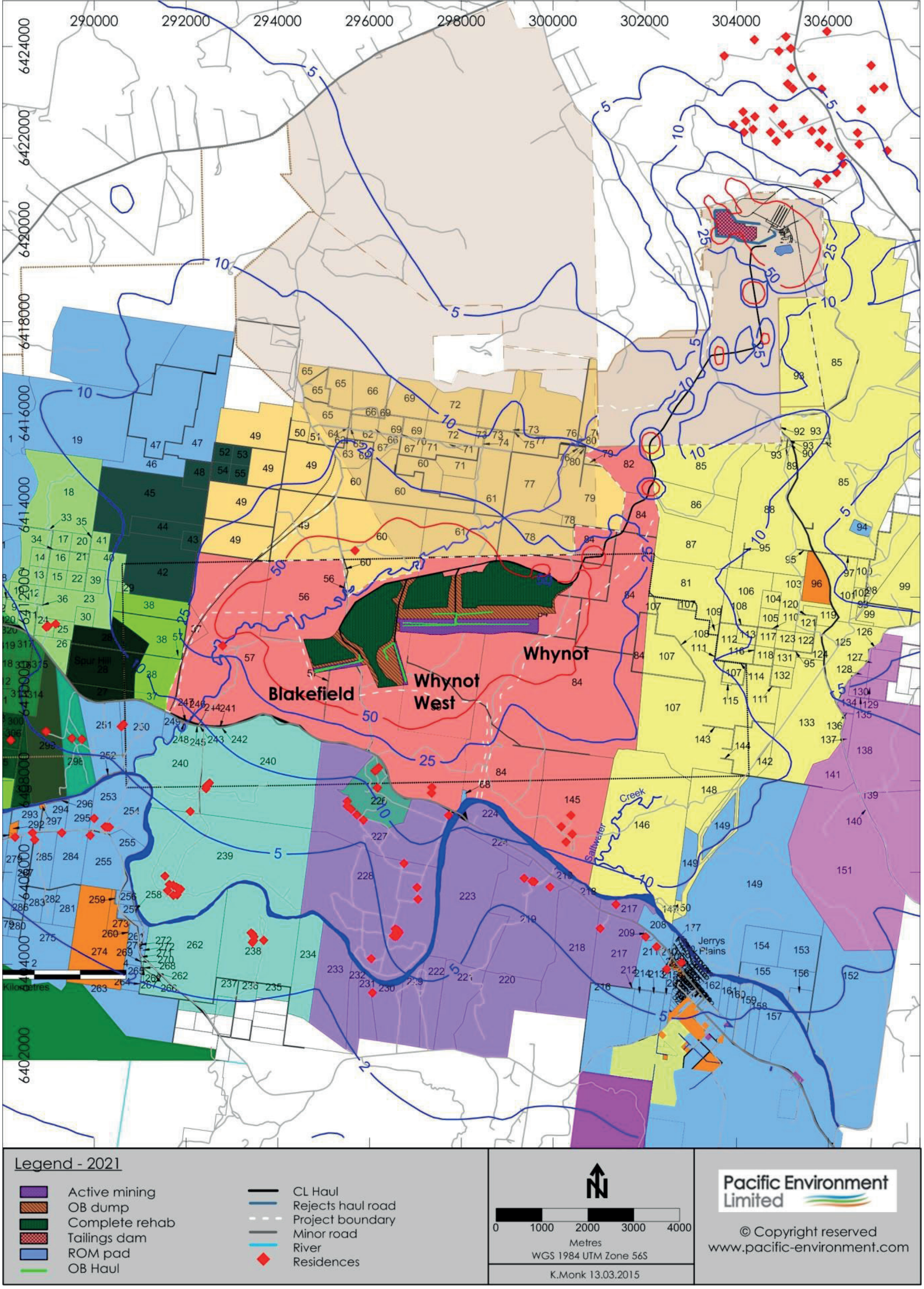
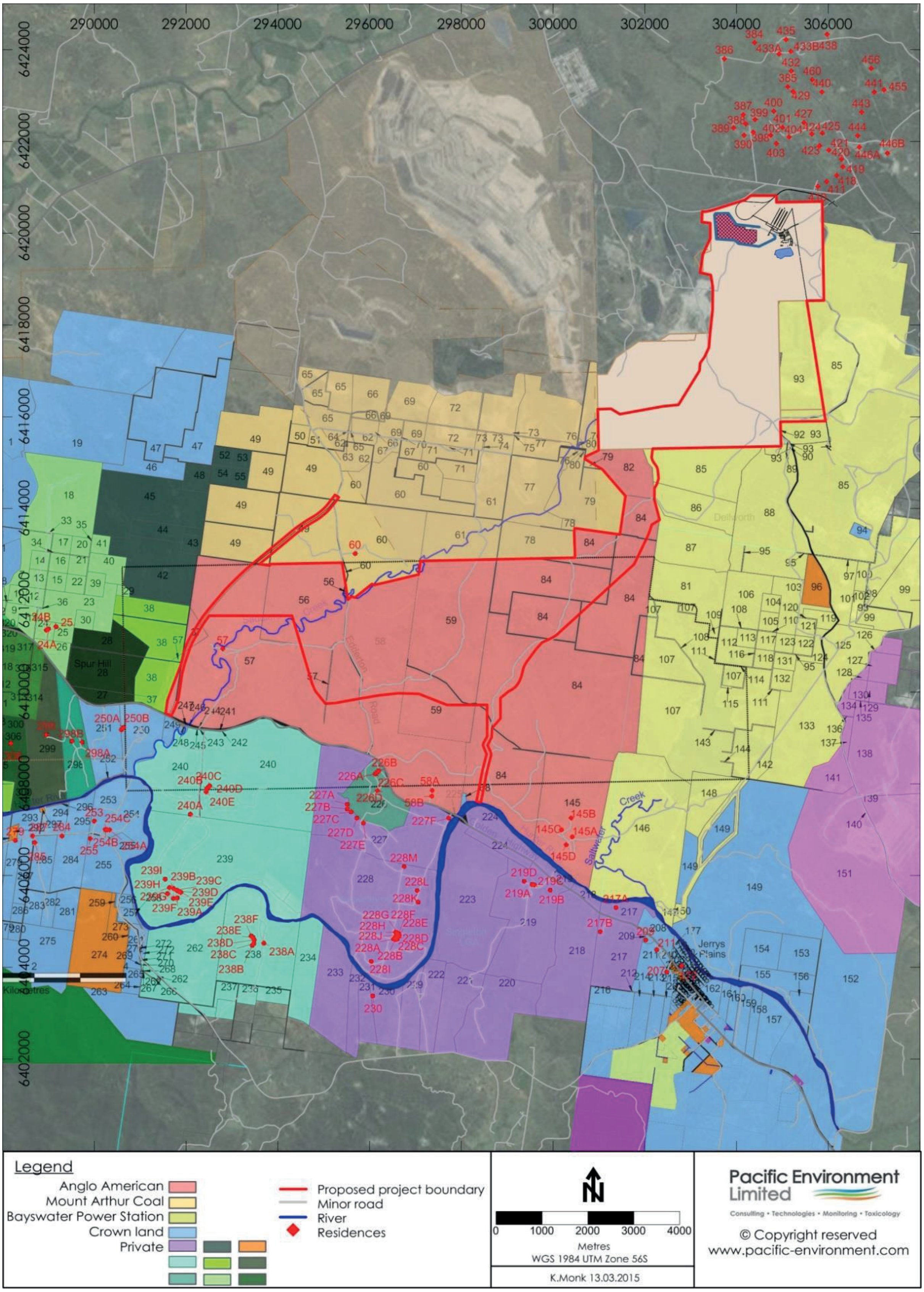


Figure 12
Representative receivers and monitoring locations (From EIS Air Quality Assessment)



5.1.3 Comparative Dust Levels from Literature Review, Worldwide and the Project

Based on the findings from the literature review, a recommended maximum value for inhalable dust in a stable is thought to be in the order of 2.5 to 3.0 mg/m^3 (2500-3000 µg/m^3). Concentrations of respirable dust in stables range from 0.15 to 9.28 mg/m^3 (150–9280 µg/m^3) with a recommended maximum value of 0.23 mg/m^3 (230 µg/m^3) (Cargill 1999). Total dust concentration in normal pasture environment for horses has been measured at 0.17 mg/m^3 (170 µg/m^3), respirable dust at 80 µg/m^3 and endotoxin levels of 0.00129 µg/m^3 in total airborne dust (McGorum et al, 1998).

Airborne concentrations of dusts in looseboxes, mostly small fungal and actinomycete spores, regardless of quality of ventilation, can be 2-50 times higher when bedding in looseboxes is being changed and cleaned.

A summary of dust levels from the dust literature review and the EIS Air Quality Assessment is provided in

Table 4. This comparison shows that at all stages of the Project and in all locations on both Coolmore and Woodlands Studs, the levels of dust predicted to be experienced by horses will be less than that which has been recommended for stable horses. This is less than that found in some other studies at pasture and is far less than would be experienced in a normal stable setting. This includes stables in a training environment as well as those that are located on the studs.

Worth noting is that even when worst case operating conditions are modelled the Project will not lead to any exceedances of the cumulative annual average PM_{10} levels over Coolmore and Woodlands Studs. The cumulative levels remain comparable to or better than those recorded in Kentucky, USA, which is renowned as the premier area for horse breeding in the world (see **Section 3.3**).

The issue of the possibility of an increased risk of transmission of disease due to higher dust levels has been addressed more fully in the equine literature review. In the Hunter Valley, *R Equi* would be considered the most serious potential problem. As manure from “carrier” mares is the primary source of *R Equi* and no horses have been on the land associated with the Project for some considerable time it is considered there will be no risk of an increased incidence of *R Equi* arising from the Project.

Table 4
Comparative Data from Literature Review and Air Quality Review

Activity	Inhalable dust µg/m³	Respirable dust µg/m³	Author
Preparing feed	14970	1080	Reed et al 2006 (Australia)
Conventional stable **In pasture**	2190-5480 80-170	440-2200 80-170	McGorum et al 1998
Stables sawdust **Straw bedding**	397 606	-	Banhazi et al 2002 (Aust)
Stables	1130	-	Banhazi et al 2002 (Aust)
Stable Cleaning	1200-2810	-	Davidson 2004 (Aust)
Stables	410-20,000	-	Ghio et al 2006
Breathing zone, stabled horse	17510	9280	Woods et al 1993
Stable	200-17200	150-9280	Cargill 1999
Maximum recommended level stables, **Europe**	2500-3000	230	Cargill 1999
Coolmore, Woodlands existing receivers, PM_{10}	-	Annual average - 25 (12-42) 24hr – max approx. 190	PEL 2015
Projected annual average increase Project only, worst case **Yr 6**	-	0(Darley receivers) 0-2 (Coolmore receivers) 01 (generally pasture) 1- 2- (north paddocks)	PEL 2015
Predicted cumulative PM_{10} (Project and background) **Yr 6**	-	23 (Annual average PM_{10}) at Coolmore receivers 217A and 227F	PEL 2015
Hong Kong	-	PM_{10} 43-53	PAE Holmes 2012
Saudi Arabia	-	PM_{10} 104-148	PAE Holmes 2012
Randwick	-	PM_{10} 15-22	PAE Holmes 2012
Lexington USA	-	PM_{10} 19-24	PAE Holmes 2012

5.1.4 Relevance of Reviewing Dust Exposure in Stables and During a Race Career Compared to that in a Paddock

The nature of dust experienced in a stable has been well demonstrated in many scientific reports to be far more severe in quantity and composition than any dust horse may be exposed to in a paddock.

In the absence of large amounts of data regarding dust exposure in paddock horses it is considered very useful to compare the dust that horses are exposed to away from the paddock. This has allowed generation of defined levels of dust at which it is considered likely that, in the presence of appropriate fungi, bacteria, and viruses endotoxin, may result in disease of the lower respiratory tract.

Given that the nature of the dust arising from the project is far more innocuous than the dust horses are exposed to in a stable, and that the levels will be far lower, it is possible to conclude that the threshold level for inducing IAD in horses will not be exceeded as a result of dust from the project. It is then reasonably to determine that the dust levels from the project will have no adverse effect on equine health.

A reason for the general absence of scientific studies regarding the effects of dust on paddock horses is because of the minimal to no impact dust has on horses in such an environment. It is well established that horses with many types of respiratory tract disease associated with dust resolve rapidly once the horse is returned to a paddock environment, irrespective of how much dust may be in the paddock environment.

Dust also varies considerably in its content, however determining the specific content of any dust is not regularly undertaken in equine or human studies evaluating the effects of dust on health.

There is considerable imprecision in use of the term (dust) in both the human and veterinary literature. Many articles describe studies evaluating “dust”; however the composition of this dust can vary widely. This makes comparison between reports and evaluation of data very difficult. In many papers the composition of the dust is not defined at all.

The report of Reed et al (2006) provides full details of regulatory standards in relation to human health and dust in agricultural industries from an Australian perspective and can be referred to human health guidelines if required, with definitions provided in **Section 3.2**.

In the present study the dust levels horses are exposed to in a stable has relevance in that these are levels racing horses, which are being bred on the properties surrounding the project, are regularly exposed to. Given that the levels horses are exposed to for many years after they leave a stud are many times higher than the worst case scenario in relation to the project indicates that there will be no adverse impact on the health of horse as a result of dust arising from the project.

Further, the nature of the dust generated from the Project will be far less inflammatory than that encountered in stables. The dust from the Project will almost exclusively be from the removal of overburden, which will produce inorganic dust. In order to evaluate this dust, further samples were analysed for endotoxins, as these have the greatest potential to cause IAD in horses. The levels of endotoxins in the soil were found to be very low. Therefore the organic component of the soil will not adversely impact on equine health.

There have been numerous studies which have made a direct comparison between dust in stables such as that associated with hay, feeding and cleaning and that in paddocks. So it is considered a reasonable and very useful basis for comparison in the EIS Equine Health Assessment Report.

Reed et al (2006) in a review of Australian facilities reported dust levels as follows:

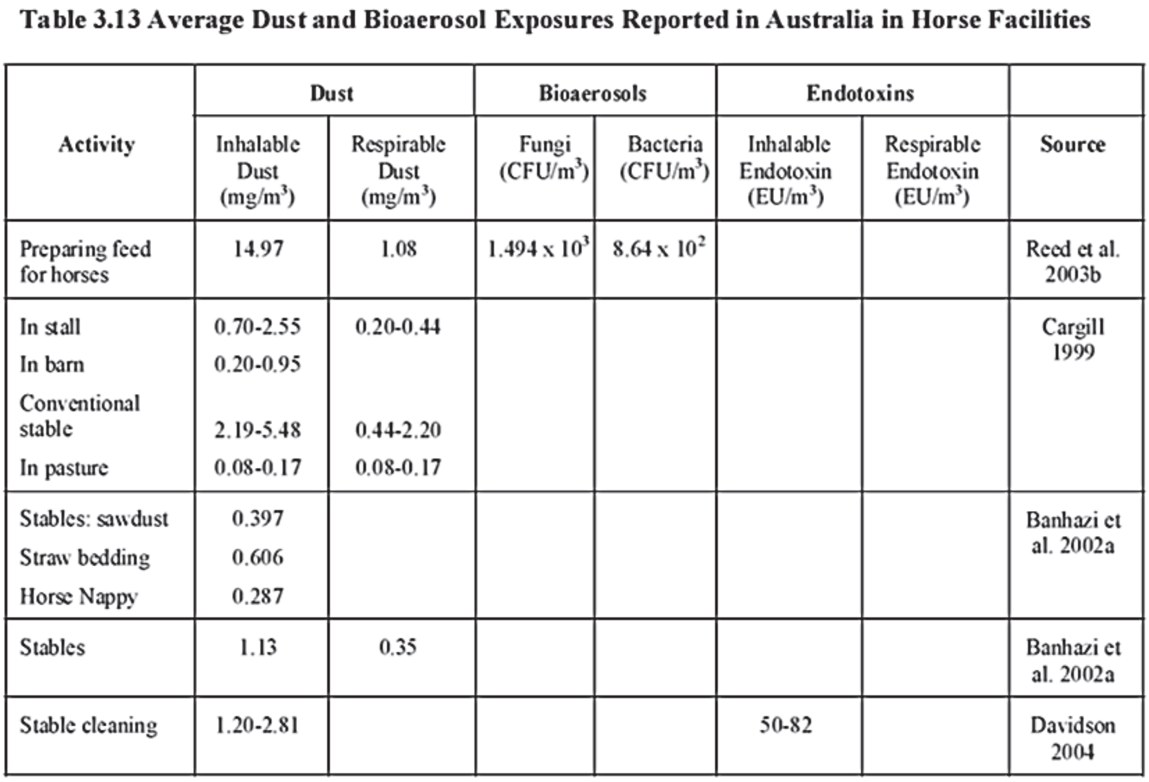


Table 3.13 Average Dust and Bioaerosol Exposures Reported in Australia in Horse Facilities

Activity	Dust		Bioaerosols		Endotoxins		Source
	Inhalable Dust (mg/m³)	Respirable Dust (mg/m³)	Fungi (CFU/m³)	Bacteria (CFU/m³)	Inhalable Endotoxin (EU/m³)	Respirable Endotoxin (EU/m³)	
Preparing feed for horses	14.97	1.08	1.494×10^3	8.64×10^2			Reed et al. 2003b
In stall	0.70-2.55	0.20-0.44					Cargill 1999
In barn	0.20-0.95						
Conventional stable	2.19-5.48	0.44-2.20					
In pasture	0.08-0.17	0.08-0.17					
Stables: sawdust	0.397						Banhazi et al. 2002a
Straw bedding	0.606						
Horse Nappy	0.287						
Stables	1.13	0.35					Banhazi et al. 2002a
Stable cleaning	1.20-2.81				50-82		Davidson 2004

(RIRDC Publication No 06/1071289)

In summary, the dust levels that horses on the properties may be exposed to are far less than that which stabled horses are exposed to and far less potentially irritating. Therefore if stabled horses can be trained and raced as elite athletes then the impact of far less dust on paddocked horses is considered inconsequential.

Horses currently do inhabit very dusty environments both on the studs in certain circumstances (particularly when stabled for any reason) and in a racing environment. Despite this dusty environment horses are still able to perform at an elite level and to all appearances to the best of their ability.

5.1.5 Environmental Pollutants

It is important to note that there is considerable difference between “environmental pollutants” and dust from primarily soil origin. The increase in dust levels the horses will be exposed to is small and as advised in **Section 5.1.4** the total levels are still below that which other thoroughbreds, as well as pleasure horses, are exposed to in a stable environment. Horses in the stable environment generally remain visibly healthy and competitive despite this high level of exposure to dust and often concurrent low grade IAD. Based on this it is reasonable to expect that there will be no detectable effect on equine health from small increases in dust levels for paddocked horses.

The increase in other environmental pollutants has not been determined and has not generally been a factor of human health guidelines in this situation.

A study on the general effects of pollution on racing thoroughbreds in the USA was undertaken by Gates (2007). It was concluded that the impact of pollution on the thoroughbred racing industry was minimal and that only under the most hazardous ozone levels were race times markedly slower, and such conditions were rarely encountered on race day.

The effects of high levels of environmental pollution on one form of respiratory disease has been evaluated in racing horses in Hong Kong ((Hurley, 2011). This found that despite considerable deterioration in air quality there was no change in incidence or severity of Exercise Induced Pulmonary Haemorrhage (EIPH) compared to an earlier study.

5.1.6 Conclusions on Predicted Dust

The dust levels predicted to be generated by the Project will be a small increase on the current levels and are still well below levels experienced by horses in a stable environment (both at the studs and while in race training). The increased levels are still approximately equivalent to those found in Lexington, Kentucky, USA, and far less than those which occur in Hong Kong and Saudi Arabia.

Short term increases in dust levels well above those predicted would be well handled by the equine population on the studs and any dust that is inhaled should be rapidly cleared with no adverse effects. There is no apparent increase risk of transmission of diseases such as Rattles as there will not be any of the infecting bacteria in the soil of the Project.

Based on the equine health literature review dust levels experienced by horses are likely to be much higher in a stable environment. All horses produced by Darley and Coolmore are intended for a racing career so that the dust levels they will be exposed to during their career will be very high. As such any contribution for the Project to background dust levels will result in no additional health or production problems for the horses on these studs.

5.2 ENDOTOXIN ANALYSIS

Endotoxins are bacterial structural components that are released when such a cell is lysed. These components are toxic if administered to humans and/or animals, causing a pyrogenic response (rise in body temperature). One of the important findings from the literature review was that the major cause of adverse effects from dust exposure in any environment is not the particulate matter as such but the endotoxins, bacteria and fungi that is attached to the particulate matter. While dust alone is relatively inert and rapidly expelled by the horse, endotoxins trigger an immediate inflammatory reaction that can result in varying severities of lower respiratory tract disease. There are high levels of endotoxin present in stables so it was considered important to determine endotoxin levels in the dust which horses might be exposed to as a result of the Project.

5.2.1 Sampling protocol

In order to determine the levels of endotoxin that are present in the soils that will be disturbed by the Project a range of samples were collected and analysed for endotoxin levels.

Sampling for endotoxin analysis involved the following:

- Topsoil – Collection of at least 10 g of soil (free of manure or organic matter) from representative areas within the Project Boundary;
- Dust Deposition – Collection of available dust from gauges;
- HVAS – Provide filter papers for lab to analyse PM_{10}.

The following samples were collected:

- Topsoil samples:
    - Site 1 – Plashett Ridge
    - Site 2 – HVAS Ridge
    - Site 3 – Stockyards Ridge
    - Site 4 – Plashett HVAS site
- Dust samples
    - D8 (Dust Deposition gauge)
    - D11 (Dust Deposition gauge)
    - D12 (Dust Deposition gauge)
    - Plashett HVAS paper

By knowing the predicted dust levels generated by the Project (as discussed in **Section 5.1.2**) an estimate could be made of potential exposure to endotoxins by horses in the paddocks near to the Project.

5.2.2 Methodology

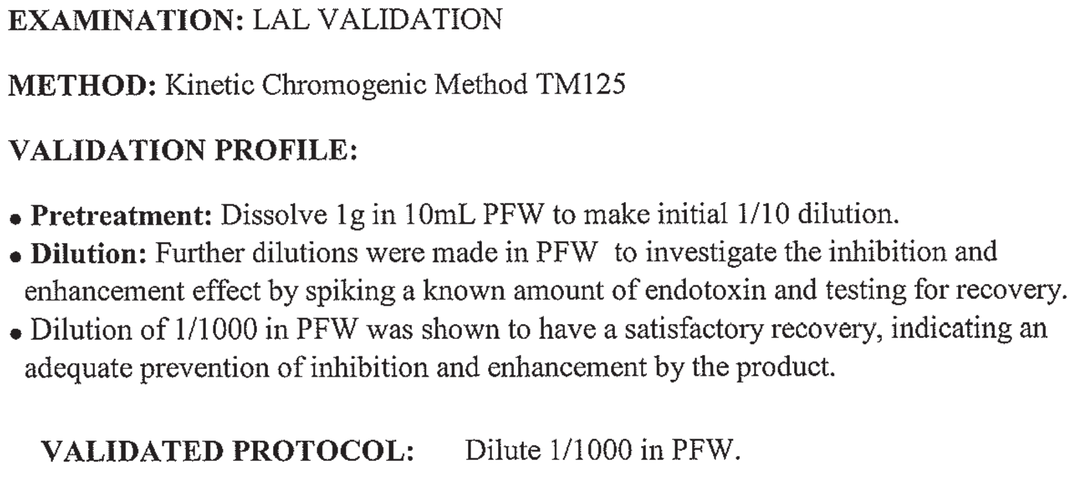
Background

There are several methods available for conducting the endotoxin test, which include the in vivo rabbit pyrogen test and several in vitro alternatives that utilize the Limulus Amebocyte Lysate (LAL) system. The latter has become the method of choice, which can be accomplished by various options including gel clot, kinetic chromogenic and kinetic turbidetric assays. This is done by extracting the test product with pyrogen-free water (PFW) and testing for the presence of endotoxin in the extracts. The method used for this assessment was the kinetic chromogenic method.

Kinetic Chromogenic Method

The kinetic chromogenic method involves an enzymatic reaction between the endotoxin and lysate which results in the production of a yellow colour in the presence of endotoxin. The intensity of the colour production is directly linked to the quantity of endotoxin present in the sample. The laboratory analysis was undertaken by AMS Laboratories.

The method used for the current testing is shown below:



EXAMINATION: LAL VALIDATION

METHOD: Kinetic Chromogenic Method TM125

VALIDATION PROFILE:

- **Pretreatment:** Dissolve 1g in 10mL PFW to make initial 1/10 dilution.
- **Dilution:** Further dilutions were made in PFW to investigate the inhibition and enhancement effect by spiking a known amount of endotoxin and testing for recovery.
- Dilution of 1/1000 in PFW was shown to have a satisfactory recovery, indicating an adequate prevention of inhibition and enhancement by the product.

VALIDATED PROTOCOL: Dilute 1/1000 in PFW.

5.2.3 Results of Endotoxin Testing

The results of the endotoxin analysis for soil and dust samples collected from the Project site are presented in **Table 5**.

Table 5
Results of Endotoxin Testing from Project Site

Location	EU/g	EU/µg	Approx. ng/mg	Approx. ng/µg
Site 1 - Plashett Ridge	189.337	0.000189	0.0189	0.0000189
Site 2 – HVAS Ridge	167.591	0.000168	0.0168	0.0000168
Site 3 – Stockyards Ridge	403.321	0.000403	0.0403	0.0000403
Site 4 – HVAS	353.152	0.000353	0.0353	0.0000353
Average	278.35	0.000278	0.0278	0.0000278
HVAS filter paper Plashett PM 10 27/3/12	<300 EU/filter paper*	-	-	-
Plashett TSP 27/3/12	3102 EU /filter paper#	-	-	-
Dust residue sample D3B (D11)	14.691 EU/mg 14691 EU/ gram	- 0.014691	- 1.4691	- 0.0014691
Dust Residue sample D12	<5 EU/mg*	-	-	-
Dust Residue sample D12	<5 EU/mg*	-	-	-

*Indicates levels less than limit of detection
# Insufficient dust on filter paper to weigh
EU = Endotoxin Unit

It is difficult to directly compare results as different studies report findings as either EU/m^3 or as ng/ m^3. Depending on the source of the endotoxin, the conversion from endotoxin units to nanograms will vary. The United States Food and Drug Administration (FDA) initially defined the Endotoxin Unit (EU) as the endotoxin activity of 0.2 ng of Reference Endotoxin Standard (RSE), EC-2 or 5 EU/ng. To convert the current FDA RSE, EC-6 from EU's into ng, the conversion is 10 EU/ng. McGorum et al (1998) used a conversion rate of 12 EU per ng. In this report a conversion rate of 10 EU/ng was used.

Based on the levels of endotoxin in soil and the amount of dust that horses will potentially be exposed to, an estimate can be made as to the amount of endotoxin exposure that might occur. Using the worst case 24hr PM$_{10}$ level of 12 µg/m^3 from the Project at receiver 217A (on Coolmore) in Year 6 and using the average endotoxin level of 0.0000278 ng/µg derived from the initial four sampling sites (see **Table 5**), this would equate to endotoxin levels of approximately 0.00033 ng/m^3 in the **PM_{10}** fraction of dust. Assuming the highest annual average PM_{10} level predicted at 217A (2 µg/m^3 in Year 12), the annual average endotoxin levels would be approximately 0.00006 ng/m^3.

At site D3B (D11) there was considerably more endotoxin in the dust samples than at other sites. The reasons for this are unclear and repeat sampling over a period of time would be required to provide greater accuracy. However even at this higher level, the endotoxin levels of dust would still only be approximately 0.018 ng/m^3 in a worst case scenario at site 217A on Coolmore in Year 6. The levels of exposure in the remaining properties for the duration of the Project will be far less than this upper level.

These results are significantly lower than those obtained by McGorum et al (1998) who reported levels of airborne endotoxin levels in respirable dust at pasture of 0.04 to 0.16 ng/m^3.

The levels are a number of orders of magnitude lower than those reported by Reed et al (2006) in other environments (horse feed sheds had 66 EU/m^3 for example) while Eduard et al (2001) reported levels of 13 x 10^3 EU/m^3.

Berndt et al (2010) found that IAD was common in stabled horses, with a prevalence of 17.3% in Michigan pleasure horses. This was a result of stable dust that was rich in endotoxin and which may induce neutrophilic airway inflammation. In this study endotoxin exposure was about eight times higher in stables than on pasture. Mean values obtained of endotoxin concentrations in the breathing zone of stabled horses was 7.08 x 10^3 EU/m^3 and for horses on pasture was 0.85 x 10^3 EU/m^3. On pasture, endotoxin varied widely, despite constant climatological conditions. It was suggested that manure was a primary source of endotoxin in both stables and at pasture.

Levels of endotoxin in horse stables were found to be generally less than 0.1 µg/m^3 (Dutkiewicz et al., 1994), the “cut-off” for occupational health and safety purposes, but in other studies, levels were reported ranging from 7.52 to 60.53 ng/m^3 (0.00752 - 0.06053 µg/m^3) in total dust and 1.25 to 11.27 ng/m^3 (0.00125 – 0.01127 µg/m^3) in respirable dust (McGorum et al, 1998).

In the latter studies, concentrations of airborne endotoxins were considerably higher in conventional stables than in “low dust stables”, which are hay and straw free environments. In the conventional stables levels in total dust samples ranged from 7.52 to 60.53 ng/m^3, (0.00752 - 0.06053 µg/m^3) compared with 2.12 to 17.41 ng/m^3 (0.00212 - 0.01741 µg/m^3) in low dust stables. The concentrations in respirable dust were 1.25 to 11.27 ng/m^3 (0.00125 – 0.01127 µg/m^3) and 0.09 to 0.56 ng/m^3 (0.00009 – 0.00056 µg/m^3) respectively. By comparison, concentrations of endotoxins in a pasture paddock at least 50 metres from the nearest hay ranged from 0.25 to 1.57ng/m^3 (0.00025 - 0.00157 µg/m^3) and 0.04 to 0.16 ng/m^3 (0.00004 - 0.00016 µg/m^3) respectively.

Table 6
Endotoxin levels in equine environment and from the Project

Location	Endotoxin level ng/m^3	Reference
Paddock	0.04 to 0.16	McGorum et al (1998)
Total dust	7.5 to 60.5	McGorum et al (1998)
Respirable dust	1.25 to 11.27	McGorum et al (1998)
Feed shed	6.6 (approx.)	Reed et al (2006)
	1300 (approx.)	Eduard et al (2001)
Breathing zone stable	708	Berndt et al (2010)
Breathing zone pasture	85	Berndt et al (2010)
Cleaning stables	5-8.2	Davidson 2004
Stables	20–9846	Samidi et al 2009
Min level likely to cause respiratory disease in horses	>20	McGorum et al (1998)
Drayton South Project **Worst case** **Average**	 0.018 0.000056	AMS/Kannegieter 2012

5.2.4 Summary Regarding Endotoxin

Given that the minimal total airborne endotoxin concentration likely to cause lower respiratory tract disease in normal horses most likely exceeds 20 ng/m^3 (0.02 µg/m³) (McGorum et al, 1998) and the worst case scenario as a result of this Project would be approximately 0.018 ng/m^3 then it is reasonable to conclude that there will not be any effect on horse health as a result of inhalation of endotoxin associated with dust that might arise from the Project. The more likely worst case exposure to horses on Coolmore and Woodlands Studs is exposure to a maximum average of approximately 12 µg/m^3 of PM$_{10}$ dust in any 24 hr period (from the EIS Air Quality Assessment) which would equate to approximately 0.018 ng/m^3 using the highest level of endotoxin or 0.0007 ng/m^3 using average endotoxin levels. Both values are well below the 20 ng/m^3 threshold suggested by McGorum et al (1998).

5.2.5 Key Points regarding Dust and Endotoxin

Key points to note in regard to dust and endotoxin are:

- The minimal total airborne endotoxin concentration likely to cause lower respiratory tract disease in normal horses most likely exceeds 20 ng/m3 (McGorum et al, 1998);
- Total dust concentration in normal pasture environment for horses has been measured as 0.17 mg/m3 (McGorum et al, 1998);
- The recommended maximum value for inhalable dust in a stable is probably in the order of 2.5 to 3.0 mg/m3. Concentrations of respirable dust in stables range from 0.15 to 9.28 mg/m3, with a recommended maximum value of 0.23 mg/m3 (Cargill 1999);
- Racehorses, who spend most of their time (up to 22 hours per day) in looseboxes, are exposed to aerosolised foreign dusts and gases almost continuously and any effects these agents have would likely be cumulative. There can be peaks of dust exposure up to 50 times greater than background levels depending on type of bedding, feed, activity of the horse and stable management (Malakides and Hodgson 2003);
- Forty percent of horses develop IAD within the first two weeks of entering racetrack stables for training. This represents a very high percentage of affected horses that are clinically well and preparing for the high stresses of racing (Malakides and Hodgson 2003);
- More than a third of horses entering racetrack stables had some form of airway inflammation prior to transport to racetrack stables but these horses were not necessarily at greater risk of continuation of inflammation or further respiratory disease (Malakides and Hodgson 2003);
- Contrary to expectation, many dust-generating activities and sources are not associated with IAD (Malakides and Hodgson 2003); and
- The dust derived from this Project has been found to have very low levels of endotoxins present which indicates that there is very low risk of the dust being a source of IAD.

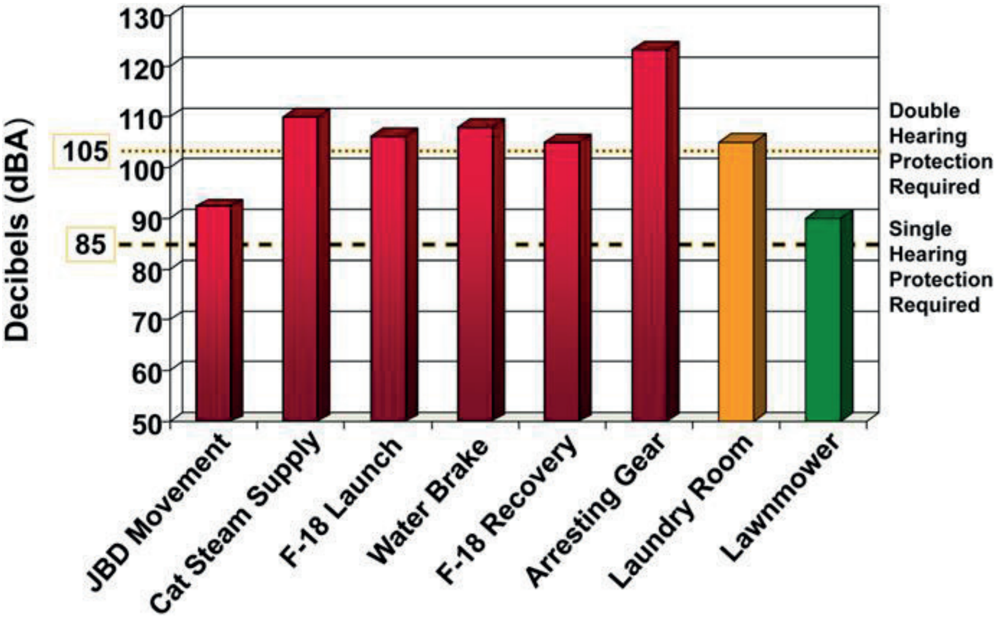
The report of Malakides and Hodgson (2003) provides comprehensive information on IAD in horses. They found that endotoxin was primarily responsible for IAD. The source of endotoxin is from degenerate gram-negative bacteria and as such endotoxin is ubiquitous in nature and is commonly present on surfaces of plants and animals.

Variable concentrations of endotoxins are found in agricultural environments such as housing for pigs, chickens, cows and horses, as well as sources such as bedding, hay, grains, straw, and bird droppings. Most environments in which horses have contact potentially can be contaminated with dusts with adherent bacteria and their cell-wall fragments, which subsequently may become aerosolised and inhaled. Endotoxin from dust sources (such as feed, bedding and sources outside boxes) in stables is associated with IAD in thoroughbred racehorses in Australia.

6 ASSESSMENT AGAINST PREDICTED PROJECT NOISE

The EIS Acoustics Assessment characterised the existing baseline noise environment for the Project site and surrounding areas and undertook modelling to predict future ambient noise during the mines development. This report also included an assessment of blasting and vibration impacts as a result of the Project. As part of the equine health impact assessment, the findings of the EIS Acoustics Assessment have been reviewed and included in this report for discussion where relevant.

Horses are exposed to much higher levels of noise than that which will occur as a consequence of the Project on a regular basis from many different sources. For example, an idling helicopter will produce noise of over 122 dBA at a distance of 25 feet (McReynolds 2005) while a lawnmower will produce noise levels approaching 90 dBA (Yankaskas 2013), as shown in the below graph. The noise from a helicopter overflying and landing would produce higher levels than this and also pose more danger to horses from a flight perspective as there would be a focal point of continuous and increasing noise as the helicopter approaches as well as a visual threat. If horses can readily identify such a source of noise it can be perceived as a threat and induce a flight response away from the noise source. In contrast, blasting noise will be at a very low level and of such short duration that it is extremely unlikely that horses, even those that may be unaccustomed to any noise, will be able to identify a focal source and further the noise will have stopped before any flight response can be initiated or sustained.



6.1 EXISTING BASELINE NOISE LEVELS

As part of the EIS Acoustics Assessment background noise monitoring was undertaken at key locations surrounding the Project for the purpose of characterising the existing baseline noise levels for the area. From the results of the background noise monitoring, the adopted rating background levels were able to be determined for each of the key receiver areas surrounding the Project. The adopted rating background levels as presented in the EIS Acoustics Assessment are provided in **Table 7**. It should be noted that Coolmore Stud is represented by the results for Receiver group C whereas Darley's Woodlands Stud is represented by receiver group D.

Table 7
Adopted Rating Background Levels (From EIS Acoustics Assessment)

Receiver Area	Rating Background Level, LA90,15min		
	Day	Evening	Night
Receiver Group C M1 – Jerrys Plains and surrounds M2 – Coolmore Stud	35	33	33
Receiver Group D M3 – Woodlands Stud, private properties M4 – private properties	30	30	30

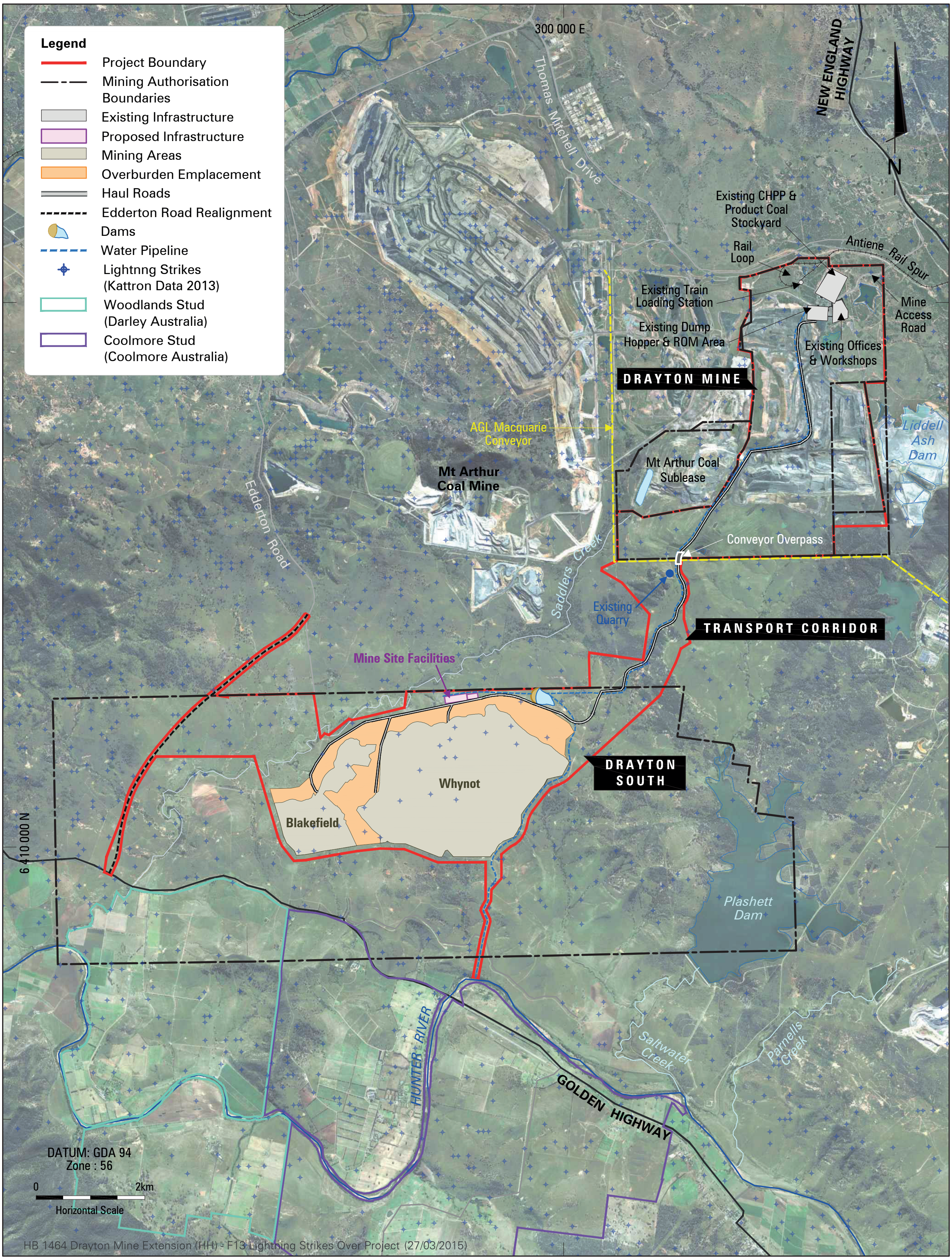
6.2 LIGHTNING STRIKES OVERPRESSURE LEVELS

Thunderstorms occur regularly in the Hunter Valley, particularly in the Upper Hunter Valley. **Figure 13** shows the number of lightning strikes that were recorded within the vicinity of the Project and adjoining Coolmore and Woodlands Studs during the 2013 calendar year.

Overpressure from lightning strikes range from 120 dBL Pk to 130 dBL Pk. As can be seen in **Figure 13** during 2013 (i.e. in a 12 month period) many of these strikes have occurred directly within the paddocks of Coolmore and Woodlands Studs where their horses are kept.

6.3 EIS ACOUSTIC ASSESSMENT PREDICTIONS

From the EIS Acoustics Assessment, it is predicted that there will not be any discernible increases in ambient noise levels above existing background levels as a result of the Project at either Coolmore or Woodlands Horse Studs. **Figure 14** shows the worst case noise envelope for all modelled years for prevailing meteorological conditions during the evening/night.



DRAYTON SOUTH COAL PROJECT

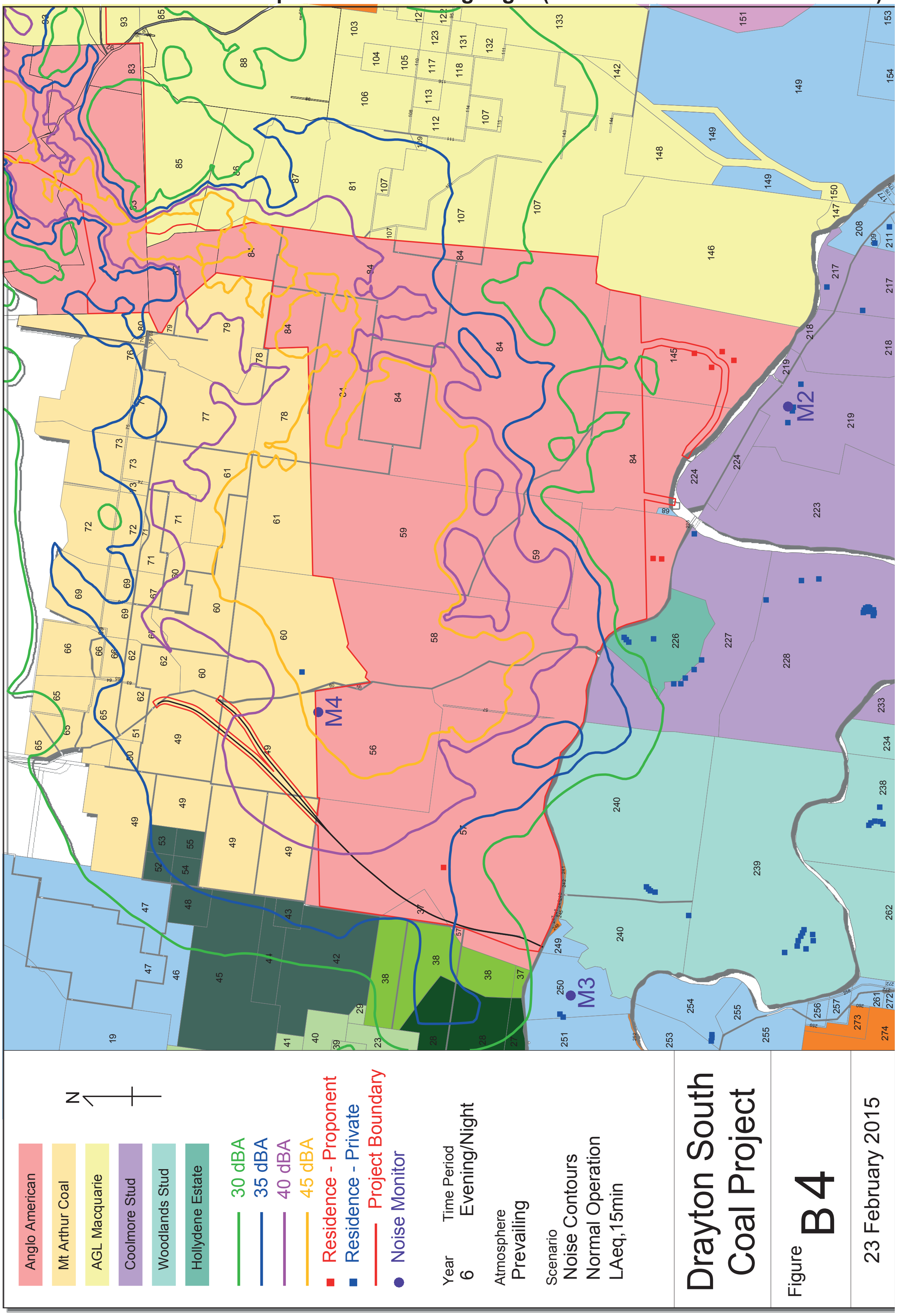
AngloAmerican

Hansen Bailey
ENVIRONMENTAL CONSULTANTS

Lightning Strikes (2013) Over Project Site

FIGURE 13

Figure 14
Worse Case Noise Envelope for Yr 6 Evening/Night (From EIS Acoustic Assessment)



6.4 ANALYSIS OF OVERPRESSURE

6.4.1 General

No scientific literature in regard to the specific effects of overpressure on horses could be found. However, given the findings regarding hearing in horses (which is reported as being slightly less sensitive than in humans) as well as the significant differences in anatomical shape of horse compare to human ears, in particular the location of the auditory canal in relation to the external structures of the ear, it is anticipated that any effects from over pressure would be less than in humans. In this regard and in the absence of any other data, using human safety levels for over pressure would most likely be more than adequate for horses.

The following is provided in order to provide background and context as to how overpressure from blasting is heard and experienced by receivers. An overpressure level of 90 dBL appears, subjectively, similar to a mild and distant thunderclap, while an overpressure level of 115 dBL appears similar to a moderate yet still distant thunderclap. Assuming overpressure primarily occurs in the range 10 Hz to 16 Hz, an overpressure level equal to the 115 dBL peak criterion would appears similar to a maximum noise level in the range 28 to 53 dBA for a period of less than one second (Bridges Acoustics, 2015).

6.4.2 Project Levels

Overpressure levels from blasting (when closest to receivers) are predicted up to 100 dBL for indicative locations on Coolmore Stud and between 98 and 105 dBL at Woodlands Stud. Overpressure from blasting will remain far below that of frequent helicopter landings at both horse studs and well below that of lightning strikes that occur during frequent thunderstorms in the Hunter Valley. Horses will assimilate to mine blasting impacts as blasting slowly moves closer to the horse studs so long as they remain within human amenity levels as is predicted by modelling for the Project.

It is extremely unlikely that over pressure will have any adverse effects on horse health.

6.4.3 Edinglassie Stud

Edinglassie Stud at Muswellbrook is subjected to blast impacts of overpressure over 120 dBL (up to 124 dBL) and vibration over 5 mm/s (up to 6 mm/s) as a result of activities at the nearby Mt Arthur Coal Mine.

Despite this, there have been no reported issues with horse health (for new born foals, visiting mares or any other horses) residing on the property which is located less than 130 m from mining operations at Mt Arthur. According to the stud manager, Mick Talty "*Both industries have been around a long time and the fact that we are continuing to provide the local industry with quality horses shows that mining and thoroughbred farmers have worked side by side*" (NSW Minerals Council, 2012).

6.4.4 Conclusion

The EIS Acoustic Assessment confirms that the blast impacts resulting from the Project are predicted to be, at worst for overpressure up to 105 dBL and for vibration between 0.4 mm/s and 1.2 mm/s. These levels are well below the regulatory criteria and considerably lower than other sources of overpressure that horses on the studs are already subjected to (helicopter and aircraft landing and lightning strikes).

Based on the case study of Edinglassie Stud, which is located less than 130 m from blasting at Mt Arthur Coal Mine, there is no evidence to suggest that overpressure generated from blasting causes any adverse impacts to horse health.

Given that the Project is located 1 km from horse studs boundary and over 2 km from the horse studs primary areas of operations (including paddocks where horse are kept), it is considered that overpressure will not have any adverse effects on horse health.

6.5 NOISE LEVEL DISCUSSION

In comparison to the background noise levels at any locations on Coolmore or Darley owned land (which are currently influenced by traffic on the Golden Highway), higher noise levels would be experienced by horses in a stable environment and on race day when noise levels can approach 90 dBA in stalls close to major grandstands during the running of each race. This peaking of noise at high levels would generally be considered the most unsettling for horses. However in the majority of cases horses can tolerate sudden increases in noise well, particularly once they have become accustomed to it.

As the resultant overpressure (or noise from blasting) will gradually (over 15 years) advance towards the horse receptors and blast over pressure is well regulated and limited to human amenity levels it is considered that horses will assimilate and not be stressed by this activity (as has been demonstrated by the Edinglassie Stud example).

A concern that has been expressed is that individual responses of horses may vary and that not all horses might react in a similar way. A further concern raised has been in relation to the transitory horse population and that animals on the stud may not have time to habituate to any noise that may arise from the project. Again, the Edinglassie Stud example (of a fully operational horse stud located in close proximity to two operating mines) has provided evidence that even transitory horse populations are not at risk of any adverse impacts as a result of blasting. As noted above Edinglassie Stud is located much closer to two operational open cut mines (recording overpressure impacts from blasting well above those predicted for the Project).

It is acknowledged that in extreme cases some horses may be more reactive to noise than other horses. However such horses will be more reactive in a wide variety of situations, in particular to noise associated with normal operations on horse studs as well as during training, transport and racing.

This equine health report also recognises that there is a percentage of horses on every property that will be transient. However horses coming onto the property will have generally experienced a great deal of adverse noise during transport to the property and particularly during a racing or breeding career. It is considered unlikely that any horse will come from an environment where noise, dust or vibration has not previously been experienced in the immediate environment or during transport to the stud.

As far as foals born on the property are concerned, they are probably in the best position to habituate to the noise and vibration as they will grow with any excess noise and vibration being considered a normal part of their environment (as is evidenced by the fact that no foals have been adversely impacted by blasting at Edinglassie Stud). New foals coming onto the property will typically follow herd behaviour, particularly that of their mothers. As noted above, for new foals to arrive at any property they will already have experienced considerably more noise and vibration just during transport than they will at the stud.

Habituation to noise is reported to take approximately one month for an animal unaccustomed to that particular type of noise. Given that the noise of blasting is anticipated to be very similar to many other noises horses currently hear e.g. plane and car engines, tractor noise, and helicopters, it is likely there will be no acclimatisation period required. It is unreasonable to argue that a stallion that has flown half way around the world and been subjected to many “new” noises that they will then be concerned by low level background blasting. If there is any effect it would last only a few days at the very most however it is highly likely there will be no effect.

The same can be said for mares coming onto the stud. In any event even if they are mildly concerned over the noise in the first few days there are numerous reports in horses and in other domestic production species that there will be no effect on reproductive capacity.

The noise from blasting will be barely perceptible and it occurs just once per day and will in most instances not be heard, and when heard would not cause any alarm to any horses much less affect their breeding capacity. Horses would be at far greater risk from thunder and lightning strikes than they would be from mine blasts. During a single storm horses may be exposed to more noise, accompanied by sudden flashes of light, than they might during the entire life of the Project.

Further as noted above both studs adjoin the Golden Highway and as confirmed by background noise monitoring in the EIS Acoustics Assessment are currently impacted by noise from it. The Golden Highway is a major state road connecting central western NSW to the Hunter Valley and Newcastle. This road carries substantial numbers of heavy vehicles transporting goods. A study conducted by Hyder Consulting for Regional Development Australia (Hyder, 2013) concluded that the use of the Golden Highway for heavy transport is forecast to double in the next 15 years. As such Golden Highway road transport noise will be the most source of additional noise outside of the studs boundaries.

CONCLUSIONS

Equine hearing is similar to humans although less sensitive. As a guide it is probable that horses are slightly deafer, with hearing approximately 15 dBA less sensitive than humans. In light of this, it is reasonable to conclude that human guidelines regarding noise will be relevant in assessing the potential impact of noise on horses.

There is a broad range of credible, validated scientific studies and literature available to indicate that habituation often occurs for horses in response to extreme noise and overpressure sources ranging from concerts to lightning strike events and sonic booms associated with jet plane engines.

Given that the noise levels are not predicted to exceed the existing background levels at any locations on Coolmore or Darley owned land, noise levels from the Project will not have any impact on the equine population. As a result there should be no concern that noise or overpressure from blasting or mine operations will induce a flight response in horses on the studs or have any impact on their behaviour (as indicated by the Edinglassie Stud example). Horses are far more likely to react to lightning strikes and thunder, helicopter landings and farm machinery such as tractors and lawnmowers.

7 ASSESSMENT AGAINST PREDICTED VIBRATION

The EIS Acoustics Assessment also included an assessment of blasting vibration impacts as a result of the Project. As part of the equine health impact assessment the relevant findings of the EIS Acoustics Assessment have been reviewed and included in this report for discussion where relevant.

Table 8 shows calculated ground vibration levels for closest blast events for two representative receiver locations on both Coolmore and Woodlands Stud, taking into account topographical or other shielding between the blast site and the receiver where relevant. Results have been calculated assuming blasting in the closest part of the mine to each location in the absence of mitigation measures, and are therefore representative of worst case impacts.

Table 8
Predicted Vibration Effects for Locations on Coolmore and Darley (No Mitigation)

MIC, kg	500	1,000	1,500	2,000	Criteria
Receiver (closest distance)	**Ground Vibration, mm/s**				**mm/s**
Coolmore Stud					
227 Coolmore Office, 3200 *	0.4	0.7	1.0	1.2	5
Strowan Homestead, 4600m	0.2	0.4	0.5	0.7	5
Woodlands Stud					
Woodlands Homestead, 5500m	0.2	0.3	0.4	0.5	5
Randwick Homestead, 3300m	0.4	0.7	0.9	1.2	5

* Overpressure level has been reduced by 5 dBL due to significant topographical shielding.

Results in **Table 8** indicate blast vibration effects will be barely perceivable at all receivers on the Coolmore and Darley properties. Based on the Edinglassie Stud example, (located adjacent to Mt Arthur and Bengalla Coal Mines) and further anecdotal evidence from the Muswellbrook Racecourse and its stable facilities (located adjacent to the Bengalla Mine), the levels of impact from vibration will not startle either grazing or stabled racehorses.

8 ASSESSMENT AGAINST PREDICTED LIGHT

A peer review of the 2012 EA report was conducted by Dr Deborah Racklyeft in 2014. Her findings support the evidence from the literature review that there would be no adverse impact on horse health or reproductive capacity as a result of any fugitive light that might arise from the project. Dr Racklyefts advice in regard to light is as follows:

> *"In considering this issue I reviewed several studies examining the manipulation of light duration, intensity and wavelength to influence mare's reproductive performance. I also sought examples of levels of illuminance that could be encountered in the lighting of outdoor work areas at night.*
>
> ***The use of artificial light in mare reproduction***
>
> *Increasing the exposure to artificial light of broodmares is an established practice, used to increase the length of the effective breeding season by suppressing melatonin secretion and altering circadian rhythm in the mare (Burkhardt 1947, Palmer and Guillaume 1992). The original photoperiod regimen of 16h light: 8h dark was provided by a 100W incandescent light bulb in a 3.65 x 3.65m stable. It was loosely described as "enough light to read the fine print in a newspaper" and was equivalent to an illuminance (level of illumination) of approximately 100 lux.*
>
> *Recent work to determine the minimum intensity of light required to reliably inhibit melatonin secretion (Walsh et al 20132) determined that equine photoreceptors are most sensitive to the short wavelength (blue) region of the visible spectrum. They also found that exposure to a lower illuminance of 10 lux from a blue-spectrum light-emitting diode mounted in a facemask was required to reliably affect mare cyclicity. Three (3) lux was not statistically different from darkness.*
>
> *Illuminance of outdoor work areas at night*
>
> *Examples of illuminance (Dell et al 2000);*
>
> *full moon on a clear night - 0.27 – 1 lux*
> *Private car park – 10 lux **
> *Mine loading bays – 150 lux **
> *Inspection areas (requiring the highest illuminance for workplace safety)– 1000 lux **
>
> - *Illuminance level directly under light at ground level*
>
> *The intensity of light or illuminance at areas distant from the light source will be attenuated according to the inverse square law, ie inversely proportional to the square of the distance from the source. For example, if the illuminance of a one*

metre square area directly under the brightest light on a 10 metre pole is 1000 lux, the illuminance of a one square metre area 100 metres away will be 1/100 the intensity (10 lux). If the light is one kilometer away, the luminance will only be 0.1 lux. This calculation does not take into account additional measures to mitigate fugitive light pollution such as limiting the light direction and by the provision of physical barriers preventing a direct line of sight between the light source and the adjoining properties.

Therefore, it would be unlikely in my opinion that fugitive light from the Project would be of sufficient intensity to interfere with broodmare reproductive performance if an adequate visual barrier and distance existed as a buffer between the mining operations and farms.

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9 OBSERVATIONS IN RELATION TO ADJACENT EQUINE CRITICAL INDUSTRY CLUSTER PROPERTIES

In regard to observations about Coolmore and Woodlands Studs and there standing in the Equine Critical Industry Cluster (CIC), I would make the following comments based on my 25 years practical experience in the thoroughbred industry, both racing and breeding, in Australian and New Zealand, as well as my time growing up and regularly working in the Upper and Lower Hunter Valley of NSW.

The concern has been raised during the assessment of the previous project that the two adjacent horse studs may leave the Hunter Valley. This seems to have evolved as a result of comments made by Dr Cameron Collins (current President of Hunter Valley Thoroughbred Breeders Association (HTBA) as well as a Senior Partner in the Scone Equine Hospital) at the PAC Public hearing 10th October 2013. It is not, to my knowledge, supported by documentation or direct advice from Coolmore or Darley.

Thoroughbred horse breeding in the Hunter Valley has been established for over 100 years. In that time many studs have risen to great prominence and dominance in the region and equally many studs have declined in influence. This occurs naturally as a result of many factors, being in particular the success of any stallion or stallions that may be standing at the studs. The commercial success of any stallion cannot be guaranteed and in some respects there is an element of good fortune in acquiring a good stallion. The chances of obtaining a successful stallion increases greatly if a stud has the financial resources to continually purchase well-bred and successful young, well-bred racehorse stallions. Studs such as Darley and Coolmore have these financial resources.

The attraction of Coolmore and Darley to breeders is primarily the stallions they stand. Success in racing and breeding is determined mostly by genetics. Owners wish to breed the best with the best and will do so irrespective of where the horse stands. The best stallions, which can demand the highest service fees, are determined purely by the success of their progeny on the racetrack. Owners do not choose a stallion based on the visual appeal and amenity that the stud presents. They will send a mare to a stallion anywhere in Australia if they consider him the most suitable mating for that mare.

Mare owners also expect that their horses will be well managed while at the stud. Good management consists of providing good nutrition, well grassed and fenced paddocks and regular monitoring to ensure any health issues are dealt with in an appropriate manner. The onsite veterinarians at the studs provide excellent veterinary care and routine breeding management expected in a major breeding operation.

The PAC has previously referred to the “Brand” of Coolmore and Darley being adversely impacted by the proximity to the Project rather than any significant physical effect from dust or noise on the property, personnel or equine health. Branding is important as it helps to identify one sellers good or service from competitors. As identified by Kevin Keller, Professor of Marketing at Dartmouth College[1], *“A brand is a product, then, but one that adds other* *dimensions to differentiate it in some way from other products designed to satisfy the same need.*" These other dimensions include, at one extreme, intangible emotional elements such as satisfaction. At the other extreme are rational and tangible elements specific to the features and functions of a product such as safety or in this instance bloodline.

While the brand of these studs is important in the equine industry it primarily relates to the racing and breeding credentials of the stallions and brood mares it uses and the progeny that can be produced rather than the landscape within which they operate. By way of example, most horse owners from Australia will never visit the operations base for Coolmore in Ireland but they will have great respect for the Coolmore brand in that country based on the horses it owns and races, in particular the breeding stallions. It is difficult to visit any stud in the Hunter Valley without seeing coal mines in close proximity to horse operations which has the effect of minimising any effect on any one equine stud "brand" in the Hunter Valley.

It should also be taken into consideration that Darley's Woodlands Stud is only used for broodmares and foals, with the stallions kept at a separate property (Kelvinside) which is located at Scone and well away from Woodlands Stud and the Project. Even if Woodlands relocated their mares from the current property they would be very unlikely to move the stallions from Kelvinside as they are reliant on the high concentration of broodmares in the Hunter Valley for commercial success.

The scientific evidence strongly supports there will be no adverse impact on equine health, including mares, foals or reproductive rates.

If as a worst case scenario, either or both studs chose to leave their current locations it is likely to have only a short term effect on the CIC. The CIC has developed over the past 100 years as result of the congregation of a large number of studs and the associated infrastructure and personnel. The history of the Hunter Valley Equine Industry shows that over the years some studs have had periods of dominance followed by periods of less influence. New studs are developed while older studs may no longer operate or might relocate. A relevant example of this is Coolmore's purchase of the former Arrowfield Stud (now Coolmore Stud) in 1991 and Darley's purchase of Woodlands Stud from the Ingham Brothers in 2008. This will continue to happen as part of the economics of the horse industry, the success associated with individual stallions, and the economic and personal situation of stud owners.

For example, Patinack Farm, formerly operated by coal mine owner Nathan Tinkler, has previously been identified as one of the "main actors in the CIC". Patinack had a rapid rise in prominence and influence in the CIC and could rightly be considered one of the dominant players in the CIC. Unfortunately Patinack Farm no longer exists in its previous form. This "main actor" has effectively been lost to the CIC yet despite this the CIC has continued to function effectively. The horses owned by Patinack were taken over by other studs so that the gap left by the demise of Patinack was rapidly filled.

It is highly unlikely that either stud would relocate overseas, the only realistic options would be considered to be New Zealand or possibly South Africa. The racing industries in both these countries are relatively weak, with prize money only a fraction of that available in Australia. More importantly, there are insufficient broodmares and owners in either of these countries that would pay the service fees for the large number of stallions that are present on the studs. While the top few stallions may attract sufficient mares many of the other stallions would struggle to fill a book at the currently advertised service fees. Further, the progeny born are likely to be less valuable in these countries as the value of horses achieved at the two major sales in Australia (Inglis and Magic Millions main yearling sales) are unlikely to be achieved in New Zealand or South Africa. The option would be to bring them back to Australia to sell which results in additional risk and cost.

Relocating overseas to a Northern Hemisphere country would result in stallions serving only half the year generating half the income. This is very unlikely to occur given the strength of the Australian racing and breeding scenes.

If the studs were to relocate it is most likely to be elsewhere in the Hunter Valley, which would also not negatively affect the CIC.

The studs may choose to relocate to elsewhere in NSW or interstate, however there are few areas with the same infrastructure that is close to Sydney and both major sale centres. Were they to leave the Hunter Valley, it is very likely that other “critical actors” would fill the void left. They may not be as dominant as Coolmore or Darley, however many in the industry may view that as a benefit rather than a detrimental result. The high concentration of stallions in one or two studs may not be healthy for the CIC and can adversely affect the ability of smaller studs to operate or compete effectively.

It is important to remember that stallions need mares to serve and were Coolmore or Darley to leave the Hunter Valley the mares would likely not follow in the numbers that currently use the stud. It is my understanding that the Hunter Valley has the highest concentration of thoroughbred broodmares in Australia. Therefore while these studs are useful for the CIC it is equally important for them to be in the Hunter Valley to benefit their own business models. It is very much a symbiotic relationship with mare owners in that without the mares Darley and Coolmore could not maintain their position in the CIC.

Therefore while any change in the structure of the CIC has the potential to impact the CIC it is likely in the long term that it will return to its normal level. Scone could continue to promote itself as the “Horse Capital of Australia” with or without Darley and or Coolmore.

In regard to vibration and noise levels any habituation that may be required would be expected to occur probably within days, if not sooner, and at most a few weeks.

The increase in dust levels, which will be minimal, will have no noticeable effect. The increase in dust levels the horses may be exposed to in a year in the worst case scenario could be seen as the equivalent of the dust exposure experienced by a horse placed in a stable in a few hours. Importantly the dust from the Project will be generally free of any other irritants such as endotoxins, moulds, bacteria and other allergens which are the primary causative factors in equine lower respiratory tract disease.

Given that the minimal total airborne endotoxin concentration likely to cause lower respiratory tract disease in normal horses most likely exceeds 20 ng/m^3 (0.02 μg/m^3) (McGorum et al, 1998) and the worst case scenario as a result of this Project would be approximately 0.018 ng/m^3 , which is approximately 300 times less, then it is reasonable to conclude that there will not be any effect on horse health as a result of inhalation of endotoxin associated with dust that might arise from the Project. Levels of endotoxin in stables has been measured to reach nearly 10,000 ng/m^3 (Samidi et al 2009).

Horse Stud Plans in China

Media reports indicate that Coolmore is involved in setting up a racing and breeding program in Tianjin, China which is on the outskirts of Beijing.

> *"The project covers approximately 3.3 million square metres site in Panzhuang, Ninghe County in Tianjin, of which approximately 820 acres of land will cover the immediate needs of the horse industry. It will also include extensive facilities for all training support services, including farriers, grooms, administrative organisations, feed and bedding suppliers and transportation providers. A world class breeding facility will be located outside the Tianjin Equine Culture City and will be a vital supply chain to China's thoroughbred industry.*
>
> *Housed in farm-like settings, these facilities will be compared to centres of excellence in the NSW Hunter Valley, Kentucky in the US, Deauville in France and the Hokkaido breeding and training centres of Japan.*
>
> *Coolmore's involvement in the project includes the initial establishment of a stud farm, stocked with broodmares which will be sourced in Ireland. The breeding program has commenced and will involve the export [from Ireland] to China of over 100 mares over three years (http://www.independent.ie/irish-news/theyre-off-coolmore-sends-first-horses-to-china-29422216.html and http://www.racingandsports.com.au/en/racing/coolmore-partners-massive-china-racing-project-story-274878)."*

It should be noted that this horse breeding and racing enterprise is located on the outskirts of Beijing and is well recognised as having some of the worst air pollution on earth (see **Plate 2** and below photos).

International sports stars openly complain of the difficulties of performing in these conditions.

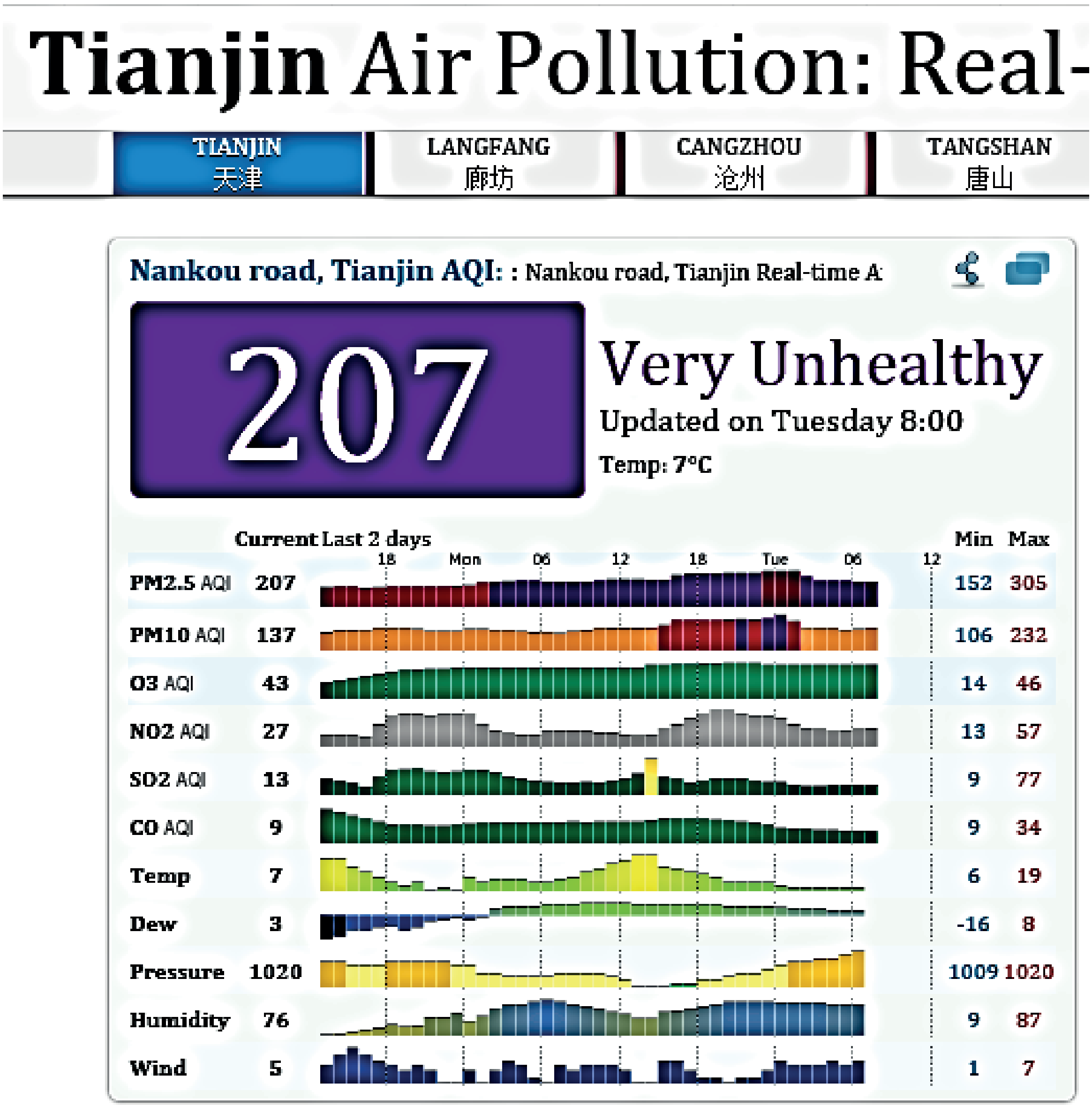
> *"Melbourne City's Erik Paartalu knows all too well the impact of China's pollution on an athlete's body after spending the whole 2013 Chinese Super league season with Tianjin Teda.*
>
> *"You could taste the pollution" Paartalu said on playing in the thick of China's smog. Pollution in China is now an openly discussed topic, the much publicised smog that engulfs some cities is frequently the center of conversation among local residents. News stories negative or positive are published almost weekly but some of the most damning criticisms have come from visiting sports personalities.*
>
> *In 2013 the China Open tennis final between Novak Djokovic and Rafael Nadal almost didn't happen when Nadal was reluctant to play. Most recently, in the build up to Brazil and Argentina's friendly in Beijing, pollution drew harsh criticism from some big stars.*
>
> *"The Chinese people do not deserve to live like this," said Brazil and Paris Saint-Germain defender David Luiz. His international colleague Philippe Coutinho noted: "The air is rather strange."*
>
> *"The pollution affected me on a daily basis," the 28-year-old said.*
>
> *"There was an adaptation period at first – sore eyes, burning lungs and even blood in the mornings in my nose. Once I got used to it, it would still be hard to train on those bad days.*
>
> *"Football clubs need to cancel games and training sessions when pollution reaches certain limits. "You could taste the pollution, an almost metallic taste on your teeth on the really bad days."*
>
> *"The Chinese government has promised improvements by 2017 and researchers at China's Tsinghua University have suggested that levels of the dangerous PM2.5 particle would fall by 25.6% in Beijing and 18.7% in Tianjin by this time (http://www.fourfourtwo.com/au/news/paartalu-airs-player-concerns-about-smoggy-china and http://www.reuters.com/article/2014/05/19/uk-china-pollution-idUSKBN0DZ19O20140519).*

Plate 2
Smoking chimneys are seen in front of residential buildings in Tianjin January 2013.
Credit: Reuters/Petar Kujundzic

The Air Quality Index (AQI) is an index used for reporting on daily air quality. It is a non-linear scale. The AQI can be converted into concentrations such that an average PM_{10} of 137 equates to 228 µg/m³. The range at this location in Tianjin is 165 -377 µg/m³ which is far in exceedance of any levels that might be experienced on horse studs near the project. Further the $PM_{2.5}$ levels are on average 157 µg/m³ which is considered very unhealthy on this index (http://www.airnow.gov/index.cfm?action=resources.aqi_conc_calc).

Given the concern Coolmore is showing for levels of PM_{10} which in a worst case scenario will be less than 30 µg/m³ on some individual days it seems unreasonable that they would accept being part of establishing a breeding and racing industry in this location in China. The level of pollution from both PM_{10} and $PM_{2.5}$ greatly exceeds the levels that will be present on the studs and should be considered as a potential major health hazard to any horses that breed or race in this area. Levels of $PM_{2.5}$ as a result of mining projects are not considered to be an issue in the Hunter Valley Projects in relation to any potential effects on equine health yet is a major contaminant in air in China.

It is further claimed that these centres will be *compared to centres of excellence in the NSW Hunter Valley, Kentucky in the US, Deauville in France and the Hokkaido breeding and training centres of Japan*. If this is the case then clearly air pollution (or perceptions of potential impacts) is not a concern to the international horse racing and breeding industry.



Tianjin Air Pollution: Real-

Nankou road, Tianjin AQI: : Nankou road, Tianjin Real-time A

207

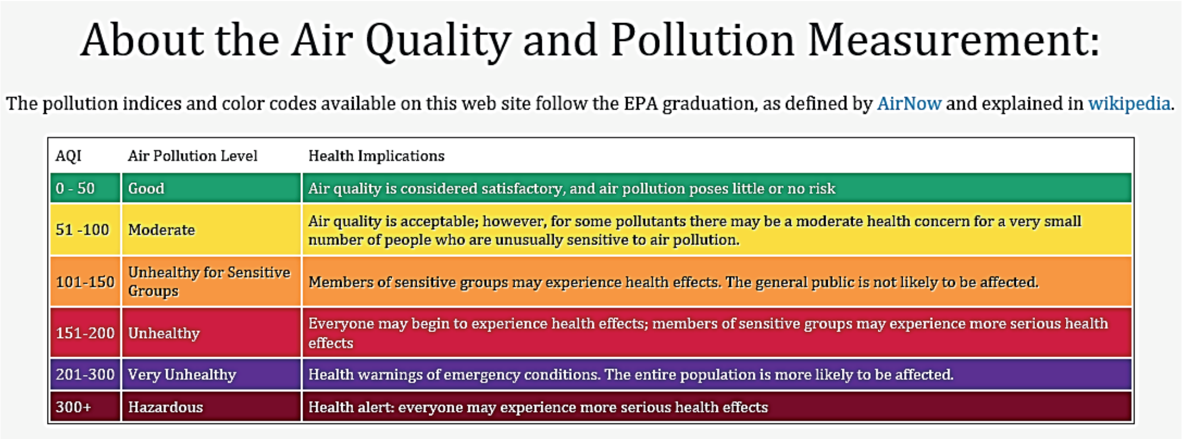
Very Unhealthy

Updated on Tuesday 8:00

Temp: 7°C

	Current	Last 2 days	Min	Max
PM2.5 AQI	207		152	305
PM10 AQI	137		106	232
O3 AQI	43		14	46
NO2 AQI	27		13	57
SO2 AQI	13		9	77
CO AQI	9		9	34
Temp	7		6	19
Dew	3		-16	8
Pressure	1020		1009	1020
Humidity	76		9	87
Wind	5		1	7

(Air Quality Tianjin 17 March 2015 (http://aqicn.org/city/tianjin/nankoulu/). See table below for key)



About the Air Quality and Pollution Measurement:

The pollution indices and color codes available on this web site follow the EPA graduation, as defined by AirNow and explained in wikipedia.

AQI	Air Pollution Level	Health Implications
0 - 50	Good	Air quality is considered satisfactory, and air pollution poses little or no risk
51 -100	Moderate	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
101-150	Unhealthy for Sensitive Groups	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
151-200	Unhealthy	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects
201-300	Very Unhealthy	Health warnings of emergency conditions. The entire population is more likely to be affected.
300+	Hazardous	Health alert: everyone may experience more serious health effects

10 RECOMMENDATIONS

The findings of this report are that the Project will have no adverse impact on equine health or the viability of Coolmore or Woodlands Studs. As such it is considered that few specific recommendations are required. Ensuring that dust, noise and blasting levels correlate with projected outcomes throughout the duration of the Project would be considered important. Specific recommendations are as follows:

10.1 DUST

- No recommendations specific to horse health are considered necessary. However it is understood that real-time monitoring of dust levels and regular consultation with Darley and Coolmore will be undertaken throughout the duration of the Project.

10.2 NOISE

- No recommendations specific to horse health are considered necessary. However it is understood that noise and blast overpressure monitoring will be undertaken to confirm that all regulatory criteria are met as predicted by the modelling.

10.3 BLASTING

- No recommendations specific to horse health are considered necessary. However it is understood that monitoring of blasting will be undertaken to confirm that overpressure and vibration levels are in accordance with the Blast Management Plan.

10.4 LIGHT

- No recommendations specific to horse health are considered necessary. The lighting used at Drayton South will not be directly visible from the studs and any indirect light will not be of sufficient brightness to have any negative effect on breeding cycles.

11 CONCLUSIONS

Comparison with data generated in the EIS Air Quality Assessment, EIS Acoustics Assessment and EIS Visual Assessment indicated that the levels of dust, noise, vibration and light that the horses would be exposed to as a result of the Project would be far less than that which they are exposed to in a breeding and racing career. Based on the literature review and evaluation of data generated in the EIS assessments it is concluded that in terms of dust, noise, vibration and lighting, the Project will have no adverse effects on the health of horses on the Coolmore and Woodlands Studs.

As stated in **Section 10** based on the conclusion that there will be no adverse impacts on horse health, few specific recommendations are required. In particular monitoring of horses responses to mining is not required to address uncertainty as sufficient evidence has been provided by the assessments completed as part of the EIS and the Edinglassie Stud example of how horses respond to mining. The Edinglassie example is considered far more extreme when compared to the Project (as it is located much closer to two active mines) as such provides certainty to the findings and conclusions of this assessment.

11.1 DUST

11.1.1 EIS Air Assessment

The dust levels expected to be generated by Project will be a small incremental increase on the current levels and still well below levels experienced by horses in a stable environment (both at the studs and while in race training). When mining is occurring air quality will remain at levels approximately equivalent to those found in Lexington, USA, and far less than those which occur in locations in Hong Kong and Saudi Arabia where thoroughbreds concentrate.

This report has confirmed that even if there were short term increases in dust levels well above those predicted by modelling then they would be well handled by the equine population on the studs and any dust that is inhaled would be rapidly cleared with no adverse effects. There will be no increased risk of transmission of diseases such as Rattles as there will not be any of the infecting bacteria in the soil of the Project.

Based on the equine health literature review, dust levels experienced by horses are likely to be much higher in a stable environment. All horses produced by Darley and Coolmore are intended for a racing career so the dust levels that they will be exposed to over their life will be very high.

It is concluded that the minor increase in dust levels resulting from the Project will not result in any additional health or production problems for the horses on the adjacent horse studs.

11.1.2 Endotoxin Analysis

Given that the minimal total airborne endotoxin concentration likely to cause lower respiratory tract disease in normal horses most likely exceeds 20 ng/m^3 (McGorum et al, 1998) and the extreme worst case scenario (considered unlikely to actually occur) as a result of this Project would be approximately 0.018 ng/m^3 then it is highly unlikely that there will be any effect on horse health as a result of inhalation of endotoxin associated with dust that might arise from the Project.

11.2 NOISE

Equine hearing is similar to human hearing although less sensitive. As a guide, it is probable that horses are slightly deafer, with hearing approximately 15 dBA less sensitive than humans. In light of this, human guidelines regarding noise will have some relevance and it is recommended that noise level criteria suggested for human exposure is appropriate and could be utilised. Horses will habituate to any noise that may arise from the project very quickly, including the transient horse population.

Those individual horses that may be more sensitive to noise will also be more sensitive to other noises arising from routine farm operations, noise associated with transport to and from the stud as well as noise from the environment, in particular thunder from lightning strikes and those noises emanating from the immediately adjacent Golden Highway and from the use of helicopters and aircraft on the horse studs. Unexpected noise arising from these sources will be far more of an issue for these horses than will any noise that may arise from the Project. Such individual horses may require different management irrespective of any noise arising from mining.

The noise from blasting is predicted to be far less than that of the thunder associated with thousands of lightning strikes that occur on or in the direct vicinity of the studs each year.

Given that the noise levels are not predicted to exceed background levels at the horse studs it is highly unlikely that noise levels will have any impact on the equine population.

11.3 BLASTING

The ground vibration arising from the Project is expected to be intermittent and barely discernible across the Coolmore and Woodlands Studs and is very unlikely to have any adverse effects on equine health. Any vibration experienced is likely to be far less than that experienced by horses during road or plane transport.

Similarly, overpressure from blasting will remain far below that of the resultant frequent helicopter landings at both horse studs and lightning strikes. Impacts will also be significantly lower than those that are experienced at the Edinglassie Stud (which have not resulted in any adverse impacts to horse health) as a result of operations at Mt Arthur Coal Mine. Horses will continue to assimilate to blasting as operations slowly move closer to the horse studs so long as they remain within human amenity levels as predicted.

11.4 LIGHT

It is highly unlikely that light of sufficient intensity will reach the horse studs as a result of the direct natural physical barriers in place between the Project and the horse studs.

It has been confirmed by this assessment and further supported by the advice of Dr Racklyeft that there will be no adverse effect of light. In order to manipulate breeding cycles in mares, artificial lighting needs to be of a certain intensity and prolonged exposure. The lighting used at Drayton South will not be directly visible from the studs and any indirect light will not be of sufficient brightness to have any negative effect on breeding cycles.

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APPENDIX 1

Horse Health Literature Review – The effects of dust on the equine lower respiratory tract

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Drayton South Coal Project – Literature Review

The effects of dust on the equine lower respiratory tract

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Summary and Key Points

a) Based on the literature search it was concluded that there is likely to be a poor correlation between humans and horses in regards to the adverse effects of dust pollution on health.

b) Horses are exposed to a large amount of dust in their lives particularly when performing as athletes. The primary sources of dust are bedding, hay and feed.

c) The major causes of adverse effects from dust exposure in any environment is not the particulate matter as such but the endotoxins, bacteria and fungi etc. that is attached to the particulate matter.

d) Horses have a highly refined respiratory tract that greatly protects against contamination of the upper and lower respiratory tracts.

e) Despite exposure to high levels of dust horses can compete to the best of their ability

f) Dust that does not have high levels of endotoxin associated with it (e.g. nuisance or crustal dust) does not appear to increase the incidence of Inflammatory Airway Disease in horses.

Conclusion: The amount of dust horses are exposed to as an “occupational hazard” both as a result of being fed hay and in particular being kept in a stabled environment is very high. There are undoubtedly effects of this “dust” on the respiratory tract, particularly Inflammatory Airway Disease. However it is well documented that the effects of dust are primarily a result of endotoxins attached to the dust particle, rather than the inorganic dust component itself.

Key Points

a) The minimal total airborne endotoxin concentration likely to cause lower respiratory tract disease in normal horses most likely exceeds 20 ng/m^3 (0.02μg/m^3) (McGorum et al, 1998)

b) Total dust concentration in normal pasture environment for horses has been measured as 0.17mg/m^3 (170 μg/m^3), respirable dust at 80 μg/m^3 and endotoxin levels of 0.00129 μg/m^3 in total airborne dust (McGorum et al, 1998).

c) The recommended maximum value for inhalable dust in a stable is probably in the order of 2.5 to 3.0 mg/m^3 (2500-3000μg/m^3) Concentrations of respirable dust in stables range from 0.15 to 9.28 mg/m^3 ,(150–9280 μg/m^3) with a recommended maximum value of 0.23 mg/m^3 (230 μg/m^3). (Cargill 1999)

d) Racehorses, who spend most of their time (up to 22 hours) in looseboxes, are exposed to aerosolised foreign dusts and gases almost continuously and any effects these agents have would likely be cumulative. There can be peaks of dust exposure up to 50 times greater than background levels depending on type of bedding, feed, activity of the horse and stable management. (Malakides and Hodgson 2003)

e) Forty percent of horses develop Inflammatory Airway Disease within the first 2 weeks of entering racetrack stables for training. This represents a very high percentage of affected horses that are clinically well and preparing for the high stresses of racing. (Malakides and Hodgson 2003)

f) More than a third of horses entering racetrack stables had some form of airway inflammation prior to transport to racetrack stables but these horses were not necessarily at greater risk of continuation of inflammation or further respiratory disease . (Malakides and Hodgson 2003)

g) Contrary to expectation, many dust-generating activities and sources are not associated with Inflammatory Airway Disease (Malakides and Hodgson 2003)

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1 Introduction

The author has been engaged by Hansen Bailey Environmental Consultants (Hansen Bailey) on behalf of Anglo American Metallurgical Coal Pty Ltd (Anglo American) to complete a horse health literature review for the Drayton South Coal Project (the Project). The Project involves the continuation of the existing Drayton Mine by the development of open cut and highwall mining operations within the Drayton South area (Drayton South) while continuing to utilise the existing infrastructure and equipment from Drayton Mine.

The Project is located approximately 10 km north-west of the village of Jerrys Plains and approximately 13 km south of the township of Muswellbrook in the Upper Hunter Valley of New South Wales (NSW). Two major thoroughbred horse studs are situated to the immediate south of the Project. The purpose of the review is to gain an understanding of the available information that exists with regard to the potential impacts of dust on horse health. This literature review will form part of an Environmental Assessment (EA) being prepared by Hansen Bailey to support an application for Project Approval under Part 3A of the Environmental Planning and Assessment Act 1979 (EP&A Act).

1.1 Overview

There is very little published scientific information which evaluates the effects of dust of topsoil or crustal origin on the health of pastured horses. In contrast there is a large amount of data that examines the effects of dust from bedding, feed and the environment on stabled horses. This review evaluates the available data in both areas. There is also a vast amount of information regarding the effects of dust and pollution on human health. As this is not my area of expertise and there would appear to be sufficient differences between equine and human responses to dust exposure, few reliable conclusions can be made.

The primary aim of this review is to provide information on known sources of dust as well as the composition and effect of this dust on the equine lower respiratory tract (LRT). Considerable data has been presented in regards to dust in a stabled environment even though this may not seem totally applicable to the situation in pastured horses as generally exists in the horse studs immediately adjacent the Project. This has been done for two reasons. Firstly to provide data on "occupational" background dust levels experienced by horses that undertake any athletic career and secondly to examine the effects that different levels and types of dust may have on the LRT. Unless otherwise stated all information presented relates to horses.

Definition of dust:

There is considerable imprecision in use of the term (dust) in both the human and veterinary literature. Many articles describe studies evaluating "dust" however the composition of this dust can vary widely. This makes comparison between reports and evaluation of data very difficult. In many papers the composition of the dust is not defined at all.

The report of Reed et al (2006) provides full details of regulatory standards in relation to human health and dust in agricultural industries from an Australian perspective and can be referred to if human health guidelines are required.

Inspirable Dust - Inspirable (inhalable) dust is defined as a material that may be deposited anywhere along the respiratory tract, where the aerodynamic diameter of the dust may range from 0 to 100 µm.(ACGIH, 2005)

Respirable Dust - Respirable dust is defined as the proportion of airborne dust levels that when inhaled may penetrates to the unciliated airways of the lung. The median diameter of the dust particles is 4.25 µm. Respirable dust fraction is defined by ISO 7708 (AS2985, 2004) (Reed et al 2006)

Particulate matter is derived from several sources:

- *Background crustal dust from local and distant areas.*
- *Biologically derived;*
  - *'hay dust' at the horse stud infrastructure, and*
  - *pollen, and plant and insect fragments in ambient air blown from local and distant areas.*
- *Combustion derived particulates (e.g. automobile exhaust, emissions from industrial boilers and other processes, smoke from domestic and grass/bush fires).*
- *Dust associated with the proposed mine (e.g. over burden and coal dust).*

Dust may often be a combination of several of the above sources.

1.2 Data Bases Searched

The following data bases were searched in compiling this report.

a) CAB abstracts (1990 to present)
b) PUBMED
c) Science Direct
d) Wiley Online Library.
e) Medline (1950 to present)
f) Personal data base N Kannegieter
g) Web of Science
h) Cambridge Journal Online

2 Literature Search results

2.1 Effects of Dust or Pollution on animals in an open environment

There are few studies evaluating this effect.

Newman (1979) documents a large number of outbreaks of pollution causing problems in many species, including horses. Despite a long list of documented pollution associated incidents in a variety of species, all were associated with specific pollutants rather than the general effects of dust. They concluded that some of the major effects of industrial air pollution on wildlife included direct mortality, debilitating industrial-related injury and disease, physiological stress, anaemia, and bioaccumulation.

An example is given below.

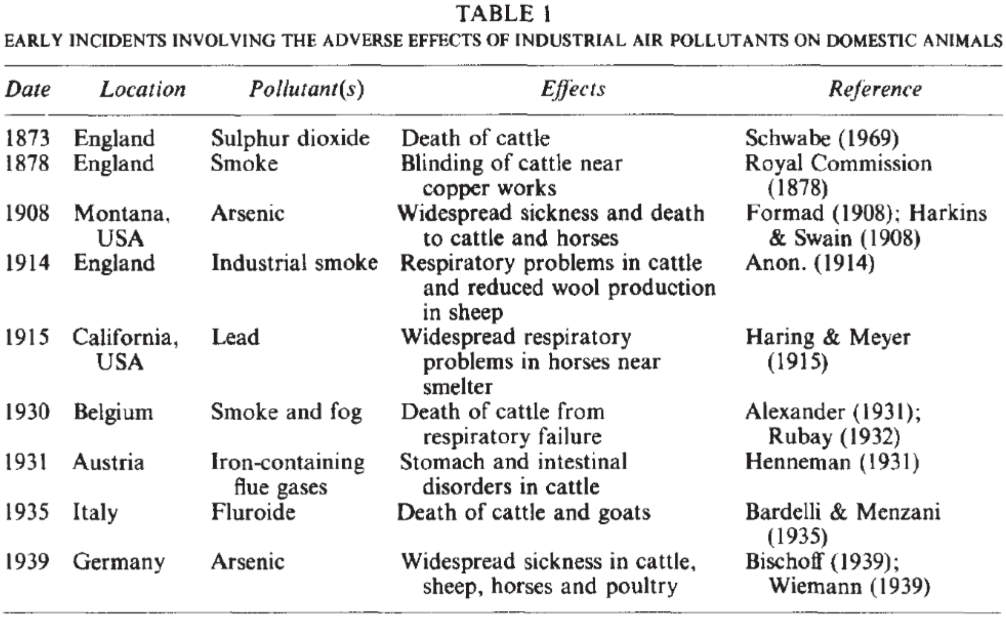


TABLE 1

EARLY INCIDENTS INVOLVING THE ADVERSE EFFECTS OF INDUSTRIAL AIR POLLUTANTS ON DOMESTIC ANIMALS

Date	*Location*	*Pollutant(s)*	*Effects*	*Reference*
1873	England	Sulphur dioxide	Death of cattle	Schwabe (1969)
1878	England	Smoke	Blinding of cattle near copper works	Royal Commission (1878)
1908	Montana, USA	Arsenic	Widespread sickness and death to cattle and horses	Formad (1908); Harkins & Swain (1908)
1914	England	Industrial smoke	Respiratory problems in cattle and reduced wool production in sheep	Anon. (1914)
1915	California, USA	Lead	Widespread respiratory problems in horses near smelter	Haring & Meyer (1915)
1930	Belgium	Smoke and fog	Death of cattle from respiratory failure	Alexander (1931); Rubay (1932)
1931	Austria	Iron-containing flue gases	Stomach and intestinal disorders in cattle	Henneman (1931)
1935	Italy	Fluroide	Death of cattle and goats	Bardelli & Menzani (1935)
1939	Germany	Arsenic	Widespread sickness in cattle, sheep, horses and poultry	Bischoff (1939); Wiemann (1939)

From Wildlife, Biol. Conserv. 15:181-190

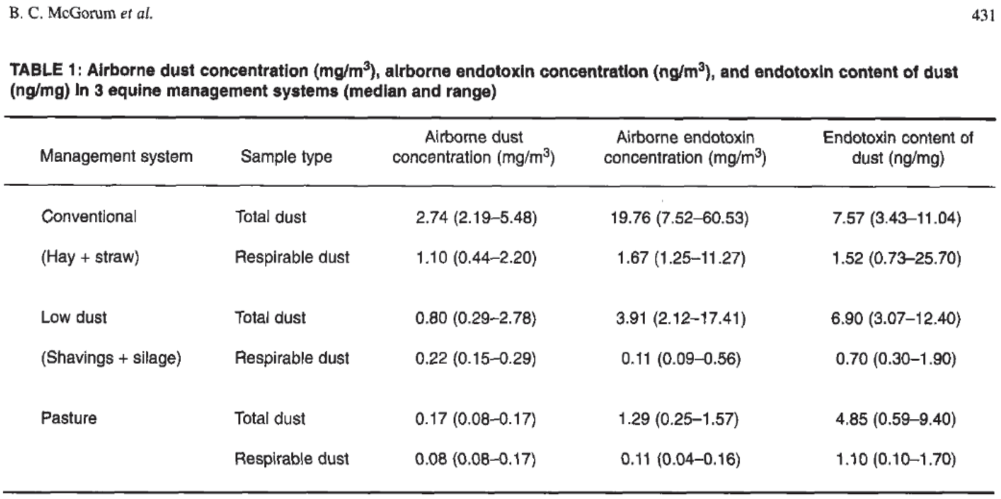
Crichlow et al (1980) found that the concentration of airborne particles in stables was more than ten times greater than that of outdoor air.

A report from India (Dogra et al, 1984) examined the effects of pollution from mining on the lungs of bovines. These authors collected lungs from bovines slaughtered in areas identified as being in high density mining areas and compared them to those from remote regions in which no mining was conducted. The report documented there was considerable gross microscopic lung pathology in cattle from mining areas. This was mostly and possible exclusively due to the presence of heavy metals in the lungs. They identified the presence of as many as 20 trace metals, in particular mercury, iron, zinc and lead. They concluded that the main finding in the lungs of animals inhabiting mining and industrial areas were deposits of particulate dust. The implication was that animals living in mining and industrial areas, but not actually associated with mining and industrial operations, can accumulate large amounts of particulate matter with adsorbed heavy metals in their lungs.

Unfortunately the paper does not provide sufficient detail on levels of pollution, nor the condition under which the cattle were kept. Given that there is a much closer interaction between cattle and pollution in India, where stock frequently live and graze on major highways and roads, it is difficult to differentiate effects of mining from general industrial pollution, particularly from motor vehicles. This paper seems to evaluate the effects of heavy metal pollution rather than dust on the LRT.

As a result of the rapid industrial development in the Hunter Region in New South Wales, which was considered to be a result of its vast coal reserves, James et al (1985) explored the use of applied input output analysis for air quality assessment and management in the region. The technique linked economic activities to pollutant emissions and yields total emissions, which are spatially allocated across the region for use with air pollutant dispersion models. These authors considered this a useful model to address the issue of air quality in relation to human health which they considered had emerged as a major public issue and a possible constraint on development.

Work by McGorum et al (1998) gives a good indication of base line levels for dust in a pasture management system for horses although the pasture setting was in Edinburgh (UK) so dust levels may be low compared with general Australian conditions. It was found that as total airborne endotoxin concentrations exceeded 20 ng/m^3 (0.02 μg/m^3) in half the stables examined that even healthy horses in these environments may be exposed to sufficient endotoxin to cause airway inflammation and bronchial hyperresponsiveness. However, as normal horses do not develop detectable pulmonary inflammation or hyper-responsiveness when housed in conventional stables (Derksen et al, 1985; McGorum et al, 1993), it is likely that that the minimal total airborne endotoxin concentration causing LRT disease in normal horses exceeds 20 ng/m^3 (0.02 μg/m^3).



B. C. McGorum *et al.* 431

TABLE 1: Airborne dust concentration (mg/m^3), airborne endotoxin concentration (ng/m^3), and endotoxin content of dust (ng/mg) in 3 equine management systems (median and range)

Management system	Sample type	Airborne dust concentration (mg/m^3)	Airborne endotoxin concentration (mg/m^3)	Endotoxin content of dust (ng/mg)
Conventional	Total dust	2.74 (2.19–5.48)	19.76 (7.52–60.53)	7.57 (3.43–11.04)
(Hay + straw)	Respirable dust	1.10 (0.44–2.20)	1.67 (1.25–11.27)	1.52 (0.73–25.70)
Low dust	Total dust	0.80 (0.29–2.78)	3.91 (2.12–17.41)	6.90 (3.07–12.40)
(Shavings + silage)	Respirable dust	0.22 (0.15–0.29)	0.11 (0.09–0.56)	0.70 (0.30–1.90)
Pasture	Total dust	0.17 (0.08–0.17)	1.29 (0.25–1.57)	4.85 (0.59–9.40)
	Respirable dust	0.08 (0.08–0.17)	0.11 (0.04–0.16)	1.10 (0.10–1.70)

From Equine Vet. J 30:431

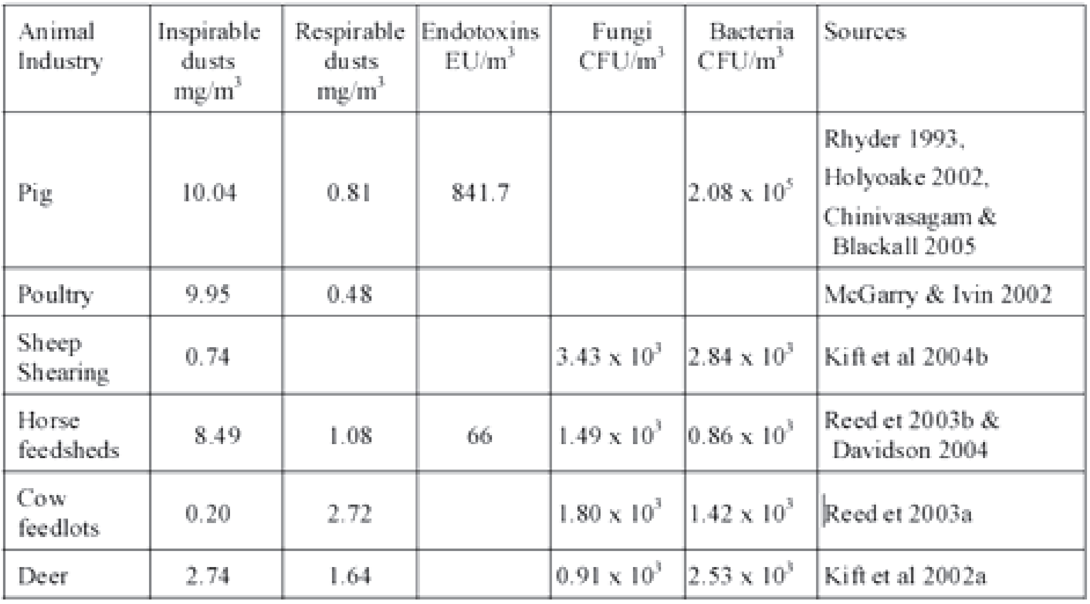
According to Mazan et al (2001) horses from urban areas did not have increased airway inflammation or bronchoconstriction compared with horses from rural locations.

Malikides and Hodgson (2003) reported that under normal outdoor circumstances low concentrations of endotoxin are inhaled however the respiratory tract has efficient defence mechanisms to counteract this airborne endotoxin. It is only when high concentrations of dusts containing endotoxin is inhaled and deposited within the airways that inflammation develops.

Deaton and Marlin (2004) undertook a r eview of the potential effects of general industrial pollution on equine respiratory health but provided no actual data. This report is speculative and based mainly on experiences in people. They summarised that despite numerous publications on the effects of dust from the housing environment in humans that the effects of chemical pollutants on equine lung function were largely unknown. The concentration and type of pollutants to which horses are exposed to in any situation is affected by factors such as time of day of exercise, wind direction and other environmental factors, including sunlight, temperature and cloud cover. Also the responses between horses to airborne pollutants are likely to be highly variable. They concluded that the effects of airborne pollutants on a irway inflammation and performance, if they occurred at all, were likely to be sub-clinical and impossible to differentiate from other causes of airway inflammation such as transport, heat or pre-existing airway inflammation.

Reed et al (2006) reviewed dust levels in several industries from a human exposure perspective, as documented in the table below.

Table 1 Summary of Worker Exposures to Dust and Bioaerosols in Animal Handling Facilities



Animal Industry	Inspirable dusts mg/m^3	Respirable dusts mg/m^3	Endotoxins EU/m^3	Fungi CFU/m^3	Bacteria CFU/m^3	Sources
Pig	10.04	0.81	841.7		2.08×10^5	Rhyder 1993, Holyoake 2002, Chinivasagam & Blackall 2005
Poultry	9.95	0.48				McGarry & Ivin 2002
Sheep Shearing	0.74			3.43×10^3	2.84×10^3	Kift et al 2004b
Horse feedsheds	8.49	1.08	66	1.49×10^3	0.86×10^3	Reed et 2003b & Davidson 2004
Cow feedlots	0.20	2.72		1.80×10^3	1.42×10^3	Reed et 2003a
Deer	2.74	1.64		0.91×10^3	2.53×10^3	Kift et al 2002a

From RIRDC Publication No 06/1071289

Reed at al (2006) also documented average dust levels associated with mixed farming, which included a range of animal types.

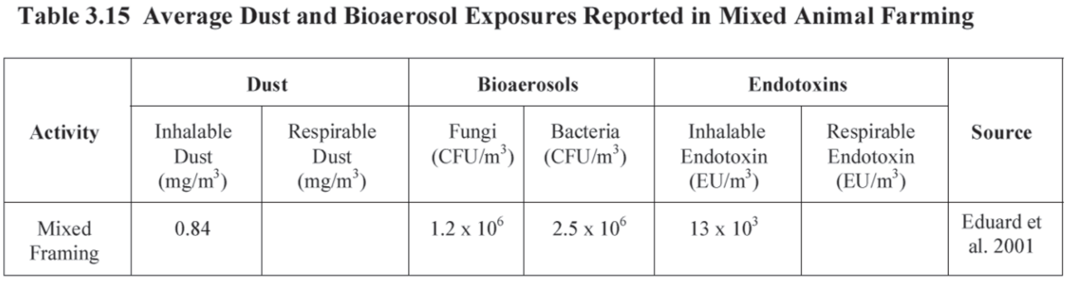


Table 3.15 Average Dust and Bioaerosol Exposures Reported in Mixed Animal Farming

Activity	Dust		Bioaerosols		Endotoxins		Source
	Inhalable Dust (mg/m^3)	Respirable Dust (mg/m^3)	Fungi (CFU/m^3)	Bacteria (CFU/m^3)	Inhalable Endotoxin (EU/m^3)	Respirable Endotoxin (EU/m^3)	
Mixed Framing	0.84		1.2×10^6	2.5×10^6	13×10^3		Eduard et al. 2001

From RIRDC Publication No 06/1071289

A study on the general effects of pollution on racing TBs in US was undertaken by Gates (2007). It was concluded that the impact of pollution on the Thoroughbred racing industry was minimal and that only under the most hazardous ozone levels were race times markedly slower, and such conditions were rarely encountered on race day.

Berndt et al (2010) found that inflammatory airway disease was common in stabled horses, with a prevalence of 17.3% in Michigan pleasure horses. This was a result of stable dust that was rich in endotoxin and which may induce neutrophilic airway inflammation. In this study endotoxin exposure was about 8 times higher in stables than on pasture. Mean values obtained of endotoxin concentrations in the breathing zone of stabled horses was 7.08 x 10^3 EU/m^3 and for horses on pasture was 0.85 x10^3 EU/m^3. On pasture, endotoxin varied widely, despite constant climatological conditions. It was suggested that a primary source of endotoxin in both stables and at pasture was manure.

2.2 Respiratory Defence mechanisms and Comparative Physiology between human, equine and other species

2.2.1 General comments

Species difference in histamine release from lungs in response to cotton dust were found both between species as well as intra-species by Evans and Nicholls (1974). In this study horses were less refractory to dust while human and pig lungs were most sensitive. Reactivity was also found to increase with age. These authors cited earlier works by Nicholls et al (1967) and. Douglas et al (1970) that failed to detect any histamine release in response to dust in cattle, sheep and horses. (Douglas et al (1970) Histamine release and bronchoconstriction due to textile dusts and their components , Proc. 2nd Int. Conf. Respiratory Diseases in Textile Workers, Alicante, Spain, 1968 pp. 148-155): NICHOLLS, P. J., NICHOLLS, G. R., & BOUHUYS, A.(I967) , ' Histamine release by compound 48/8o and textile dusts from lung tissue in vitro ', in Inhaled Particles and Vapours. II (ed. Davies), pp. 69-74. Oxford: Pergamon.)

Sweeney et al (1989) confirmed there was good tracheal mucus clearance rates in horses with a tracheal mucus velocity of approximately 20mm/min, as had been shown in many studies. These authors considered there were considerable differences between species in structure and function of the respiratory tract.

Malakides and Hodgson (2003) in a major review article cited other authors and advised that endotoxin concentrations in airborne dust measured over an 8-hour/5-day week must generally be above 4.5 to 10 ng/m^3 (0.0045 – 0.01 µg/m^3) for detectable airway inflammation to occur in humans and be substantially higher, approximately 100 to 200 ng/m^3 (0.1 -0.2 µg/m^3) to induce general respiratory symptoms and disease (Rylander R. Evaluation of the risk of endotoxin exposure. International Journal of Occupationaland Environmental Health 1997;3:S32-S36 ; Douwes J, Heederik D. Health-based Recommended Occupational Exposure Limit for Endotoxin.Wageningen, The Netherlands: Agricultural University of Wageningen, 1995;1-3) . Although these "no-effect levels" frequently are found in human occupational settings as well as in horse stable environments (Pirie RS, Dixon PM, Collie DDS, McGorum BC. Pulmonary and systemic effects of inhaled endotoxin in control and heaves horses. Equine Veterinary Journal 2001;33:311-318) they cannot be used as guidelines for horses due to extreme differences in duration and types of exposure.

Ghio et al (2006) provided information that suggests there is a close correlation between inhaled particulate matter lung injury in humans and both RAO and COPD in horses. The observations are very general in in many respects and reflect more the similar nature of a chronic inflammatory response rather than a response to any specific particulate matter.

Purdy et al (2008) undertook an experiment in goats which were exposed 7 times to sterilized fine feedyard dust (mean+/-SD particle diameter, <7.72+/-0.69 micron) for 4 hours in a specially constructed tent. Half had been inoculated intra-tracheally with fungal spores prior to dust exposure. They concluded that fine dust inhalation appeared to decrease the ability of goats to successfully clear fungal spores from the lungs following intratracheal inoculation.

2.2.2 What size particles reach the lungs

O'Callaghan et al (1987) reported that in humans the distribution of aerosol particles in the lung is dependent on two principal factors; particle size and the character of the respiration. Larger particles (2 to 10 µm) tend to deposit on the larger airway surfaces while moderate sized particles (0.5 to 2.0 µm are more easily able to follow the direction of air flow and are deposited by sedimentation when air flow velocity slows sufficiently, allowing then to gravitate out in the smallest airways or alveoli. Initially, particles smaller than 0.1 to 0.5 µm distribute in the same way but may be further affected by humidity in the airways causing significant increases in droplet size. Nearly all deposition of particles less than 2 µm in size is by sedimentation. Furthermore, the quantity of particles deposited by sedimentation increases with increasing bronchial number. Based on studies using radioaerosols in the horse similar behaviour seems probable since no significant central deposition occurred to indicate impaction of large particles in the major airways, and uniform distribution of the radioaerosol in the lung periphery was consistently observed.

Clements and Pirie (2007a) reported that the respirable dust concentration (RDC) (defined in this report as the portion that is of a sufficiently small aerodynamic size, usually with a diameter of <5 µ m, to allow penetration of the peripheral, smaller airways) is considered a good index of the health hazard posed by airborne dust inhalation in humans and horses (Derksen and Woods, 1994). The respirable dust particles have been measured in stables (Dunlea and Dodd, 1994, 1996) and are generally accepted to have an aerodynamic diameter of 0.5–5 µm.

Fleming et al (2008b) stated that particle fractions are subdivided into (a) an inhalable fraction being particles less than 100 µm (the proportion by mass of all suspended particles that are inhaled through the nose and mouth); (b) the extrathoracic proportion, being 100 to 10 µm (proportion by mass of the inhaled particles that can reach as far as the larynx but not further in the respiratory tract); (c) tracheobronchial fraction, being less than 10 µm (proportion by mass of the inhaled particles which can reach beyond the larynx, but not in the non-cilia region of the lungs [alveoli]); (d) the fraction that can reach the alveoli, less than <5 µm (percentage by mass of the inhaled particles that can reach right into the non-cilia region of the lungs).

Votion et al (1997) reported only particles under having a diameter less than 5 µm potentially reach the lower respiratory tract. Factors affecting the deposition of droplets into the lungs include droplet size and respiratory conditions, such as the inhalation and exhalation flow rates and the tidal volume, and anatomical peculiarities. Since characteristics relating to physiological and anatomical factors have a significant influence on aerodynamic behaviour and hence the deposition of the inhaled particles, extrapolation of results obtained in human medicine to horses is not appropriate. These authors documented that the majority (92.6%) of the particles produced by nebulisation of a 0. 9% saline solution will have a M MAD smaller than 5 µm. Aerosol deposition in the lungs expressed as percentage of the activity released from the nebuliser were mean +/- s.d. 5.09 +/- 0.66% and 7.35+/- 1.96%, respectively, meaning that only a fraction of that released at the nostrils actually reaches the lungs. The percentage of aerosol reaching the lungs was smaller than the average 10% of aerosol deposition achieved in human medicine.

Malikides and Hodgsen (2003) provided a very detailed report regarding dust and IAD in horses. They reported that *During normal breathing more than 95% of inhaled particles greater than 5 µm (e.g. small hay and straw fibres, fine wood shaving fibres, sand, pollens, plant spores, and larger bacteria, such as Streptococci) are filtered in the nasal passages, pharynx and tracheal bifurcation as a result of collision and impaction between high velocity particles within the airflow and changing airway anatomy. In the nasal passages, soluble noxious gases are concomitantly removed and neutralised via buffering by fluid and protein found in nasal mucus, and the air is humidified and warmed before entering the smaller lower airways. Once a particle impacts upon the moist nasal respiratory epithelium, it is trapped by mucus and removed by ciliary transport. It is important to note that even though few particles larger than 5 to 15 µm enter the trachea and more distal airways, those travelling with high velocity and volume of air can reach these airways and induce an inflammatory response. This response may be cleared or worsen depending on the agents' toxicity and concentration, particularly if particles contain or have adherent toxins such as bacterial endotoxin. As air reaches the small bronchi and terminal bronchioles of the LRT, total airway cross-section increases and air velocity drops. Deposition of smaller particles, between 0.5 to 5 µm (e.g. large viruses, fungal spores and small to medium sized bacteria, fine feed or bedding particle, smoke and motorised pollution) subsequently occurs by sedimentation onto airway surfaces under the force of gravity where, under certain circumstances, they may induce pulmonary inflammation.*

In general, slow, deep breathing (at rest) enhances sedimentation and leads to relatively uniform deposition of particles throughout the LRT. However, rapid breathing with increased airflow as occurs in horses during exercise increases impaction in the larger lower airways producing high local particle concentrations (100 times more) around the bifurcation carinas of these airway compared to airway walls. This pattern and nature of deposition of potentially harmful particles may therefore be an important determinant of distribution of inflammatory responses in the LRT of racehorses (e.g. diffuse or localised to airways with major branches).

When air reaches the level of the respiratory bronchioles and alveoli, most particles < 0.5 μm do not contact the respiratory epithelium and are expelled in exhaled air. However, because air velocity is very low in the gas exchanging structures, particles with a diameter < 0.1 μm (e.g. gas molecules, endotoxin molecules, viruses, proteins, combustion nuclei, ultra-fine particles) are subject to random thermal kinetic buffeting (Brownian motion/diffusion) and have time to diffuse to the walls of surrounding air surfaces.

Except perhaps for ozone and ammonia, there are no scientific studies demonstrating that exposure to noxious gases in stables or outdoor air pollution plays an equivalent role in equine airway inflammation, and TLVs (threshold limiting values) for any noxious gas for horses are unknown.

2.2.3 Equine respiratory tract defence mechanisms

Due to the absence of information specifically addressing the effects of dust on equine respiratory health many authors look to the results from human studies. Unfortunately the differences in anatomy, physiology, environment and lifestyle make such comparisons unreliable. While the data from human studies, in particular that relating to acceptable exposure levels, should not be ignored, it needs to be evaluated carefully in the correct context.

There are considerable anatomical and physiologically differences between horses and humans. In humans the nostrils, which serve as an entry and exit point for PM lies directly above the lungs so deposition of PM into the lungs would be considered much easier, while removal would be much harder. In contrast the nostrils of horses are much lower than the lungs for most of the time, which means it is very difficult for particulate matter to enter the lungs. It is also easier to excrete, particularly in grazing horses and those fed from ground level. Also the trachea in horses is considerably longer and has a very efficient muco-cilary clearance mechanism.

Riihimäki et al (2008) found that the innate immunity in the airways of stabled horses improved in response to mild elevations in respirable dust, 1,3-beta-glucan, and/or cold ambient air.

2.3 Potential Influence of Dust on known Equine Lower Respiratory Tract diseases

There are a large number of potential causes of lower respiratory tract disease in horses.

The following table form Spendlove et al (2008) summarises these causes.

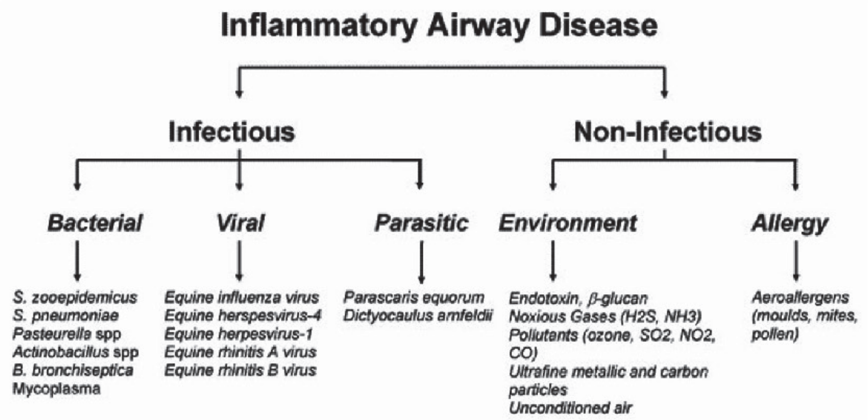


Figure 2: *Potential causes of lower airway inflammation in horses.*

From RIRDC Publication No 08/051

Buechner-Maxwell (1993 a,b) found that airway hyper responsiveness in horses was due to many factors, but dust alone not cited as a major cause. In a later report the same author (Buechner-Maxwell et al, 1996) found that short term exposure (4 weeks) to a stabled environment did not increase any inflammatory mediators in normal horses, although there were some limitations to this study.

Hoffman et al (1993) examined the incidence of distal respiratory tract disease in TB foals in breeding farms in Canada. The study found that 82% (+/- 5%) of foals were affected at one time by lower respiratory tract disease over a 7 mth period with bacterial infection the most common inciting factor.

Hoffman et al (1993b) considered that respiratory tract infection in young foals was regarded as enzootic on horse breeding farms. Bacteria, in particular strep zooepidemicus, were primarily responsible. Dust may also be involved in the spread of infections within stables, and it was suggested that stables need to be at least 100 to 150 metres apart to prevent dust-driven disease spread between buildings (Collins and Algers, 1986).

2.3.1 COPD (Heaves)

Chronic Obstructive Pulmonary Disease (COPD) often referred to as heaves is a common LRT disease in horses in the Northern Hemisphere. It was sometimes referred to as recurrent airway obstruction (RAO). It is uncommon, even in stabled horses, in the Southern Hemisphere.

The disease is seen virtually exclusively in stabled horses and is considered to be an allergic reaction to environmental contamination, in particular “dust”. It is not the dust particles alone, rather the material attached to them. In any stable environment there is considerable dust, and attached to that are endotoxins and fungi which are considered the most likely trigger of COPD. While it is beyond the scope of this review to evaluate all the data on COPD in horses, it is clear that COPD would not be considered a potential problem in pastured horses as a result of exposure to dust. For COPD to develop it would be likely the affected horses would need to have a predisposition to the disease (which if they did would manifest in a far more severe form once the horse entered stables for race training); there would have to be prolonged levels of exposure to high levels of dust for repeated, prolonged periods (e.g. days to weeks); and most importantly the specific allergenic trigger (e.g. fungi) would need to be on the dust. It is considered extremely unlikely that such a scenario would exist in the Lower Hunter Region in pastured horses.

McGorum et al (1993) reported that the absence of pulmonary disease in control horses after fungal challenge suggests that COPD is a pulmonary hypersensitivity rather than a non-specific toxic response.

Robinson et al (1996) concluded that as natural and specific antigen challenge affects only COPD-susceptible horses that COPD is a pulmonary hypersensitivity to specific antigens rather than a non-specific response to dusts and irritants in the stable environment.

Art and Lekeux (2005) reported that several equine respiratory disorders are directly caused by, or exacerbated by, inhalation of agents in airborne organic dust, including moulds and bacterial endotoxins. Keeping horses permanently on pasture, with a shelter against inclement weather and no supplementary hay feeding, is the ideal dust-free regime. Unfortunately, for numerous practical reasons, sport horses are often stabled indoors.

Deaton et al (2006) found that healthy horses demonstrated a mild but significant early phase (within 20 minutes) response to inhaled organic dust. This response may serve to decrease the subsequent dose of dust inhaled and as such provide a protective mechanism, which may be compromised in horses with RAO. The duration of organic dust exposure required before RAO affected horses develop clinical evidence of airway obstruction varies from hours to days, and clinical evidence of an early/immediate obstructive response is not apparent.

2.3.2 Exercise Induced Pulmonary Haemorrhage (EIPH)

EIPH or “Bleeding” affects over 95% of racing horses at one time or another. Most horses bleed into their lungs only, while a small percentage show evidence of bleeding at their nostrils. Horses that show external evidence of bleeding (i.e. From both nostrils) after a race or trial face bans from racing including a permanent ban for repeat offences.

EIPH occurs primarily as a result of extremely high physiological blood pressures achieved in the equine lungs during maximal exercise. While it is generally regarded as a physiological event there is speculation that other factors, including lower respiratory tract disease, may increase the incidence or severity of bleeding. As a result of the adverse effects on human RTD from inhaling pollution some work has looked at the possible effect of respirable pollution on the incidence of EIPH.

Mason et al (1984) carried out an investigation into the incidence of exercise induced pulmonary haemorrhage (EIPH) in thoroughbreds in Hong Kong between the 1981 and 1983 racing seasons. As it had been postulated that dust, especially from straw, could be implicated in lung haemorrhage a proportion of horses were bedded on paper in the 1982-83 season. No significant differences could be demonstrated in the incidence of EIPH resulting from the use of paper bedding in preference to straw.

A more recent follow up study (Hurley, 2011) was undertaken in an attempt to evaluate if the increasing levels of pollution in Hong Kong had caused an increase in the incidence EIPH. Despite considerable deterioration in air quality there was no change in incidence or severity of EIPH compared to the earlier study.

It is concluded that increased dust levels or other forms of pollution is extremely unlikely to have any effect on the incidence or severity of EIPH in horses raised on the horse studs immediately adjacent the Project.

2.3.3 Inflammatory Airway Disease (IAD)

There is a relatively recently categorised condition that covers most LRT diseases of horses apart from COPD. It is recognised in Australia and well over 20-55% of horses in any form of athletic endeavour may have IAD. The incidence in pastured horses is much lower.

IAD is a very general response to a wide variety of stimuli. Causes include viruses, bacteria, fungi, stable dust, etc. The effects that IAD have on horse health and performance vary greatly from no effect through to death in cases that become complicated. IAD is primarily a disease of stabled horses. IAD is considered to be more a response to the presence of irritant material in the lower airways, rather than the more severe allergic response seen in COPD. No doubt the precise definition of both these diseases will evolve with future research and as the links between IAD and COPD, if any, are further evaluated.

As IAD is a non-specific response to general irritants this is potentially a disease that can have an increased incidence directly as a result of increased exposure to dust. The concentration and composition of dust the horses might be exposed to in a paddock situation needs to be evaluated before any conclusion can be drawn as to the potential risk of IAD in pastured horses.

The report of Malakides and Hodgsen (2003) provides comprehensive information on IAD in horses. They found that endotoxin was primarily responsible for IAD. The source of endotoxin is from degenerate g*ram-negative bacteria and as such endotoxin is ubiquitous in nature and is commonly present on surfaces of plants and animals. Variable concentrations of endotoxins are found in agricultural environments such as housing for pigs, chickens, cows and horses, as well as sources such as bedding, hay, grains, straw, and bird droppings. Endotoxins also are present in industrial processing and storage of organic materials such as cotton and flax, wood chips, timber, fibreglass, wastes, potatoes and paper, as well as in animal slaughter and processing facilities, domestic water, house dust contaminated by pets and vermin, and cigarette smoke. Most environments in which horses have contact potentially can be contaminated with dusts with adherent bacteria and their cell-wall fragments, which subsequently may become aerosolised and inhaled. In addition, endotoxins are present in the oral, pharyngeal and nasal cavities as well as the intestinal tracts of humans and animals. Aspiration of secretions from the mouth and nasopharynx may lead to bronchial contamination by endotoxins although horses are more likely to be exposed to endotoxin-contaminated dusts via inhalation.*

It was found that a significant linear (or exposure-response) relationship existed between the average percentage of neutrophils in lower airways and exposure to high (>4-5ng/m^3) (0.004-0.005 µg/m³) respirable endotoxin concentrations in breathing zone dust. In addition, young racehorses that became cases (as defined) and developed neutrophilic IAD were approximately 4 times more likely to have been exposed to either low (<1.2ng/m^3) or high (>4.2ng/m^3) (0.0042 µg/m³) concentrations of endotoxin. These associations controlled for the possible confounding effects of many other variables, highlighting the importance of endotoxin alone in the genesis of neutrophilic lower airway inflammation.

In conclusion, results of this study indicate that endotoxin from dust sources (such as feed, bedding and sources outside boxes) in stables is associated with neutrophilic IAD in 2 and 3 year old thoroughbred racehorses in Australia. As in humans, the severity of this airway inflammation is related to the endotoxin concentration of the inhaled dust. Ventilation quality and meteorological conditions, particularly evaporation level, in looseboxes and stables also were significant risk factors for IAD.

Malikides and Hodgsen (2003) also performed a number of experiments and concluded that 40.3% (range 30-50%) developed IAD within the first 2 weeks of entering racetrack stables for training. This represents a very high percentage of affected horses that are clinically well and preparing for the high stresses of racing. In half these horses the problem persists and may develop into clinical disease as a result of training and management stresses. More than a third of horses entering racetrack stables for training had some form of airway inflammation prior to transport to racetrack stables. The conditions young racehorses are placed in and their health management (particularly with regard to regular anthelmintic treatment) prior to transport to racetrack stables may influence whether or not horses arrive with some form of IAD. However, the high proportion of young racehorses that develop IAD prior to arrival at racetrack stables are not necessarily at greater risk of continuation of inflammation or further respiratory disease.

A further key conclusion was that Contrary to expectation, many dust-generating activities and sources were not associated with IAD.

These studies provided the strong evidence that inhaled dust endotoxin is associated with and may cause neutrophilic IAD in young thoroughbred racehorses housed in racetrack stables. In addition, the higher the concentration of endotoxin inhaled by racehorses, the higher the proportions of neutrophils in lower airways. Although it is difficult to predict what dust sources contain higher endotoxin content, reducing overall airborne particle burdens in horse looseboxes and stables clearly is of paramount importance to health and welfare of racehorses.

Millerick-May et al (2008) found that IAD had an overall prevalence of 67%. They confirmed an association with PM<10 µm in diameter (PM10; odds ratio [OR] = 5.8, 95% CI = 1.64 – 20.56, p<0.0064) and PM 2.5 µm in diameter (PM2.5; OR = 4.5, CI=1.35 – 14.90, p<0.0151). The prevalence of tracheal mucus was highest in the stables and months with highest overall PM. The prevalence of tracheal mucus was least in the open-sided stable with low PM and after a period of wet weather when PM was low. Significant improvement can be seen by just opening a window in a stable.

Hughes et al (2011) undertook a study that indicated IAD of horses is associated with increased mRNA expression of proinflammatory cytokines in BALF cells, which may reflect stimulation of the innate immune responses to inhaled antigens. There was no evidence of a polarised T-cell cytokine response suggesting hypersensitivity responses may not be involved in the aetiopathogenesis of IAD. The prevalence of IAD in racehorses has been reported to be between 11.2% and 50% (McNamara et al., 1990; Burrell et al., 1996; Wood et al., 2005).

Laan et al. (2006a) found increased expression of mRNA of these cytokines in isolated alveolar macrophages from RAO horses compared to healthy horses after inhalational challenges with LPS, hay dust suspension (HDS) or Aspergillus fumigatus extract (AF), suggesting differences in innate immune responses exist between healthy horses and those susceptible to RAO.

2.3.4 Rhodococcus equi (Rattles)

Rattles is a common LRT disease in foals and is particularly prevalent in the Hunter Valley of NSW. There is an increased incidence of the disease associated with dry dusty conditions and dust particles may carry the R Equi bacteria considerable distances. The most common source of R Equi is considered to be the manure from “carrier” mares, which is then compacted into soil and in dry dust conditions can be inhaled by foals. As the foals immune system is poorly developed they are susceptible to the disease.

A comprehensive review of this disease, which has included studs in the Hunter Valley, has been published by Muscatello et al (2006). They found the most dangerous areas on studs for foals are likely to be laneways and holding pens and that control may be aided by minimising the time that foals spend in these environments. In addition areas on farms that had low pasture cover, sandy, dry and acidic soils seemed to be a greater risk.

While there is a potential risk to foals as a result of short term increased exposure to dust in reality it is extremely unlikely to be a problem unless R Equi bacteria is present in considerable numbers in the topsoil over the areas proposed to be mined by the Project.

2.3.5 Other diseases

Diseases such as Hendra virus, Herpes virus etc are not known to be transmitted by dust over long distances. Such diseases should not be considered a potential problem.

2.4 Dust exposure in the normal horse population

Horses are exposed to large amounts of dust from many sources. These are well reviewed in the report of Malikides and Hodgson (2003) as follows.

> *Factors Contributing to Dust Exposure - In order to be inhaled and cause an effect, dusts must be aerosolised such that solid particles (dusts or smoke) or liquid droplets (mists) of sufficiently small diameter maintain stability as a suspension in air. In racehorse environments this is achieved by machinery (eg., mechanical walkers), ventilation air, or movement of humans and horses in and around stables. Particles that are aerosolised (eg., large viruses, fungal spores and small to medium sized bacteria, fine feed or bedding dust,*

smoke and motorised pollution) usually range between 0.1 to 10 μm in diameter. They are cleared from air via direct removal by ventilatory airflow (particularly small fungal spores), removal of pathogenic potential while airborne (eg., death of infectious agent) or by reaching an equilibrium and subsequently falling out of the air. Although aerosolised bacteria and viruses may die within seconds, viruses being particularly sensitive to changes in relative humidity, many species still maintain their pathogenicity, antigenicity and ability to induce airway inflammation. This is an important mechanism for certain bacteria, which after death release endotoxin and (1→3)-β-D-glucan, potent pro-inflammatory agents when inhaled into airways. In general, clearance of airborne dusts takes many hours whereas gases such as ammonia or ozone diffuse through air and can remain airborne in still air for much longer. Racehorses, who spend most of their time (up to 22 hours) in looseboxes, are therefore exposed to aerosolised foreign dusts and gases almost continuously and any effects these agents have would likely be cumulative. However, it is important to note that these "steady state" dust levels do not reflect the true levels to which racehorses are exposed due to large variation induced by horse behaviour in loose boxes, horse and human activity in and outside looseboxes, and stable ventilation, bedding type and management. This large variation in concentrations of dusts can occur within horse looseboxes, between looseboxes in the same stable and particularly around the horse's head. Airborne concentrations of dusts in looseboxes, (mostly small fungal and actinomycete spores), regardless of quality of ventilation, can be 2-50 times higher when bedding in looseboxes is being changed and cleaned. On average, this increase in concentration is higher when horses are bedded on straw rather than wood shavings or paper. As well, short periods lying and resting on dust rich bedding exposes horses to massive quantities of infectious and non-infectious particles. Sweeping laneways or stable corridors, catching and moving horses, delivery of feed and bedding to stables, and proximity to roads and urban environments also contribute to increasing exposure of horses to airborne dusts. In addition, airborne concentration of dusts is significantly higher during the day, due to increased stable activity, than at night. During the night, aerosolisation of larger dust particles is reduced and equilibration and settling of these airborne dusts occurs. Although this results in decreased concentration of large size dusts, concentrations of very small dust particles remains similar or greater than values during the day, which ensures that racehorses in looseboxes continue to be exposed to pathogenic dusts. Finally, although not well studied in horses, ambient temperature, relative humidity and wind may alter airborne dust concentrations with hot, dry and/or windy conditions increasing exposure to dusts. Low temperature and humidity (<60%) can significantly reduce viability of most microorganisms. Conversely, increased humidity promotes fungal and bacterial growth in bedding and on walls, with subsequent spore and endotoxin elaboration, and may also increase moisture content of airborne dusts and increase their settling rate.

2.4.1 Stable environment

Horses are exposed to large amounts of dust in a stable and this has been well documented in a number of sophisticated studies. Stabled horses can be exposed to very high levels of organic dusts that contain a variety of moulds and other components capable of inducing airway inflammation (McGorum et al, 1998).

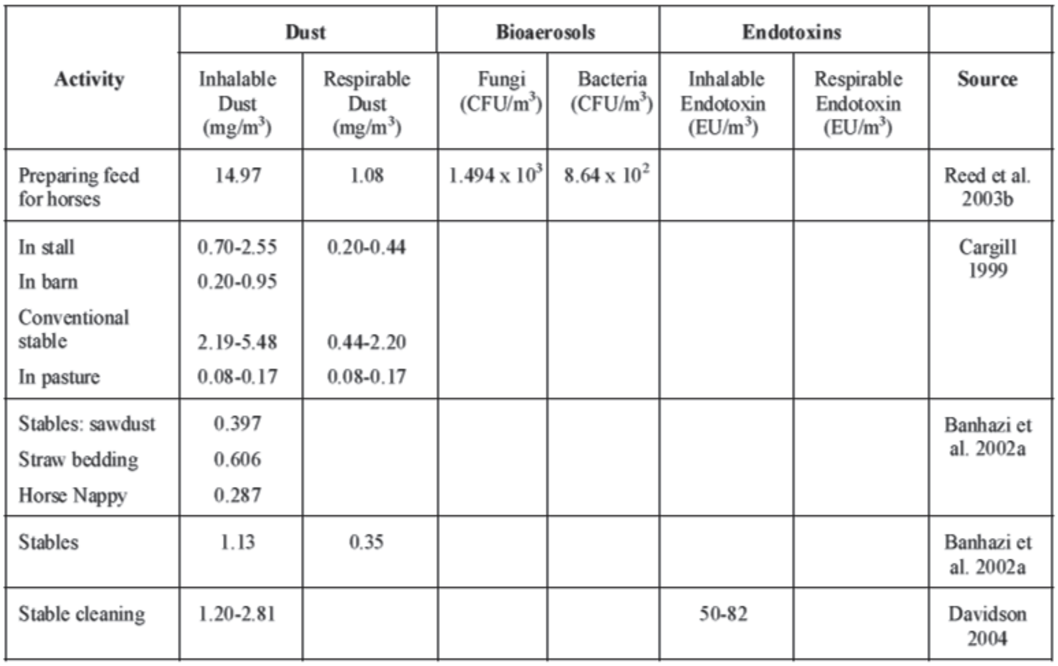
Woods et al. (1993) measured mean total and respirable dust concentrations of 17.51 mg/m^3 (17510 µg/m³) and 9.28 mg/m^3 (9280 µg/m³) respectively, in the breathing zone of a horse managed in a conventional hay and straw stable.

Cargill (1999) reported that dust is mostly measured as mg (airborne dust) per cubic metre of airspace (mg/m^3) but can also be measured in terms of particles per cubic metre or particles/ml. The size of the particles varies from less than 0.1 µm to over 100 µm. The important fractions are inhalable dust (less than 10 µm) and respirable dust (less than 5.0 µm). The levels of dust in Australian stables have received little study, but concentrations of inhalable dust in European stables range from 0.2 to 17.2 mg/m^3 (200-17200 µg/m³). The recommended maximum value is probably in the order of 2.5 to 3.0 mg/m^3 (2500-3000 µg/m³) Concentrations of respirable dust in stables range from 0.15 to 9.28 mg/m^3 (150 – 9280 µg/m³) with a recommended maximum value of 0.23 mg/m^3 (230 µg/m³). The important airborne micro-organisms present in stables and horse boxes appear to be a combination of Actinomycete and fungal spores, although mesophilic bacteria such as Corynebacterium spp and Arthrobacter sp, and gram positive organisms such as Micrococci spp, have been isolated in significant amounts.

Levels of endotoxin in horse stables were found to be generally less than 0.1 µg/m3 (Dutkiewicz et al., 1994), the "cut-off" for OH&S purposes, but in other studies levels were reported ranging from 7.52 to 60.53 ng/m^3 (0.00752- 0.06053 µg/m³) in total dust and 0.1.25 to 11.27 ng/m^3 (0.00125 – 0.01127 µg/m³) in respirable dust (McGorum et al., 1998). In the latter studies concentrations of airborne endotoxins were considerably higher in conventional stables than in "low dust stables", which are hay and straw free environments. In the conventional stables levels in total dust samples ranged from 7.52 to 60.53 ng/m^3, (0.00752- 0.06053 µg/m³) compared with 2.12 to 17.41 ng/m^3 (0.00212- 0.01741 µg/m³) in low dust stables. The concentrations in respirable dust were 1.25 to 11.27 ng/m^3 (0.00125 – 0.01127 µg/m³) and 0.09 to 0.56 ng/m^3 (0.00009 – 0.00056 µg/m³) respectively. By comparison, concentrations of endotoxins in a pasture paddock at least 50 metres from the nearest hay ranged from 0.25 to 1.57ng/m^3 (0.00025- 0.00157 µg/m³) and 0.04 to 0.16 ng/m^3 (0.00004- 0.00016 µg/m³) respectively.

Reed et al (2006) in a review of Australian facilities reported dust levels as follows.

Table 3.13 Average Dust and Bioaerosol Exposures Reported in Australia in Horse Facilities



Activity	Dust		Bioaerosols		Endotoxins		Source
	Inhalable Dust (mg/m^3)	Respirable Dust (mg/m^3)	Fungi (CFU/m^3)	Bacteria (CFU/m^3)	Inhalable Endotoxin (EU/m^3)	Respirable Endotoxin (EU/m^3)	
Preparing feed for horses	14.97	1.08	1.494×10^3	8.64×10^2			Reed et al. 2003b
In stall	0.70-2.55	0.20-0.44					Cargill 1999
In barn	0.20-0.95						
Conventional stable	2.19-5.48	0.44-2.20					
In pasture	0.08-0.17	0.08-0.17					
Stables: sawdust	0.397						Banhazi et al. 2002a
Straw bedding	0.606						
Horse Nappy	0.287						
Stables	1.13	0.35					Banhazi et al. 2002a
Stable cleaning	1.20-2.81				50-82		Davidson 2004

From RIRDC Publication No 06/1071289

Ghio et al (2006) reported that particle concentration in the stables ranges from 410–20,000 µg/m^3 (Crichlow et al. 1980; Woods et al 1993) and are biological in composition originating from feed and bedding.

Fleming et al (2008a) reported that means of gaseous ammonia were found to be 178.0 mg/m^3 for wheat straw, 155.2 mg/m^3 for wood shavings, 144.6 mg/m^3 for hemp, 133.7 mg/m^3 for linen, 60.3 mg/m^3 for straw pellets, and 162.6 mg/m^3 for paper cuttings. Horses exposed to high levels of ammonia in stables A further important factor linked to climate in the stable is the concentration of air particle impurities. In addition to the mechanical irritation caused by particles, there is an allergenic, infectious, and toxic effect that can damage respiratory health. Stable air contains, in addition to gases, animate and inanimate particulate pollutants (citing Art et al 2002). Microorganisms such as bacteria, yeasts, fungi, viruses, mites, or protozoa are classified as animate particles; inanimate particles are referred to as dust. However, the latter are also able to carry other substances, such as microorganisms and endotoxins. (citing Pearson et al 1995).

(Art T, McGorum BC, Lekeux P. Environmental control of respiratory disease. In: Lekeux P, ed. Equine respiratory diseases. Ithaca, New York: International Veterinary Information Service (www.ivis.org); 2002. ; Pearson CC, Sharples TJ. Airborne dust concentrations in livestock buildings and the effect of feed. J Agr Eng Res 1995;60: 145–154)

Dunlea and Dod (1994, 1996) stated that respirable dust particles have been measured in stables and are generally accepted to have an aerodynamic diameter of 0.5–5 um.

Wålinder et al (2011) measured carbon dioxide (CO2), ammonia, particles, horse allergen, microorganisms and endotoxin in a riding-school stable after placement of ventilation devices. Levels of CO2 were nearly halved and airborne horse allergen levels were markedly reduced (5-0.8 kU/m^3) after the intervention. A decreased level of ultrafine particles was observed (8000-

5400 particles/cm^3) after the intervention, while total and respirable dust levels were mainly unchanged (200 and 130 µg/m^3). Levels of microorganisms in surface samples decreased following the intervention, whereas airborne microorganisms and endotoxin increased. In horses, the mean score of lower airway mucus and inflammation was significantly reduced. The installation of a mechanical ventilation system resulted in an increased air exchange rate, as demonstrated by reduced levels of CO2, ammonia, ultrafine particles and horse allergen. There was no significant clinical effect on human airways, but there was a tendency for reduced inflammation markers. The results on the horses may have indicated less impact on their airways after the intervention.

Clements and Pirie (2007a, b) examined dust levels in stables under various management systems. The results are shown below.

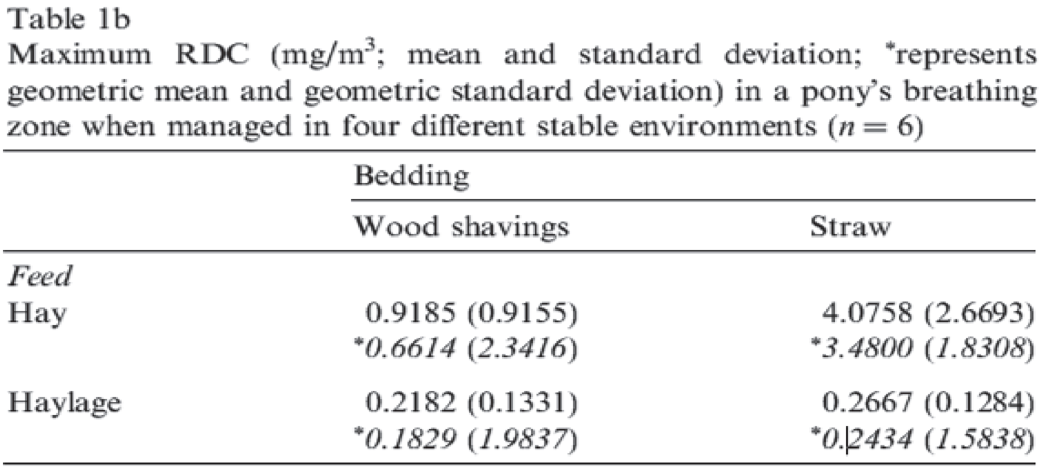


Table 1b

Maximum RDC (mg/m^3; mean and standard deviation; *represents geometric mean and geometric standard deviation) in a pony's breathing zone when managed in four different stable environments ($n = 6$)

	Bedding	
	Wood shavings	Straw
Feed		
Hay	0.9185 (0.9155) **0.6614 (2.3416)*	4.0758 (2.6693) **3.4800 (1.8308)*
Haylage	0.2182 (0.1331) **0.1829 (1.9837)*	0.2667 (0.1284) **0.2434 (1.5838)*

From Research in Veterinary Science 83: 256–262

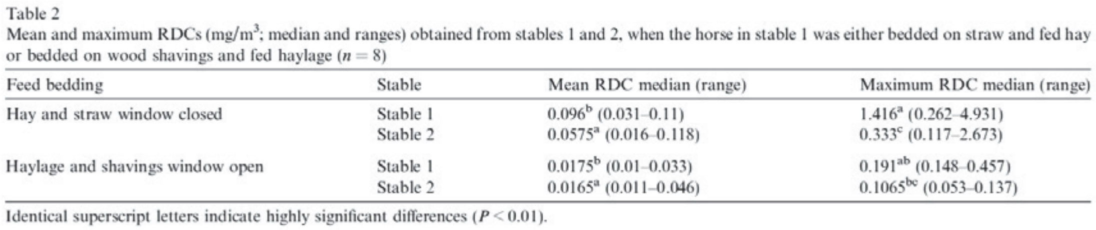


Table 2

Mean and maximum RDCs (mg/m^3; median and ranges) obtained from stables 1 and 2, when the horse in stable 1 was either bedded on straw and fed hay or bedded on wood shavings and fed haylage ($n = 8$)

Feed bedding	Stable	Mean RDC median (range)	Maximum RDC median (range)
Hay and straw window closed	Stable 1	0.096^{b} (0.031–0.11)	1.416^{a} (0.262–4.931)
	Stable 2	0.0575^{a} (0.016–0.118)	0.333^{c} (0.117–2.673)
Haylage and shavings window open	Stable 1	0.0175^{b} (0.01–0.033)	0.191^{ab} (0.148–0.457)
	Stable 2	0.0165^{a} (0.011–0.046)	0.1065^{bc} (0.053–0.137)

Identical superscript letters indicate highly significant differences ($P < 0.01$).

From Research in Veterinary Science 83: 263–268

Vandenput et al. (1997) reported higher numbers of respirable dust particles to be liberated from dusty or good quality hay (60.88 and 6.30 x10^4 particles/litre air, respectively) than from silages of 78% and 50 % dry matter and alfalfa pellets (0.88, 0.45 and 0.95 x10^4 particles/litre air, respectively), using a Rion particle counter. Airborne dust liberated from a variety of bedding materials has also been documented (Clarke, 1987) including wood shavings, good quality straw and flax straw (3.15, 1.16 and 0.93 x10^4 respirable particles per litre air, respectively) (Vandenput et al., 1997).

Cargill (1999) considered that dust in animal housing is a mixture of organic material, including bacteria, bacterial and fungal toxins and spores, urine, dung, pollen, and other feed and animal components. (When horses eat feed out of a trough, they agitate it in such a way that dust is released. Under such conditions, the dust concentration in the breathing zone can be 30 to 40 times higher than that measured a few feet away (Cargill 1999).

Gerber et al (2003) determined that all horses housed in a stable environment examined in their study showed evidence of inflammatory airway disease.

Hessel et al (2009) reported that stabled horses are constantly exposed to high concentrations of airborne particles (ie, dust), because they spend up to 23 hours per day in the stable. This study demonstrated that feed also can generate a high dust load, which is situated directly in the breathing zone of horses.. Results are shown in tables below.

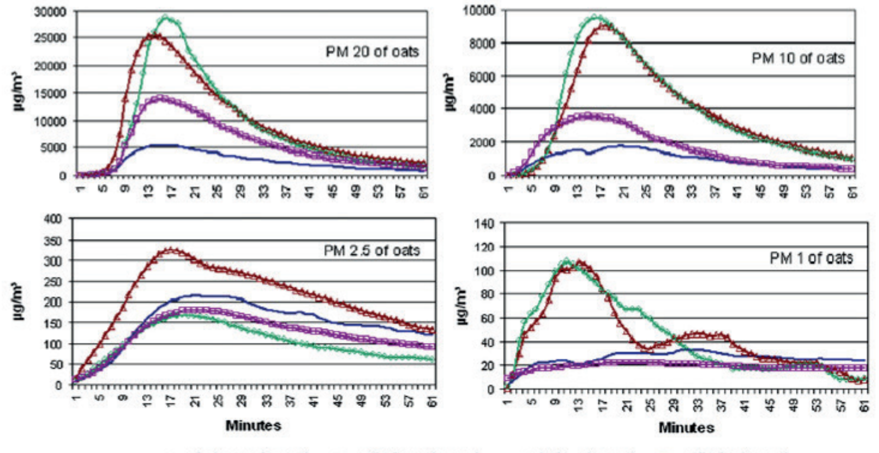


Fig. 2. Generation of airborne particles (PM 20, PM 10, PM 2.5, and PM 1) of oats as a function of time and processing (per 2-kg feed, n = 3 repetitions per fraction size and processing).

From Journal of Equine Veterinary Science 29: 665-674

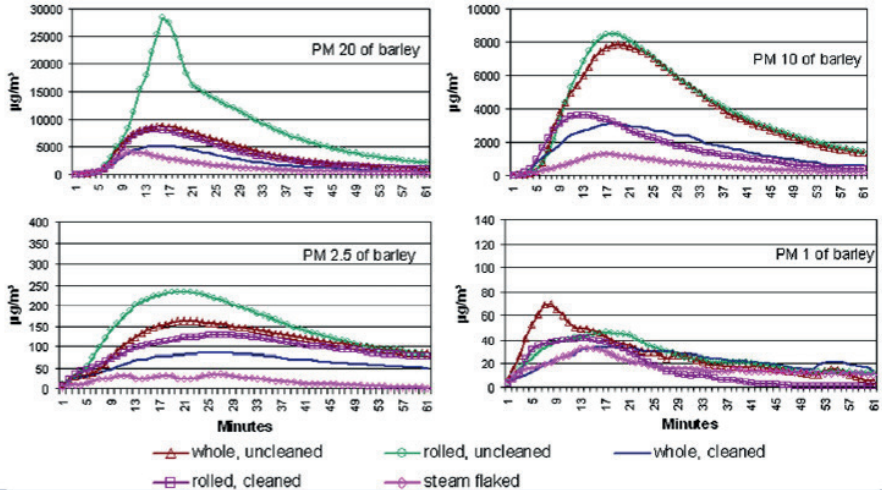


Fig. 3. Generation of airborne particles (PM 20, PM 10, PM 2.5, and PM 1) of barley as a function of time and processing (per 2-kg feed, n = 3 repetitions per fraction size and processing).

From Journal of Equine Veterinary Science 29: 665-674

Garlipp et al (2010) undertook a study that looked at the effects of four different treatment procedures on the levels of dust in hay. Particle separation techniques (involving use of highspeed airflows) resulted in a reduction in the airborne particle (PM $_{20}$) generation in all materials: hay 49.16 to 22.79 mg/m^3 (49160 to 22790 µg/m^3) (53.6% reduction), haylage 28.57 to 25.04 mg/m^3 (12.3%), wood shavings 141.68 to 15.04 mg/m^3 (141680 to 15040 µg/m^3) (89.4%), wheat straw 143.08 to 22.97 mg/m^3 (83.9%), flax 135.11 to 53.31 mg/m^3 (60.5%), and hemp 63.67 to 17.64 mg/m^3 (72.3%). The 8-week storage of the treated materials as compressed materials led to a renewed significant increase in the airborne particle (PM_{10}) concentration in the haylage (+29.9%), wheat straw (+104.0%), wood shavings (+40.4%), and hemp shives (+30.7%). Storage of the incoherent materials caused a significant increase in these particles only in the wheat straw (+44.2%). Detailed results are shown in two tables below.

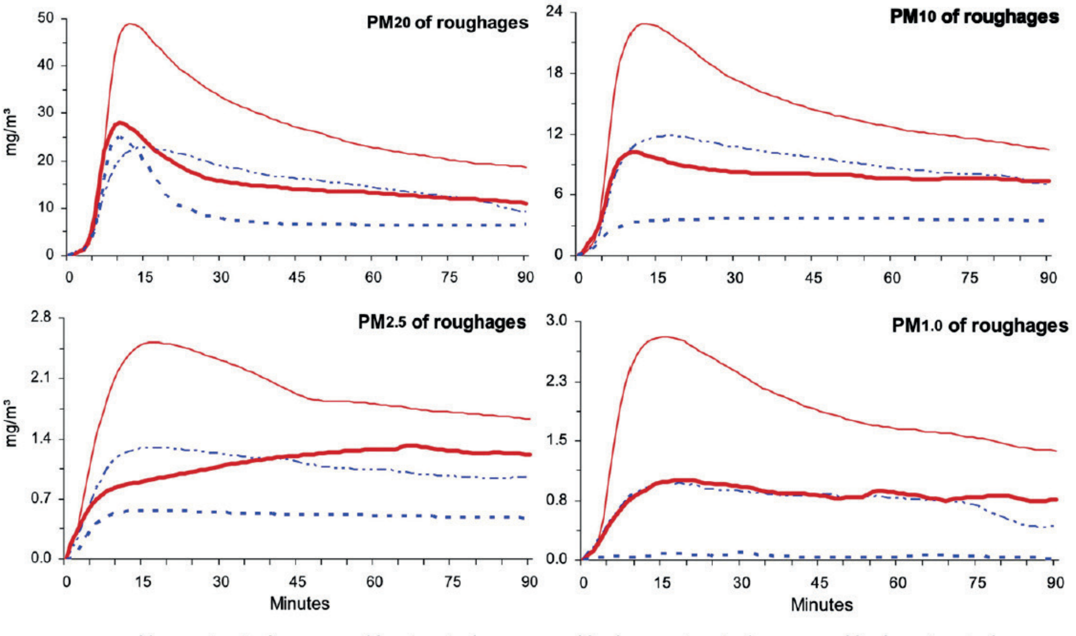


Figure 3. Mean generation of airborne particles (PM_{20}, PM_{10}, $PM_{2.5}$ and $PM_{1.0}$) of hay and haylage (untreated/treated) as a function of time (per 1.5 kg; n = 3 repetitions per fraction size and material).

From Journal of Equine Veterinary Science 30: 545-559

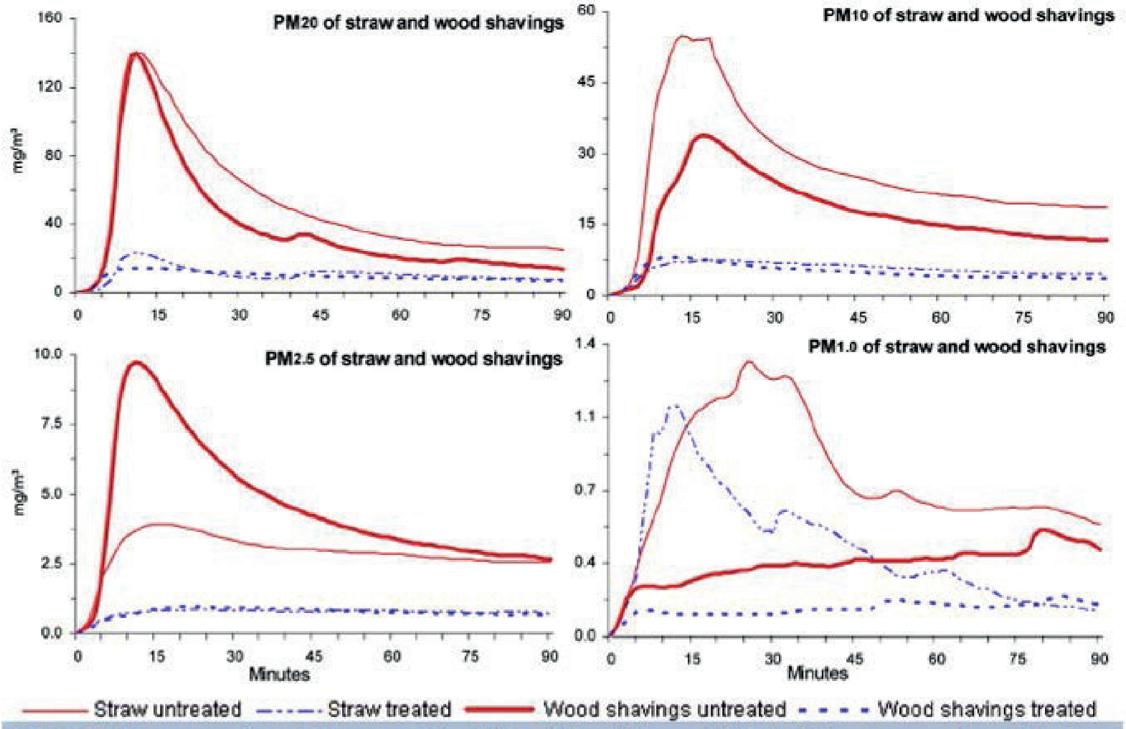
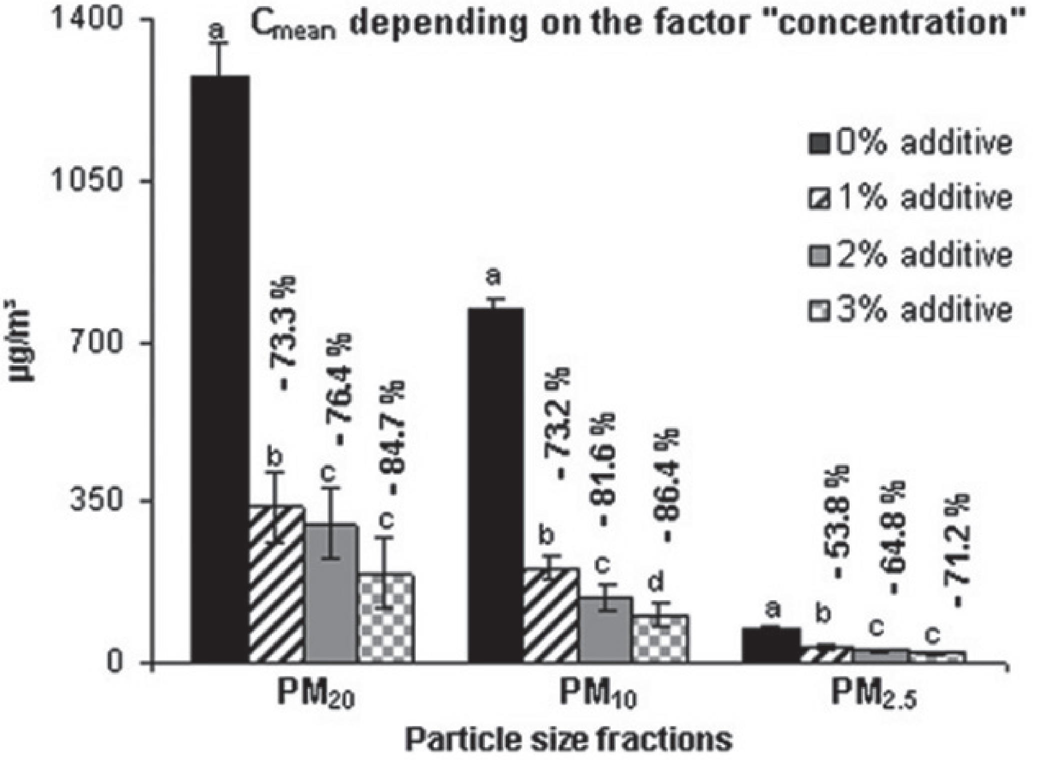


Figure 4. Mean generation of airborne particles (PM_{20}, PM_{10}, $PM_{2.5}$ and $PM_{1.0}$) of wheat straw and wood shavings (untreated/treated) as a function of time (per 1.5 kg; n = 3 repetitions per fraction size and material).

From Journal of Equine Veterinary Science 30: 545-559

Garlipp et al (2011) stated that in many reports respiratory diseases are considered to be “occupational diseases” in horses. As large numbers of horses are housed in stables there is a direct correlation between the stable climate (including permanent mechanical irritation by particles) and the occurrence of respiratory diseases. They found that although horses are usually provided with small amount of oats per day (<2 kg), which they consume within a few minutes, a critical concentration of airborne particles can also occur from oats.

The figure below shows the percentage reduction in airborne particle generation as a consequence of adding different concentrations of the liquid additive with respect to the airborne particle generation of the controls (0% additive).



From Journal of Equine Veterinary Science 31 630-639

Samidi et al (2009) and Whitaker et al (2009) looked at human dust exposure levels in horse stables. Means of personal exposure to dust, endotoxin, and b-glucan were 1.4 mg/m^3 (1400 µg/m^3) (range 0.2–9.5, 200-9500), 608 EU/m^3 (20–9846), and 9.5 mg/m^3 (9500 µg/m^3) (0.4–631 mg/m^3), respectively. The mean and range of culturable bacteria and fungi were 3.1 x 10^3 colony-forming unit (CFU) perm^3 (6.7 x 10 to 1.9 x 10^4) and 1.9 x 10^3 CFU/m^3 (7.4 x 10 to 2.4 x 10^4), respectively. It was found that the predominant task explaining exposure levels of dust, endotoxin, and b(1/3)-glucan was sweeping the floor. For b(1/3)-glucan, feeding the horse was also an important determinant. It was concluded that dust, endotoxin, and b(1/3)-glucan exposure are considerable in horse stables.

Millerick-May et al (2011) used Direct reading instruments to determine the mass concentration and numbers of particles 3 times daily (early morning, midday and late afternoon) in July, September and November (northern hemisphere), in 3 different racing stables. The results are presented below.

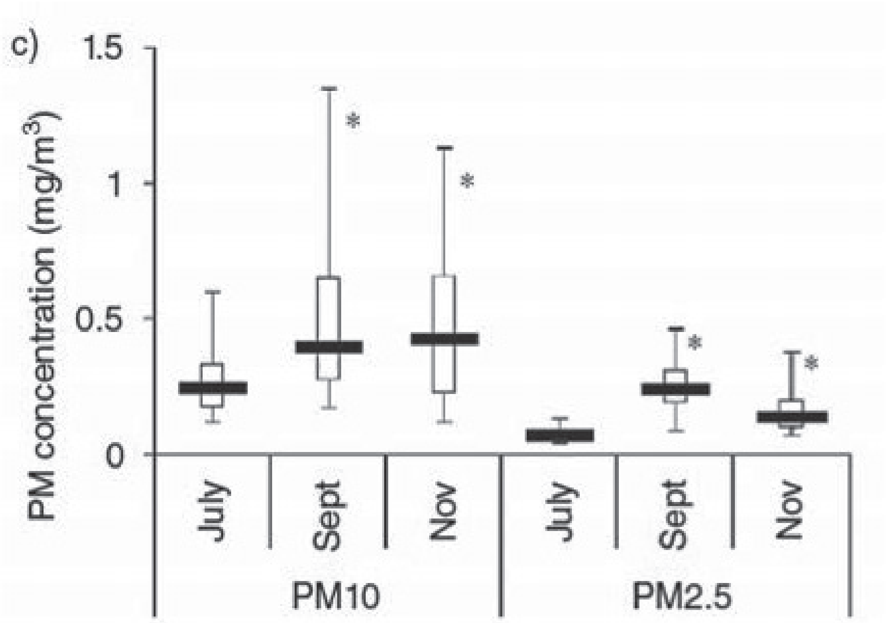


*Fig 1: Effect of stable (a), time of day (b) and month (c) on concentrations of PM10 and PM2.5. Median, interquartile range and 5th and 95th percentiles are shown for 3 racing stables. *Significantly different from referents, which were* Stable 3, *afternoon and July.*

From Equine Vet. J. 43 (5) 599-607

2.4.2 From bedding

Currently the most popular forms of bedding in stables in Australia would be straw and saw dust. These both produce large amounts of dust. As a result of both the production process and the stable environment, whereby horses manure regularly into the bedding, dust in from the stable bedding is very high in endotoxins, bacteria and fungi. These can be very detrimental to equine health.

Kirschvink et al (2002) determined the respirable dust fraction (0.5-5 μ m diameter), determined as dust particles per litre of air, and the concentration of viable spores of Aspergillus fumigatus, Faenia rectivirgula and Thermoactinomyces vulgaris in shredded cardboard bedding compared to values for other forms of bedding, the results of which are shown below.

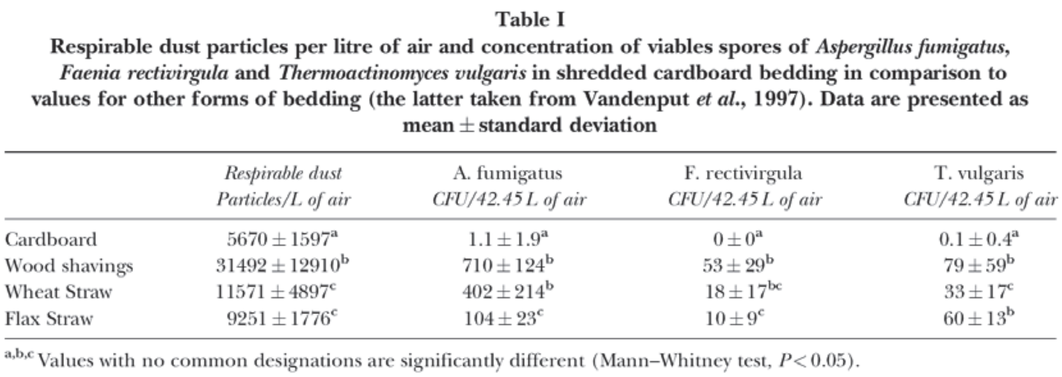


Table I
Respirable dust particles per litre of air and concentration of viables spores of *Aspergillus fumigatus*, *Faenia rectivirgula* and *Thermoactinomyces vulgaris* in shredded cardboard bedding in comparison to values for other forms of bedding (the latter taken from Vandenput *et al.*, 1997). Data are presented as mean ± standard deviation

	Respirable dust *Particles/L of air*	A. fumigatus *CFU/42.45 L of air*	F. rectivirgula *CFU/42.45 L of air*	T. vulgaris *CFU/42.45 L of air*
Cardboard	5670 ± 1597^{a}	1.1 ± 1.9^{a}	0 ± 0^{a}	0.1 ± 0.4^{a}
Wood shavings	31492 ± 12910^{b}	710 ± 124^{b}	53 ± 29^{b}	79 ± 59^{b}
Wheat Straw	11571 ± 4897^{c}	402 ± 214^{b}	18 ± 17^{bc}	33 ± 17^{c}
Flax Straw	9251 ± 1776^{c}	104 ± 23^{c}	10 ± 9^{c}	60 ± 13^{b}

[a,b,c] Values with no common designations are significantly different (Mann–Whitney test, $P < 0.05$).

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Spendlove et al (2008) reported that endotoxin is a recognised cause of lower airway inflammation in both humans and horses. They found that bedding type was a significant factor ($p=0.001$) in contributing to aerosolised stable endotoxin concentrations, and different bedding types generated different concentrations of endotoxin in the horse's breathing zone.

Fleming et al (2008b) found that particle generation from straw pellets (average of 111.2 +/- 149.2 µ g/m^3) was significantly lower than that from wheat straw (227.5+/- 280.8 µ g/m^3). The particle generation of wood shavings had an average of 140.9+/- 141.9 µ g/m^3.

2.4.3 From feed

Dusty feed presents a big problem in that the nostrils of a horse are placed immediately above the feed and the inhalation of dust from fed can be extremely high. Even though this may be for only short periods during a day it represents a further source of "occupational" dust exposure for horses. One of the worst feeds for dust generation is hay. This is not only for stabled horses but is also a potential source of dust for paddock horses that receive supplemental feeding. Hay dust is well recognised as containing large amounts of endotoxins and fungi etc. and has the potential to cause IAD and COPD.

Malakides and Hodgson (2003) reported that the dust concentrations in the breathing zone (i.e. a hemisphere of 300 mm radius extending around the nostrils) of horses housed in conventional looseboxes (i.e. hay feed, straw bedding with adequate ventilation) can be 7 to 21 times higher respectively than background loosebox concentrations as a result of considerable amounts of time eating with their muzzles in close contact with feed and sometimes bedding

Art and Lekeux (2005) found that some degree of fungal contamination is present in all batches of hay, regardless of their quality. Hay that has heated during production and is very dusty may contain very high levels of many different pro-inflammatory agents, including mould spores, bacteria, endotoxins, proteinases, and forage mites (Clarke and Madelin, 1987; Woods et al., 1993). A horse consuming heated hay may inhale 10^{10} dust particles per breath (Clarke and Madelin, 1987).

Clements and Pirie (2007b) measured respirable dust concentrations (RDC) in association with different feeding conditions.

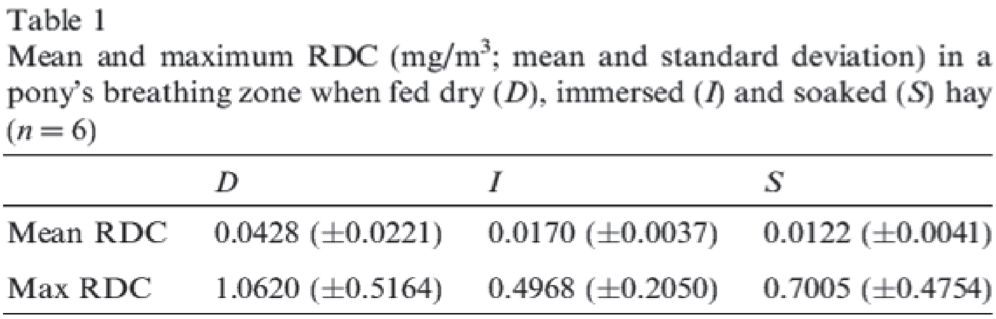

Table 1
Mean and maximum RDC (mg/m^3; mean and standard deviation) in a pony's breathing zone when fed dry (D), immersed (I) and soaked (S) hay ($n = 6$)

	D	I	S
Mean RDC	0.0428 (±0.0221)	0.0170 (±0.0037)	0.0122 (±0.0041)
Max RDC	1.0620 (±0.5164)	0.4968 (±0.2050)	0.7005 (±0.4754)

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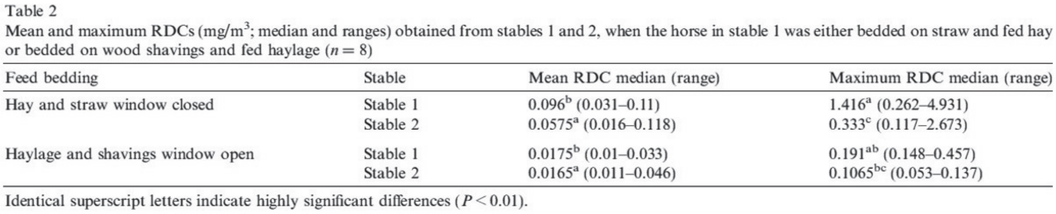

Table 2

Mean and maximum RDCs (mg/m^3; median and ranges) obtained from stables 1 and 2, when the horse in stable 1 was either bedded on straw and fed hay or bedded on wood shavings and fed haylage ($n = 8$)

Feed bedding	Stable	Mean RDC median (range)	Maximum RDC median (range)
Hay and straw window closed	Stable 1	0.096^{b} (0.031–0.11)	1.416^{a} (0.262–4.931)
	Stable 2	0.0575^{a} (0.016–0.118)	0.333^{c} (0.117–2.673)
Haylage and shavings window open	Stable 1	0.0175^{b} (0.01–0.033)	0.191^{ab} (0.148–0.457)
	Stable 2	0.0165^{a} (0.011–0.046)	0.1065^{bc} (0.053–0.137)

Identical superscript letters indicate highly significant differences ($P < 0.01$).

From Research in Veterinary Science 83: 263–268

Seguin et al (2010) confirmed there was a large number of fungi in all hay. The highest fungal contamination in airborne particles and dust contamination occurred during late harvest, when hay moisture remained high during (rainfall after cut) or after the making process. (Eurotium amstelodami and Eurotium repens were mainly found in all hays, while Aspergillus fumigatus was mostly found in hays showing the highest colony forming units (CFUs).

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APPENDIX 2

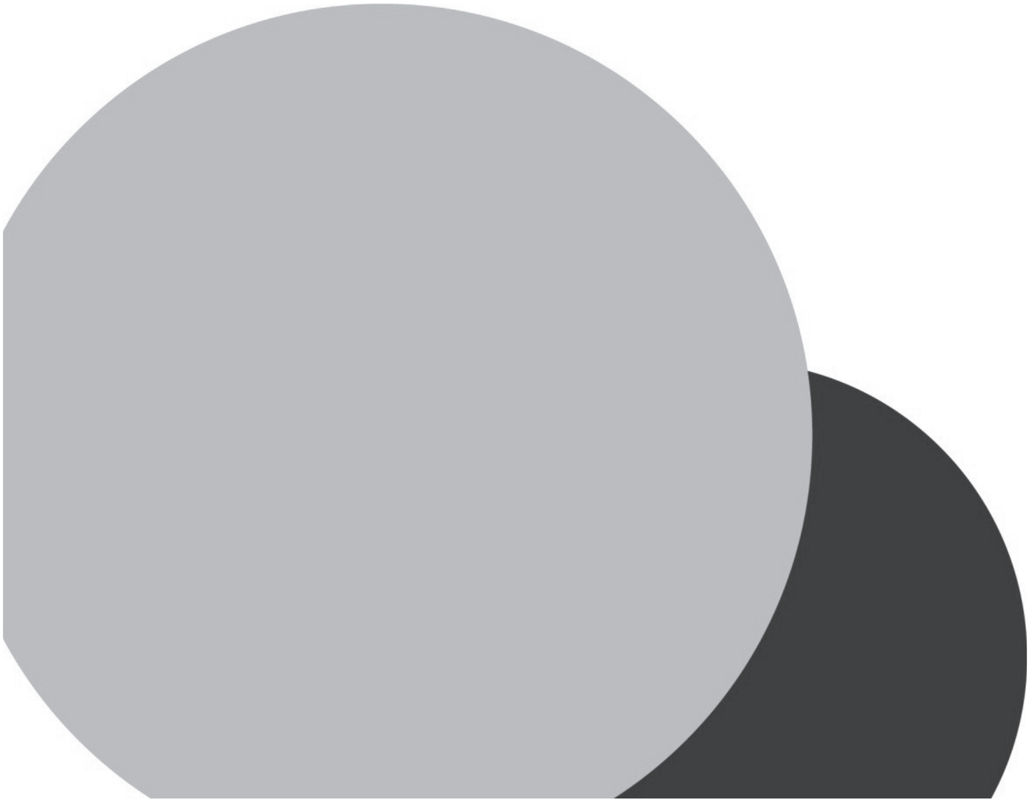
Comparative review of air quality backgrounds near horse breeding and racing areas

DRAYTON SOUTH COAL PROJECT
COMPARATIVE REVIEW OF AIR QUALITY BACKGROUNDS NEAR HORSE BREEDING AND RACING LOCATIONS

for
Hansen Bailey on behalf of Anglo American Metallurgical Coal Pty Ltd

Job No: 3617c

18 April 2012



A PEL Company

PROJECT TITLE:	Drayton South Coal Project: Comparative Review of Air Quality Backgrounds Near Horse Breeding and Racing Locations
JOB NUMBER:	**3617C**
PREPARED FOR:	Daniel Sullivan Hansen Bailey on behalf of Anglo American Metallurgical Coal Pty Ltd
PREPARED BY:	Chris Marsh
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V1	18.04.2012	Chris Marsh	Judith Cox

Queensland Environment Pty Ltd trading as
PAEHolmes ABN 86 127 101 642

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GLADSTONE:
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1 INTRODUCTION

PAEHolmes was commissioned by Hansen Bailey Environmental Consultants on behalf of Anglo American Metallurgical Coal Pty Ltd to complete a desktop review of air quality backgrounds near horse breeding and racing areas within Australia and internationally.

2 METHODOLOGY

The review targeted key horse breeding and racing locations within Australia and internationally. Locations identified included:

- Australia:
  - Hunter Valley, NSW.
  - Randwick, NSW.
  - Flemington, Victoria.
- United States of America:
  - Louisville, Kentucky.
  - Lexington, Kentucky.
- Ireland:
  - Kildare.
  - Tipperary.
  - Meath.
- United Kingdom:
  - Newmarket.
- Saudi Arabia.
- Hong Kong:
  - Sha Tin.
  - Happy Valley.

Background data for particulate matter less than 10 micron (PM_{10}) was obtained from monitoring stations closest to each horse breeding and racing location, including:

- Australia:
  - Singleton, NSW.
  - Muswellbrook, NSW.
  - Tamworth, NSW.
  - Randwick, NSW.
  - Footscray, Victoria.
- United States of America:
  - Louisville, Kentucky.
  - Lexington-Fayette, Kentucky.
  - Elizabethtown, Kentucky.
  - Richmond, Kentucky.
- Ireland:
  - Tipperary.
  - Kildare.
  - Meath.
  - Cork.
  - Dublin.

- United Kingdom:
  - Newmarket.
- Saudi Arabia.
- Hong Kong:
  - Sha Tin.
  - Eastern.

Data was sourced between August and October 2011 from various government departments and international agencies associated with each monitoring station, including:

- NSW Office of Environment and Heritage (OEH).
- Victorian Environmental Protection Agency (EPA).
- United States EPA.
- Ireland EPA.
- United Kingdom Department of Environment, Food and Rural Affairs (DEFRA).
- World Bank.
- Hong Kong Environmental Protection Department (EPD).

3 RESULTS

Available background concentrations for PM_{10} were collated from 2001 to 2011 for each of the monitoring stations closest to each horse breeding and racing location (see **Table 1**). The concentrations are illustrated in **Figure 1**.

Table 1 PM_{10} Annual Average Concentrations ($\mu g/m^3$)

Location		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
		PM_{10} Annual Average Concentration ($\mu g/m^3$)										
Saudi Arabia	Saudi Arabia	148	143	137	128	118	112	107	104	-	-	-
Hong Kong	Sha Tin	-	-	-	-	53	53	51	50	45	45	-
	Eastern	-	-	-	-	49	47	49	46	43	43	-
Australia	Footscray	-	-	-	-	21	22	20	21	22	-	-
	Singleton	-	-	-	-	-	-	-	-	-	20	19
	Muswellbrook	-	-	-	-	-	-	-	-	-	20	19
	Tamworth	-	-	-	-	-	18	16	16	18	12	13
	Randwick	-	-	-	-	-	22	18	17	20	16	15
United States of America	Louisville	-	-	25	23	26	23	25	22	-	-	-
	Louisville 2	-	-	23	21	24	22	24	21	-	-	-
	Lexington-Fayette	-	-	23	21	24	21	23	19	-	-	-
	Elizabethtown	-	-	19	18	21	17	-	-	-	-	-
	Richmond	-	-	20	18	21	18	-	-	-	-	-
Ireland	Cork, Old Station Road	-	24	26	22	19	16	15	16	18	22	-
	Cork, Heatherton Park	-	21	20	19	17	18	17	15	15	18	-
	Dublin, Dun Laoghraine	-	-	-	-	-	-	-	15	15	15	-
	Tipperary, Clonmel	-	-	-	20	19	-	-	-	-	-	-
	Kildare, Naas	-	-	17	17	-	-	-	-	-	-	-
	Kildare, Newbridge	-	-	-	-	-	-	-	-	14	20	-
	Meath, Navan	-	-	-	-	-	-	23	-	-	-	-
United Kingdom	Newmarket Racecourse	-	-	-	21	20	17	17	16	16	16	16

The results indicate that Saudi Arabia represents the highest PM_{10} concentrations ranging between 104 and 148 $\mu g/m^3$ followed by Hong Kong (Sha Tin and Eastern). All other locations maintain a similar PM_{10} concentration range typically between 15 and 26 $\mu g/m^3$.

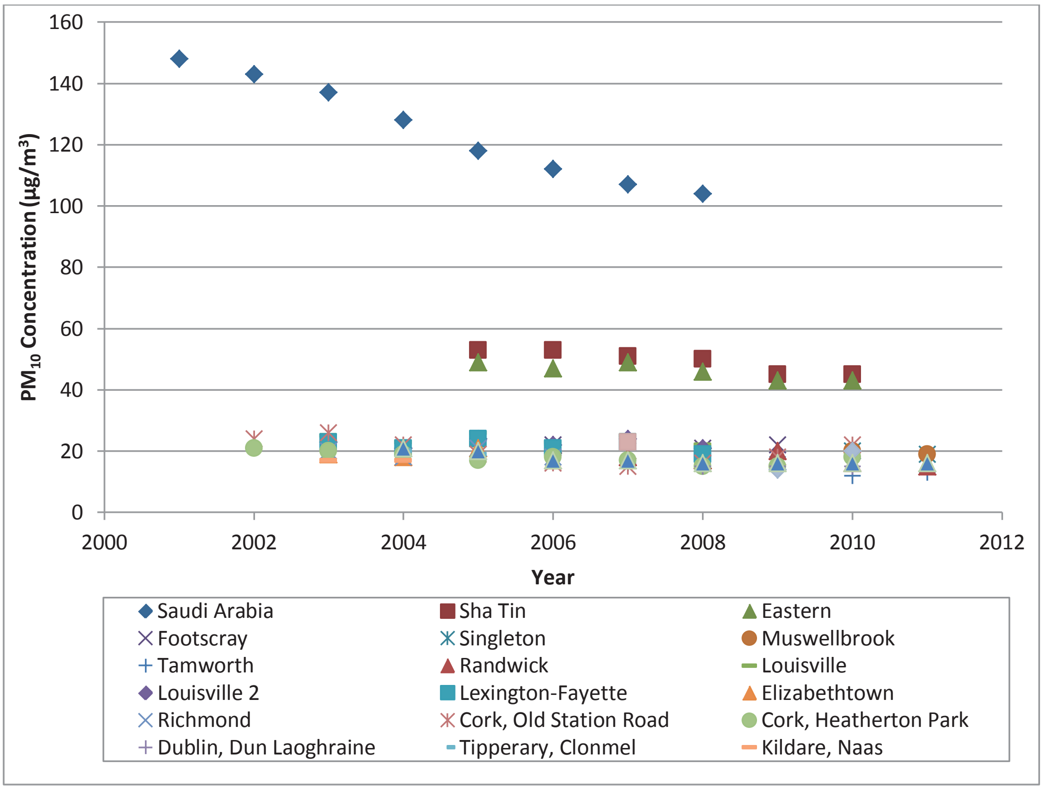

Figure 1 PM_{10} Annual Average Concentrations

4 CONCLUSION

From the review, it can be concluded that the majority of horse breeding and racing enterprises within Australia and internationally operate in similar and comparable PM_{10} air quality backgrounds, typically ranging between 15 and 26 µg/m³. The outliers include Saudi Arabia and Hong Kong, which have significantly higher concentrations between 104 and 148 µg/m³ and 53 and 43 µg/m³, respectively.

5 REFERENCES

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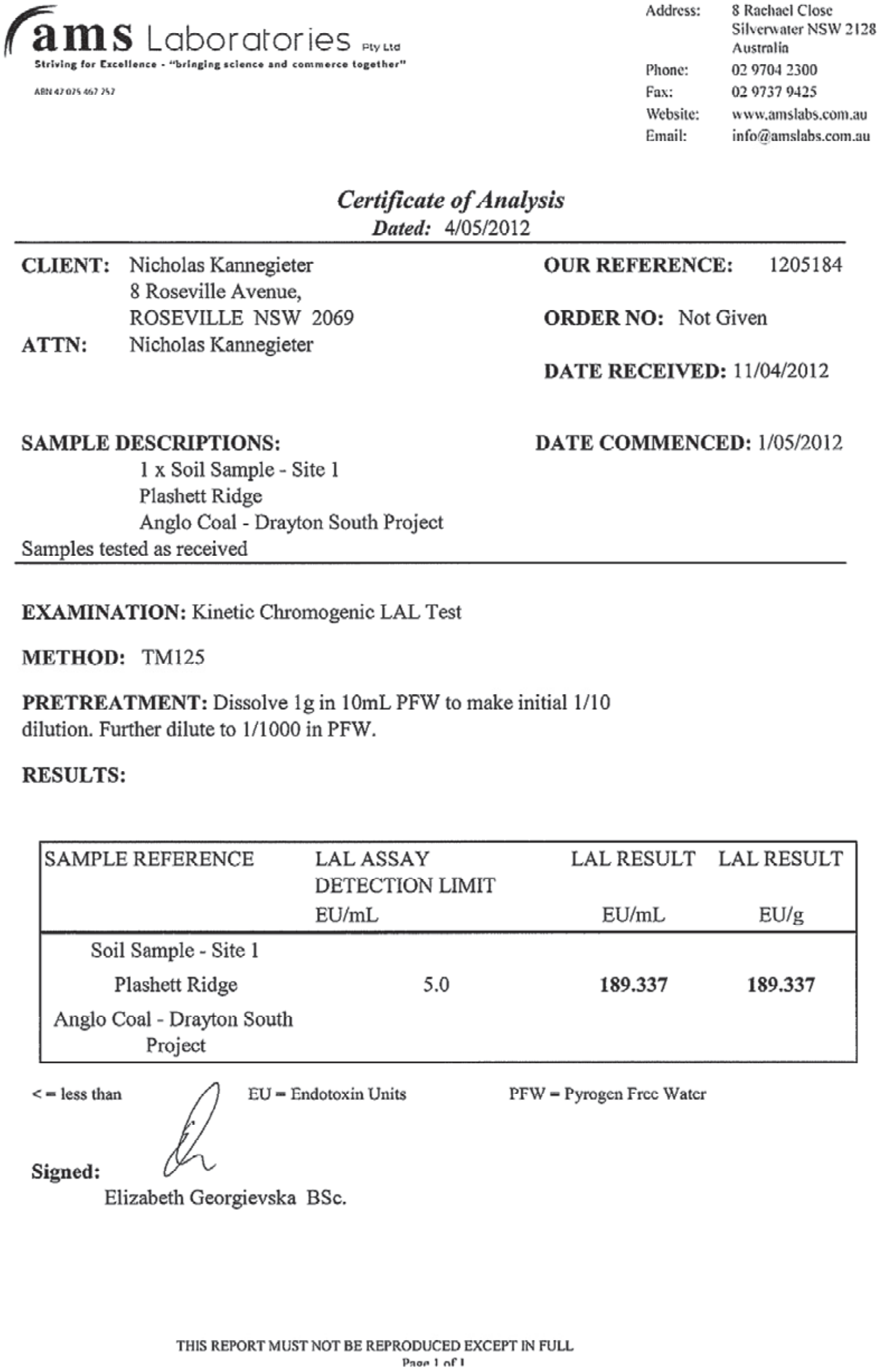
Office of Environment and Heritage, NSW (2011) Search Air Quality Data, Viewed 31 August 2011, *http://www.environment.nsw.gov.au/AQMS/search.htm*

World Bank (2011) PM_{10} Country Level (Micrograms per Cubic Meter), Viewed 30 August 2011, *http://data.worldbank.org/indicator/EN.ATM.PM10.MC.M3*

APPENDIX 3

Results of Endotoxin Analysis



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Silverwater NSW 2128
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Certificate of Analysis

Dated: 4/05/2012

CLIENT: Nicholas Kannegieter
8 Roseville Avenue,
ROSEVILLE NSW 2069
ATTN: Nicholas Kannegieter

OUR REFERENCE: 1205184

ORDER NO: Not Given

DATE RECEIVED: 11/04/2012

SAMPLE DESCRIPTIONS:
1 x Soil Sample - Site 1
Plashett Ridge
Anglo Coal - Drayton South Project
Samples tested as received

DATE COMMENCED: 1/05/2012

EXAMINATION: Kinetic Chromogenic LAL Test

METHOD: TM125

PRETREATMENT: Dissolve 1g in 10mL PFW to make initial 1/10 dilution. Further dilute to 1/1000 in PFW.

RESULTS:

SAMPLE REFERENCE	LAL ASSAY DETECTION LIMIT EU/mL	LAL RESULT EU/mL	LAL RESULT EU/g
Soil Sample - Site 1 Plashett Ridge Anglo Coal - Drayton South Project	5.0	**189.337**	**189.337**

< = less than EU = Endotoxin Units PFW = Pyrogen Free Water

Signed:
Elizabeth Georgievska BSc.

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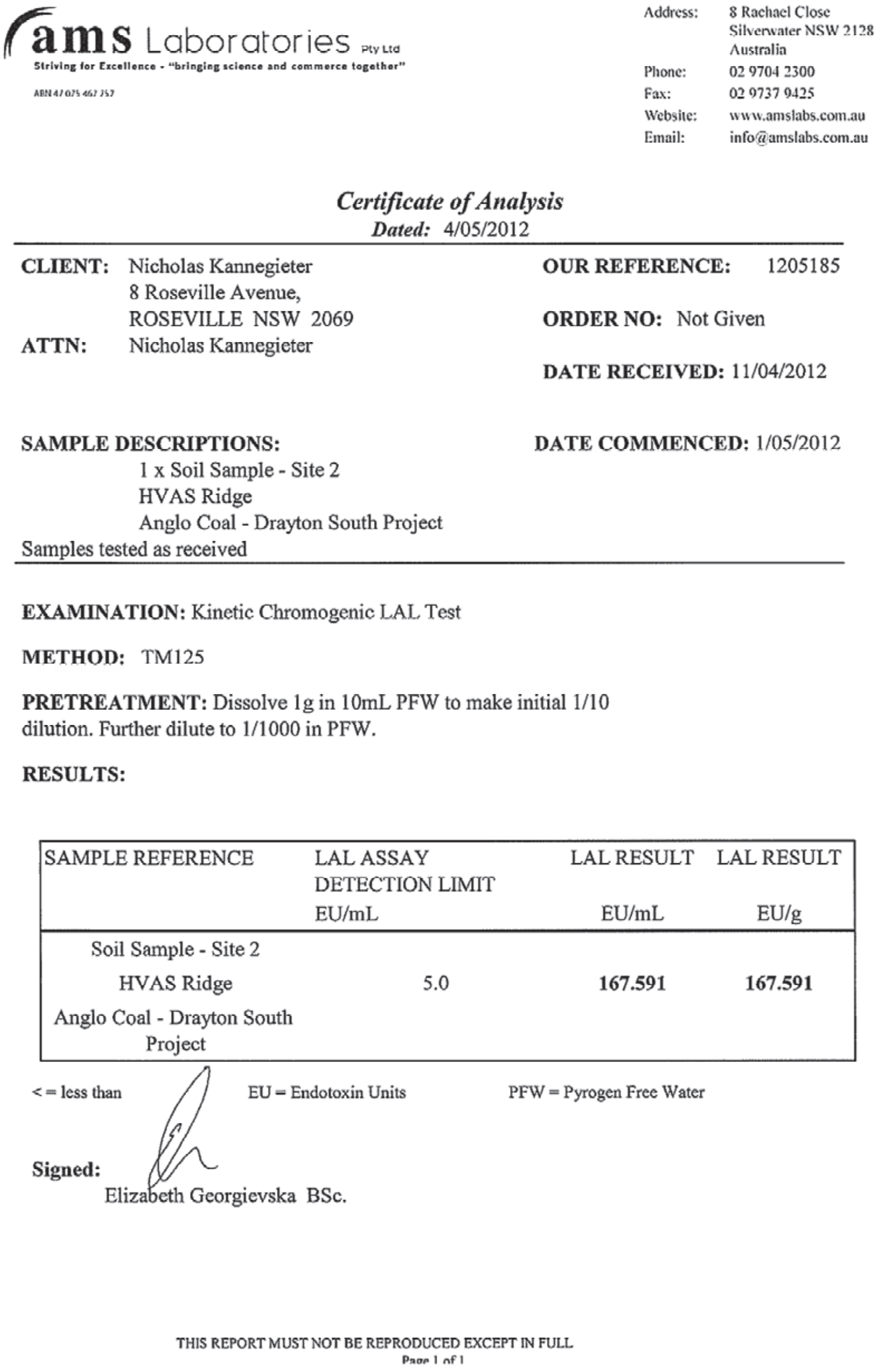

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Dated: 4/05/2012

CLIENT: Nicholas Kannegieter
8 Roseville Avenue,
ROSEVILLE NSW 2069
ATTN: Nicholas Kannegieter

OUR REFERENCE: 1205185

ORDER NO: Not Given

DATE RECEIVED: 11/04/2012

SAMPLE DESCRIPTIONS:
1 x Soil Sample - Site 2
HVAS Ridge
Anglo Coal - Drayton South Project
Samples tested as received

DATE COMMENCED: 1/05/2012

EXAMINATION: Kinetic Chromogenic LAL Test

METHOD: TM125

PRETREATMENT: Dissolve 1g in 10mL PFW to make initial 1/10 dilution. Further dilute to 1/1000 in PFW.

RESULTS:

SAMPLE REFERENCE	LAL ASSAY DETECTION LIMIT EU/mL	LAL RESULT EU/mL	LAL RESULT EU/g
Soil Sample - Site 2 HVAS Ridge Anglo Coal - Drayton South Project	5.0	**167.591**	**167.591**

< = less than EU = Endotoxin Units PFW = Pyrogen Free Water

Signed:
Elizabeth Georgievska BSc.

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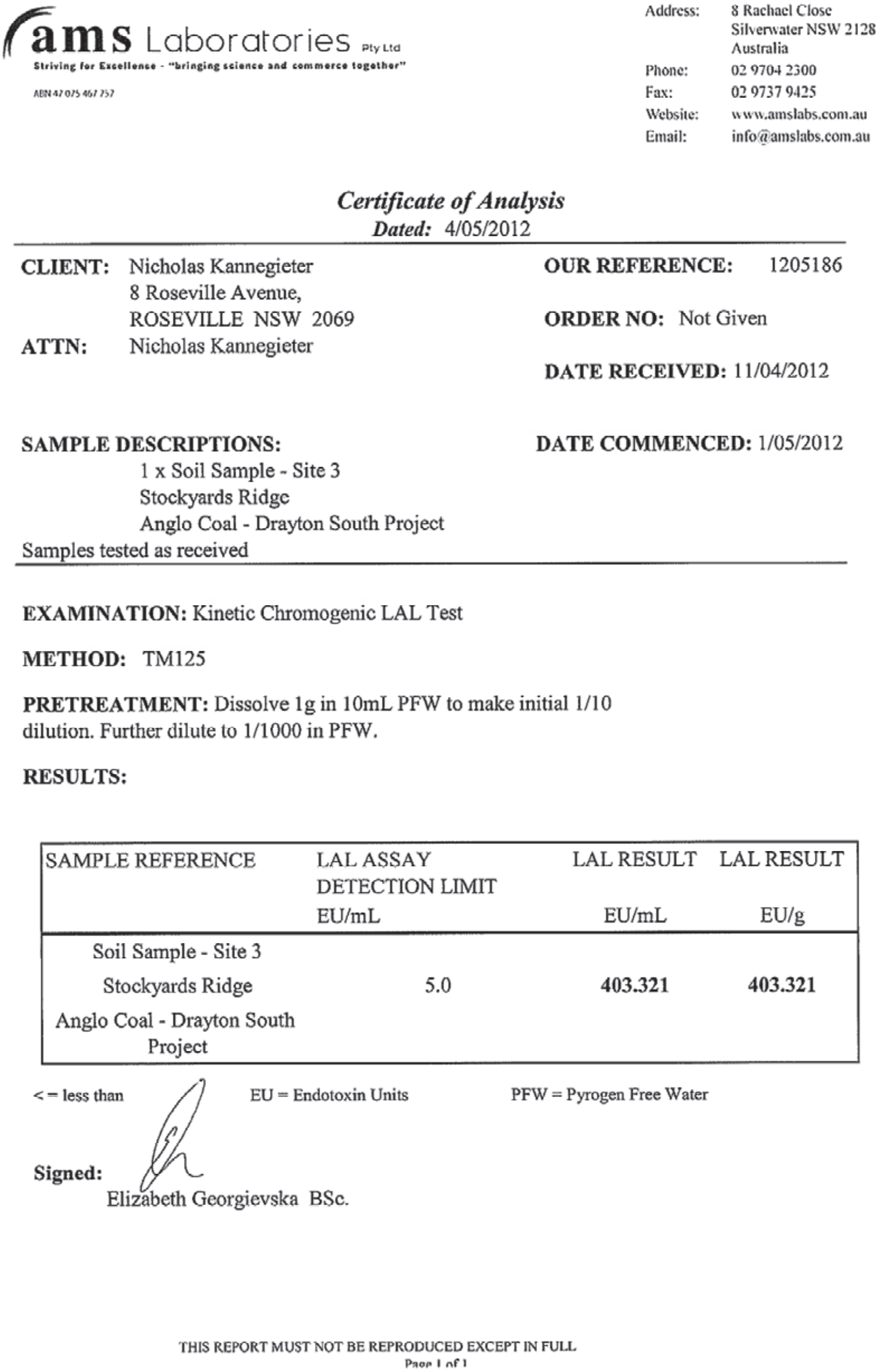

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Dated: 4/05/2012

CLIENT: Nicholas Kannegieter
8 Roseville Avenue,
ROSEVILLE NSW 2069
ATTN: Nicholas Kannegieter

OUR REFERENCE: 1205186

ORDER NO: Not Given

DATE RECEIVED: 11/04/2012

SAMPLE DESCRIPTIONS:
1 x Soil Sample - Site 3
Stockyards Ridge
Anglo Coal - Drayton South Project
Samples tested as received

DATE COMMENCED: 1/05/2012

EXAMINATION: Kinetic Chromogenic LAL Test

METHOD: TM125

PRETREATMENT: Dissolve 1g in 10mL PFW to make initial 1/10 dilution. Further dilute to 1/1000 in PFW.

RESULTS:

SAMPLE REFERENCE	LAL ASSAY DETECTION LIMIT EU/mL	LAL RESULT EU/mL	LAL RESULT EU/g
Soil Sample - Site 3 Stockyards Ridge Anglo Coal - Drayton South Project	5.0	**403.321**	**403.321**

< = less than EU = Endotoxin Units PFW = Pyrogen Free Water

Signed:
Elizabeth Georgievska BSc.

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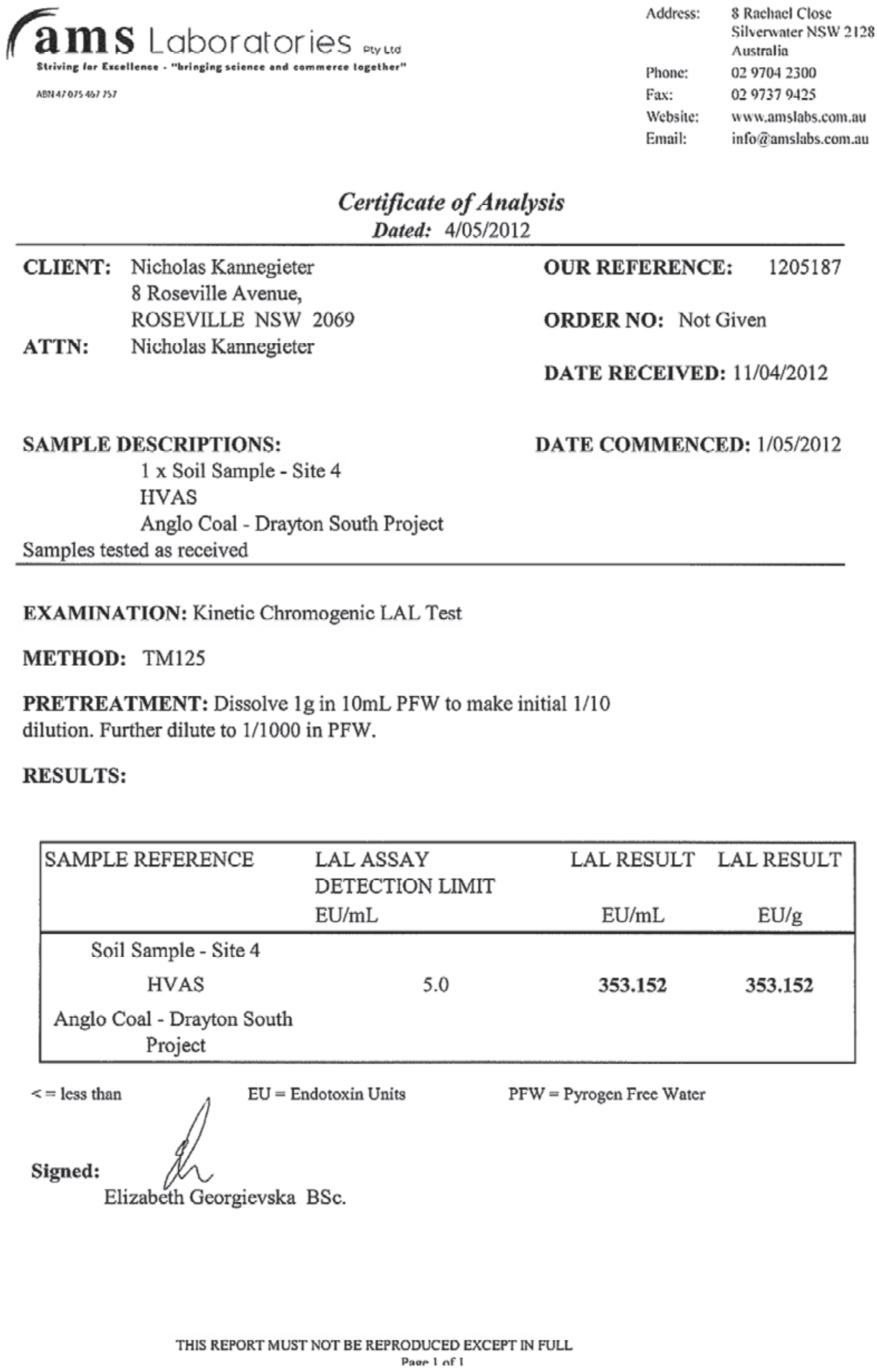

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Dated: 4/05/2012

CLIENT: Nicholas Kannegieter
8 Roseville Avenue,
ROSEVILLE NSW 2069
ATTN: Nicholas Kannegieter

OUR REFERENCE: 1205187

ORDER NO: Not Given

DATE RECEIVED: 11/04/2012

SAMPLE DESCRIPTIONS:
1 x Soil Sample - Site 4
HVAS
Anglo Coal - Drayton South Project
Samples tested as received

DATE COMMENCED: 1/05/2012

EXAMINATION: Kinetic Chromogenic LAL Test

METHOD: TM125

PRETREATMENT: Dissolve 1g in 10mL PFW to make initial 1/10 dilution. Further dilute to 1/1000 in PFW.

RESULTS:

SAMPLE REFERENCE	LAL ASSAY DETECTION LIMIT EU/mL	LAL RESULT EU/mL	LAL RESULT EU/g
Soil Sample - Site 4 HVAS Anglo Coal - Drayton South Project	5.0	**353.152**	**353.152**

< = less than EU = Endotoxin Units PFW = Pyrogen Free Water

Signed:
Elizabeth Georgievska BSc.

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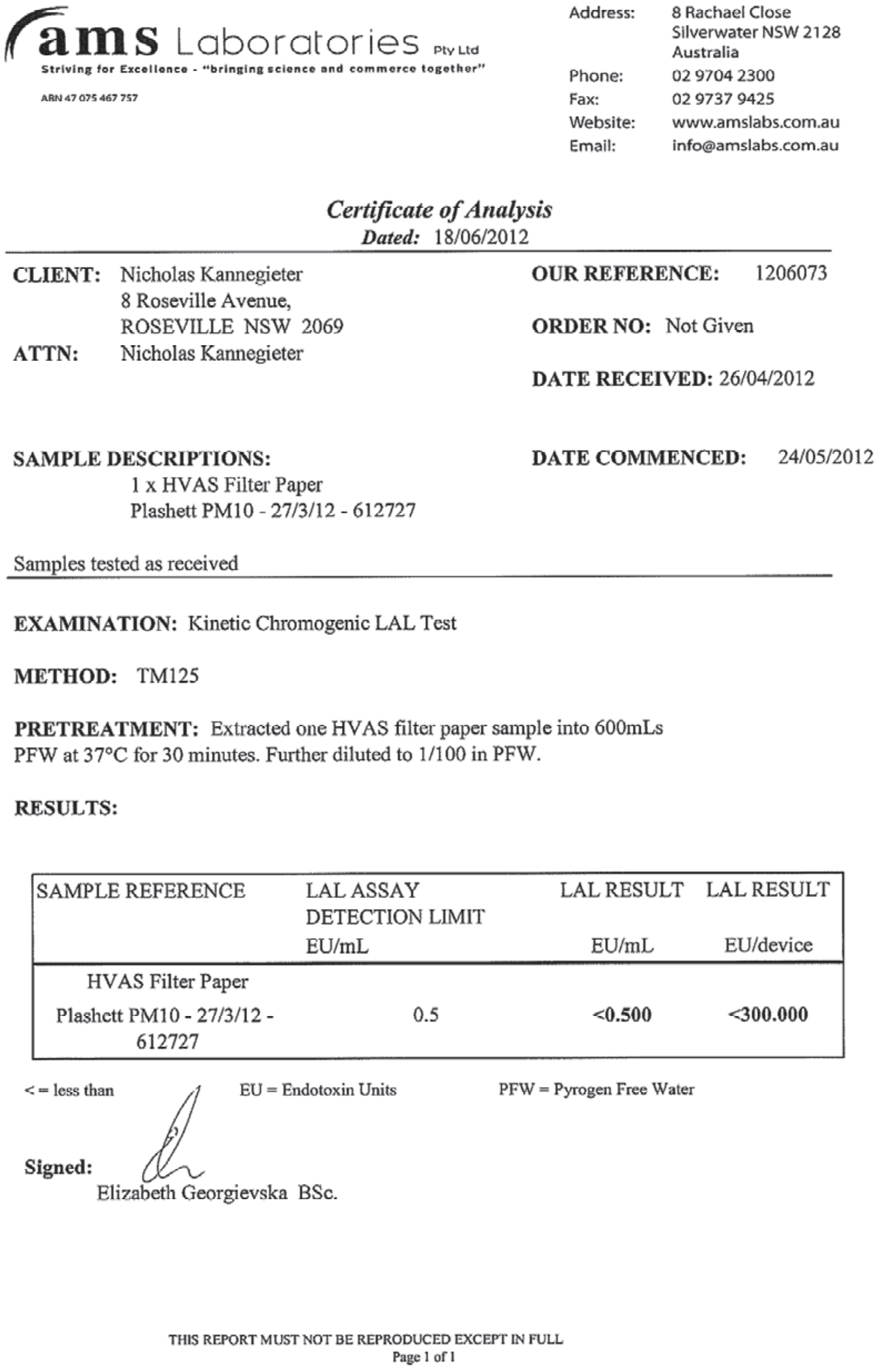

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Dated: 18/06/2012

CLIENT: Nicholas Kannegieter
8 Roseville Avenue,
ROSEVILLE NSW 2069
ATTN: Nicholas Kannegieter

OUR REFERENCE: 1206073

ORDER NO: Not Given

DATE RECEIVED: 26/04/2012

SAMPLE DESCRIPTIONS:
1 x HVAS Filter Paper
Plashett PM10 - 27/3/12 - 612727

DATE COMMENCED: 24/05/2012

Samples tested as received

EXAMINATION: Kinetic Chromogenic LAL Test

METHOD: TM125

PRETREATMENT: Extracted one HVAS filter paper sample into 600mLs PFW at 37°C for 30 minutes. Further diluted to 1/100 in PFW.

RESULTS:

SAMPLE REFERENCE	LAL ASSAY DETECTION LIMIT EU/mL	LAL RESULT EU/mL	LAL RESULT EU/device
HVAS Filter Paper Plashett PM10 - 27/3/12 - 612727	0.5	**<0.500**	**<300.000**

< = less than EU = Endotoxin Units PFW = Pyrogen Free Water

Signed:
Elizabeth Georgievska BSc.

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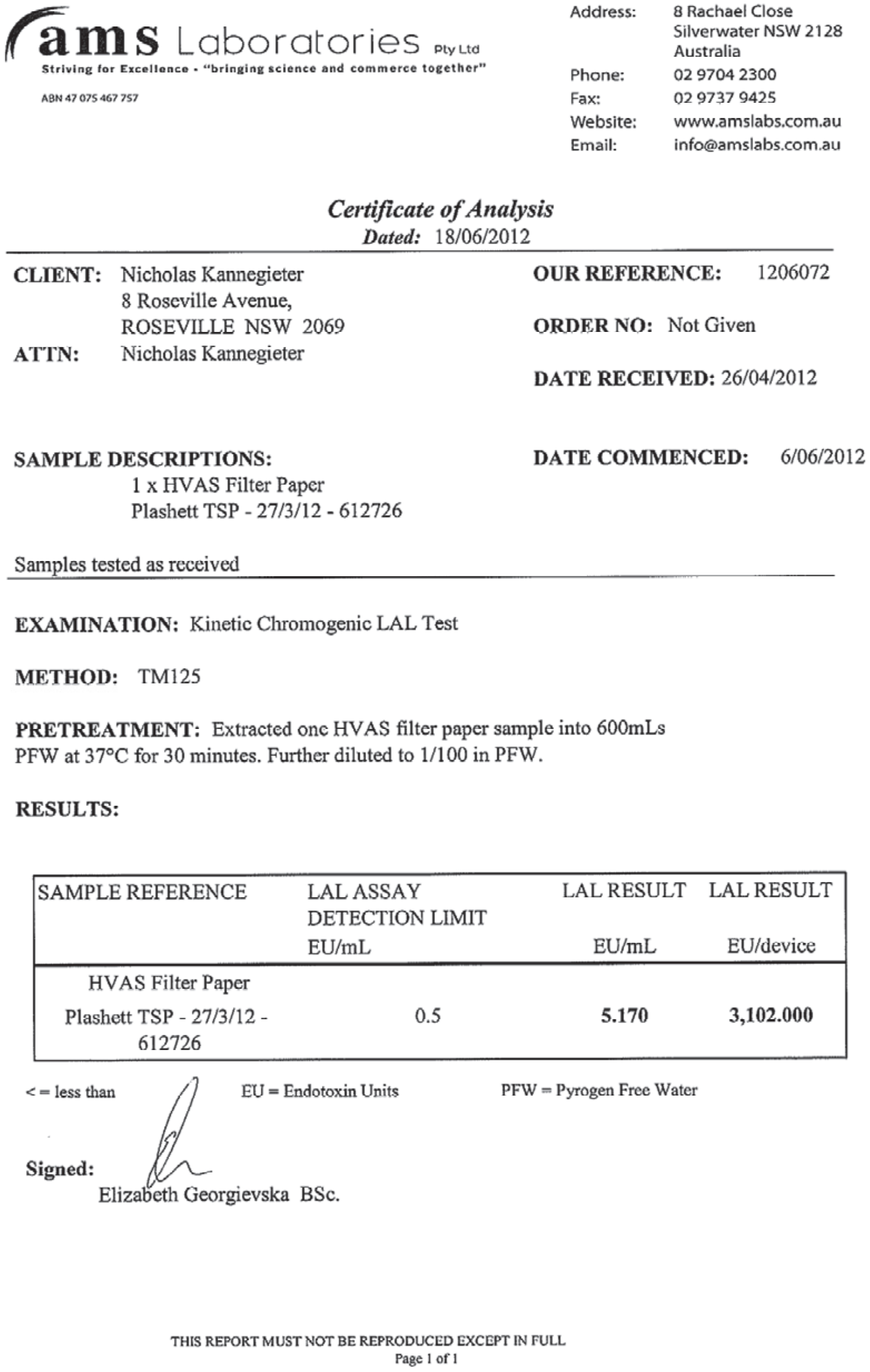

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Dated: 18/06/2012

CLIENT: Nicholas Kannegieter
8 Roseville Avenue,
ROSEVILLE NSW 2069
ATTN: Nicholas Kannegieter

OUR REFERENCE: 1206072

ORDER NO: Not Given

DATE RECEIVED: 26/04/2012

SAMPLE DESCRIPTIONS:
1 x HVAS Filter Paper
Plashett TSP - 27/3/12 - 612726

DATE COMMENCED: 6/06/2012

Samples tested as received

EXAMINATION: Kinetic Chromogenic LAL Test

METHOD: TM125

PRETREATMENT: Extracted one HVAS filter paper sample into 600mLs PFW at 37°C for 30 minutes. Further diluted to 1/100 in PFW.

RESULTS:

SAMPLE REFERENCE	LAL ASSAY DETECTION LIMIT EU/mL	LAL RESULT EU/mL	LAL RESULT EU/device
HVAS Filter Paper Plashett TSP - 27/3/12 - 612726	0.5	**5.170**	**3,102.000**

< = less than EU = Endotoxin Units PFW = Pyrogen Free Water

Signed:
Elizabeth Georgievska BSc.

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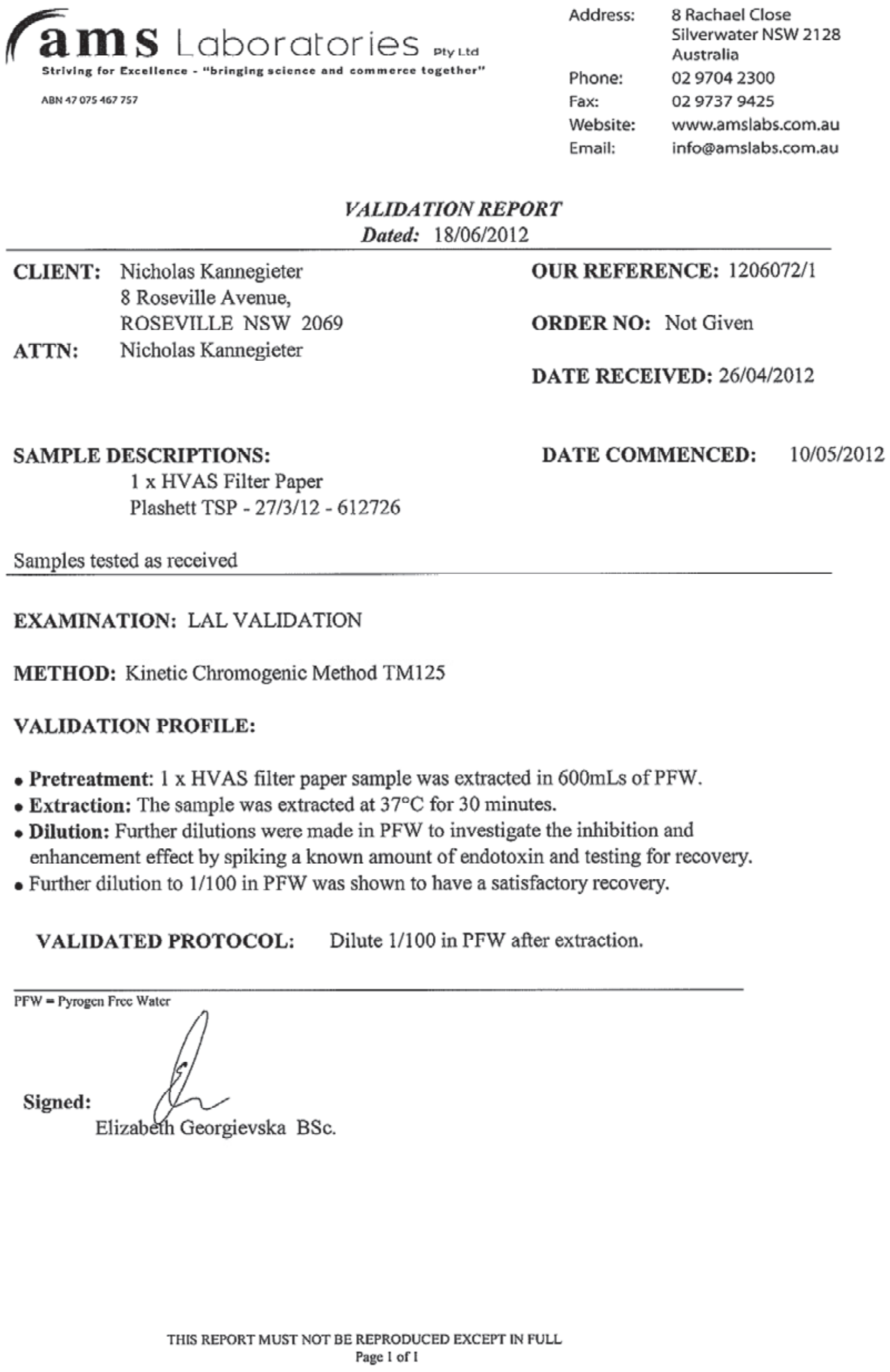

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VALIDATION REPORT

Dated: 18/06/2012

CLIENT: Nicholas Kannegieter
8 Roseville Avenue,
ROSEVILLE NSW 2069
ATTN: Nicholas Kannegieter

OUR REFERENCE: 1206072/1

ORDER NO: Not Given

DATE RECEIVED: 26/04/2012

SAMPLE DESCRIPTIONS:
1 x HVAS Filter Paper
Plashett TSP - 27/3/12 - 612726

DATE COMMENCED: 10/05/2012

Samples tested as received

EXAMINATION: LAL VALIDATION

METHOD: Kinetic Chromogenic Method TM125

VALIDATION PROFILE:

- **Pretreatment**: 1 x HVAS filter paper sample was extracted in 600mLs of PFW.
- **Extraction:** The sample was extracted at 37°C for 30 minutes.
- **Dilution:** Further dilutions were made in PFW to investigate the inhibition and enhancement effect by spiking a known amount of endotoxin and testing for recovery.
- Further dilution to 1/100 in PFW was shown to have a satisfactory recovery.

VALIDATED PROTOCOL: Dilute 1/100 in PFW after extraction.

PFW = Pyrogen Free Water

Signed:
Elizabeth Georgievska BSc.

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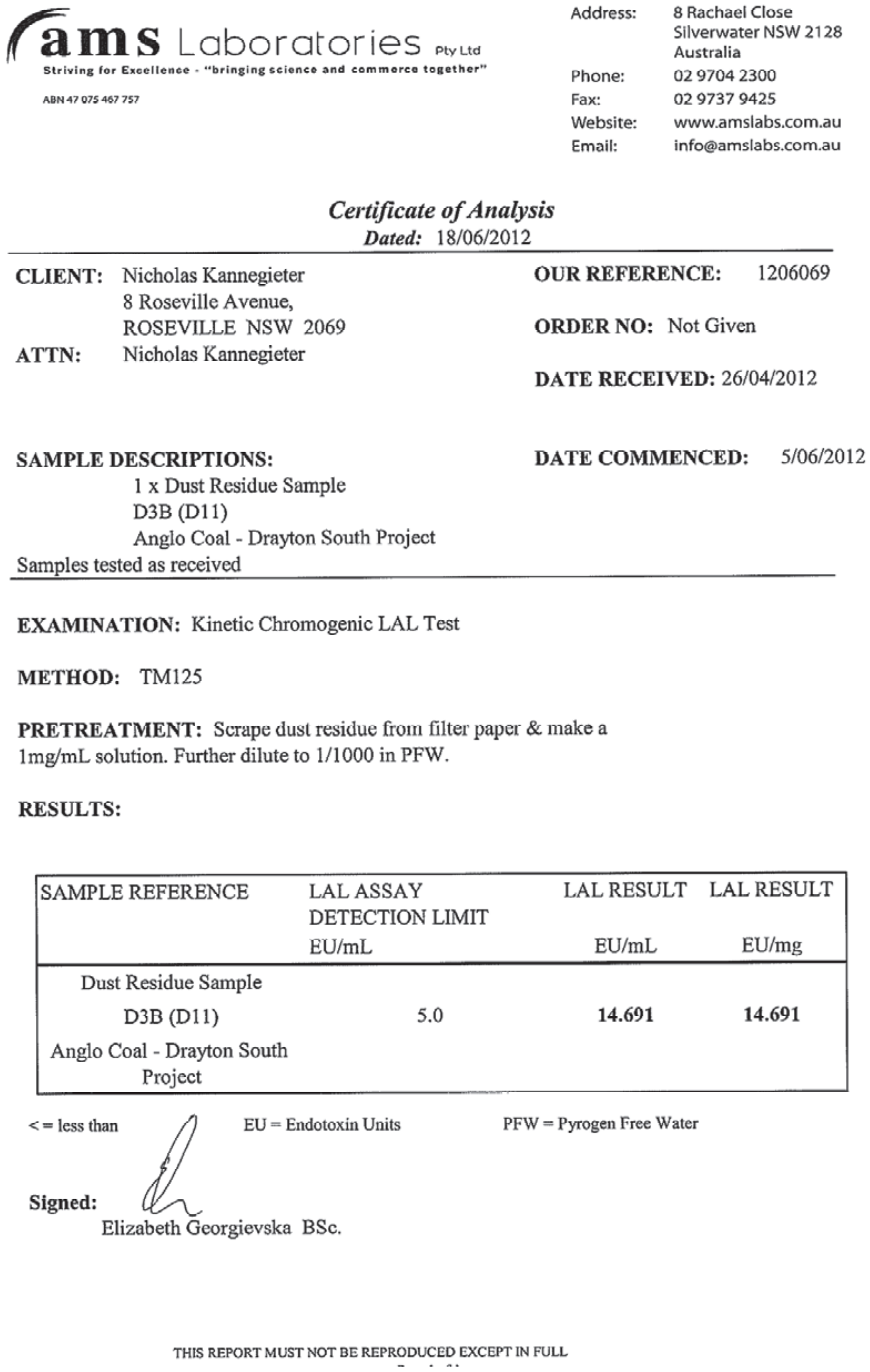

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Dated: 18/06/2012

CLIENT: Nicholas Kannegieter
8 Roseville Avenue,
ROSEVILLE NSW 2069
ATTN: Nicholas Kannegieter

OUR REFERENCE: 1206069

ORDER NO: Not Given

DATE RECEIVED: 26/04/2012

SAMPLE DESCRIPTIONS:
1 x Dust Residue Sample
D3B (D11)
Anglo Coal - Drayton South Project
Samples tested as received

DATE COMMENCED: 5/06/2012

EXAMINATION: Kinetic Chromogenic LAL Test

METHOD: TM125

PRETREATMENT: Scrape dust residue from filter paper & make a 1mg/mL solution. Further dilute to 1/1000 in PFW.

RESULTS:

SAMPLE REFERENCE	LAL ASSAY DETECTION LIMIT EU/mL	LAL RESULT EU/mL	LAL RESULT EU/mg
Dust Residue Sample D3B (D11) Anglo Coal - Drayton South Project	5.0	**14.691**	**14.691**

< = less than
EU = Endotoxin Units
PFW = Pyrogen Free Water

Signed:
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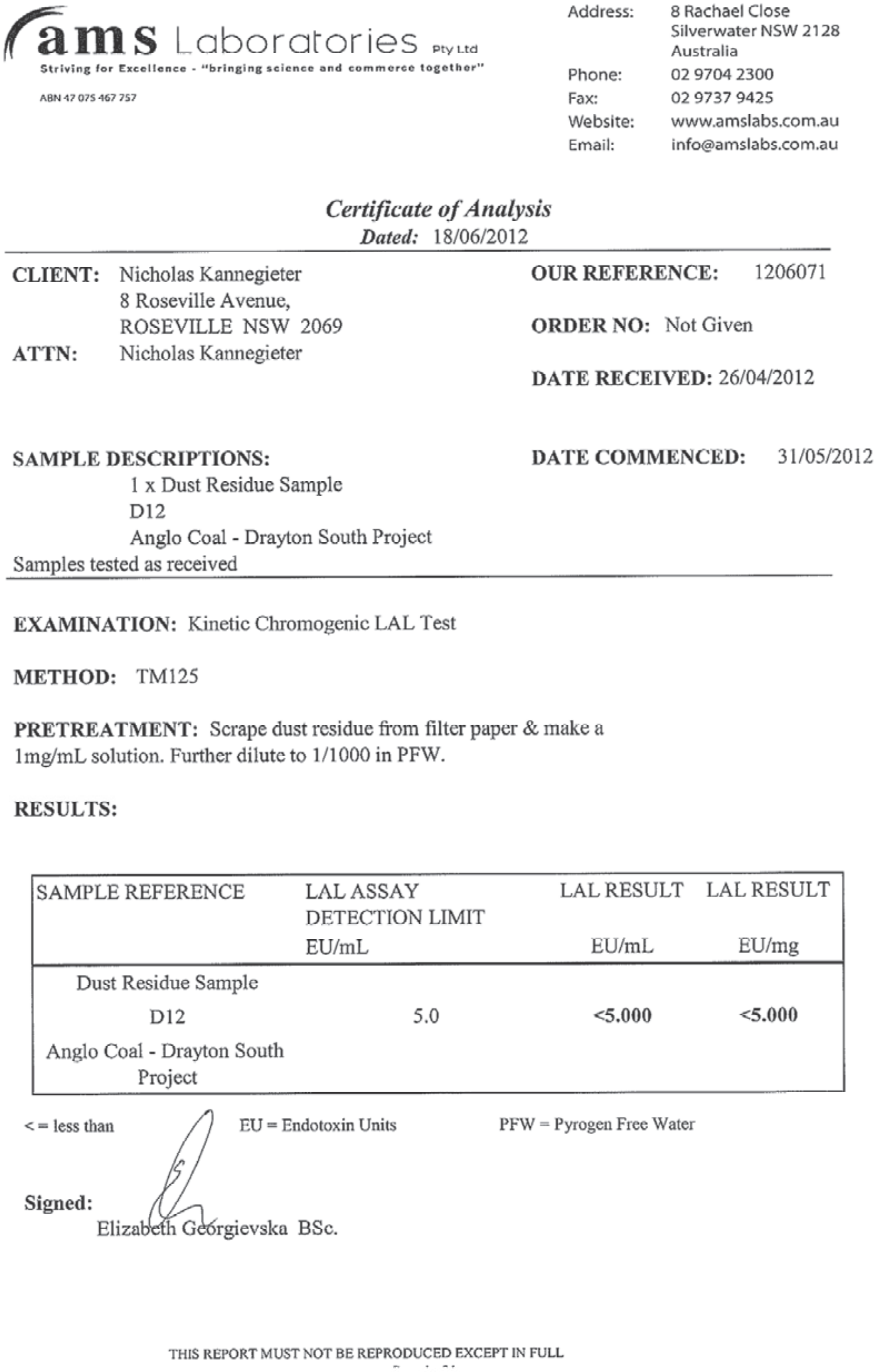

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Dated: 18/06/2012

CLIENT: Nicholas Kannegieter
8 Roseville Avenue,
ROSEVILLE NSW 2069
ATTN: Nicholas Kannegieter

OUR REFERENCE: 1206071

ORDER NO: Not Given

DATE RECEIVED: 26/04/2012

SAMPLE DESCRIPTIONS:
1 x Dust Residue Sample
D12
Anglo Coal - Drayton South Project
Samples tested as received

DATE COMMENCED: 31/05/2012

EXAMINATION: Kinetic Chromogenic LAL Test

METHOD: TM125

PRETREATMENT: Scrape dust residue from filter paper & make a 1mg/mL solution. Further dilute to 1/1000 in PFW.

RESULTS:

SAMPLE REFERENCE	LAL ASSAY DETECTION LIMIT EU/mL	LAL RESULT EU/mL	LAL RESULT EU/mg
Dust Residue Sample D12 Anglo Coal - Drayton South Project	5.0	**<5.000**	**<5.000**

< = less than EU = Endotoxin Units PFW = Pyrogen Free Water

Signed:
Elizabeth Georgievska BSc.

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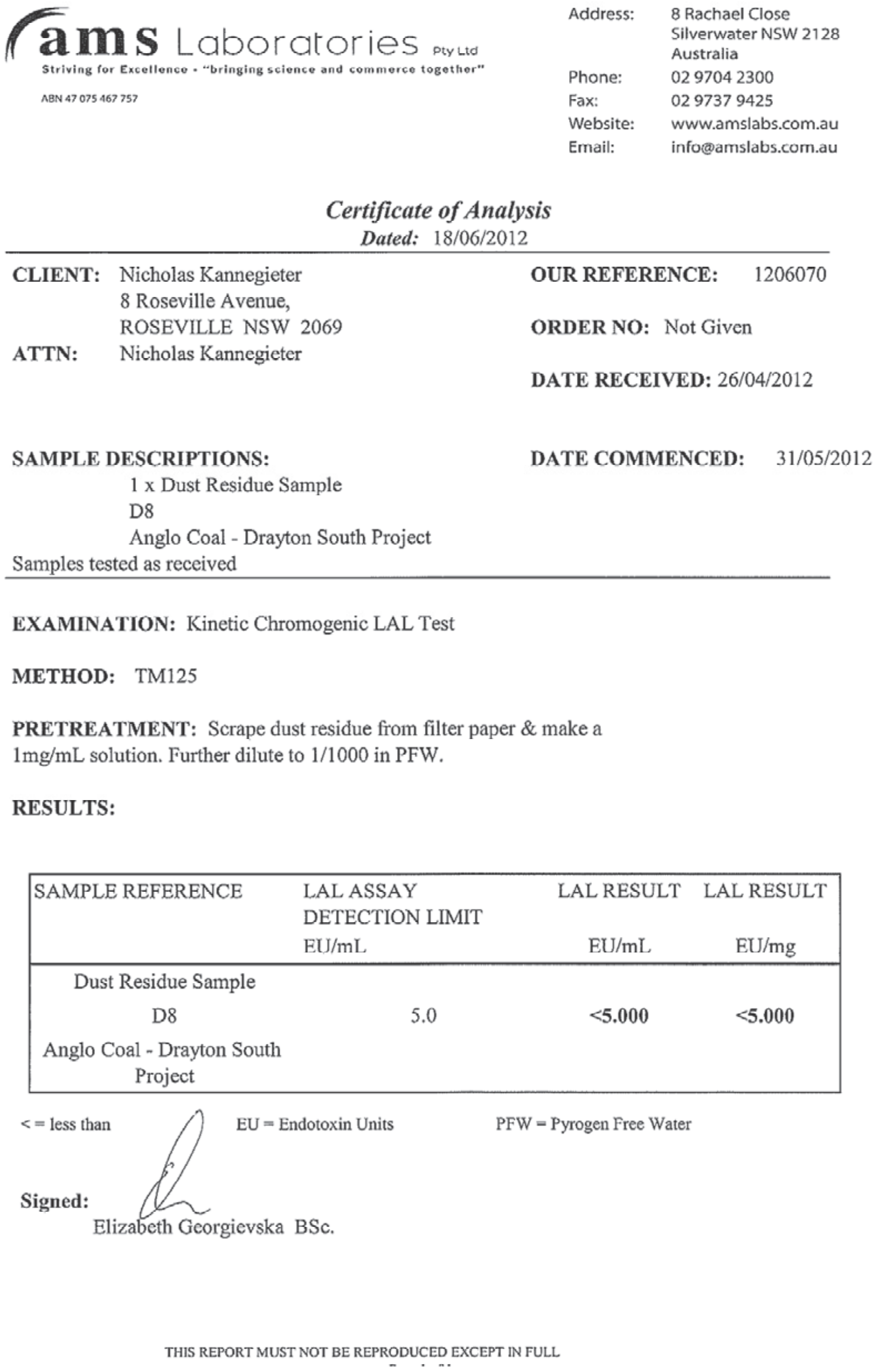

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Certificate of Analysis

Dated: 18/06/2012

CLIENT: Nicholas Kannegieter
8 Roseville Avenue,
ROSEVILLE NSW 2069
ATTN: Nicholas Kannegieter

OUR REFERENCE: 1206070

ORDER NO: Not Given

DATE RECEIVED: 26/04/2012

SAMPLE DESCRIPTIONS:
1 x Dust Residue Sample
D8
Anglo Coal - Drayton South Project
Samples tested as received

DATE COMMENCED: 31/05/2012

EXAMINATION: Kinetic Chromogenic LAL Test

METHOD: TM125

PRETREATMENT: Scrape dust residue from filter paper & make a 1mg/mL solution. Further dilute to 1/1000 in PFW.

RESULTS:

SAMPLE REFERENCE	LAL ASSAY DETECTION LIMIT EU/mL	LAL RESULT EU/mL	LAL RESULT EU/mg
Dust Residue Sample D8 Anglo Coal - Drayton South Project	5.0	**<5.000**	**<5.000**

< = less than EU = Endotoxin Units PFW = Pyrogen Free Water

Signed:
Elizabeth Georgievska BSc.

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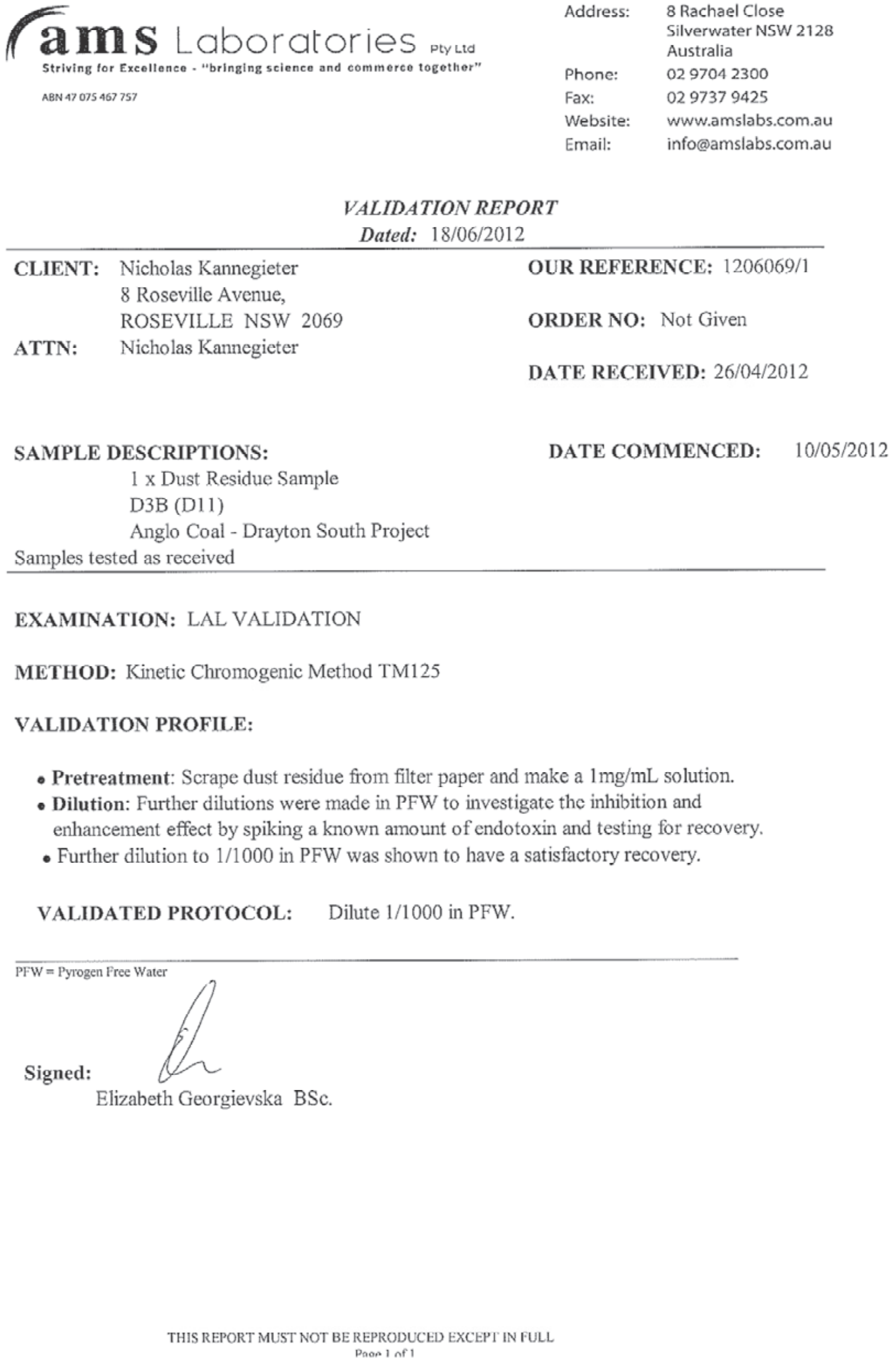

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Email: info@amslabs.com.au

VALIDATION REPORT

Dated: 18/06/2012

CLIENT: Nicholas Kannegieter
8 Roseville Avenue,
ROSEVILLE NSW 2069
ATTN: Nicholas Kannegieter

OUR REFERENCE: 1206069/1

ORDER NO: Not Given

DATE RECEIVED: 26/04/2012

SAMPLE DESCRIPTIONS:
1 x Dust Residue Sample
D3B (D11)
Anglo Coal - Drayton South Project
Samples tested as received

DATE COMMENCED: 10/05/2012

EXAMINATION: LAL VALIDATION

METHOD: Kinetic Chromogenic Method TM125

VALIDATION PROFILE:

- **Pretreatment**: Scrape dust residue from filter paper and make a 1mg/mL solution.
- **Dilution**: Further dilutions were made in PFW to investigate the inhibition and enhancement effect by spiking a known amount of endotoxin and testing for recovery.
- Further dilution to 1/1000 in PFW was shown to have a satisfactory recovery.

VALIDATED PROTOCOL: Dilute 1/1000 in PFW.

PFW = Pyrogen Free Water

Signed:
Elizabeth Georgievska BSc.

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