Appendix R
Environmental Evaluation of Coal Dust Emissions (QR, 2008)

eco access

Statutory declaration

Environmental Operations

Environmental evaluation

In accordance with section 325 of the Environmental Protection Act 1994, *this statutory declaration must be completed by the recipient of a* Notice to conduct or commission an environmental evaluation. *A copy of the environmental report must be attached to this statutory declaration.*

Oaths Act 1867

QUEENSLAND
TO WIT

I JOHN SCHERER on behalf of QR LIMITED

Insert the name of the person making this declaration

of 127 Creek Steet, Brisbane, QLD

Insert the street address of the person making this declaration

in the State of Queensland do solemnly and sincerely declare that in accordance with section 325 of the *Environmental Protection Act 1994*, I have:

- not knowingly given any false or misleading information; and
- given all relevant information

to the auditor/investigator who, over the period October 2007 to 31 March 2008, conducted:

Insert start date / Insert end date

(tick applicable box)

☐ the environmental audit, or

☒ environmental investigation

for the purpose of submitting a report in accordance with the *Notice to conduct or commission an environmental evaluation* pursuant to section 324 of the *Environmental Protection Act 1994* issued by the administering authority to:

QR Limited — 2 July 2007

Insert name of recipient of the notice / Insert date of the notice

Environmental Protection Agency
www.epa.qld.gov.au ABN 87 221 158 786

Queensland Government
Environmental Protection Agency
Queensland Parks and Wildlife Service

A copy of my report is attached to this statutory declaration and marked "A".

And I make this solemn declaration conscientiously believing the same to be true, and by virtue of the *Oaths Act 1867.*

Taken and declared before me, at 127 Creek Street, Brisbane

Insert location

this 31st day of March in the year 2008

Insert day (e.g. 18th) | Insert month | Insert year

Signed

(Person making this declaration)

Signed

(Delete whichever is not applicable — ~~Justice of the Peace~~ / ~~Commissioner for Declarations~~ / Solicitor / ~~Barrister~~)

GAIL ROBYN MALONE

Printed name and registration number (if applicable) eco access

Statutory declaration

Environmental Operations

Auditor/investigator

A statutory declaration is a written statement of facts that is sworn or declared under the Oaths Act 1867. *In accordance with section 325 of the* Environmental Protection Act 1994, *this statutory declaration must be completed by the auditor/investigator who conducted the environmental evaluation. A copy of the environmental report must be attached to this statutory declaration.*

Oaths Act 1867

QUEENSLAND
TO WIT

I Simon John Welchman

Insert the name of the person making this declaration

of Katestone Environmental, Unit 5, 249 Coronation Drive, Milton, QLD 4064

Insert the street address of the person making this declaration

in the State of Queensland do solemnly and sincerely declare that in accordance with section 325 of the *Environmental Protection Act 1994*:

- I am the auditor/investigator and author of an environmental report entitled

  Final Report, Environmental Evaluation of Fugitive Coal Dust Emissions from Coal Trains, Goonyella, Blackwater and Moura Coal Rail Systems, Queensland Rail Limited

  Insert title of the environmental report

In accordance with the *Notice to conduct or commission an environmental evaluation* pursuant to section 324 of the *Environmental Protection Act 1994* issued to:

QR Limited — 2 July 2007

Insert name of recipient of the notice — Insert date of the notice

- A copy of my report is attached to this statutory declaration and marked "A";
- I possess the following qualifications and experience relevant to this environmental evaluation:

  Environmental Engineer

- I have not knowingly included any false, misleading or incomplete information in the report; and
- I have not knowingly failed to reveal any relevant information or document to the administering authority.

Environmental Protection Agency
www.epa.qld.gov.au ABN 87 221 158 786

Queensland Government
Environmental Protection Agency
Queensland Parks and Wildlife Service

ecoaccess
environmental licences and permits

Statutory declaration

In relation to an application

I certify that:

- The report addresses the relevant matters for the evaluation and is factually correct; and
- The opinions expressed in it are honestly and reasonably held.

And I make this solemn declaration conscientiously believing the same to be true, and by virtue of the *Oaths Act 1867*.

Taken and declared before me, at 127 Creek Street, Brisbane

Insert location

this	31st	day of	March	in the year	2008
	Insert day (e.g. 18th)		Insert month		Insert year

Signed

(Person making this declaration)

Signed

(Delete whichever is not applicable — ~~Justice of the Peace / Commissioner for Declarations~~ / Solicitor / ~~Barrister~~)

GAIL ROBYN MALONE

Printed name and registration number (if applicable)

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Final Report
Environmental Evaluation of Fugitive Coal Dust Emissions from Coal Trains Goonyella, Blackwater and Moura Coal Rail Systems Queensland Rail Limited

31 March 2008
Reference H327578-N00-EE00.00

Revision 1

Connell HATCH
Infrastructure for Industry

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Executive summary

QR Limited has appointed Connell Hatch, John Planner of Introspec Consulting and Katestone Environmental to prepare an Environmental Evaluation of fugitive coal dust emissions from trains travelling on the Moura, Blackwater and Goonyella coal transport systems in response to a Notice issued by the Queensland Environmental Protection Agency (EPA). This final report presents the outcomes of the Environmental Evaluation. An interim report was previously issued on 31 January 2008.

The primary scope of the project is described in the Terms of Reference for the Environmental Evaluation and is reproduced below:

a) *Identify all potential sources of coal dust emissions from QR trains in Central Queensland on land described as rail lines connecting coal mines in the Bowen and Callide Basins with ports at Dalrymple Bay, Hay Point and Gladstone*

b) *Quantify the potential risk of environmental harm posed by each dust source*

c) *Identify the factors and circumstances that contribute to dust emissions and/or impacts from each source. Consideration should be given to (but not limited to) issues such as coal type, coal properties and meteorological conditions.*

d) *Based on the findings from the above, identify locations within QR's Central Queensland operations where proximity of railway lines to communities may give rise to higher risk of environmental harm due to fugitive coal dust*

e) *Identify ways to reduce the risk being caused by coal dust emissions and assess each for practicability, effectiveness and cost, in relation to the mitigation of environmental impacts of fugitive coal dust emissions*

The Environmental Evaluation has reached the following conclusions:

- Demand for coal has increased significantly over the last decade due to its low cost and stable supply compared to other fossil fuels. Growth is expected to remain strong over the coming years leading to plans to expand most of the key coal terminals and the addition of a new coal terminal at Gladstone. Coal tonnages on the Moura, Blackwater and Goonyella Systems contained are projected to increase by 50% by 2014/15

- Coal dust can be emitted from the following sources in the coal rail system:

  – Coal surface of loaded wagons
  – Coal leakage from doors of loaded wagons
  – Wind erosion of spilled coal in corridor
  – Residual coal in unloaded wagons and leakage of residual coal from doors
  – Parasitic load on sills, shear plates and bogies of wagons

- The key factor that contributes to the emission rate of coal dust from wagons is the speed of the air passing over the coal surface. This is influenced by the train speed and the ambient wind speed. Other factors that are also found to contribute include:

  – Coal properties such as: dustiness, moisture content and particle size
  – Frequency of train movements
  – Vibration of the wagons
  – Profile of the coal load
  – Transport distance

  - Exposure to wind
  - Precipitation

- In 2006/07 the emission rate of coal as TSP is estimated to be in the order of 5416 tonnes per annum from the Blackwater, Moura and Goonyella Systems. This is estimated to increase to 7882 tonnes per annum in 2014/15.

- At least six ambient air quality monitoring studies have been undertaken since 1993 to specifically investigate and quantify concentrations of TSP, PM_{10} and dust deposition rates adjacent to rail lines carrying coal. These studies did not find the potential for health impacts inside or outside of the rail corridor as assessed against current air quality goals due to coal dust emissions from trains. These studies did not find the potential for amenity impacts outside the rail corridor due to coal dust emissions from trains when assessed against current air quality guidelines for nuisance.

- The current air quality goals may not provide an adequate basis to delineate nuisance associated with coal dust, particularly if those impacts occur over short-time periods. The current amenity goals are based on annual or one-month averages.

- We are unaware of any nuisance related air quality goals for coal dust that are for shorter time periods that are employed in Australia or in other countries. The recent approval for the Wiggins Island Coal Terminal in Queensland has incorporated objectives that are lower than the current goals that are implemented through legislation in Queensland. The basis of these objectives and their relevance, if any, to nuisance associated with coal dust is unclear. Consequently, these are cautiously applied in this study.

- Although atypical, observations and photographs taken by the study team and others show that visible dust is emitted by some trains and this dust has been observed to travel beyond the rail corridor. Such occurrences suggest that coal dust emissions are not under control in certain circumstances, leaving open the possibility that a claim could be made that QR Limited has breached the General Environmental Duty under The Act because QR Limited has not taken "…all reasonable and practical measures…" to minimise harm.

- From a review of resident complaints and other observations it has been noted that there exists a community perception that "nuisance" dust levels are generated from current coal train operations. Although the complaints may be due to a number of "peak" events rather than the general operation of coal trains, the community perception must be given serious consideration, particularly in view of the proposed substantial increase in coal transport volumes.

- Considering short-term averages the most recent studies conducted at Callemondah in 2007 and for this Environmental Evaluation at locations along the Moura, Goonyella and Blackwater Systems, indicate that the effect of coal dust emissions on ambient dust concentrations is measurable at 15 metres from the rail centreline and that coal from some mines may be consistently dustier than others.

- There is a low risk of adverse impacts on flora, fauna, crops and livestock due to emissions of TSP from coal wagons. Even within the rail corridor, dust deposition rates have been measured to be well below thresholds that have been shown in literature studies to have little or no effect on crops and livestock.

- Dispersion modelling of coal dust emissions from coal trains operating at Mount Larcom and Grasstree for current train movements and future projections suggests that ground-level concentrations of PM_{10} are unlikely to exceed the current EPP(Air) goal or NEPM(Air) standards at 10 metres from the tracks or at residential locations.

- Wind tunnel tests conducted at the University of Sydney using 1:50 scale models of typical QR coal wagons, typical loading profiles, 80 km/hour travel speed, and typical operating conditions indicate that wind speeds over the coal surface will exceed 20 metres per second (72 km per hour).

- Laboratory tests conducted at the University of Newcastle on 30 typical coal types transported by QR Limited indicate that major dust lift-off from the coal surface can occur from the majority of tested coal types when the wind speed over the coal surface is less than 40 km/hr.

- Laboratory tests conducted at the University of Newcastle on seven typical coal types transported by QR Limited and five veneer treatments indicate that all surface veneer products, when applied at the supplier's recommended application rate and solution strength, achieved a significant reduction in dust lift-off compared with nil treatment.

- All surface veneer products were applied at a common application rate of one litre per square metre. The solution strength varied according to the supplier's recommendation. All test samples were exposed to a wind speed of 20 metres per second (72 km/hr) under test conditions for a period of 8 hours. Due to very rapid dust lift-off, the untreated samples (Nil treatment) were removed from the wind tunnel after exposure to the test conditions for only 1 minute. This observation applied to all tested coal types and indicates a high potential for lift-off for untreated wagons under normal train speeds.

- A range of measures have been identified that show potential to reduce the risk being caused by coal dust emissions. The following techniques have been identified as being practical and cost-effective and could be implemented within the Goonyella, Blackwater and Moura rail systems:

  – Coal surface veneering using chemical dust suppressants at the mine
  – Improved coal loading techniques at the mine to reduce parasitic load on horizontal wagon surfaces and reduce over-filling and hence spillage during transport
  – Load profiling to create a consistent surface of coal in each wagon. To be implemented at the mine, and
  – Improved unloading techniques to minimise coal ploughing and parasitic load on wagons

- Whilst wagon lids are likely to substantially reduce coal dust emissions from wagons, this cannot be considered in isolation of other issues. It is acknowledged that there are many potential operational impacts and costs associated with implementing wagon lids that cannot be estimated without a thorough detailed investigation. Such an investigation would need to consider the operational decisions, reliability of lids and facilities at very intricate level of detail. It is therefore considered prudent not to consider wagon lids as a potential mitigation strategy without undertaking the aforementioned course of action. The preliminary work presented in the environmental evaluation suggests that wagon lids are unlikely to be a feasible solution.

- The major concerns with the introduction of lids is the untried nature of these in the coal industry, a harsh environment. The lids proposed as a retrofit are of an experimental nature, hence are not able to be tried with any certainty as to whether they are reliable, safe or effective. The lids which would be incorporated in any design are by definition untried, however QR Limited's experience with this style of lids in other industries has proven that these are maintenance intensive, hence cannot be recommended without significant development work being undertaken.

The Environmental Evaluation makes the following recommendations to QR Limited:

- QR Limited should develop a coal dust management plan as a framework for the ongoing management of the coal dust issue. The coal dust management plan should detail short-, medium- and long-term strategies for minimising coal dust emissions from the key dust sources that are highlighted in this document. The coal dust management plan should incorporate the principle of continual environmental improvement. The coal dust management plan should incorporate the subsequent recommendations.

- Further works should be undertaken to provide a more reliable estimate of coal leakage from Kwik-Drop doors to assist the assessment of the benefits of control of coal leakage from doors.

- Further laboratory tests and field trials should be conducted to explore the effectiveness of veneering for a broader range of coal types and to investigate the potential impact of slip failures in the coal on the overall effectiveness in terms of dust control.

- Further laboratory tests should be conducted on all coal types to explore the relevant treatment selection for each coal type and to refine the most cost-effective surface veneer treatment approach to achieve an acceptable level of dust emission during rail transport from mine to port. The responsibility for the costs of conducting this work could be negotiated as part of the Code of Practice.

- Ongoing monitoring should be implemented at strategic points within the Goonyella, Blackwater and Moura Systems to augment the baseline information collected in the Environmental Evaluation and to quantify the improvement in coal dust emissions as mitigation measures are implemented. The measurement technique adopted needs to:

  – Provide a reliable measure of the magnitude of coal dust emitted from a coal train during transport
  – Be relatively simple to maintain, calibrate and operate, and
  – Link measurements of coal dust with specific trains in a transparent way

- A Code of Practice should be developed by QR Limited in consultation with, and agreement from, all relevant stakeholders in the mine to port coal chain with the aim of minimising coal dust emissions from the rail corridor. The code of practice could state the ways of achieving compliance with the General Environmental Duty for activities that cause or are likely to cause environmental harm. The Code of Practice could give clear guidance on measures that should be taken to prevent or minimise environmental harm. The Code of Practice could state the minimum level of performance of surface veneers in controlling dust and the information that needs to be generated to certify that this is achievable.

Glossary

ACCU	Automatic Cartridge Collection Unit. An accessory for a TEOM that is used to collect discrete filters for compositional analysis
CFD	Computational Fluid Dynamics modelling
DEM	Dust extinction moisture level is the moisture level at which the small particles in the matrix of the product are cohesively bound together in such a manner in which it is unlikely that the small particles are able to be liberated. This is a function of the coal type and each coal has an individual DEM level which is determined by analysis and testing.
Dust deposition rate	The amount of dust that deposits over an area of 1 square metre per month. This is a common measure of nuisance dust and has units of $mg/m^2/day$
Environmental harm	Is defined under Schedule 3 of the Act as any adverse effect, or potential adverse effect (whether temporary or permanent and of whatever magnitude, duration or frequency) on an environmental value, and includes environmental nuisance
Environmental value	Is a quality or physical characteristic of the environment that is conducive to ecological health or public amenity or another quality of the environment identified and declared an environmental value under an environmental protection policy or regulation
EPA	Environmental Protection Agency
EP Act or The Act	*Environmental Protection Act 1994*
EP Regulation	*Environmental Protection Regulation 1998*, subordinate legislation under the *Environmental Protection Act 1994* that defines activities that are ERAs
EPP(Air)	*Environmental Protection (Air) Policy 1997*, subordinate legislation under the *Environmental Protection Act 1994*
ERA	Environmentally Relevant Activity as defined under the *Environmental Protection Regulation 1998*
IPA	*Integrated Planning Act 1994*
ktpa	Kilotonnes per annum
$\mu g/m^3$	Micrograms per cubic metre
Mtpa	Million tonnes per annum
NEPM(Air)	National Environment Protection (Ambient Air Quality) Measure 1998
NEPC	National Environment Protection Council
OSIRIS	Equipment used to continuously measure the concentration of particulate matter in the ambient air that correspond to various particle sizes
Partisol	Equipment used to measure concentrations of particulate matter in the ambient air
PM_{10}	Particulate matter with an aerodynamic diameter of less than 10 micrometres

Saltation	Occurs due to airflow across a particle laden surface when particles begin to move and bounce in the layer close to the interface between the particle surface and the flow of air.
TSP	Total suspended particulates
TEOM	Tapered element oscillating microbalance. Instrument capable of continuously monitoring the concentration of particulate matter

1. Introduction

QR Limited has appointed Connell Hatch, John Planner of Introspec Consulting and Katestone Environmental to prepare an Environmental Evaluation of fugitive coal dust emissions from trains travelling from mines to ports (or end-users) on the Moura, Blackwater and Goonyella coal transport systems in response to a Notice issued by the Queensland Environmental Protection Agency (EPA). This report presents the outcomes of the Environmental Evaluation and follows an interim report issued on 31 January 2008, responding to points (a) to (d) of the Terms of Reference.

1.1 Environmental Evaluation Terms of Reference

Under Sections 323 and 324 of the Environmental Protection Act 1994, the Queensland EPA has requested QR Limited to conduct an Environmental Evaluation of fugitive emissions of coal dust from trains.

The primary scope of the project is described in the Terms of Reference for the Environmental Evaluation and is reproduced below:

a) *Identify all potential sources of coal dust emissions from QR trains in Central Queensland on land described as rail lines connecting coal mines in the Bowen and Callide Basins with ports at Dalrymple Bay, Hay Point and Gladstone*

b) *Quantify the potential risk of environmental harm posed by each dust source*

c) *Identify the factors and circumstances that contribute to dust emissions and/or impacts from each source. Consideration should be given to (but not limited to) issues such as coal type, coal properties and meteorological conditions.*

d) *Based on the findings from the above, identify locations within QR's Central Queensland operations where proximity of railway lines to communities may give rise to higher risk of environmental harm due to fugitive coal dust*

e) *Identify ways to reduce the risk being caused by coal dust emissions and assess each for practicability, effectiveness and cost, in relation to the mitigation of environmental impacts of fugitive coal dust emissions*

The Terms of Reference relates specifically to coal dust from trains and consequently, this Environmental Evaluation has focused on coal dust emissions and has not assessed the potential for impacts that could be associated with washing out of coal build up within the ballast.

Figure 1.1 identifies the parts of the QR Limited coal network that is the subject of this Environmental Evaluation.

Although previous studies by QR Limited have not identified a substantial risk of nuisance or harm associated with coal trains, this study has been triggered by:

- Dust complaints that have been received by QR Limited over a number of years
- Public perception of air quality problems in the Gladstone region as evidenced by recent media reports, and
- The commencement of a two year investigation into air quality in Gladstone by the EPA (Queensland Government, 2007)

The amount of coal that is transported from mines to the ports by QR Limited is projected to increase over the coming years and so there is a need to resolve the potential dust issues to ensure the future viability of the industry.

Figure 1.1 QR Limited Coal Systems Covered by Environmental Evaluation

In response to the requirements of the Environmental Evaluation a detailed study program has been undertaken including:

- Literature review
- Site inspections of representative infrastructure
- Consideration of dust complaints
- Monitoring of ambient dust levels in close proximity to the tracks at two locations on each of the Moura, Blackwater and Goonyella Systems and correlation with meteorological conditions and train movements
- Monitoring ambient dust levels at residential locations along the tracks at Gladstone, Mt Larcom, Hay Point and Grasstree
- Collation and analysis of ambient monitoring data that has been previously collected by QR Limited and others, where available
- Collation and analysis of available data relating to coal dustiness. Additional wind tunnel testing to supplement the available data
- Wind tunnel testing and computational fluid dynamics modelling to consider the effect of the load profile on relative dust emissions
- Dispersion modelling of dust emissions to estimate dust levels away from the tracks due to coal trains

- Identification of locations that are at risk of impact due to dust from coal trains, and
- Assessment of potential dust control measures and cost/benefit analysis

1.2 Overview of methodologies

The quantification and assessment of the potential for coal dust to escape from wagons and the rail corridor and to adversely affect residents and land uses adjacent to the rail corridor is complex. Given the timeframe for the Environmental Evaluation and the need for robust conclusions, this study has instigated a number of approaches to investigate the issue and to develop workable solutions. Prior to implementing the study program, the EPA was provided with an outline of the study methodology and, at that time, the EPA indicated its satisfaction with the approach.

The key components of the study are summarised below.

1.2.1 Literature review

A literature review has been undertaken to collate:

- Detailed information on the transport of coal via the Goonyella, Blackwater and Moura Systems for past, current and future years
- Relevant data that has been collected by QR Limited in relation to coal dust issues
- Data from ambient air quality monitoring studies that have been completed by QR Limited and others in the vicinity of the coal rail system
- Publicly available information on the emission rate of coal dust that could occur from coal wagons in transit
- Data and reports on the factors that can influence coal dust emissions from wagons with consideration of the experience of the staff of QR Limited, and
- Data that has been collected by the mines and ports in relation to the properties of the coal that is transported by the coal rail system

A summary report of the literature review is included in Appendix A.

1.2.2 Ambient air quality monitoring

An ambient air quality monitoring study has been conducted. The ambient air quality monitoring study has used sampling equipment and methodologies that are in accordance with the EPA's documented requirements, Australian Standards and the approaches adopted by the mines and ports. The objectives of the ambient air quality monitoring study that has been undertaken as part of the Environmental Evaluation are to:

a) Quantify the coal dust concentration and deposition rate at the edge and outside of the rail corridor
b) Correlate measurements of dust concentration with meteorological conditions
c) Correlate measurements of dust concentration with trains passing
d) Quantify contribution of coal trains to ambient concentrations of dust, and
e) Provide measurements to assist in validating dust emissions and dispersion modelling

This work is summarised in this report and more detailed information is presented in Appendix B.

1.2.3 Material characteristics wind tunnel - TUNRA

In addition to the existing data that has been collected by the mines and ports in recent years on the dustiness properties of coals from the Bowen and Callide Basins, detailed experiments have been undertaken to determine the thresholds for saltation and dust lift-off from the surface of coal wagons for typical coal types under simulated rail transport conditions. This work has utilised a specialised wind tunnel designed to quantify the dustiness moisture relationships of bulk materials and also the effectiveness of dust suppressant products.

This test program has investigated the performance of selected dust control products using the suppliers recommended solution strength and application rate, plus “equal cost” tests to evaluate performance against cost.

This work is summarised in this report and the detailed outcomes are presented in Appendix C.

1.2.4 Dispersion modelling

Dispersion modelling is the mathematical representation of the dispersion of air pollutants in the atmosphere. The dispersion model uses information on meteorological conditions as a basis of quantifying ground-level concentrations of air pollutants downwind of a source of air pollutants. Dispersion models are useful because they allow limited data to be extrapolated over a wide range of circumstances and can be used to test the effectiveness of pollution control strategies.

The Gaussian dispersion model, Cal3QHCR, is a line source model that is supplied by the United States EPA for quantification of near-field impacts from motor vehicles. This model has been used to quantify ground-level concentrations of coal dust associated with emissions from coal trains. Detailed information on current and future train movements, meteorological information and dust emission rates have been used to quantify ground-level concentrations of TSP and PM_{10} and dust deposition rates.

Ground-level concentrations have been assessed against the air quality goals that are discussed in Section 3.8 to establish the potential impact on human health and amenity of coal dust. The findings of the dispersion modelling have also been evaluated against ambient air quality monitoring.

1.2.5 Wagon and load profiling wind tunnel – University of Sydney and Computational Fluid Dynamics

The University of Sydney wind tunnel has been used to simulate the wind speed and turbulence intensities at the surface of coal wagons. Six coal wagons of a type that are typically used by QR have been modelled at 1:50 scale. This work has been used to investigate the susceptibility of wagons with “garden bed” load profiles and uneven load profiles to increased wind erosion. Work has also been undertaken to quantify the effect of “hungry boards” and other modifications on the emission rate of coal dust. The results of the wind tunnel modelling were used in a computational fluid dynamics modelling study to consider the following:

- Base case
- Review longitudinal turbulence for length of train
- Review more extensive train configurations
- Understand worst case velocity profiles (mean and variance) above coal surface
- Examine the effect of passing trains
- Assess the aerofoil deflectors to reduce mean and turbulent velocities
- Optimise height and shape of side “hungry boards”, and
- Examine the effect of inclined track

This work is summarised in this report and the detailed outcomes are presented in Appendix D.

2. QR Limited Coal Operations in Central Queensland

2.1 Background

Coal mining is Queensland's largest export industry with export sales in 2006/07 totalling about $15.5 billion. Total exports for the twelve months to March 2007 totalled 150.41 million tonnes and domestic use totalled approximately 27.2 million tonnes. Coal transport on the Goonyella, Blackwater and Moura Systems represents about 97% percent of total Queensland exports and domestic use of Queensland coals.

Coal is transported from open cut and underground coal mines in the Bowen and Callide Basins to the coal terminals and ports at Hay Point and Gladstone and for domestic use to the Stanwell and Gladstone Power Stations, Queensland Alumina Limited (QAL) and Fishermans Landing.

Table 2.1 Coal transported by QR Limited in Central Queensland by rail system (Mtpa[1]).

System	2002/03	2003/04	2004/05	2005/06	2006/07
Goonyella	76.8	80.0	88.3	83.8	88.4
Blackwater	39.4	40.5	44.5	46.9	50.5
Moura	10.0	10.9	11.2	11.0	12.6
Grand Total	126.2	131.4	144.0	141.7	151.5
Table Note: [1]Calculated from Gross Tonnage					

Demand for coal has increased significantly over the last decade due to its low cost and stable supply compared to other fossil fuels. Growth is expected to remain strong over the coming years leading to plans to expand most of the key coal terminals and the addition of a new coal terminal at Gladstone. The Bowen and Callide Basins produce high quality coking coal, pulverised injection coal and thermal coal that is exported to Japan, Korea, Taiwan, China, India, Europe and Brazil.

Works in progress, including committed track-capacity expansions, will provide a total rail coal haulage capacity on the Goonyella, Blackwater and Moura Systems, including coal to domestic markets, of about 177 Mtpa in 2008/9 (Table 2.2). By 2014/15, these systems are expected to transport 225.6 Mtpa with 29% of coal transported by the Blackwater System, 55% by the Goonyella System and 16% by the Moura System.

Table 2.2 Projected demand for coal as estimated by QR Limited (Mtpa)

System	2008/9	2009/10	2010/11	2011/12	2013/14	2014/15
Goonyella	100.9	121.4	123.3	123.3	123.3	123.3
Blackwater	58.9	65.3	65.3	65.3	65.3	66.3
Moura	17.2	16.6	16.6	16.6	16.6	36.0
Grand Total	177.0	203.3	205.19	205.2	205.2	225.6

2.2 Goonyella system

The Goonyella System services mines in the Bowen Basin and carries coal to the Dalrymple Bay Coal Terminal and the Hay Point Coal Terminal at Hay Point and other destinations by way of connections to the North Coast Line at Yukan and the Central Line via Gregory to Burngrove. The Goonyella System is illustrated in Figure 2.1.

Parts of the Goonyella System are bi-directional duplicated track with crossovers between Dalrymple Junction (7.975 km) and Broadlea (157.050 km) with the remainder being single line. The junction for the Peak Downs, Saraji, Norwich Park, German Creek and Oaky Creek line is at Coppabella (144.520 km), whilst the junction for the Blair Athol line is at Wotonga (174.020 km).

Balloon loops are located at all mines. The loading stations are owned and operated by the coal mines.

There is a single line connection from Oaky Creek to Gregory linking the Goonyella System with the Blackwater System. Dual unloading balloons are located at the Hay Point Coal Terminal and the Dalrymple Bay Coal Terminal. A third unloading balloon has recently been completed at Dalrymple Bay Coal Terminal. The unloading stations are owned and operated by the coal terminals.

The Goonyella System is electrified by an auto transformer system with overhead line equipment. The largest population areas on the Goonyella System are the towns of Moranbah, Sarina and Dysart.

Towns that are located along the Goonyella System are shown in Table 2.3.

Table 2.3: Towns located along the Goonyella System (ABS, 2006, Census of Population and Housing)

Town	Population	Town	Population
Grasstree Beach	544	Moranbah	7,133
Hay Point	1,386	Capella	796
Sarina	3,285	Clermont	1,854
Dysart	3,137		

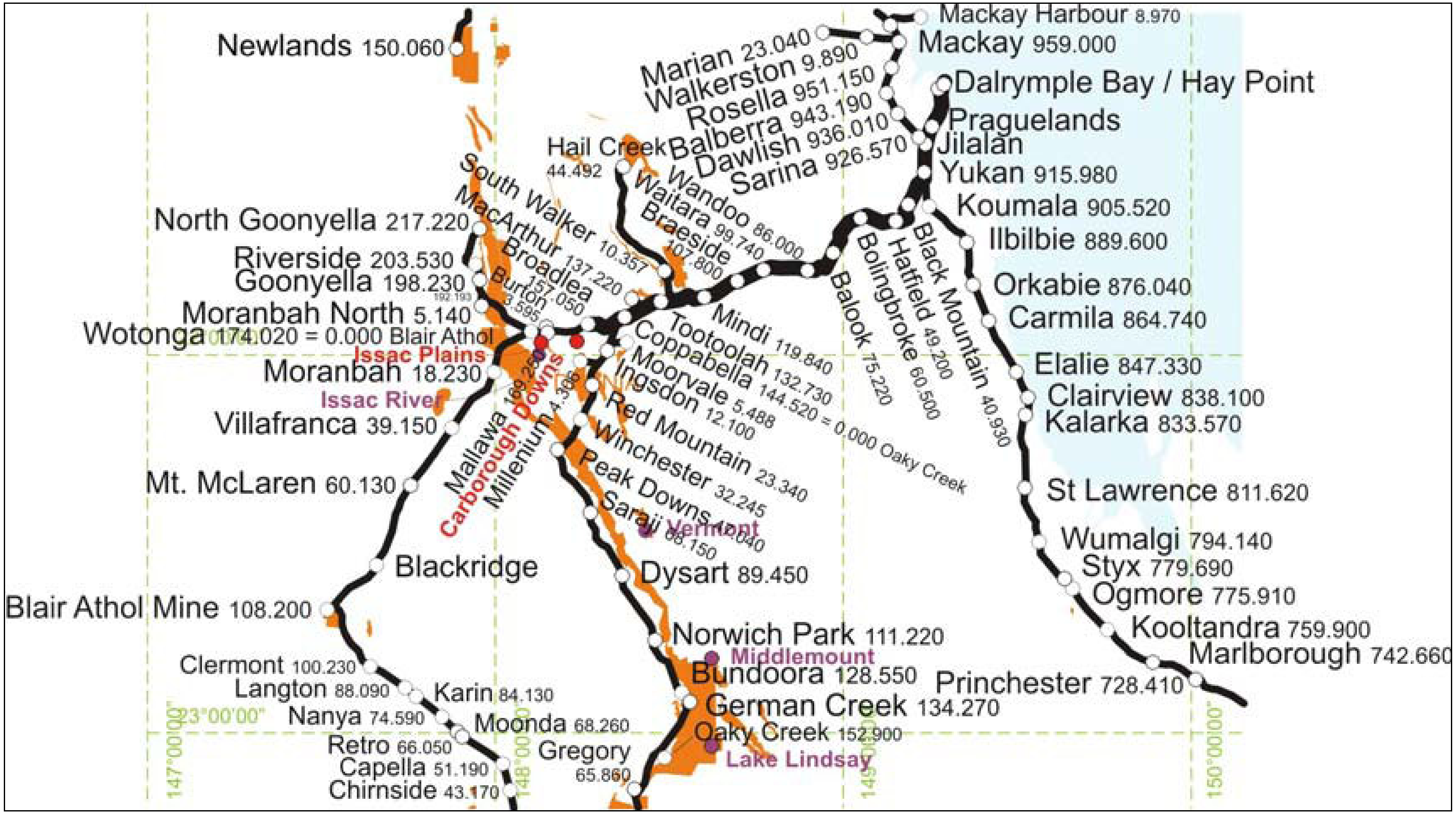

Figure 2.1 The Goonyella system and coal mines

Data that has been collected concurrently with the dust monitoring program is used here and subsequently to quantify coal tonnages on the coal transport systems.

Between 22 October 2007 and 2 March 2008, the Dalrymple Bay Coal Terminal received 53% of the coal transported on the Goonyella system, corresponding to 13.3 million tonnes whilst the Hay Point Coal Terminal received 47% (11.7 million tonnes). In 2006, the annual average percentage of coal shipped through the Dalrymple Bay Coal Terminal and Hay Point Coal Terminal were 61% and 39%, respectively. Table 2.4 provides a summary of the relative amounts of coal transported from each mine from 22 October 2007 to 2 March 2008. The Oaky Creek mine is the furthest from its destination with coal travelling about 300 kilometres to the coal terminal. The Macarthur mine is the closest mine to the port at about 144 kilometre transport distance.

Table 2.4: Mines that transport coal to port via the Goonyella system (22 October 2007 to 2 March 2008).

Mine	% of coal transported originating from mine	Distance between mine and terminal (kilometres)
Bidgerley	3.8%	160.0
Blair Athol	9.2%	282.2
Burton	2.6%	168.3
Carborough Downs	0.8%	160.8
German Creek	8.4%	278.8
Goonyella	10.3%	198.2
Gregory	1.2%	297.4
Hail Creek	6.6%	171.9
Isaac Plains	1.4%	171.9
MacArthur	3.3%	144.5
Millennium	6.0%	161.1
Moorvale	1.9%	152.9
Moranbah	5.4%	192.3
North Goonyella	2.8%	217.2
Norwich Park	4.7%	255.7
Oaky Creek	7.4%	297.4
Peaks Downs	11.0%	191.6
Riverside	6.3%	203.5
Saraji	6.8%	212.7

On the Goonyella system, there is an average of 21 trains per day travelling to the terminals and then returning to the mines. Each loaded train carries an average of 9,565 tonnes of coal. This results in a weekly average of 140 trains en route to the terminals. There is a small variation in the delivery of coal on this system during the week, with the minimum amount of coal delivered on Wednesday and the maximum on Sunday as can be seen in Table 2.5. Coal transport is lower on Mondays because scheduled maintenance occurs on this day.

Table 2.5: Weekly profile of trains on the Goonyella system (22 October 2007 to 2 March 2008).

Weekday	Average number of trains	Average tonnes of coal carried to terminal	% of total weekly coal tonnage
Sunday	23.2	224 069	16.1%
Monday	18.5	177 800	12.8%
Tuesday	21.3	204 284	14.7%
Wednesday	17.7	168 485	12.1%
Thursday	20.9	200 505	14.4%
Friday	20.7	199 266	14.3%
Saturday	22.4	218 371	15.7%

2.3 Blackwater system

The system primarily services coal mines off the Central Line and carries the product through to Stanwell Power Station, Gladstone Power Station and the Port of Gladstone via the North Coast Line. The Blackwater System is bi-directional duplicated track with crossovers between Callemondah and Rocklands, between Westwood and Windah, between Tunnel and Aroona and between Duaringa and Wallaroo, with the remainder being single line. The Blackwater System is illustrated in Figure 2.2.

Loading balloon loops are located at Boonal, Koorilgah, Laleham, Curragh, Boorgoon, Kinrola, Ensham, Kestrel and Gregory with a spur line at Fairhill for Yongala. The loading stations are owned and operated by the coal mines.

Three unloading balloons are located at the RG Tanna Coal Terminal with unloading balloons at Stanwell Power Station, Fisherman's Landing, Rio Tinto Aluminium, Gladstone Power Station, Auckland Point and Barney Point Coal Terminal. The unloading stations are owned and operated by the coal terminals and industries.

The Blackwater System is electrified by an autotransformer system with overhead line equipment.

Towns that are located along the Blackwater System are shown in Table 2.6. Gladstone is the largest population centre with a population of 31,000 people.

Table 2.6: Towns located along the Blackwater System (ABS, 2006, Census of Population and Housing)

Town	Population	Town	Population
Gladstone	31,000	Bluff	357
Mount Larcom	253	Blackwater	5,147
Raglan	263	Comet	233
Gracemere	5,061	Emerald	11,575
Stanwell	516	Capella	796
Duaringa	247	Clermont	1,854

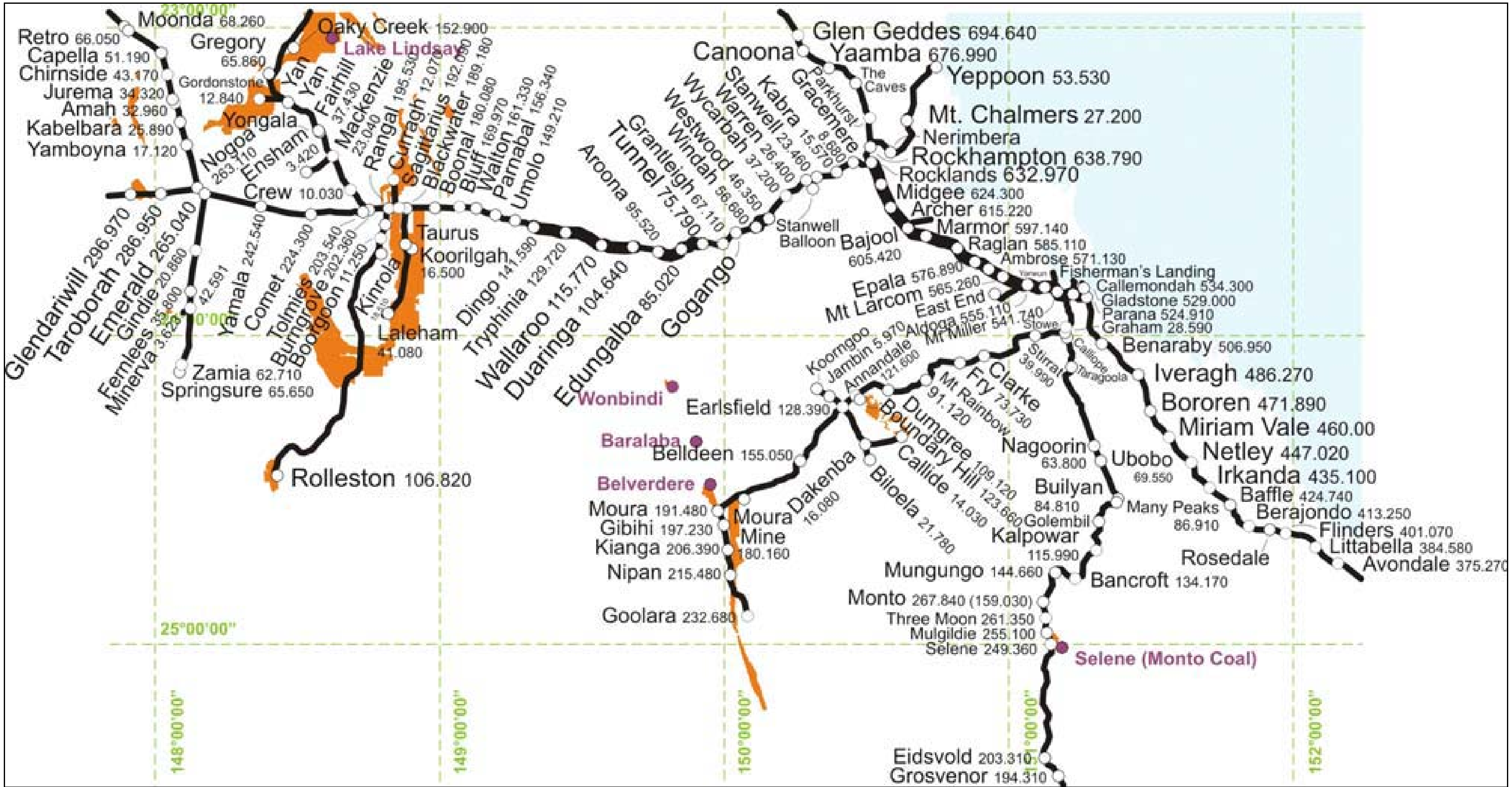

Figure 2.2 The Moura and Blackwater systems and coal mines

Between 22 October 2007 and 2 March 2008, 89% or 14.3 million tonnes of coal were transported to the RG Tanna Coal Terminal. Barney Point Coal Terminal received 5.9% (0.965 million tonnes), the Gladstone Power Station received 4.7% (0.76 million tonnes) and Fisherman's Landing received 0.6% (0.10 million tonnes). Table 2.7 provides a summary of the relative amounts of coal transported from each mine from 22 October 2007 to 2 March 2008 and the distances from each mine to its destination. The Rolleston mine is the furthest from its destination with coal travelling about 420 kilometres to the RG Tanna Coal Terminal. Although not shown in this data, coal is also transported via the Blackwater System to the Stanwell Power Station.

Table 2.7: Mines that transport coal to port via the Blackwater system (22 October 2007 to 2 March 2008).

Mine	Destination	% of coal transported that originates from mine	Distance between mine and destination (kilometres)
Blackwater	Barney Point	0.7%	287.9
	Fisherman's Landing	0.0%	287.9
	RG Tanna Terminal	7.5%	287.9
Blair Athol	RG Tanna Terminal	0.6%	483.0
Boonal	RG Tanna Terminal	12.5%	278.8
Boorgoon	Fisherman's Landing	0.2%	305.5
	RG Tanna Terminal	3.1%	305.5
Carborough Downs	Barney Point	0.4%	502.8
Curragh	Barney Point	1.3%	302.8
	RG Tanna Terminal	11.6%	302.8
Ensham	Fisherman's Landing	0.2%	342.8
	Gladstone Power Station	0.2%	342.8
	RG Tanna Terminal	10.7%	337.5
German Creek	RG Tanna Terminal	3.5%	394.7
Gordonstone	Barney Point	1.2%	364.9
	Fisherman's Landing	0.0%	364.9
	RG Tanna Terminal	4.4%	364.9
Gregory	Barney Point	0.1%	366.9
	Fisherman's Landing	0.1%	366.9
	RG Tanna Terminal	4.3%	297.4
Kinrola	RG Tanna Terminal	0.2%	312.7
Koorilgah	RG Tanna Terminal	0.8%	304.4
Laleham	Barney Point	1.2%	328.9
	RG Tanna Terminal	9.5%	328.9
Minerva	RG Tanna Terminal	5.2%	404.4
Oaky Creek	Barney Point	1.0%	366.9
	RG Tanna Terminal	6.1%	366.9
Rolleston	Gladstone Power Station	4.5%	419.2
	RG Tanna Terminal	8.6%	419.2
Yongala	RG Tanna Terminal	0.2%	338.5

The Blackwater system has an average of 18.1 trains per day travelling to unloading facilities and then returning to mines. Trains carry, on average, 6749 tonnes of coal. There is an average of 124 trains per week travelling to and from the unloading points. There is a small variation in the delivery of coal on this system during the week, with the minimum amount of coal delivered on Monday and the maximum on Saturday, as can be seen in Table 2.8. Coal transport is lowest on Mondays because scheduled maintenance occurs on this day.

Table 2.8: Weekly profile of trains on the Blackwater system (22 October 2007 to 2 March 2008).

Weekday	Average number of trains	Average tonnes of coal carried to terminal	% of total weekly coal tonnage
Sunday	20.5	139 182	16.1%
Monday	13.9	92 904	10.8%
Tuesday	18.6	127 492	14.8%
Wednesday	16.3	112 589	13.0%
Thursday	17.0	116 971	13.5%
Friday	19.4	132 432	15.3%
Saturday	20.7	141 841	16.4%

2.4 Moura system

The Moura System services the industrial and rural communities of the Dawson and Callide Valleys in Central Queensland with all trains being hauled by diesel electric locomotives. Coal product is hauled to the export facilities at RG Tanna Coal Terminal and Barney Point. The Moura System is illustrated in Figure 2.2 (page 16).

Trains destined for the RG Tanna Coal Terminal or the Power Station travel via the Byellee flyover, through Callemondah Yard, which is part of the Blackwater System and therefore under live overhead wires. Trains destined for Barney Point Coal Terminal and Auckland Point travel via the Moura Short Line, which is electrified as is the Barney Point line. The port facilities at RG Tanna Coal Terminal and Barney Point Coal Terminal are under the control of the Central Queensland Ports Authority.

The Moura System is single line with passing loops. There are balloon loops at Boundary Hill, Callide Coalfields and Moura Mine. The loading stations are owned and operated by the coal mines. The unloading stations are owned and operated by the coal terminals and industries.

Towns that are located along the Blackwater System are shown in Table 2.9. Gladstone is the largest population centre with a population of 31,000 people.

Table 2.9: Towns located along the Moura System (ABS, 2006, Census of Population and Housing)

Town	Population
Gladstone	31,000
Calliope	1,550
Biloela	5,371
Moura	1,774
Monto	1,159

Between 22 October 2007 and 2 March 2008, 55.8% or 2.2 million tonnes of coal were delivered to the RG Tanna Coal Terminal. The remainder of coal travelling by the Moura system was transported to Queensland Alumina Limited (14.3% or 0.55 million tonnes of coal), Barney Point Coal Terminal (13.6% or 0.53 million tonnes), the Gladstone Power Station (13.3% or 0.52 million tonnes) and Rio Tinto Aluminium (3.1% or 0.12 million tonnes).

Table 2.10 provides a summary of the relative amounts of coal transported from each mine from 22 October 2007 to 2 March 2008 and the distances from each mine to its destination. The Moura mine is the furthest from its destination with coal travelling approximately 180 kilometres to the RG Tanna Coal Terminal. The remainder of the mines are between 120 and 160 kilometres from the port.

Table 2.10: Mines that transport coal via the Moura system (22 October 2007 to 2 March 2008).

Mine	% of coal transported that originates from mine	Distance between mine and destination (kilometres)
Baralaba	2.6%	155.1
Boundary Hill	33.5%	123.7
Callide	5.3%	158.4
Moura	58.7%	180.2

The Moura system has an average of 7 trains per day travelling to the unloading facilities and then returning to the mines. Trains carry, on average, 4183 tonnes of coal. There is an average of 45.8 trains per week travelling to and from the unloading points. There is a small variation in the delivery of coal on this system during the week, with the minimum amount of coal is delivered on Monday and the maximum on Friday as can be seen in Table 2.11. As with the other systems, coal transport is lower on Monday because scheduled maintenance occurs on this day.

Table 2.11: Weekly profile of trains on the Moura system (22 October 2007 to 2 March 2008).

Weekday	Average number of trains	Average tonnes of coal carried to terminal	% of total weekly coal tonnage
Sunday	7.4	31 719	15.2%
Monday	6.2	25 573	12.3%
Tuesday	7.4	30 696	14.7%
Wednesday	6.8	28 947	13.9%
Thursday	6.8	28 947	13.9%
Friday	7.7	32 034	15.4%
Saturday	7.4	30 678	14.7%

3. Regulatory framework relevant to fugitive dust emissions from coal transport by rail

3.1 Summary

The overriding obligations of QR Limited in relation to the potential impacts of fugitive dust emissions from coal transport by rail are defined under the *Environmental Protection Act 1994* (The Act). These obligations include:

- To obtain relevant development permits and Registration Certificates for all Environmentally Relevant Activities that are undertaken. Principally, QR Limited holds Registration Certificates for rail maintenance facilities and petroleum storage and provisioning facilities. The Registration Certificates do not apply beyond the boundaries of the facility as defined in the Registration Certificate. Registration Certificates are not required for the transportation of coal by rail
- To abide by the conditions of any Registration Certificate that QR Limited holds
- In all areas including those areas that are not covered by Registration Certificates, to take all reasonable and practical steps to minimise Environmental Harm as defined under The Act
- To undertake activities in a manner that is consistent with the General Environmental Duty
- To abate unreasonable releases, and
- To comply with a Notice issued under The Act.

It should be noted that Environmental Harm is defined quite broadly and is not simply defined in terms of quantitative air quality goals. Consequently, Environmental Harm may be found to occur even if those air quality goals that are defined under The Act are not found to have been exceeded.

The air quality standards and goals that are currently recognised in the Act mainly relate to impacts on human health. There is, in some cases, information in the literature that can help us to quantify adverse impacts on some plants and animals and longer-term impacts on amenity, such as through deposition on surfaces. However, other potential effects of coal dust on amenity such as short-term degradation of visibility or short-term deposition rates are not well-studied and consequently thresholds for impact are not well defined.

Short-term objectives for TSP have been specified in recent approvals (eg the Wiggins Island Coal Terminal). However, these approvals lack a clear basis that articulates how the objectives have been determined.

In the absence of goals and standards that can be used to determine the degree of acceptability of a specific type of impact, it is important to consider the provisions of The Act and in particular, the General Environmental Duty that requires a person to take all reasonable and practicable measures to prevent or minimise environmental harm. Hence, to establish the acceptability of a particular incidence of potential environmental harm, the measures that are taken to prevent or minimise that harm need to be considered.

The following sections detail the regulatory framework that is applicable to fugitive dust emissions from coal transport by rail in Queensland.

3.2 *Environmental Protection Act 1994*

The Act is the primary legislation for environmental regulation in Queensland. The object of the Act is to protect Queensland's environment while allowing for development that improves the total quality of life both now and in the future, in a way that maintains the ecological processes on which life depends. In particular, the Act:

- Defines the EPA's powers to issue Notices to investigate and mitigate emissions

- Defines the framework for licensing Environmentally Relevant Activities (ERA). ERAs are defined in Schedule 1 of the *Environmental Protection Regulation 1998*
- In conjunction with the *Integrated Planning Act 1997 (IPA)*, defines the framework for the approval of new ERAs
- Defines environmental harm, the offences of causing environmental harm and penalties
- Defines the general environmental duty
- Defines best practice environmental management
- Gives the Minister for Sustainability, Climate Change and Innovation the power to create Environmental Protection Policies that identify and aim to protect environmental values of the atmosphere that are conducive to the health and well-being of humans and biological integrity. The Environmental Protection (Air) Policy was gazetted in 1997

3.3 Requirements of the EPA Notice

Under Sections 323 and 324 of the *Environmental Protection Act 1994*, the Queensland EPA has requested QR Limited to conduct an Environmental Evaluation (EE) of fugitive emissions of coal dust from trains. The Terms of Reference for the Environmental Evaluation are detailed in Section 1.

Section 323 of the Act states:

323 When environmental investigation required

(1) If the administering authority is satisfied on reasonable grounds—

(a) an event has happened causing environmental harm while an activity was being carried out or

(b) an activity or proposed activity is causing, or is likely to cause environmental harm; the authority may require the person who has carried out, is carrying out or is proposing to carry out the activity to conduct or commission an investigation (an environmental investigation) and submit a report on the investigation to it.

(2) The authority must, within 8 business days after deciding to make the requirement, give the person an information notice about the decision

(3) The person must comply with the requirement.

(4) This section does not apply if the administering authority requires an environmental audit for the event or activity

*(5) In this section—**activity** includes rehabilitation or remediation work*

Section 324 of the Act states:

324 Notice to conduct or commission environmental evaluation

(1) A requirement to conduct or commission an environmental evaluation must be made by written notice.

(2) The notice must—

(a) state the grounds on which the requirement is made and

(b) outline the facts and circumstances forming the basis for the grounds and

(c) state the relevant matters for the evaluation and

(d) state the day (at least a reasonable period after the notice is given) by which an environmental report must be submitted to the administering authority

3.4 Environmentally relevant activities

The purpose of Schedule 1 of the *Environmental Protection Regulation 1998* is to define Environmentally Relevant Activities (ERAs). Organisations that undertake ERAs are required to hold a development permit and a Registration Certificate and to abide by the conditions of the permit and Registration Certificate.

The transportation of coal by rail is not defined as an Environmentally Relevant Activity under Schedule 1 of the *Environmental Protection Regulation 1998* and consequently, the majority of QR Limited's coal transport infrastructure is not regulated as an ERA. QR Limited's facilities for refuelling, maintaining and repairing rolling stock, crude oil or petroleum storage and other ancillary activities are defined as an ERA. The Environment Permits for these facilities apply only to the place nominated in the permit and do not apply to the rail corridor that extends outside of these facilities. Stockpiling, loading and unloading of bulk goods such as coal at a port is defined as an ERA, but the ERA does not apply to the rail lines outside of the port precinct. The Registration Certificates for these ERAs are held by the owners or operators of the ports and loading facilities.

QR Limited holds Registration Certificates for the following ERAs relevant to the coal freight business:

- Rail facility for refuelling, maintaining and repairing rolling stock (ERA 72)
- Crude oil storing or petroleum product storing – crude oil or petroleum product in tanks or containers having a combined total storage capacity of 10000L or more but less than 500000L (ERA 11(a))
- Sewage treatment – operating – a standard sewerage treatment works having a peak design capacity to treat sewage of 100 or more equivalent persons but less than 1500 equivalent persons (ERA 15(b))
- Regulated waste treatment – operating a facility for receiving and treating regulated waste to render it less or non-hazardous, other than by (a) manufacturing a saleable product under another environmentally relevant activity; or (b) incineration; or (c) recycling, reprocessing or reconditioning under items 77 to 79 or 81 (ERA 85).

The EPA is responsible for the administration and enforcement of these ERAs.

QR Limited holds Registration Certificates for the following facilities related to the coal freight business for example:

- Jilalan Rolling Stock Depot (ERA 11(a), 15(b), 72, 85)
- Callemondah Rail Depot (ERA 72) and
- Mark Fenton Drive, Gladstone (ERA 11(a))

These Registration Certificates include the following conditions that relate to fugitive emissions of coal dust:

Release of Contaminants to the Atmosphere

(B1) Except as otherwise provided by the conditions of the air schedule of this environmental authority, the environmentally relevant activity must be carried out by such practicable means necessary to prevent or minimise the release or likelihood of release of contaminants to the atmosphere.

Dust Control

(B2) Dust is not allowed to create a nuisance off site.

Nuisance

(A5) Notwithstanding any other condition of this environmental authority, this environmental authority does not authorise any release of contaminants which causes or is likely to cause an environmental nuisance beyond the boundaries of the licenced place.

Agency Interest: Air
Air 1: *Nuisance*

The release of noxious or offensive odours or any other noxious or offensive airborne contaminants resulting from the activity must not cause a nuisance at any nuisance sensitive or commercial place.

The remainder of QR Limited's coal transport networks in the Moura, Blackwater and Goonyella Systems are not covered by a Registration Certificate. In these areas, QR Limited is subject to the General Environmental Duty. QR Limited's obligations under the General Environmental Duty and the Registration Certificates that it holds are essentially the same.

3.5 General Environmental Duty

The General Environmental Duty is defined under Section 319 of the Act and states:

General Environmental Duty

(1) A person must not carry out any activity that causes, or is likely to cause, environmental harm unless the person takes all reasonable and practicable measures to prevent or minimise the harm (the ***general environmental duty****).*

(2) In deciding the measures required to be taken under subsection (1), regard must be had to, for example—

(a) the nature of the harm or potential harm; and
(b) the sensitivity of the receiving environment; and
(c) the current state of technical knowledge for the activity; and
(d) the likelihood of successful application of the different measures that might be taken; and
(e) the financial implications of the different measures as they would relate to the type of activity.

3.6 Environmental harm and environmental value

Environmental Harm is defined in Section 14 of The Act as:

Environmental harm *is any adverse effect, or potential adverse effect (whether temporary or permanent and of whatever magnitude, duration or frequency) on an* ***environmental value****, and includes environmental nuisance.*

Environmental harm may be caused by an activity—

(a) whether the harm is a direct or indirect result of the activity; or

(b) whether the harm results from the activity alone or from the combined effects of the activity and other activities or factors.

Environmental nuisance is defined in Section 15 of The Act as:

> *Environmental nuisance is unreasonable interference or likely interference with an environmental value caused by-*
>
> *(a) noise, dust, odour, light; or*
> *(b) an unhealthy, offensive or unsightly condition because of contaminants; or*
> *(c) another way prescribed by regulation.*

Environmental Value is defined in Section 9 of The Act as:

> *Environmental Value is—*
>
> *(a) a quality or physical characteristic of the environment that is conducive to ecological health or public amenity or safety; or*
>
> *(b) another quality of the environment identified and declared an environmental value under an environmental protection policy or regulation.*

The Environmental Protection (Air) Policy 1997 (Section 3.8) defines air quality goals for heath related dust (i.e. PM_{10}) and for long-term nuisance (i.e. TSP). However, air quality goals are not defined for the protection of vegetation, fauna and short-term amenity impacts such as reduction in visibility or deposition.

3.7 Best practice environmental management

In assessing the acceptability of an environmental management plan, the EPA will consider the Best Practice Environmental Management of the activity. The Act defines best practice environmental management as:

> *Best practice environmental management*
>
> *(1) The best practice environmental management of an activity is the management of the activity to achieve an ongoing minimisation of the activity's environmental harm through cost-effective measures assessed against the measures currently used nationally and internationally for the activity.*
>
> *(2) In deciding the best practice environmental management of an activity, regard must be had to the following measures -*
>
> > *(a) strategic planning by the person carrying out, or proposing to carry out, the activity*
> >
> > *(b) administrative systems put into effect by the person, including staff training and monitoring and review of the systems*
> >
> > *(c) public consultation carried out by the person*
> >
> > *(d) product and process design*
> >
> > *(e) waste prevention, treatment and disposal.*
>
> *(3) Subsection (2) does not limit the measures to which regard may be had in deciding the best practice environmental management of an activity.*

3.8 Environmental Protection (Air) Policy and National Environment Protection (Ambient Air Quality) Measure

The Act gives the Minister for Sustainability, Climate Change and Innovation the power to create Environmental Protection Policies that identify and aim to protect environmental values of the atmosphere that are conducive to the health and well-being of humans and biological integrity. The Environmental Protection (Air) Policy (EPP(Air)) was gazetted in 1997. The administering authority must consider the requirements of the EPP(Air) when it decides an application for an environmental authority, amendment of a licence or approval of a draft environmental management plan. Schedule 1 of the EPP(Air) specifies air quality indicators and goals for Queensland. Indicators and goals that are relevant for this project are reproduced in Table 3.1. The EPA is currently undertaking a review of the EPP(Air).

The National Environment Protection Council defines national ambient air quality standards and goals in consultation, and with agreement from, all state governments. These were first published in 1997 in the National Environment Protection (Ambient Air Quality) Measure (NEPM(Air)). Compliance with the NEPM(Air) standards is assessed via ambient air quality monitoring undertaken at locations prescribed by the NEPM(Air) and that are representative of large urban populations. The goal of the NEPM(Air) is for the ambient air quality standards to be achieved at these monitoring stations within ten years of commencement; in 2008.

The National Environment Protection Council (NEPC) in conjunction with the various state governments, is currently reviewing the NEPM(Air).

The NEPM(Air) standards for PM_{10} are based on studies of exposure to urban air pollutants that includes the very fine particles associated with motor vehicles. Consequently, the application of these standards to coal dust emitted by coal trains is likely to overestimate the potential for adverse impact because coal dust is relatively coarse compared with the very fine particulate from motor vehicle exhausts. Notwithstanding this, these standards will be applied here as a screening level assessment to determine whether further consideration of the potential for health impacts is required.

The EPP(Air) goals are used to assess impacts at sensitive locations (such as residential areas and isolated dwellings) that are located near industrial activities. The EPP(Air) goals are therefore applicable to the activities of QR Limited. The NEPM(Air) standards are used to assess the exposure of large residential populations in urban centres.

There is no information that the authors are aware of that suggests that coal dust that would have a greater impact on human health than undifferentiated particles as PM_{10}.

Dust nuisance can occur due to the deposition of dust particles in residential areas. Elevated dust deposition rates can cause reduced public amenity through, for example, soiling of clothes, building surfaces and other surfaces. Table 5.1 shows the dust deposition guideline commonly used in Queensland as a benchmark for avoiding amenity impacts due to dust. The dust deposition guideline is not defined in the EPP(Air) and is therefore not enforceable by legislation, but was recommended by the EPA as a design goal. It is also recognised that this dust deposition guideline was established through surveys conducted in the Hunter Valley during the 1980s and relate to impacts over relatively long time periods from months to a year. This guideline does not deal with the potential impact of short-term dust levels that are elevated and that may cause adverse impacts to residential amenity as a consequence.

Table 3.1 Existing ambient air quality goals and guidelines

Pollutant	Goal/ Standard	Units	Averaging period	Source
Particulates as TSP[1]	90	µg/m³	Annual	EPP(Air)
Dustfall	120	mg/m²/day	Annual	Recommended EPA
Particulates as PM_{10}[2]	150	µg/m³	24 hour	EPP(Air)
	50	µg/m³	24 hour	NEPM(Air) Standard
	50	µg/m³	Annual	EPP(Air)

Table Note:

[1]TSP - Total suspended particulates.

[2]PM_{10} are particles that have aerodynamic diameters that are less than 10 µm.

Whilst the EPP(Air) describes air quality goals for biological integrity, there are no goals defined for the protection of flora, fauna or waterways from coal dust. All available information and studies suggest that the standards and goals that are defined to protect human health and amenity are more stringent than required to protect against dust impacts on flora, fauna and waterways.

Section 14 of the EPP(Air) defines the concept of an unreasonable release and requires that an unreasonable release is abated.

> *Management of certain sources of contamination*
>
> *Division 1 – Abatement of unreasonable releases of contamination to air environment*
>
> *In this division–*
>
> *"unreasonable release", of a contaminant to the air environment, means the release of odours, dust, smoke or other atmospheric contaminant that–*
>
> *(a) causes unlawful* environmental harm *and*
>
> *(b) is unreasonable having regard to the following matters–*
>
> *(i) its characteristics*
>
> *(ii) its intrusiveness*
>
> *(iii) other releases of contaminants at the place affected by the release*
>
> *(iv) where the effects of the release of the contaminant can be noticed*
>
> *(v) the order in which the person releasing the contaminant started to carry out the activity from which the release is made and persons affected by the release started to carry out other activities that may be affected by the release of the contaminant.*

Of significance is that an unreasonable release must cause unlawful environmental harm and be unreasonable having regard to five matters one of which is that the order in which the person releasing the contaminant and affected person began their activities.

3.9 Recent conditions of approval for coal terminals

The Wiggins Island Coal Terminal was approved by the Coordinator-General on 7 January 2008. The Coordinator-General's report attached at Appendix 1 Part 2 has a list of stated conditions that apply to the Environmentally Relevant Activity that includes construction and operation of the rail dump stations, coal terminal and port facilities associated with the Wiggins Island Coal Terminal. It is noted that the conditions impose air quality objectives that are tighter than those specified in the EPP(Air) for the protection of health and amenity. These objectives have been set by the EPA. However, there is no detailed description in the Coordinator-General's report of how these air quality objectives have been derived.

The objectives are summarised as follows:

Dust Management Objectives

(B13) Dust must not exceed the following levels:

Dust deposition

- *Less than four (4) grams total insoluble solids per square metre per month at site boundaries nearest the closest nuisance sensitive place*
- *Less than two (2) grams coal per square metre per month at site boundaries nearest the closest nuisance sensitive place*
- *Less than three (3) grams total insoluble solids per square metre per month (total) at any nuisance sensitive place*
- *Less than one (1) gram coal per square metre per month at any nuisance sensitive place*

Total Suspended Particulates (TSP)

- *Less than 50 micrograms per cubic metre above background, expressed as a 24 hour rolling average*
- *Less than 100 micrograms per cubic metre above background, expressed as a one hour rolling average*

NOTE: 'Above background' means the arithmetic difference between most upwind and most downwind monitoring points as depicted in Map 2.

PM_{10} Particulates

- *Less than 150 micrograms per cubic metre expressed as a 24-hour rolling average at the site boundary*
- *Less than 50 micrograms per cubic metre expressed as an annual rolling average at the site boundary*

NOTE: In respect of the PM10 (24 hour rolling average) objective, the holder of this development approval is not in breach of this limit if it can shown that other site(s), not impacted by the activities to which this development approval relates, is also in exceedence of this (24 hour) limit

The conditions of approval also require monthly monitoring of dust deposition rate and continuous monitoring of TSP and PM_{10} at locations to be determined in consultation with the EPA.

4. Potential sources of coal dust emissions from coal trains

Coal dust can be emitted from the following sources in the coal rail system:

- Coal surface of loaded wagons
- Coal leakage from doors of loaded wagons
- Wind erosion of spilled coal in corridor
- Residual coal in unloaded wagons and leakage of residual coal from doors
- Parasitic load on sills, shear plates and bogies of wagons

Each of these is discussed in the following sections.

4.1 Coal surface of loaded wagons

The coal surface of the loaded coal wagons is the major source of dust emissions from QR Limited trains. Table 4.1 shows the surface area of the open top of various wagon types. The total open surface area of a train with 122 wagons is about 4,000 square metres or 0.4 hectares. The total area of emission will depend on the profile of the coal that is loaded into the wagons. A flat 'garden bed' shape will have a smaller coal surface area than an irregularly shaped load. The effect of the load profile on the emission rate of dust is discussed in more detail in Section 5.7.

The magnitude of coal dust emissions from this source will depend on a number of factors, but most importantly on the level of exposure of the open surface to air moving at high speeds and the inherent dustiness of the material. Table 4.1 illustrates the fact that although the payload capacity of wagons can be different by more than 15%, the open area of the top of the wagon is relatively consistent.

Table 4.1 Dimensions of Common QR Limited Coal Wagons

Wagon type	Wagon mass, load (tonnes)	Exposed area at top
VCAS	106, 86	13.108 x 2.318 = 30.38m^2
VSHL	104, 80.2	13.0 x 2.597 = 33.76 m^2
VSAL	106, 85.6	13.108 x 2.317 = 30.37 m^2
VSNL	90, 69.6	13.0 x 2.356 = 30.63 m^2

Data supplied by QR Limited in relation to the train sets used on each of the systems indicates that wagons on the Moura System have a greater potential for dust emissions because they have, on average, smaller wagons with a greater surface area per tonne of coal shipped by 15% to 18% compared with the Blackwater and Goonyella Systems.

Wind tunnel modelling and observations indicates that the final two or three wagons emit more dust than others and that two or three wagons following the locomotives are shielded somewhat from the air flow and therefore tend to emit less.

Figure 4.1 is a photograph illustrating coal dust emissions from the surface of coal wagons. Visible dust emissions are atypical of normal operations based on observations and information collected during the Environmental Evaluation.

Figure 4.1 Photograph showing and example of coal dust emitted from the surface of coal wagons (Photograph taken by Jim Harrison on 15 December 2007 at Nebo road turnoff on Goonyella System)

4.2 Coal leakage from doors of loaded wagons

Coal can leak from the Kwik-Drop doors of the coal wagons during transit from the mine to the port. Whilst the doors of the wagons are designed to have a gap of less than 2 mm, empirical data collected by QR Limited suggests that the gaps could be up to 11 mm in some cases.

The amount of coal dust falling from the Kwik-Drop doors will depend on the nature of the coal being transported (e.g. moisture level, particle sizes) and the vibrational forces acting on the wagons. Dust particles falling from the Kwik-Drop doors may become entrained in the aerodynamic wake induced by the movement of the train.

There is no quantitative data that allows the relative contribution of door leakage to coal dust emissions to be quantified. It is likely that its contribution to environmental impacts outside of the corridor is relatively small compared to lift-off from wagons because:

- The relatively small surface area of release compared to the open surface of the coal wagons;
- The release height is relatively close to the ground and
- Air movement will be predominantly in the direction of the tracks with very little opportunity for cross winds to entrain the particles due to the shielding effect of the bogies and wagon structure

Some coals contain quite a lot of moisture and water can drain out of the Kwik-Drop doors and carry with it particles of coal. In this instance the coal is likely to fall directly into the ballast. Little, if any, is likely to be carried outside of the rail corridor.

Hence the majority of the material from the Kwik-Drop doors will fall into the ballast. Once in the ballast, the coal dust is unlikely to be re-entrained into the ambient air because of the shielding effect of the large ballast particles.

A preliminary upper bound estimate of the amount of coal dust emitted from the ballast is of the order of 400 tonnes per annum. This is based on USEPA emission factors for wind erosion of an exposed surface and accounting for the frequency of trains and the total length of the Blackwater, Moura and Goonyella Systems.

Notwithstanding the above, the loss of coal from the Kwik-Drop doors is an important issue for QR Limited and studies are currently underway to quantify door leakage and identify and implement mitigation measures.

Figure 4.2 is a photograph showing leakage of coal from Kwik-Drop doors. This degree of leakage is typical of trains observed during the Environmental Evaluation.

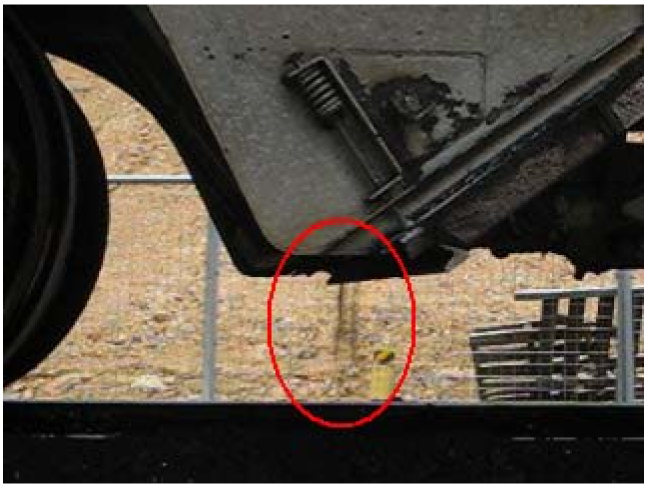

Figure 4.2 Photograph showing an example of coal leaking from Kwik-Drop doors (Photograph taken by Simon Welchman on 15 November 2007 at DBCT rail loop on Goonyella System)

4.3 Wind erosion of spilled coal in corridor

Coal can also be spilt from the tops of wagons. This occurs due to a combination of poor, uneven loading or overloading (volume) at the coal mine and the rocking and tipping of wagons in transit and on bends. Whilst the amount of coal that may be lost into the corridor can be significant, the amount of this material that is likely to be emitted as TSP is considered to be small relative to lift-off from wagons.

A preliminary upper bound estimate of the amount of coal dust emitted from coal deposited in the corridor is 600 tonnes per annum. This estimate is based on average coal deposition rates measured in the Blackwater System, assuming that this deposition rate occurs throughout all systems and that all of this deposited material is eventually emitted as dust.

4.4 Residual coal in unloaded wagons

Empty coal wagons travelling from the port back to the coal mines are a source of coal dust emissions due to the residual coal in the wagons. This residual coal can dry quickly and can become entrained in the air currents that develop in the empty wagons as the trains travel back to the mine. Empty trains can travel at up to 100 km/hr on the return journey. Some of this coal will fall into the wagon above the Kwik-Drop doors and if emitted will fall through the gap in the doors. As discussed above, the coal that falls through the Kwik-Drop doors is likely to remain in the ballast.

The CSIRO and QR Limited are conducting a study of the volume of coal that is left in the wagons after the train leaves the unloading station at the RG Tanna Coal Terminal. On average, the worst-case coal carry-back was found to be 0.13 tonnes per wagon (CSIRO et al, 2007).

Work undertaken in Canada (D. Cope Enterprises, 2001) indicates that about 2% of empty trains cause medium or high levels of dust emission. The travel distances within the Canadian coal transport systems are substantially larger than the Moura, Blackwater and Goonyella Systems and consequently frequency of dusty empty trains may be overestimated. Ambient monitoring work that was undertaken by Simtars at Callemondah (Simtars, 2008) suggests that, where the ambient concentration of dust is statistically higher than for loaded trains compared with unloaded trains, the loaded trains produce 1.3 to 1.8 times more dust than the unloaded trains.

CSIRO and QR Limited study this issue to identify ways to minimise the amount of coal carry-back.

4.5 Parasitic load

Coal dust can be emitted by the parasitic load that is carried by the wagons. The parasitic load is coal that is spilt on the sills, shear plates and bogies of the wagons during loading. Parasitic load can also occur due to coal ploughing that can occur during unloading the wagons at the port. Coal ploughing occurs when the rate of wagon unloading is too fast for the discharge pits at the port. This results in the buildup of coal above the discharge grates and the wagons travelling through the built up coal. Coal ploughing results in coal being carried on the wagon bogies.

Compared to the open surface of the coal wagon, the shear plates, sills and bogies are likely to provide about 20% additional surface area for emission if all of these surfaces are covered. Short-term observations at the Dalrymple Bay Coal Terminal rail corridor suggests that the sills are, at most, partly carrying coal and that the coal on shear plates may be build up and harden over a number of trips. Consequently, it is unlikely that the parasitic load is a substantial source of emissions and is estimated here to be of the order of 5% of total emissions from the surface.

The parasitic load that occurs as a result of coal ploughing may be a more important source of coal dust in close proximity to the rail loops in the afternoons in conjunction with the sea breeze. This is likely to be most important for the older unloading stations such as at Barney Point Coal Terminal. The newer unloading stations such as at Dalrymple Bay Coal Terminal and RG Tanna Coal Terminal have been designed to avoid the problems of some of the older unloading stations and so coal ploughing is an irregular occurrence.

Figure 4.3 and Figure 4.4 are photographs illustrating parasitic load on sills and bogies.

Figure 4.3 Photograph showing an example of coal on sills (Photograph taken by Simon Welchman on 15 November 2007 at DBCT rail loop on Goonyella System)

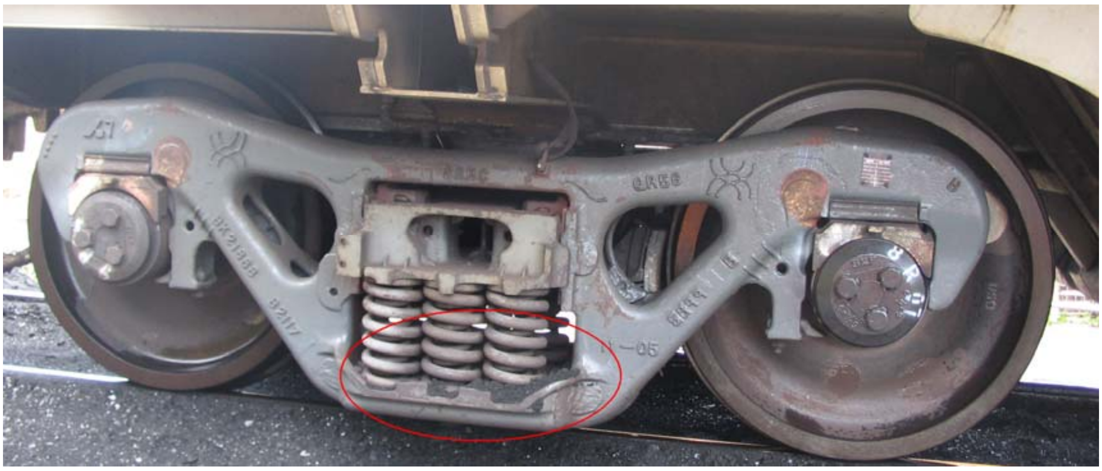

Figure 4.4 Photograph showing an example of coal on bogies (Photograph taken by Simon Welchman on 15 November 2007 at DBCT rail loop on Goonyella System)

5. Factors and circumstances contributing to dust emission rate

5.1 General description of coal dust lift-off

The focus of the available literature that considers the emission of coal from rail systems is focused on wind erosion of the loaded wagons and to a lesser extent on wind erosion of the unloaded wagons. Upper bound estimates of the emission rates from the other sources suggest that coal dust from the surface of loaded wagons is substantially greater. Notwithstanding this, the final report of this Environmental Evaluation will identify ways to reduce the risk being caused by coal dust from each source.

The primary mechanism for coal dust lift-off from QR Limited coal trains is the erosion of the transported coal by the movement of air. All of QR Limited's coal trains consist of open wagons, to facilitate quick and efficient loading from the top. This provides a substantial surface area of coal that may be subject to erosion. The airflow induced by the movement of the train travelling at a speed of 60-80 km/hr is the dominant factor with the effect of the ambient wind adding up to 10-15 km/hr on average and peaking at about 36 km/hr. The effect of the ambient wind will be greatest when the train is travelling directly into the wind. The influence of the ambient wind on dust emissions will be relatively minor when the wind is perpendicular or behind the train

The airflow across the wagon can move particles by three transport modes: suspension, saltation and surface creep. Saltation occurs when particles (from 75 to 500 μm in size) move and bounce in the layer close to the interface between the coal surface and the flow of air. Particles that are less than 75 μm in size are small enough to become suspended in the airflow and readily follow the air currents. Larger particles (from 500 to 1000 μm) move by surface creep propelled by wind and the impact of particles moving by saltation.

The surface wind speed (or friction velocity) at which dust begins to be raised from the surface is called the threshold friction velocity. Dust emissions will be negligible below the threshold friction velocity. The threshold friction velocity is intrinsic to the material. Wind tunnel testing of coals from the Callide and Bowen Basins has shown a wide variability in wind tunnel speeds that result in saltation and lift-off of coal dust.

Visual observations, ambient monitoring data and anecdotal evidence suggest that dust emissions from coal trains are not uniform. There are a range of factors that contribute to the magnitude of dust emissions from coal trains. The most important factors are discussed below based on a review of the literature and previous works undertaken by the authors and QR Limited.

5.2 Coal properties

Works undertaken at the coal terminals show that the dustiness of coals is variable between mines. The variability between coal types is likely to be related to a range of different characteristics of each of the coals, such as:

- Hydrophobic/hydrophilic nature
- Density
- Chemical composition
- Fines content and particles size distribution

The individual influence of each of these characteristics on dustiness has not been studied in detail. However, the relative dustiness of coals has been measured in terms of the dust extinction moisture level (DEM) and the wind speeds that can cause saltation, minor and major dust lift-off.

At the ports, the addition of water is a traditional and effective method of controlling airborne dust emission. However, coal in transit will be subject to a reduction in moisture level due to evaporation, seepage, or when exposed to hot dry and windy conditions.

There is a direct relationship between dustiness and moisture content of coal. A laboratory test procedure has been developed, as detailed in Australian Standard AS 4156.6-2000, Coal Preparation Part 6: Determination of dust/moisture relationship for coal, to determine the relationship between moisture content and dustiness for each coal type. From this procedure it is possible to determine the DEM for each coal type.

A series of laboratory tests have been previously conducted on more than 30 typical coal types that are shipped through the Dalrymple Bay, Hay Point and RG Tanna Coal Terminals to determine the relationships between wind speed, dustiness and moisture content. The tests were conducted at the Tunra Bulk Solids Handling Research Associates (Tunra) laboratory at the University of Newcastle.

The program was conducted to simulate the typical condition in which various coal types depart from coal loading facilities prior to commencement of the rail transport operation from mine to port.

The tests were conducted on coal samples that were prepared with a mass moisture level equal to 75% of the relevant DEM to simulate the typical moisture content prior to loading of a coal wagon. Each sample tray was placed in an oven for 30 minutes exposed to a temperature of 30 degrees Censius to simulate the average loading time for a wagon located at the mid position in a train and exposed to typical weather conditions.

Tests were conducted using sample trays inclined at slopes of 10 degrees or 37 degrees to simulate a range of slopes that may occur in the load profile.

After a train departs from the loading point and travels along the transport route the coal surface will lose more moisture due to evaporation, so it is possible that dust lift-off may start to occur at lower wind speeds than those observed in the laboratory test program.

The wind speeds of saltation, minor and major lift-off for the thirty tested coal types are shown in Table 5.1 and Table 5.2 for coal surface inclinations of 37 degrees and 10 degrees. It is important to note from the table that the saltation wind speeds are substantially lower than the peak train travel speeds of 60-80 km/hr when loaded. This means that except when the train is stopped or travelling quite slowly, the speed of air moving across the surface of the wagons may be sufficient to induce dust liftoff.

For the coal samples tested the wind tunnel speed at which saltation occurs ranged between 13 km/hr and 27 km/hr and major liftoff occurred in the range of 27 km/hr to 53 km/hr for samples at 37 degree incline. For the majority of coals, major dust lift-off occurs for wind speeds below 40 km/hr.

The wind tunnel speed required for dust liftoff is generally higher for the 10 degree incline samples.

Table 5.1 Wind speed at which saltation, minor dust lift-off and major dust lift-off was observed from coded coal samples at 37 degree incline

Material	Saltation (m/s, km/hr)	Minor Dust Lift-off (m/s, km/hr)	Major Dust Lift-off (m/s, km/hr)
A1	6.1, 22.0	8.1, 29.2	9.8, 35.3
B1	5.7, 20.5	6.1, 22.0	7.5, 27.0
C 1	5.1, 18.4	6.8, 24.5	9.5, 34.2
D1	5.8, 20.9	7.6, 27.4	10.5, 37.8
E1	3.6, 13.0	5.5, 19.8	8.4, 30.2
F1	5.0, 18.0	6.9, 24.8	9.3, 33.5
G1	4.9, 17.6	6.7, 24.1	10.1, 36.4
H1	4.3, 15.5	5.8, 20.9	7.8, 28.1

Material	Saltation (m/s, km/hr)	Minor Dust Lift-off (m/s, km/hr)	Major Dust Lift-off (m/s, km/hr)
I1	5.1, 18.4	6.5, 23.4	11.8, 42.5
J1	5.3, 19.1	6.7, 24.1	8.5, 30.6
K1	5.9, 21.2	7.8, 28.1	11.2, 40.3
L1	5.8, 20.9	7.6, 27.4	9.8, 35.3
M1	4.4, 15.8	5.8, 20.9	9.3, 33.5
N1	5.0, 18.0	7.2, 25.9	9.5, 34.2
O1	5.1, 18.4	6.7, 24.1	11.2, 40.3
P1	4.4, 15.8	7.0, 25.2	9.6, 34.6
Q1	5.0, 18.0	7.0, 25.2	9.7, 34.9
R1	5.6, 20.2	7.0, 25.2	8.5, 30.6
S1	7.4, 26.6	9.7, 34.9	11.6, 41.8
T1	6.5, 23.4	8.4, 30.2	10.4, 37.4
U1	6.0, 21.6	7.5, 27.0	10-12, 36-43.2
VI	4.5, 16.2	7.5, 27.0	10-11.6, 36-41.8
W1	4.4, 15.8	5.8, 20.9	10.0, 36.0
X1	4.0, 14.4	5.8, 20.9	9.5, 34.2
Y1	4.6, 16.6	5.6, 20.2	10.0, 36.0
Z1	5.9, 21.2	7.5, 27.0	11.3, 40.7
AA1	5.8, 20.9	8.7, 31.3	12.0, 43.2
AB1	5.6, 20.2	8.1, 29.2	10.0, 36.0
AC1	5.9, 21.2	8.4, 30.2	11.2, 40.3
AD1	7.5, 27.0	9.6, 34.6	14.8, 53.3

Table 5.2 Wind speed in metres per second at which saltation, minor dust lift-off and major dust lift-off was observed from coded coal samples at 10 degree incline

Material	Saltation (m/s, km/hr)	Minor Dust Lift-off (m/s, km/hr)	Major Dust Lift-off (m/s, km/hr)
A1	6.3, 22.7	8.8, 31.7	11.1, 40.0
B1	6.1, 22.0	8.1, 29.2	11.6, 41.8
C1	5.5, 19.8	7.6, 27.4	12.6, 45.4
D1	5.6, 20.2	7.2, 25.9	9.6, 34.6
E1	5.4, 19.4	6.7, 24.1	9.4, 33.8
F1	5.7, 20.5	8.2, 29.5	9.6, 34.6
G1	6.6, 23.8	7.7, 27.7	9.5, 34.2
H1	5.5, 19.8	7.1, 25.6	8.3, 29.9
I1	7.4, 26.6	8.6, 31.0	10.7, 38.5
J1	5.7, 20.5	7.4, 26.6	9.1, 32.8
K1	6.0, 21.6	9.1, 32.8	11.5, 41.4
L1	6.0, 21.6	8.5, 30.6	11.1, 40.0
Ml	5.4, 19.4	7.1, 25.6	9.5, 34.2
N1	6.0, 21.6	7.1, 25.6	10.2, 36.7
O1	7.2, 25.9	8.9, 32.0	10.3, 37.1
P1	5.0, 18.0	7.8, 28.1	10.2, 36.7
Q1	6.4, 23.0	8.9, 32.0	10.8, 38.9
R1	7.4, 26.6	8.7, 31.3	10.4, 37.4
S1	7.0, 25.2	9.6, 34.6	12.0, 43.2
T1	6.8, 24.5	9.0, 32.4	11.6, 41.8

5.3 Train speed and ambient wind speed

As discussed earlier, it is most likely that the primary mechanism for coal dust lift-off from QR Limited coal trains is the erosion of the transported coal by the movement of air. However, there is limited information available that can directly relate the emission rate of coal dust from a train to the speed of air flowing over the coal surface. The air speed travelling across the coal surface will be the combination of the speed of travel of the train and the component of the wind in the local area travelling against the direction of travel of the train.

For a loaded train travelling at 80 km/hr the air speed travelling across the coal surface may reach 120 km/hr on rare occasions due to the local wind. On average, the local wind would probably add about 10-15 km/hr to the air speed travelling across the surface of the coal.

In the literature, the rate of dust lift-off is commonly reported to vary in proportion to the speed of air travelling across the surface raised to the power of two or three. For example, Parrett (1992) and Witt et al (1999) report quadratic functions that relate the air speed to the rate of dust emission. McGilvray (2006), in a literature review that was undertaken for QR Limited, summarised the work of Bagnold (1954) that showed that the dust emission rate is likely to vary with the air speed (expressed as the friction velocity) raised to the power of three, as follows:

$$\frac{\dot{m}}{A} = c_1 . u_*^3 \ \ if \ \ u_* \geq u_{*t} \qquad \text{Equation 1}$$

Where:

- $\dot{m}$ is the mass emission rate;
- A is the area of emission;
- C_1 is the constant;
- U_* is the surface friction velocity, and
- U_{*t} is the threshold of surface friction velocity.

Figure 5.1 shows the relative rate of dust lift-off based on Witt et al (1999). The quadratic function that was reported in Witt et al (1999) was based on wind tunnel measurements of dust lift-off and computational fluid dynamics modelling of a simulated conveyor. This figure indicates that the rate of dust lift-off is likely to almost double with an increase in air speed from 60 km/hr to 80 km/hr. A similar increase in lift-off is found with the Bagnold (1954) relationship.

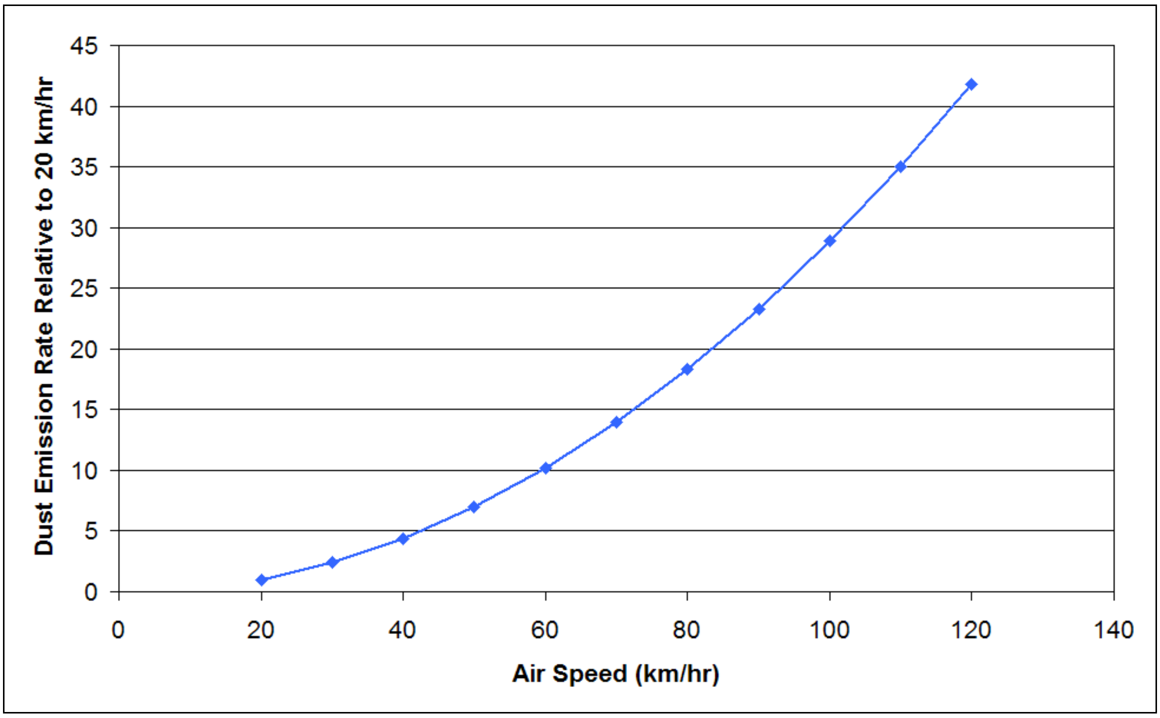

Figure 5.1 Dust emission rate due to airflow across an erodable surface based on Witt et al (1999)

Given the above, the parts of the rail transport system that are relatively exposed to the local wind will have a greater potential for dust lift-off compared with areas that are somewhat sheltered, such as in a cutting. Frequent moderate to strong winds that are associated with the sea breeze in coastal areas are also likely to lead to a greater degree of dust lift-off than at inland locations.

Table 5.3 presents a summary of wind statistics for various locations that are relevant to this Environmental Evaluation. More detailed information is presented in Appendix E. The data indicates that strongest winds occur more frequently at Mackay.

Table 5.3 Average Wind Speed and Frequency of Moderate and Strong Winds at Various Locations Representative of the Moura, Blackwater and Goonyella Systems

Monitoring Location	Average Wind Speed (km/hr)	Frequency of Moderate and Strong Winds - > 18 km/hr (%)
Emerald	14.0	13.5%
Gladstone	13.8	16.6%
Mackay	18.0	36.3%
Moranbah	5.6	2.7%
Rockhampton	11.9	8.4%
Thangool	5.7	4.9%

As part of this Environmental Evaluation, QR Limited has instigated a wind tunnel study and computational fluid dynamics modelling to investigate this issue further and to quantify the beneficial reduction in dust emissions that can be achieved through various mitigation measures. A summary report of this work is included in Appendix D.

5.4 Train passing a loaded train

Significant lengths of the QR Limited Coal transport systems have duplicated (or more) tracks allowing trains to pass travelling in opposite directions. Empty trains can travel at up to 100 km/hr and can, therefore, induce significant air flows and turbulence within the region of the neighbouring tracks.

The induced turbulence and airflow from the passing trains will enhance the emission rate of dust from both trains.

On average on the Goonyella and Blackwater Systems, each loaded train is likely to pass about 6 or 7 unloaded trains whilst travelling from the mine to the port. At top speed, the trains will take about 45 seconds to pass. Hence the potential enhancement of dust emissions during a journey of seven or more hours will be much less than 1%.

At the point where the trains pass, the emission rate may increase by a factor of 5-10 depending on the degree to which the unloaded train contributes to dust emissions and the magnitude of turbulence induced by the trains. However, even given this, the total increase in dust due to passing trains is unlikely to be more than 1%.

On single lines, unloaded trains are normally stopped in the crossing loop whilst a loaded train passes. Only on double track can trains pass potentially contributing to a higher relative wind speed.

5.5 Train frequency or system throughput

The emission rate of coal dust from coal trains will increase in proportion with any increase in the frequency of train movements or the coal throughput of the coal transport system; in the case of the latter, provided the characteristics of the coal transport system (e,g. train speed), mix of coal types and so on, remain unchanged.

5.6 Train vibration

Evidence from coal fouling of ballast indicates that coal loss is more intense in areas where the vibration forces are greater. This is consistent with Parrett (1992) that indicates that disturbance of the surface of static stockpiles of material increases the emission rate of dust particles. Vibration could also cause coal particles to break, producing finer material that will be lifted more readily from the coal surface.

More significantly, train vibration is likely to enhance the spillage of coal from the surface of heavily loaded wagons and from Kwik-Drop doors.

5.7 Profile of coal load

The profile of the coal load refers to the shape of the exposed surface of coal above the sill of the wagon. Anecdotal evidence and previous works undertaken by QR Limited (e.g. McGilvray, 2006) indicate that coal loads in wagons that are shaped in an irregular way, such as with multiple peaks, can produce more dust than a flat 'garden bed' shape (Figure 5.2). Poorly loaded wagons can also spill coal onto the ballast and within the corridor (Figure 5.3).

The irregularly shaped load has a greater erodible surface area and is subject to greater air speeds than the 'garden bed' shape. Wind tunnel modelling that has been commissioned by QR Limited and is currently in progress shows that the three mound case (representing the irregularly shaped load) exhibits slightly higher velocities and turbulence intensities than the 'garden bed' configuration (Connell Wagner, 2007).

The effect of the greater turbulence intensities and air speeds across the coal surface will increase the dust emission rate from each irregularly shaped wagon.

Figure 5.2 Photograph showing a 'garden bed' shape load profile (Photograph taken by Jim Harrison at Boggabri Coal on 13 July 2007)

Figure 5.3 Photograph showing a poorly loaded wagon

5.8 Transport distance

Emission factors that are used to determine coal dust emission rates from trains carrying coal in Canada (D Cope Enterprises, 2001) are dependent on the distance that the train travels. This is logical given the preceding discussion of other factors that influence the magnitude of coal dust emissions from wagons. In particular, the speed and vibration of the trains will ensure that there is a continual supply of coal particles that may be emitted from the coal surface and so trains travelling larger distances will produce more coal dust.

Other factors may also exacerbate coal dust emissions at the end of a long journey such as the evaporation of moisture from the surface of the coal.

5.9 Precipitation

A review of Canadian emission factors for emissions of coal dust from trains (D Cope Enterprises, 2001), suggests that coal dust emissions will be essentially zero on days where the rainfall exceeds 3 mm. This is quite a coarse assumption that may be reasonable in the Canadian context to calculate total dust emission rates across a network.

For the purpose of site specific assessment, rainfall is likely to reduce or eliminate coal dust emissions where moderate to heavy rain falls on the wagons. After the rain event, the surface of the coal will dry out and dust levels will increase.

6. Quantification of Coal Dust Emissions from Coal Trains

6.1 Literature Review

There is limited data available on the emission rate of coal dust from coal trains. There are substantial challenges to be overcome to achieve a direct measurement of coal dust emissions in a full scale situation; however, there is data available where this has been achieved. Alternatives to direct measurement are the use of wind tunnel experiments and scale models. Often wind tunnel experiments are used in conjunction with computational fluid dynamics (CFD) modelling to provide a wider range of solutions. Wind tunnel and CFD modelling has been conducted for this study to quantify beneficial reductions in coal dust emissions due to the application of various mitigation measures.

Ambient monitoring data can also be used in conjunction with a dispersion model to estimate dust emission rates or to assess the veracity of emission estimates. The latter approach has been used here in conjunction with literature estimates of emission rates.

Emission factors are also commonly used to estimate emission rates of dust from fugitive dust sources. These emission factors have generally been derived using a combination of ambient measurement and dispersion modelling. In Australia, emission factors are published in the National Pollutant Inventory (NPI) Handbooks. These handbooks have generally been adapted from the emission factors that have been published in the United States and Europe (eg. United States EPA, AP-42). The emission factors contained in the NPI Handbooks and US EPA AP-42 are not directly related to emissions of coal dust from trains. For slower running trains (eg. 25-40 km/hr), the stockpile emission factors have been used in past studies and are likely to be reasonable. However, train speeds of more than 60 km/hr are outside the range of applicability for the stockpile emission factors.

In Canada, emission factors were developed to quantify coal dust emissions from coal trains travelling from mine to port during the late 1970s and early 1980s (D Cope Enterprises, 2001). These emission factors are based on three research studies that suggest that, for uncontrolled trains travelling over a distance of 1100 km on rough terrain during dry conditions, the maximum potential coal losses (in the form of TSP) are estimated to be in the range from 0.5% to 3.0% of the total coal load. This is equivalent to a rate of 0.0045 kg/tonne/km to 0.027 kg/tonne/km. For trains with uncontrolled dust emissions, the lower end of this range is recommended for use. Emission rates of PM_{10} are calculated by multiplying the TSP emission factor by 0.5. (D Cope Enterprises, 2001)

Given the age of these studies, their applicability to coal trains in Queensland is difficult to ascertain. Preliminary dispersion modelling using an emission rate that is consistent with those reported in Canada (that is, 0.5% loss of total load over an 1100 km journey) would suggest that the peak ground-level concentration of TSP would be 2500 $\mu g/m^3$ to 14000 $\mu g/m^3$ (1-hour average) at about 10 metres from the railway line. This is substantially greater than has been measured beside coal freight lines in Queensland.

More recently, Ferreira et al (2003) conducted full-scale measurements of coal dust emitted from coal trains. Coal dust was collected in bags mounted on top of the wagon whilst the train travelled from port to a power station in Portugal. The average train speed for a 350 km transit was estimated to be between 55 and 60 km/hr. Train speeds reached a peak of 65 km/hr to 85 km/hr. Overall the train speeds, transport distances and climatic conditions during the sampling were comparable to conditions in the study area for this Environmental Evaluation.

The total emission rate for uncontrolled coal wagons was found to be 9.6 g/km/wagon. This is equivalent to about a fiftieth of the emission rates calculated using the Canadian approach. Preliminary dispersion modelling indicates that the peak concentration of TSP would be of the order of about 300 µg/m³ to 400 µg/m³ (1-hour average) at about 10 metres from the railway line. This is consistent with peak measurements adjacent to coal freight lines in Queensland (Section 7).

As discussed earlier, Witt et al (1999) reported on wind tunnel and CFD modelling that was undertaken on conveyors carrying dusty materials. The quadratic relationship between the speed of air travelling across the conveyor has been used in this study to represent the relationship between relative mass emission rate and the air speed travelling across the wagon. From this and the emission rates reported by Ferreira et al (2003), an air speed based emission factor equation has been derived as follows:

$$m = k1.v^2 + k2.v + k3 \qquad \text{Equation 2}$$

Where:

m is the mass emission rate of coal dust (as TSP) from the wagon surface in g/km/tonne of coal transported
k1 is a constant with a value of 0.0000378
k2 is a constant with a value of -0.000126
k3 is a constant with a value of 0.000063, and
v is the air velocity travelling over the surface of the train in km/hr

6.2 Estimates of Dust Emissions from Coal Transport Systems

From the above discussion, the average annual emission rate of TSP from the surface of coal trains travelling on the Goonyella, Blackwater and Moura Systems can be estimated. The TSP emission factor calculated from Equation 2 has been used in conjunction with the transport distances and coal proportions detailed in Section 2, average travel times provided by QR Limited, the annual tonnage for 2006/07 and the projected tonnages for 2010/11 and 2014/15. For this analysis we have assumed that the average ambient wind speed is about 15 km/hr.

The results of this analysis are presented in Table 6.1 and show that in 2006/07 the emission rate of coal as TSP is estimated to be in the order of 5400 tonnes per annum. This is estimated to increase to 7814 in 2014/15. The Blackwater System has disproportionately higher dust emissions than the other Systems because of the relatively longer transport distances.

Table 6.1 Estimated Emission Rate of Coal as TSP from the Surface of QR Limited Coal Wagons for 2006/07 Actual Tonnage Transported and for Projected Tonnages for 2010/11 and 2014/15

System	2006/07			2010/11			2014/15		
	Coal (Mtpa)	Coal as TSP (tonnes)	[1]Coal as TSP (%)	Coal (Mtpa)	Coal as TSP (tonnes)	[1]Coal as TSP (%)	Coal (Mtpa)	Coal as TSP (tonnes)	[1]Coal as TSP (%)
Goonyella	88.4	2501	0.0028	123.3	3489	0.0028	123.3	3489	0.0028
Blackwater	50.5	2548	0.0050	65.3	3295	0.0050	66.3	3346	0.0050
Moura	12.6	367	0.0029	16.6	483	0.0029	36	1048	0.0029
Total	151.5	5416	0.0036	205.2	7267	0.0035	225.6	7882	0.0035

Table Note:
[1]Proportion of total coal transported that is emitted as TSP.

The estimates in Table 6.1 for 2006/07 have additionally been recalculated for an average transport speed that is reduced by 10 km/hr. The total TSP emitted per year is 44% lower in this scenario. This suggests that increases in coal tonnages and train speeds in recent years are likely to have contributed significantly to increases in coal emitted from the surface of wagons.

Table 6.2 presents estimates of the mass of coal emitted from the surface of coal wagons in each of the coal rail transport systems for projected coal tonnages for 2014/15 with the assumption that average travel speeds increase by 10 km/hr. For 2014/15, the total TSP emitted per year is estimated to be 41% higher for this scenario.

Table 6.2 Estimated Emission Rate of TSP from the Surface of QR Limited Coal Wagons for Projected Tonnages for 2010/11 and 2014/15 and Assuming an Increase in Train Speed of 10 km/hr

System	2010/11 + 10 km/hr			2014/15 + 10 km/hr		
	Coal (Mtpa)	Coal as TSP (tonnes)	[1]Coal as TSP (%)	Coal (Mtpa)	Coal as TSP (tonnes)	[1]Coal as TSP (%)
Goonyella	123.3	4956	0.0040	123.3	4956	0.0040
Blackwater	65.3	4602	0.0070	66.3	4672	0.0070
Moura	16.6	670	0.0040	36	1453	0.0040
Total	205.2	10228	0.0050	225.6	11082	0.0049

Table Note:
[1]Proportion of total coal transported that is emitted as TSP.

Figure 6.1 shows the relative proportions of coal dust emissions from the Goonyella, Blackwater and Moura coal rail systems based on the estimates of coal dust emissions from the key emissions sources within the coal transport network. Approximately 80% of coal dust emissions are due to the surface of the coal wagons. Based on this analysis the priority sources of coal dust are:

- Lift-off from the surface of loaded wagons
- Lift-off from spilled coal in the corridor
- Door leakage
- Parasitic load, and
- Residual coal in unloaded wagons

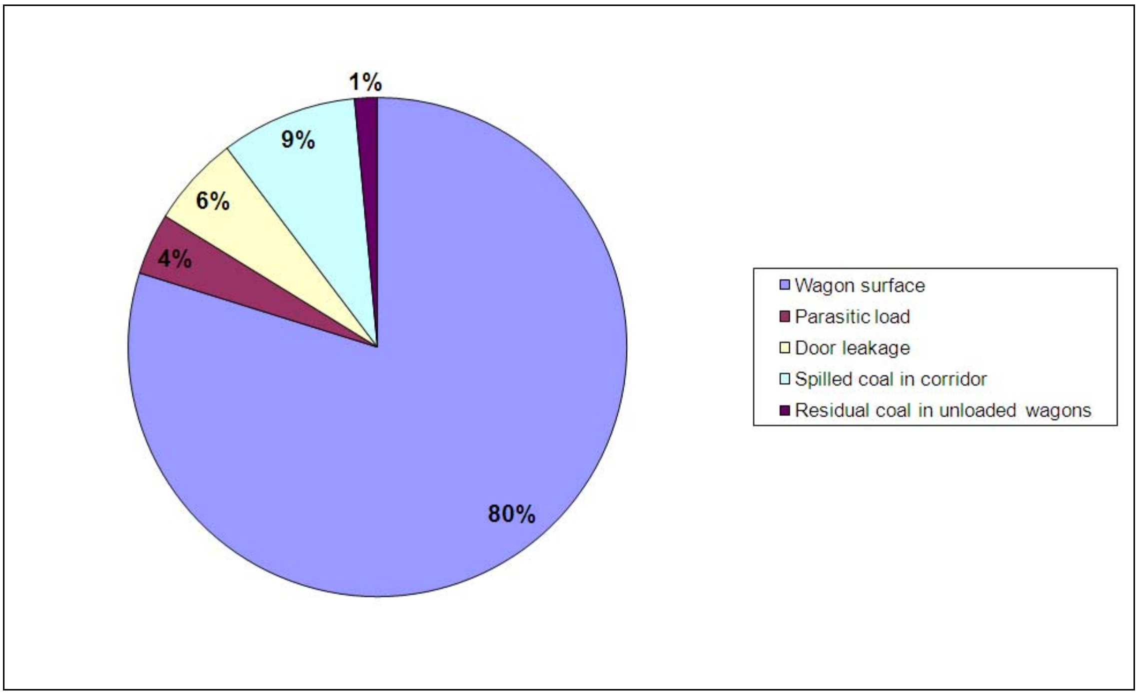

Figure 6.1 Pie chart showing proportion of coal dust emitted from the wagon surface, door leakage, spilled coal in the corridor, parasitic load and residual coal in unloaded wagons

7. Quantification of environmental impacts of coal dust

7.1 Ambient air quality monitoring

Various air quality studies have been commissioned by QR Limited to investigate the potential for adverse air quality impacts due to trains carrying coal. A short description of each study is included below and is followed by a summary of the outcomes of each study assessed against air quality goals for human health and amenity. The final section considers short-term averages and the contribution of coal trains to short-term peak concentrations.

Note that in the analysis of the monitoring studies that are discussed in Sections 7.1.1, 7.1.2, 7.1.3 and 7.1.4, concentrations of TSP and PM_{10} are presented that are undifferentiated in most circumstances. Therefore, the monitoring results include any contribution due to coal dust from wagons and contributions from other background sources of dust, such as agricultural activities and urban air pollutants.

In some cases, TSP data is compared to health based standards for PM_{10}. The TSP data is not strictly comparable to the health based air quality standards because the health based standards are for $PM_{10.}$ However, PM_{10} is a subset of TSP and so if the concentration of TSP is below the standard then, by definition, so too is the concentration of PM_{10}. If the concentration of TSP is above the standard, then account needs to be taken of the proportion of TSP that is PM_{10} before a conclusion can be reached as to whether the standard has been exceeded. Note also that the air quality standards are not applicable within the rail corridor but a comparison with air quality standards is conducted here to assess the likelihood that they would be exceeded outside of the corridor due to trains carrying coal.

7.1.1 Description of monitoring studies undertaken near rail lines

Studies prior to 2004

A number of monitoring studies have been undertaken to investigate whether emissions of coal dust from trains are likely to cause adverse impacts. Of key relevance to the Environmental Evaluation is:

- Gladstone Dust Monitoring Study 1993-94: monitoring of concentrations of TSP was undertaken using a TEOM at four sites in close proximity to rail lines in Gladstone, namely
  - Telecom yard in Far Street 30 metres from the edge of the rail line
  - Sewage treatment plant
  - Callemondah rail yards approximately 10 metres from the centre of the rail line and
  - Provisioning yard (1 km west of Callemondah) approximately 10 metres from the edge of the rail line

Simtars study at Praguelands, 2004

Simtars undertook a study of air quality at locations adjacent to a coal freight line between Jilalan and Hay Point from June to September 2004. Measurement of the following parameters was undertaken:

- Dust deposition rates on both sides of the track
- PM_{10} concentration on both sides of the track at 16 metres and 20 metres from the edge of the rail line using Partisol and Dust Scan
- $PM_{2.5}$ concentration on one side of the track at 9 metres from the edge of the rail line
- Continuous monitoring of dust concentrations using a DustTrak on both sides of the track at 9 metres and 10 metres from edge of the rail line
- Monitoring of wind speed, wind direction, rainfall and humidity at 10-minute average resolution at about 13 metres from the rail line

A discussion of the results of this study is included in Sections 7.1.2 and 7.1.3.

Simtars study at Callemondah, 2007

Simtars undertook a study of air quality at locations adjacent to a coal freight line at the feeder station near Callemondah in Gladstone from April to October 2007. Measurement of the following parameters was undertaken:

- Dust deposition rates at 3 metres (and 0.5 metres above ground) and 10 metres (and 2 metres above ground) downwind of the edge of the coal freight line
- TSP concentration at 5-minute average resolution using a TEOM with ACCU[1] system
- Monitoring of wind speed, wind direction, rainfall and humidity at 5-minute resolution at about 13 metres from the coal freight line every sixth day
- PM_{10} concentration at 24-hour average resolution using Partisols 10 metres upwind and downwind of the edge of the coal freight line
- PM_{10} concentration at 5-minute average resolution using a DustTrak light-scattering device at 10 metres downwind of the edge of the coal freight rail line
- Compositional analysis of selected filters collected using the Partisols and the TEOM ACCU system, and
- Train pass information

A discussion of the results of this study is included in Sections 7.1.2, 7.1.3 and 7.1.4.

Monitoring study conducted for Environmental Evaluation 2007-08

Monitoring of ambient concentrations of TSP has been undertaken using Partisols at the following locations detailed in Table 7.1. Photographs of some of these monitoring stations are shown in Figure 7.1, Figure 7.2, Figure 7.3 and Figure 7.4.

Table 7.1 Locations of Ambient Monitoring Stations for Monitoring Undertaken as Part of the Environmental Evaluation

Location	Equipment	Location	Period
Off Lane, Gladstone	Partisol	Residential	November 07
Side Street, Gladstone	Partisol	Residential	October 07 – January 08
Raglan Street, Mt. Larcom	Partisol	Residential	October 07 – November 07
Kin Kora Caravan Park, Hay Point	Partisol	Residential	November 07 – February 08
Hay Point Road, Hay Point	Partisol	Residential	December 07 – February 08
Horsborough Road, Hay Point	Partisol	Residential	January 08 – February 08
Grasstree Road, Sarina	Partisol	Residential	January 08 – February 08
Ironside Road, Sarina	Partisol	Residential	January 08 – February 08
Beecher, Gladstone: Moura System	TEOM	Corridor	October 07 – December 07
Earlsfield: Moura System	TEOM/OSIRIS	Corridor	December 07 – February 08
Raglan: Blackwater System	TEOM	Corridor	October 07 – December 08
Boonal: Blackwater System	TEOM/OSIRIS	Corridor	December 07 – February 08
Praguelands: Goonyella System	TEOM	Corridor	October 07 – February 08
Mindi: Goonyella System	OSIRIS	Corridor	January 08 – February 08

[1] Automated Cartridge Collection Unit

Figure 7.1 Photograph of Monitoring Station Installed for the Environmental Evaluation at Grass Tree Beach Road, Sarina

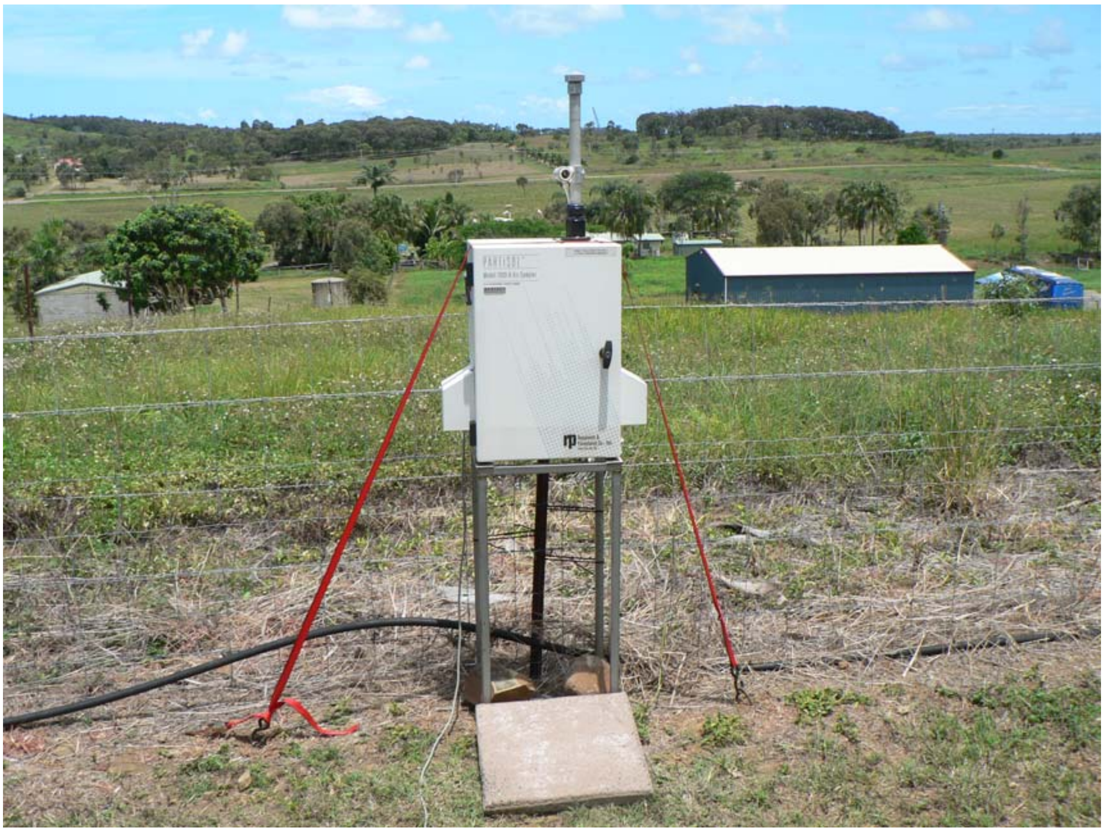

Figure 7.2 Photograph of Monitoring Station Installed for the Environmental Evaluation at Hay Point Road, Hay Point

Figure 7.3 Photograph of Monitoring Station Installed for the Environmental Evaluation at Horsborough Road, Hay Point

The residential monitoring locations were chosen based on community consultation and information on complaints associated with dust from coal trains. Measurements have been conducted over the period from October 2007 until February 2008.

Laboratory reports of the results of sampling are included in Appendix B. A discussion of the results is included in Section 7.1.2.

Continuous monitoring of ambient concentrations of TSP has been undertaken at approximately ten metres from the tracks using TEOMs and OSIRIS monitors. The continuous monitoring has been conducted to quantify dust levels in close proximity to the tracks to provide information on potential impacts and short-term concentrations for quantifying coal variability and to assist in the dispersion modelling study.

Monitoring using OSIRIS equipment has also been undertaken with the TEOMs to determine the suitability of this equipment for long-term monitoring adjacent to the rail corridor. This work had mixed success and is presented in Appendix B.

Figure 7.4 Photograph of Monitoring Station Installed for the Environmental Evaluation at Mindi

7.1.2 Assessment against air quality goals for human health

Studies prior to 2004

For each of the studies that were undertaken adjacent to QR Limited rail lines in the 1990s, dust levels were found to be below heath based air quality goals.

Simtars study at Praguelands, 2004

A summary of the 24-hour average concentrations collected by Partisol adjacent to the freight line is shown in Table 7.2. Whilst the EPP(Air) goal and NEPM standard do not apply within the rail corridor, the monitoring results have been compared to this health related goal to assess the likelihood that the goal would be exceeded outside of the rail corridor due to trains carrying coal.

Table 7.2 Concentration of PM_{10} ($\mu g/m^3$) collected by Partisol at various distances from the coal freight line at Praguelands, 24-hour average (Simtars, 2004).

Location	Maximum	Minimum	Average
West 20 metres	46	3	16
West 9 metres	70	6	19
East 10 metres	38	9	13
East 16 metres	44	9	13

The 24-hour average concentration of PM_{10} was below the EPP(Air) goal on all occasions. The peak concentration of 70 $\mu g/m^3$ occurred on 20 July 2004 and was found to be the result of earthworks in the local area.

Simtars study at Callemondah, 2007

A summary of the 24-hour average concentrations of PM_{10} that were collected by the Partisol upwind (south) and downwind (north) of the coal freight line is shown in Table 7.3. This table shows the maximum, minimum and average concentrations measured at the upwind and downwind locations and the maximum, minimum and difference between the paired measurements that were collected at the same time. Whilst the NEPM(Air) standard and the EPP(Air) goal do not apply within the rail corridor, the monitoring results have been compared to these health related standards and goals to assess the likelihood that they would have be exceeded outside of the corridor due to trains carrying coal.

The 24-hour average concentration of PM_{10} exceeded the EPP(Air) goal of 150 µg/m³ on two occasions during the monitoring period. These occurred on 31 May and 6 June with concentrations of PM_{10} of 156 µg/m³ and 168 µg/m³, respectively. Neither event was found to be caused by dust from coal trains. Compositional analysis indicates that salt contributed most significantly to the measurement on 31 May and coal dust contributed little. On 6 June the upwind measurement was 137 µg/m³, suggesting that the coal freight line was a minor contributor and other unidentified dust emission sources are likely to have contributed most significantly.

On one occasion the 24-hour average concentration of PM_{10} exceeded the NEPM(Air) standard of 50 µg/m³ at the downwind location. This occurred on 25 April when a concentration of PM_{10} of 82 µg/m³ was measured. At the same time, a concentration of 52 µg/m³ was measured at the upwind site.

Table 7.3: Concentration of PM_{10} (µg/m³) collected by Partisol at 10 metres downwind (north) and upwind (south) of the coal freight line at Callemondah, 24-hour averages (Simtars, 2008).

Month	North			South			Difference		
	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave
April 2007	26	24	25.3	24	18	21.3	8	0	4
May 2007	156	20	54.3	83	12	34.8	73	-2	19.5
June 2007	168	5	48.5	137	3	39.5	31	-1	9
July 2007	19	12	15.3	14	12	13	6	0	2.25
August 2007	26	3	17.3	22	2	15.8	6	-4	1.5
September 2007	30	2	18.3	29	3	17.4	8	-3	1.3
October 2007	15	14	14.5	18	17	17.5	-2	-4	-3.0

Figure 7.5 provides a plot of 24-hour average concentrations of TSP that were measured at Callemondah from April to October 2007. Throughout the monitoring period the concentration of TSP is below the EPP(Air) goal of 150 µg/m³ and the NEPM(Air) standard of 50 µg/m³ for PM_{10}. The peak 24-hour average concentration of TSP of 48 µg/m³ was measured on 13 October 2007. A compositional analysis of the filter that was collected on this day indicates that 10% of the sample was coal dust.

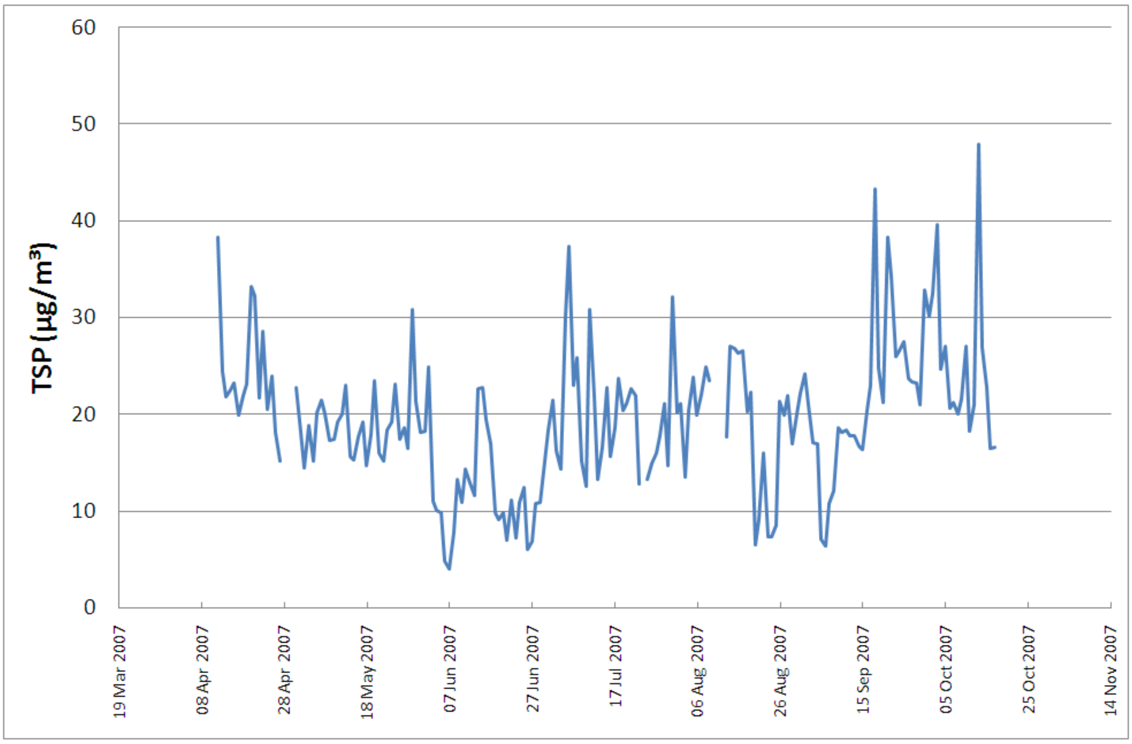

Figure 7.5 24-hour Average Concentration of TSP Measured at Callemondah from (October – December 2007)

Monitoring study conducted for Environmental Evaluation 2007-08

Monitoring was undertaken over discrete 24-hour periods using Partisol monitors. The results of monitoring at residential locations is summarised in Table 7.4. Throughout the monitoring period the concentration of TSP was below the EPP(Air) goal of 150 µg/m³. Note that the TSP data is not strictly comparable to the health based air quality standards because the health based standards are for PM_{10}. PM_{10} is a subset of TSP and PM_{10} is generally found to be 50% of TSP. On five occasions, the concentration of TSP was above the NEPM(Air) standard of 50 µg/m³ for PM_{10}. However, given the likely size distribution, the concentration of PM_{10} is unlikely to have been above the NEPM(Air) standard.

Table 7.4 Results of monitoring of the concentration of TSP (µg/m³) at residential locations adjacent to coal transport systems (24 hr average)

Monitoring location	Max	Min
Off Lane, Gladstone	30	19
Side Street, Gladstone	52	8
Raglan Street, Mt. Larcom	54	20
Kin Kora Caravan Park, Hay Point	39	8
Hay Point Road, Hay Point	96	1
Horsborough Road, Hay Point	89	8
Grasstree Beach Road, Sarina	50	9
Table Note: No data was available for Ironside Road.		

Table 7.5 provides a summary of 24-hour average concentrations of TSP that were measured at Beecher, Praguelands, Raglan, Boonal and Earlsfield. From October to December 2007, the concentration of TSP measured at Beecher, Praguelands and Raglan was below the EPP(Air) goal of 150 µg/m³ and the NEPM(Air) standard of 50 µg/m³ for PM_{10}, as can be seen in Figure 7.6.

Table 7.5 24-hour average TSP concentration statistics (µg/m³) for Beecher, Praguelands, Raglan, Boonal and Earlsfield.

Monitoring Site	24-hour Average TSP Concentration Statistics		
	Maximum	Minimum	Average
Beecher	43.6	7.8	26.6
Praguelands	39.9	7.1	20.3
Raglan	46.0	7.3	19.1
Boonal	66.2	7.8	32.0
Earlsfield	35.5	5.7	14.5

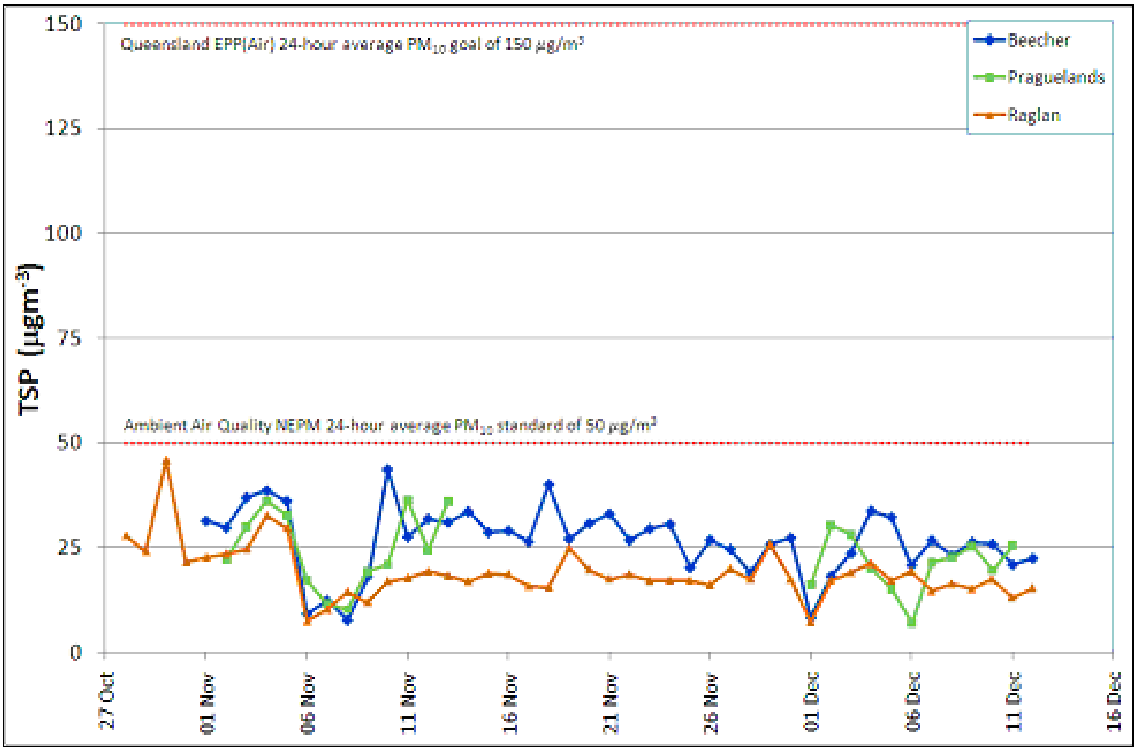

Figure 7.6 24-hour average Concentration of TSP (µg/m³) measured at about 10 metres from the tracks at Beecher, Praguelands and Raglan (October to 11 December 2007).

Figure 7.7 provides a plot of 24-hour average concentrations of TSP that were measured at Praguelands, Boonal and Earlsfield from December 2007 to February 2008. Throughout this monitoring period, the concentration of TSP was below the EPP(Air) goal of 150 µg/m³. The measurements at Boonal and Earlsfield were below the NEPM(Air) standard of 50 µg/m³ for PM_{10}; however, this standard was exceeded on four occasions at Praguelands. Given the likely size distribution of the dust, the PM_{10} standard is unlikely to have been exceeded in reality.

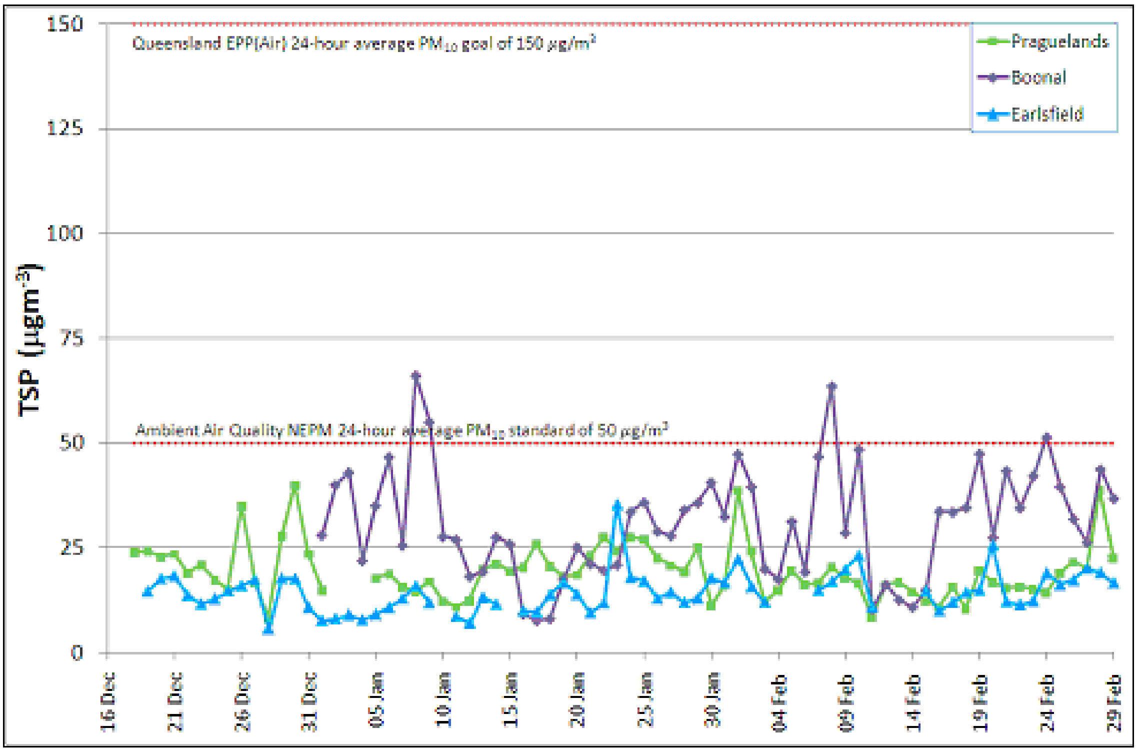

Figure 7.7 24-hour average concentration of TSP (µg/m³) measured at about 10 metres from the tracks at Praguelands, Boonal and Earlsfield (December 2007 to 29 February 2008)

7.1.3 Assessment against air quality goals for amenity

Simtars study at Praguelands, 2004

Dust deposition rates were measured for a one-month period at various distances from the rail line. The results indicate that the dust deposition rate at 5 metres from the tracks could cause nuisance impacts. At 10 metres and beyond, nuisance impacts were found to be unlikely to occur. The benchmark for nuisance is 120 mg/m²/day (annual average).

Simtars study at Callemondah, 2007

Dust deposition rates were measured every month for a six-month period from April to October 2007. The dust deposition rate samples were submitted for compositional analysis. The results of dust deposition monitoring at 3 metres and 10 metres from the edge of tracks on the downwind side are included in Table 7.6.

Table 7.6: Dust deposition and coal deposition rates (mg/m²/day) measured at 3 metres and 10 metres from the tracks at Callemondah

Sample dates	Location	Insoluble solids	Coal
15 Apr – 10 May 07	North 10 m	58	26
10 May – 12 Jun 07*	North 10 m	21	15

Sample dates	Location	Insoluble solids	Coal
14 Jun – 17 July 07*	North 10 m	23	17
17 July – 16 Aug 07	North 10 m	46	30
16 Aug – 16 Sept 07*	North 10 m	35	23
17 Sept – 15 Oct 07	North 10 m	43	15
15 Apr – 10 May 07	North 3 m	263	79
10 May – 12 Jun 07*	North 3 m	166	75
14 Jun – 17 Jul 07*	North 3 m	177	89
17 Jul – 16 Aug 07	North 3 m	137	55
16 Aug – 16 Sept 07*	North 3 m	142	57
17 Sept – 15 Oct 07	North 3 m	209	73
Table Note: *Dust gauge covered for one day during rail grinding			

The generally accepted threshold dust nuisance is 120 mg/m^2/day as the average of twelve consecutive monthly samples of insoluble solids. Whilst twelve samples were not collected at Callemondah, Table 7.6 indicates that the nuisance threshold is likely to be exceeded at 3 metres from the edge of the tracks. At 10 metres from the edge of tracks, the dust deposition rate is, at most, 58 mg/m^2/day. The dust deposition rate is unlikely to exceed the nuisance threshold at 10 metres from the tracks. At 10 metres from the edge of the tracks, the coal deposition rate ranged between 35% and 75% of insoluble solids.

7.1.4 Short-term concentrations and contribution from coal trains

There are no short-term air quality standards or goals that have been set in Queensland to protect residential amenity from impacts due to coal dust. It is likely that a threshold that could relate the effects on aesthetics or visible of emissions of TSP due to passing coal trains would need to be based on measurements over a short averaging period. The TEOMs that have been used in the monitoring conducted for the Environmental Evaluation and previously by QR Limited at Callemondah can report data for averaging periods of a short as 5-minutes or 1-hour.

A summary of this short-term data is provided below with assessments, where possible, of the degree that coal trains are likely to contribute to measurements of dust.

Simtars study at Callemondah, 2007

A summary of the concentrations of TSP measured by the TEOM is shown in Table 7.7. The highest average and maximum concentration of TSP were measured during April 2007 and were 25 μg/m^3 and 800 μg/m^3, respectively. Compositional analysis of TEOM filters indicates that the 24-hour average concentrations of TSP are between 5% and 30% coal dust.

Table 7.7 TSP concentration (µg/m³) collected by TEOM at 10 metres downwind of the coal freight line at Callemondah, 5-minute averages (Simtars, 2008).

Month	Mean	Maximum
April 2007	25	800
May 2007	19	246
June 2007	12	485
July 2007	20	570
August 2007	19	332
September 2007	22	345

A plot of the cumulative frequency distribution of concentrations of TSP measured at Callemondah (1-hour averages) is shown in Figure 7.8. This plot shows the maximum 1-hour average concentration of TSP to be about 170 µg/m³. For about 1% of the time (or 88 hours per year), the concentration of TSP that was measured at Callemondah was found to be more than 70 µg/m³. For about 0.2% of the time (or 19 hours per year), the concentration of TSP was found to be more than 100 µg/m³. The available data on the proportion of TSP that is coal suggests that the peak 1-hour average concentration of coal dust at 10 metres from the edge of rail lines is likely to be significantly less than the maximum concentration of TSP of 170 µg/m³.

This data indicates that it is unlikely that during the monitoring period the concentrations of TSP associated with coal trains would have caused nuisance at locations outside of the rail corridor.

It is likely, however, that coal dust may have been visible in the vicinity of the coal trains at Callemondah on a very infrequent basis.

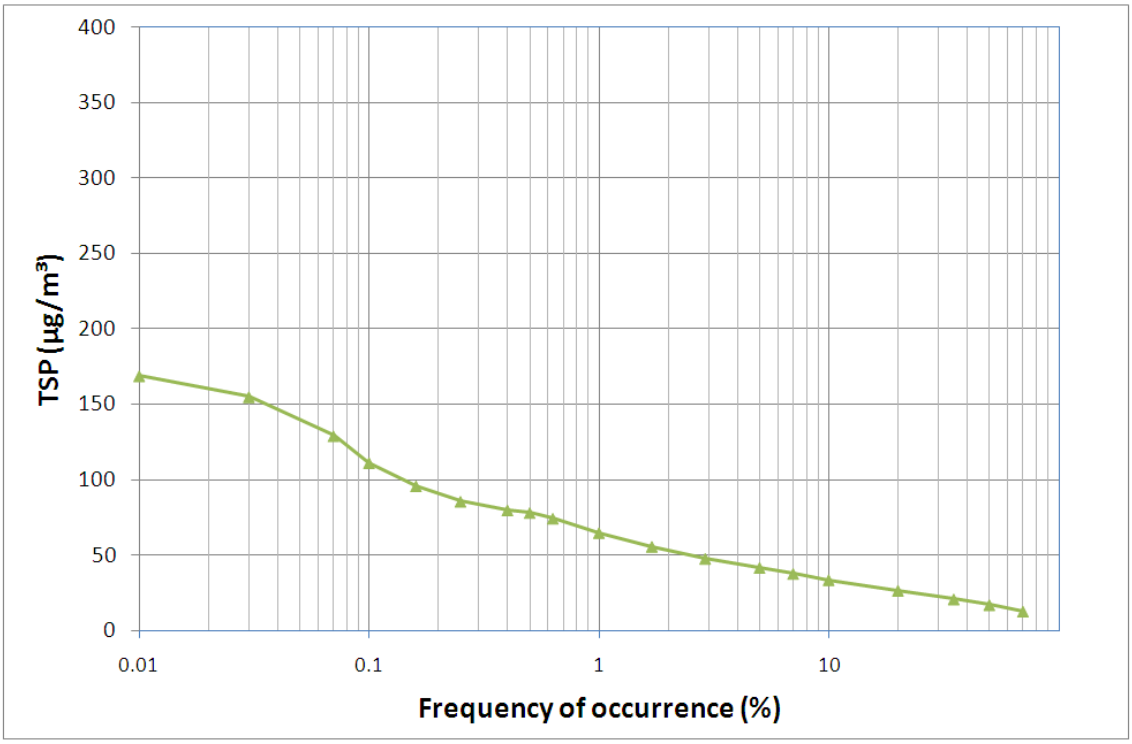

Figure 7.8 Cumulative frequency distributions of 1-hour average concentrations of TSP (µg/m³) measured at about 10 metres from the edge of tracks at Callemondah from April to October 2007.

A statistical comparison of the concentrations of TSP measured with the TEOM with train and coal movements was undertaken. The statistical analysis concluded that dust from loaded trains coming from Oaky Creek, Kestrel, Rolleston, Kinrola, Curragh, Minerva and Ensham was similar to dust from empty trains. Loaded trains from Ensham, Laleham, Gregory, Boonal, Boorgoon, Blackwater and Yongala produced more dust than empty trains. Results from Koorilgah were inconclusive. Notwithstanding this, the increases in dust associated with coal trains were relatively small in most circumstances.

Monitoring study conducted for Environmental Evaluation 2007-08

A plot of the cumulative frequency distribution of concentrations of TSP measured at Beecher, Praguelands, Raglan, Boonal and Earlsfield (1-hour averages) is shown in Figure 7.9. This plot shows the maximum 1-hour average concentration of TSP to be between 200 and 380 µg/m³. Highest 1-hour average concentrations of TSP were found at Boonal, whilst lower concentrations were found at Earlsfield. For about 1% of the time (or 88 hours per year), the concentration of TSP that was measured at Beecher, Praguelands, Raglan and Boonal were found to be more than 75-100 µg/m³. At Boonal, 1-hour concentrations of TSP were above 100 µg/m³ for about 4% of the time (or 350 hours per year).

It is likely that coal dust may have been visible in the vicinity of the coal trains at Beecher, Raglan, Praguelands and Boonal and Earlsfield on an infrequent basis.

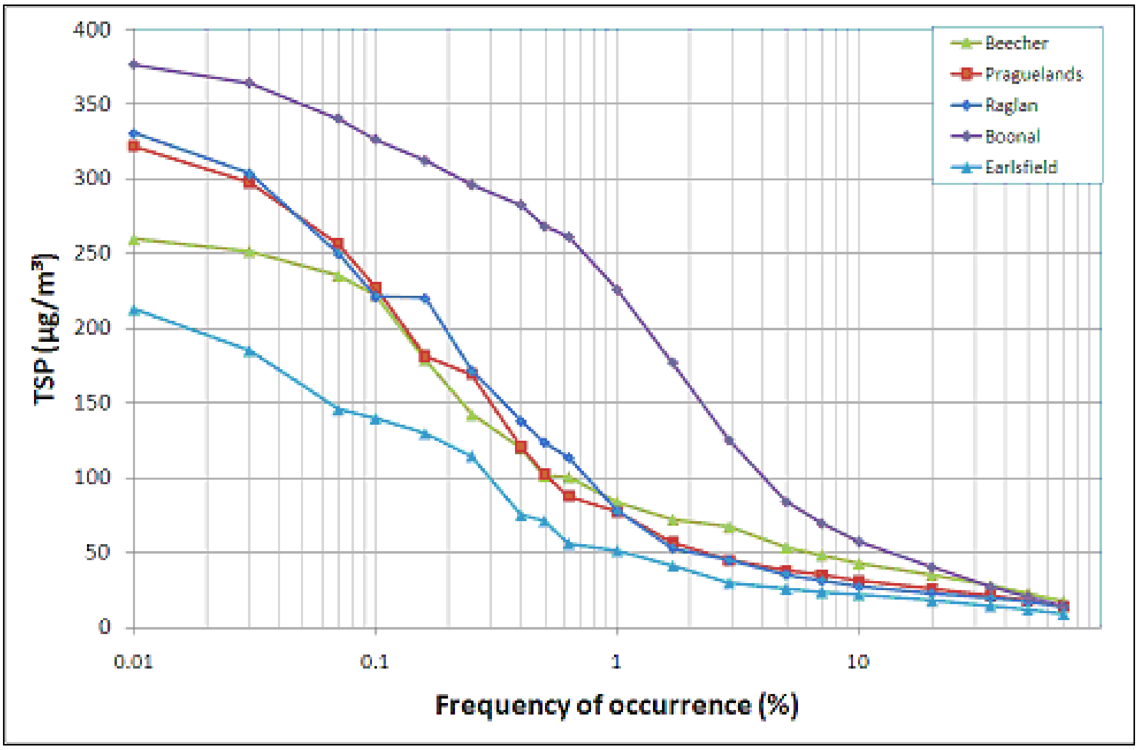

Figure 7.9 Cumulative frequency distributions of 1-hour average concentrations of TSP (µg/m³) measured at about 10 metres from the edge of tracks at Beecher, Praguelands, Raglan, Boonal and Earlsfield.

Data on movements of coal trains in the vicinity of the monitoring stations at Praguelands, Beecher, Boonal, Earlsfield and Raglan has been collected concurrently with monitoring data. This data has been compared with peak 5-minute average concentrations of TSP to quantify the frequency that peak concentrations coincide with train movements. Given that the monitoring stations have not been able to be collocated with rail signals, the exact time that the trains pass the monitoring station cannot be identified exactly. However, corrections have been made based on the distance that the rail signal is from the monitoring station and the local speed of trains.

Table 7.8 summarises the number of trains passing the monitoring stations in the period from 22 October 2007 to 29 February 2008, coinciding with a 1-hour average concentration of TSP that is greater than 10 μg/m³. A peak is deemed to occur when the 5-minute average concentration is more than twice the corresponding 1-hour average. The number of occasions that passing trains has coincided with peak concentrations of TSP is also shown in Table 7.8. Between 1.1% and 4.8% of loaded trains coincide with a peak concentration of TSP.

Table 7.8 Number of Times that Loaded Trains Coincide with Peak Concentrations of TSP. A Peak Concentration is Defined as the 1-hour Average Concentration of TSP Being Greater Than 10 μg/m³ and the Ratio of 5-minute Average and 1-hour Average Concentrations of TSP is Greater 2.

Location	Number of passing loaded trains	Peak TSP occurs as train passes		Peak TSP occurs within ± 5 mins of train passing	
		Count	%	Count	%
Beecher	280	6	2.1%	32	11.4%
Praguelands	1500	34	2.3%	123	8.2%
Raglan	355	4	1.1%	16	4.5%
Boonal	959	46	4.8%	200	20.9%
Earlsfield	69	1	1.4%	4	5.8%

If a broader window is defined to account for the uncertainty in the time that the train passes, where a peak is considered to coincide with a train passing if it occurs within 5 minutes of the train passing, then between 4.5% and 20.9% of trains coincide with peak concentrations of TSP (Table 7.8).

Table 7.9 summarises the concentrations of TSP that coincide with passing trains. The peak 5-minute average concentration of TSP that corresponds with a significant change in concentration of TSP as a loaded train passes is 209 μg/m³ at Beecher, 658 μg/m³ at Raglan and 899 μg/m³ at Booval. On average at each of the monitoring sites, the concentration of TSP when passing trains coincide with a peak is about 120 μg/m³.

Table 7.9 Maximum and Average Concentrations of TSP (μg/m³) and 5-minute to 1-hour Ratios That Coincide With a Loaded Train Passing, TSP 1-hour Average Concentration Greater Than 10 μg/m³ and 5-minute to 1-hour Ratio of Greater Than 2.

Location	Maximum 5-minute TSP when train passes and TSP ratio ≥ 2 (μg/m³)	Average TSP where TSP ratio ≥ 2 (μg/m³)	TSP 5-minute to 1-hour average ratio maximum	TSP 5-minute to 1-hour average ratio average
Beecher	209	105	2.8	2.4
Praguelands	461	88	4.5	2.6
Raglan	658	133	6.2	3.1
Boonal	899	168	45.3	3.7
Earlsfield	126	126	2.7	2.7

Table 7.10 examines the differences in the peak and average concentrations of TSP for coal trains and non-coal trains as they pass the monitoring station at Raglan. This table shows that peak concentrations of dust that are associated with coal trains are 2 times higher than those associated with trains not carrying coal when considering concentrations of TSP within 5-minutes of the train pass time. This is illustrated in Figure 7.10, indicating that concentrations of TSP associated with coal carrying trains are consistently higher than associated with trains carrying other types of freight.

Table 7.10 Maximum 5-minute and Average Concentrations of TSP (µg/m³) and 5-minute to 1-hour Ratios That Coincide With a Loaded Train Passing, TSP 1-hour Average Concentration Greater Than 10 µg/m³ and 5-minute to 1-hour Ratio of Greater Than 2.

Location	Load	TSP as train passes (µg/m³)			TSP within ± 5 mins of train passing (µg/m³)		
		Count	Maximum 5-minute average	Average	Count	Maximum 5-minute average	Average
Raglan	Non-coal	23	178	52	55	320	57
Raglan	Loaded trains	31	658	104	104	658	91

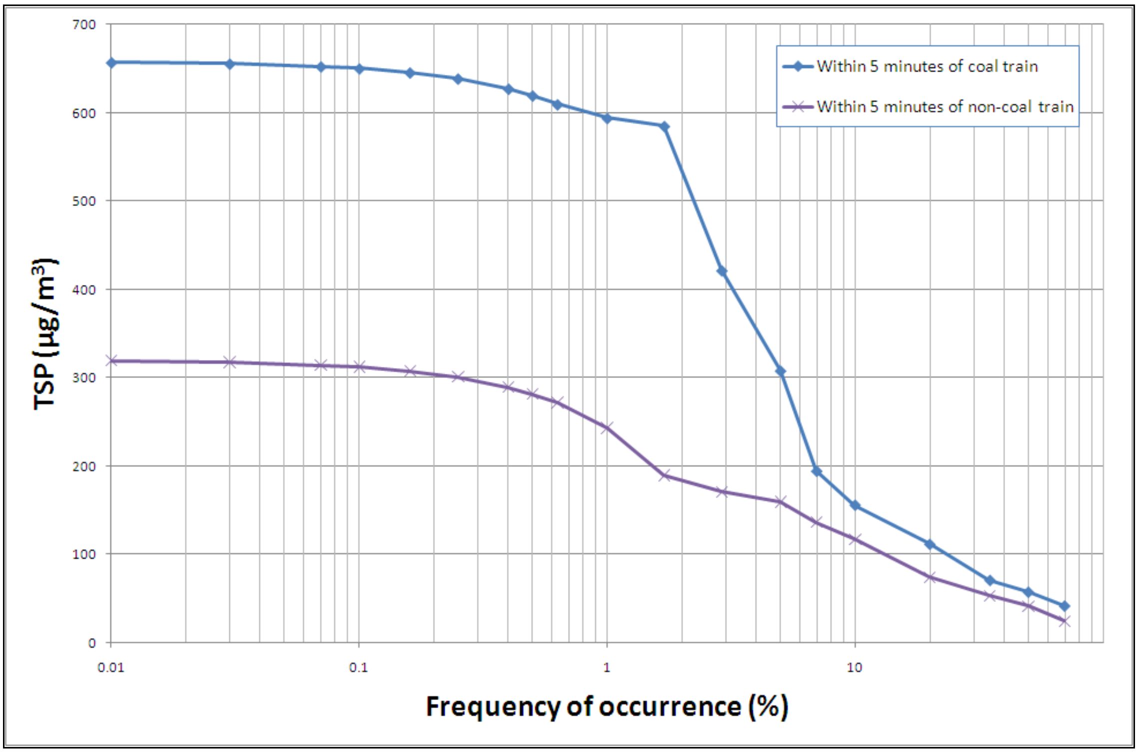

Figure 7.10 Cumulative frequency distributions of 5-minute average concentrations of TSP (µg/m³) measured at about 10 metres from the edge of tracks at Raglan and filtered for type of train passing.

7.2 Regional monitoring data

Monitoring data from the EPA's monitoring stations in Gladstone (South Gladstone and Clinton) and Mackay and the Central Queensland Port Authority's monitoring station at Auckland Point has been obtained for comparison with the monitoring data collected during the Environmental Evaluation. A comparison of this data is shown in Figure 7.11. This figure shows that the levels measured at the EPA and CQPA monitoring sites are very similar to those measured at the Environmental Evaluation monitoring locations.

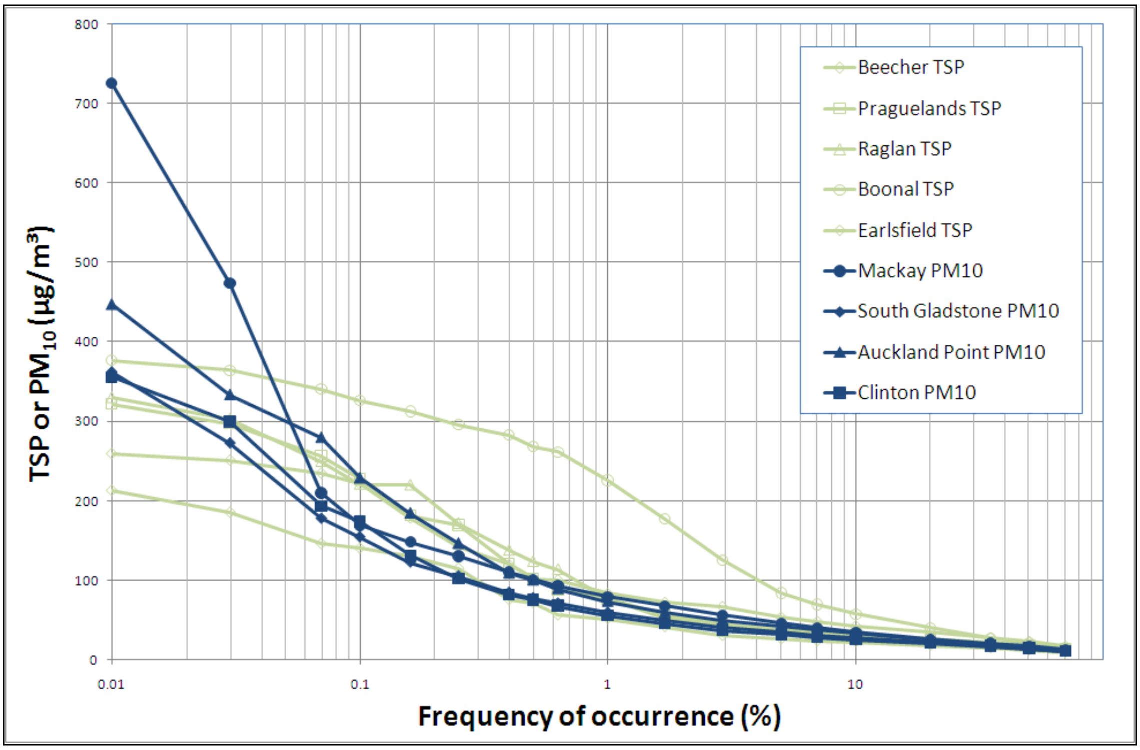

Figure 7.11 Cumulative frequency distributions of 1-hour average concentrations of TSP or PM_{10} (µg/m³) measured during the Environmental Evaluation and compared with data from the EPA's sites at Mackay and Gladstone (South Gladstone and Clinton) and CQPA's monitoring site at Auckland Point.

7.3 Dispersion modelling of dust emissions

Dispersion modelling has been undertaken using the dust emission methodology described in Section 6 to estimate the dust emission rate and meteorological data representative of the Mackay and Gladstone areas.

Dispersion modelling has been undertaken using the Cal3QHCR dispersion model. This model was developed to quantify concentrations of air pollutants in close proximity to busy roads. It is a Gaussian line-source model and so will provide a useful basis to quantify ground-level concentrations of TSP from the coal system.

Two scenarios are presented below:

- Scenario 1 is current (2006/07) train movements on the Goonyella System equating to 88.4 Mtpa with a train speed of 38 km/hr and average ambient wind speed of 13 km/hr, and
- Scenario 2 is current (2006/07) train movements on the Blackwater System equating to 50.5 Mtpa with a train speed of 80 km/hr and average ambient wind speed of 8 km/hr

Figure 7.12, Figure 7.13 and Figure 7.14 show the predicted maximum 24-hour average ground-level concentration of TSP due to emissions from the Goonyella System near Grasstree for current (2006/07) train movements. Note that concentrations of PM_{10} are likely to be less than 50% of the concentrations of TSP. The results indicate that the EPP(Air) goal and NEPM(Air) standard for PM_{10} of 150 µg/m³ and 50 µg/m³, respectively, are unlikely to be exceeded beyond the tracks. At about 10 metres from the tracks, the maximum concentration of TSP is predicted to be 14 µg/m³. This would correspond to a maximum 24-hour average concentration of PM_{10} of less than 7 µg/m³.

Figure 7.15 and Figure 7.16 show the predicted maximum 24-hour average ground-level concentration of TSP due to emissions from the Blackwater System near Mount Larcom for current (2006/07) train movements. Note that concentrations of PM_{10} is likely to be less than 50% of the concentrations of

TSP. The results indicate that the EPP(Air) goal and NEPM(Air) standard for PM_{10} of 150 µg/m³ and 50 µg/m³, respectively, are unlikely to be exceeded beyond the tracks. At about 10 metres from the tracks, the maximum concentration of TSP is predicted to be 59 µg/m³. This would correspond to a maximum 24-hour average concentration of PM_{10} of less than 29 µg/m³. At residential locations within Mount Larcom, the concentration of PM_{10} is predicted to be less than 15 µg/m³.

With projected increases in the rates of coal transport on the Goonyella System of almost 40% and on the Blackwater System of more than 31% in the coming years, concentrations of TSP and PM_{10} are expected to increase proportionally.

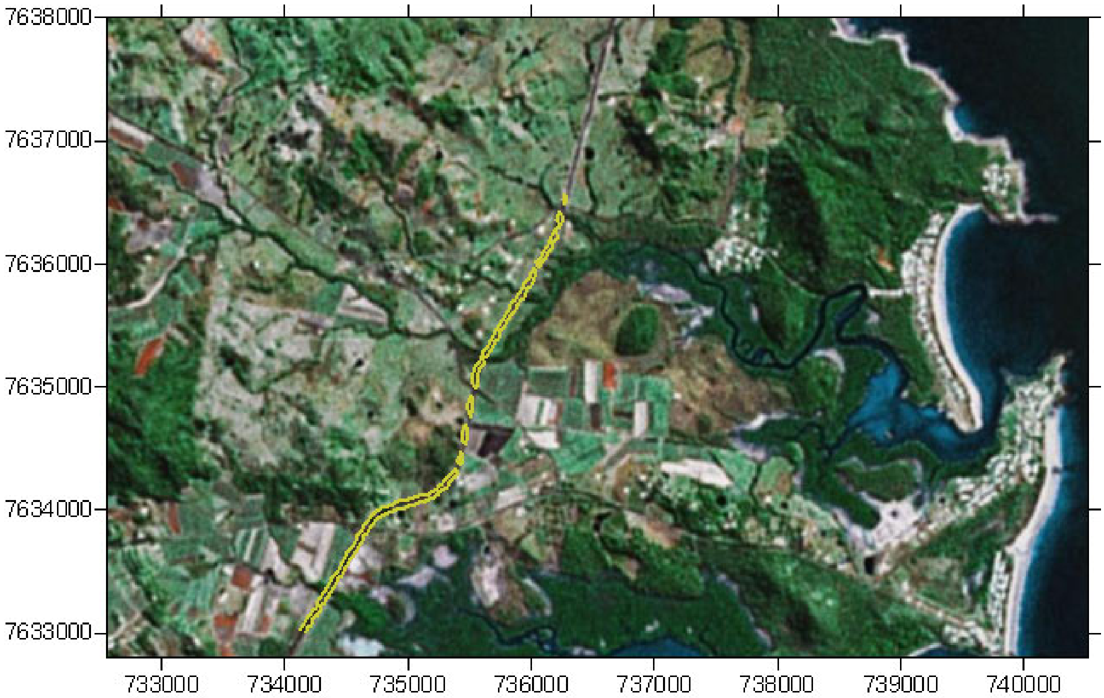

Figure 7.12 Scenario 1. Predicted maximum 24-hour average ground level concentration of TSP (µg/m³) due to 2006/07 train movements on the Goonyella system. Train speed is 38 km/hr. The yellow line represents TSP concentration of 10 µg/m³.

Figure 7.13 Scenario 1 (expanded version of Figure 7.12). Predicted maximum 24-hour average ground level concentration of TSP (µg/m³) due to 2006/07 train movements on the Goonyella system. Train speed is 38 km/hr. The yellow line represents TSP concentration of 10 µg/m³.

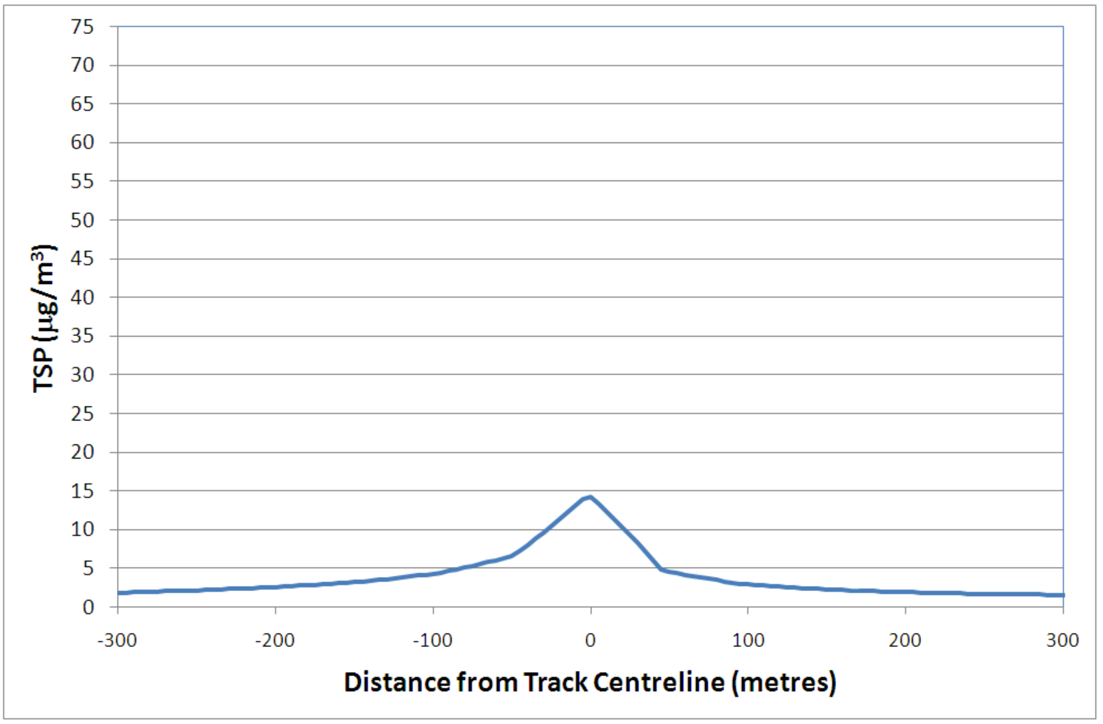

Figure 7.14 Scenario 1. Cross-section of predicted maximum 24-hour average ground level concentration of TSP (µg/m³) due to 2006/07 train movements on the Goonyella system. Train speed is 38 km/hr.

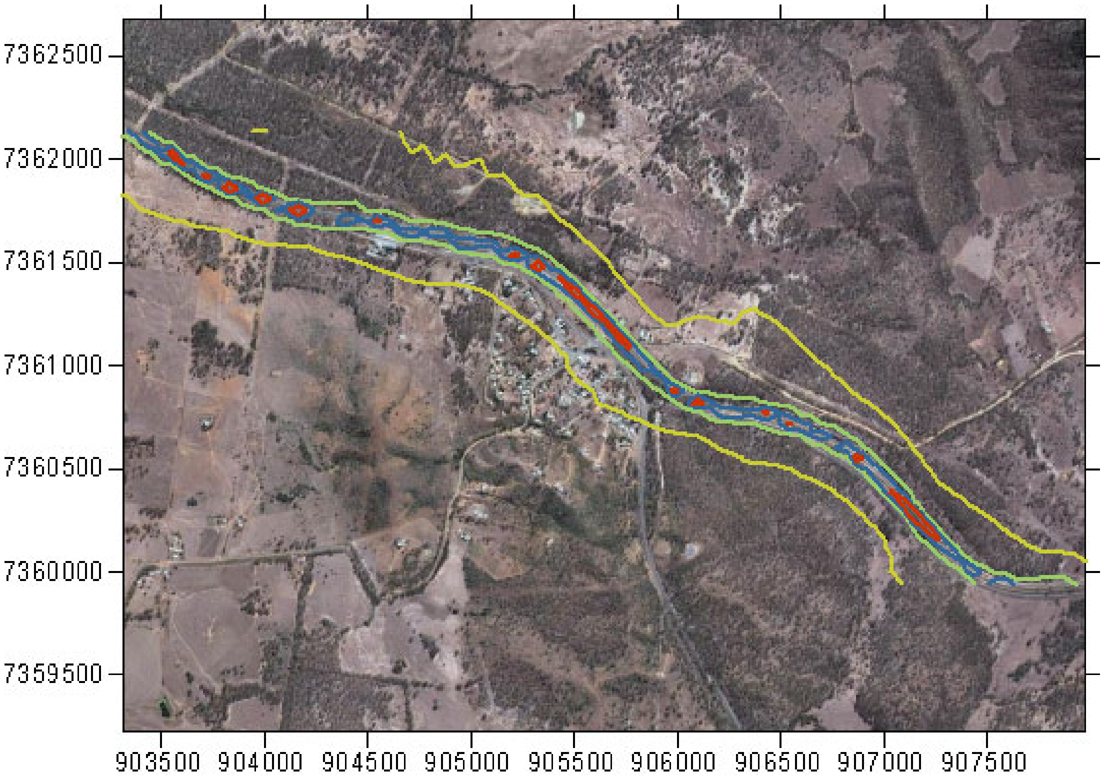

Figure 7.15 Scenario 2. Predicted maximum 24-hour average ground-level concentration of TSP (µg/m³) due to 2006/07 train movements on the Blackwater System. Train speed is 80 km/hr. The yellow line represents TSP concentration of 10 µg/m³, green 30 µg/m³, blue 50 µg/m³ and red 70 µg/m³.

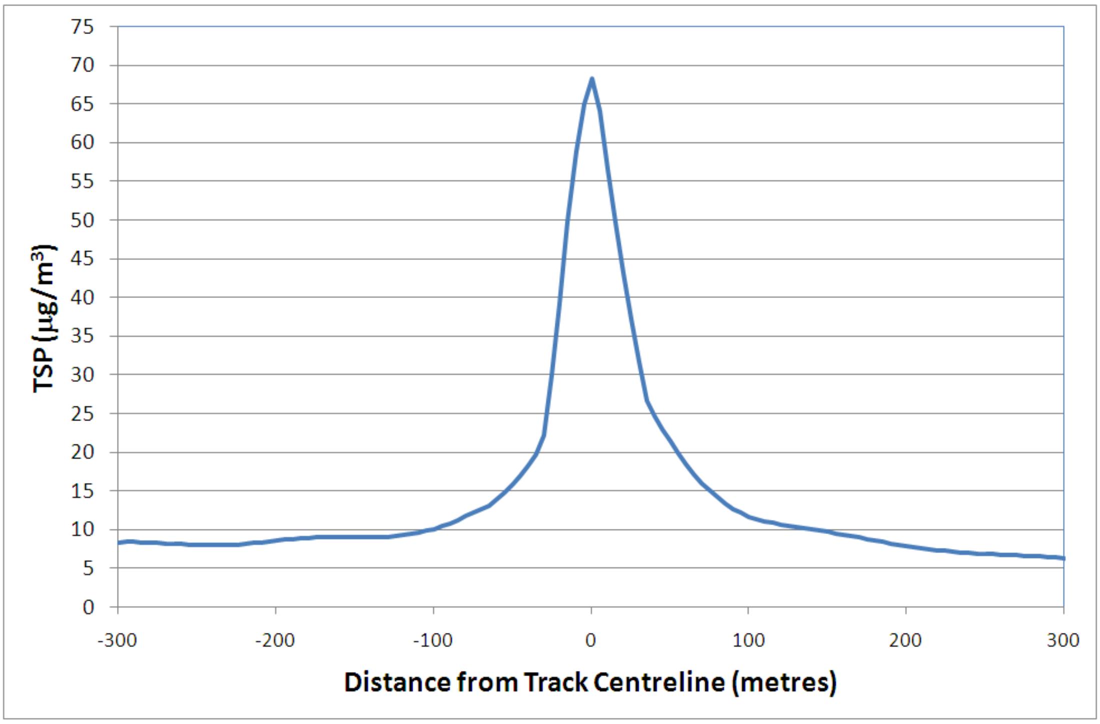

Figure 7.16 Scenario 2. Cross-section of predicted maximum 24-hour average ground-level concentration of TSP (µg/m³) due to 2006/07 train movements on the Blackwater System. Train speed is 80 km/hr.

7.4 Flora, fauna, crops and livestock

There are currently no air quality goals or standards defined for the protection of flora, fauna, crops and livestock. The available information suggest that the standards and goals that are currently defined to protect human health and amenity are more stringent than required to protect against dust impacts on flora, fauna, crops and livestock.

A review of the available research work on dust impacts on vegetation was undertaken for the Curragh North Project (Doley 2003). This review concluded that:

- *Mineral dusts, resulting from mining, quarrying, road operations, mineral processing, and wind erosion may be deposited on vegetation to the extent that they impede growth and threaten the survival of plants*
- *Dusts that are chemically inert, or which do not markedly alter substrate pH, are generally effective [adversely affecting plant growth] if the dust load is greater than 5 g/m²*
- *Model calculations on a cotton crop suggest that dust loads of 5 g/m² or dust deposition rates of 500 mg/m²/day are unlikely to have a detectable effect on vegetative growth under the sunny conditions most conducive to cotton growth. A dust deposition rate of 1000 mg/m²/day is predicted to result in measurable reductions in crop growth during overcast weather, but the effect may be more difficult to detect in sunny weather*

For the purpose of this assessment, a dust deposition rate of 500 mg/m²/day has been used as a threshold for adverse impacts on crops and vegetation.

A study undertaken at the University of Western Sydney on dairy cows (Andrews et al 1992) found that:

- Cattle did not find feed unpalatable if coal mine dust was present at a level equivalent to a dust deposition rate of 4,000 mg/m²/day

- The presence of coal mine dust in feed did not affect the amount of feed that the cattle ate or the amount of milk that the cattle produced at a level equivalent to a dust deposition rate of 4,000 mg/m^3/day and
- Cattle did not preferentially eat feed that did not contain coal mine dust. The cattle were able to choose between feed that was free of coal mine dust, feed that contained 4,000 mg/m^2/day of coal mine dust and feed that contained 8,000 mg/m^2/day of coal mine dust

The monitoring results and dispersion modelling presented in the sections above indicate that there is a low risk of adverse impacts on vegetation, crops and livestock due to emissions of TSP from coal wagons. Even within the rail corridor, dust deposition rates have been measured to be well below levels that have been shown to have little or no effect on crops and livestock.

Maximum levels of coal deposition that have been measured within the corridor are about 90 mg/m^2/day at about 3 metres from the edge of the track. Dust deposition levels of 500 mg/m^2/day and 4,000 mg/m^2/day were not found to adversely affect crops and livestock, respectively. Coal deposition rates of up to 30 mg/m^2/day were measured at 10 metres from the edge of the tracks indicating that dust deposition levels drop quickly with distance. Outside of the corridor, coal dust deposition rates are not likely to be substantially different from background when compared to the no effects thresholds of 500 mg/m^2/day and 4,000 mg/m^2/day.

8. Risk of Environmental Harm

Point (d) of the Terms of Reference of this Environmental Evaluation requires an identification of locations within QR Limited's operations where proximity of railway lines to communities may give rise to a higher risk of environmental harm due to fugitive coal dust. There are two aspects to environmental harm that are relevant here. Firstly, is harm likely to be caused due to adverse impacts on human health? Secondly, is harm likely to be caused due to adverse impacts on amenity?

In relation to the first and based on the results of monitoring and modelling, there appears to be a minimal risk of adverse impacts on human health due to fugitive coal emissions from trains throughout the coal transport networks that are the subject of this environmental evaluation.

This conclusion is based on the coarse nature of the coal particles and the relatively low concentrations of PM_{10} measured and predicted by dispersion modelling at the edge of the corridor.

In relation to the second, the results of monitoring and modelling suggest that concentrations of coal dust at the edge of the rail corridor are below levels that are known to cause adverse impacts on amenity. There is, however, a recognition that our current understanding of the threshold for amenity impacts may not adequately deal with the specific characteristics of coal dust on the peak events that could occur over relatively short timeframes.

At this stage, there is insufficient information to identify specific locations that are at a high, medium or low risk of adverse impacts on amenity. Certainly, community perception and complaints of coal dust impacts cannot be ignored.

The following locations are important and associated with relatively higher concentrations of coal dust:

- Within 15 metres of tracks carrying loaded coal wagons at a speed of more than 60 km/hr
- In areas that are open and regularly exposed to moderate to strong winds. Particularly where the tracks are elevated and trains are moving quickly, although, relatively slow moving trains may also produce dust under strong winds, and
- In close proximity to extensive areas of spilled coal, particularly during windy dry weather

Coal dust can be emitted from the following sources in the coal rail system:

- Coal surface of loaded wagons
- Coal leakage from doors of loaded wagons
- Wind erosion of spilled coal in corridor
- Residual coal in unloaded wagons and leakage of residual coal from doors, and
- Parasitic load on sills, shear plates and bogies of wagons

The key factor that contributes to the emission rate of coal dust from wagons is the speed of the air passing over the coal surface. This is influenced by the train speed and the ambient wind speed. Other factors that are also found to contribute include:

- Coal properties such as: dustiness, moisture content and particle size
- Frequency of train movements
- Vibration of the wagons
- Profile of the coal load
- Transport distance
- Exposure to wind, and
- Precipitation

9. Dust Mitigation Options

This section lists the various solutions that have been identified in the Environmental Evaluation for controlling dust emissions from the Goonyella, Blackwater and Moura Systems. The methodology that has been used to assess these options and to rank them for their cost-effectiveness and practicability is described and the results of this assessment are summarised. More detailed information has been presented on the feasibility, practicality and cost-effectiveness of higher ranked mitigation options.

9.1 Preliminary assessment of mitigation options

9.1.1 Background

A wide range of mitigation options were identified through the Environmental Evaluation. These options have come from:

- The authors experience in the coal transport and related industries
- Literature review
- Coal rail industry experience in other Australian states and other countries
- Previous work undertaken by QR Limited, and
- Approaches adopted by the mines and ports in Australia

The following mitigation options have been identified for preliminary assessment:

1. Coal transported by covered conveyor through final leg of the journey into the three ports (Gladstone, Hay point and Dalrymple Bay Coal terminal)
2. Re-align coal corridors around communities
3. Limit the capacity of the corridor (e.g. reduce speed)
4. Veneering
    a. Use of suppressants applied to the surface of the coal profile in the wagons at the mine site
    b. Use of suppressants applied at a common point at the head of each corridor
    c. Use of water/suppressants applied at entry to major cities
5. Loading at the mine site –
    a. Use of profilers to manage excess height
    b. Maintaining the 100mm freeboard around the edge of the wagon
    c. Change the types of loaders by additions to ensure a consistent profile
6. Mechanism to remove parasitic coal from surface of wagons before leaving the mine site
7. Wagon design adjustments
    a. Apply lids to wagons
    b. Apply deflector/container boards to edges of wagons
    c. Adjust the doors to underside of the wagons to contain leakage
8. Unloading Issues
    a. Washing the wagons after unloading
    b. Change in unloading techniques to minimise coal ploughing (clean up)
9. Coal dust management plan
10. Code of Practice for coal dust

Item 7b (deflector/container boards on wagons) was eliminated from further analysis because it was found in the wind tunnel and CFD studies to increase dust emissions from wagons under certain circumstances.

There was insufficient information available in relation to Item 7c (adjust doors of wagons to contain leakage) to rate its utility in terms of cost-effectiveness and practicability; hence this option has been identified for further consideration and detailed analysis within the coming months.

Items 9 (coal dust management plan) and 10 (industry code of practice) are not mitigation measures as such, but they provide a documented approach and framework for reducing coal dust emissions with reference to those mitigation measures that are to be implemented. The coal dust management plan is a document prepared by QR Limited that specifies the framework for managing coal dust emissions over short-, medium- and long-term timeframes.

The Code of Practice would be prepared in consultation with the industry stakeholders and would outline the mitigation measures that will be adopted across the coal supply chain to manage and minimise coal dust emissions. This is discussed further in Section 9.4.

9.1.2 Cost-effectiveness/practicability assessment methodology

Table 9.1 summarises the rating codes that has been used to rate the cost-effectiveness and practicability of coal dust mitigation options. Table 9.2 and Table 9.3 show the parameters that have been used to define cost-effectiveness and practicability and the rating codes and weightings that have been applied to each parameter.

Table 9.1 Cost-effectivenesss/practicability rating scheme

Rating code and description		Rating				
		5	**4**	**3**	**2**	**1**
A	Industry cost	<$1M	$1M – $10M	>$10M - $25M	>$25M - $50M	>$50M
B	Cost per wagon trip	<$1	$1 – $5	>$5 – $10	>$10 –$15	>$15
C	Reduction of overall emissions	>80%	>60 – 80%	>40 – 60%	20 – 40%	<20%
D	Implementation rating: ease, resources and maintainability	Very Easy	Easy	Achievable	Difficult	Extremely Difficult
E	Implementation timeframe	<1 month	1-12 months	>1-2 years	>2-5 years	>5 years
F	Impact on environment, safety or reliability	No Impact	Low Impact	Some Impact	High Impact	Untried
G	Implementation risk	Very Low	Low	Medium	High	Very High

Table 9.2 Rating code, weightings and cost-effectiveness parameters used to rank the cost-effectiveness of mitigation options

Cost-effectiveness	Rating Code	Weighting
Capital Investment	A	20%
Operational Cost	B	40%
Effectiveness	C	40%
Total		**100%**

Table 9.3 Rating code, weightings and practicablity parameters used to rank the practicability of mitigation options

Practicability	Rating Code	Weighting
Implementation		
- Ease	D	8%
- Time	E	8%
- Resources	D	8%
Operational Impact	D	35%
Maintainability	D	2%
Reliability	F	15%
Implementation risk	G	14%
Safety	F	5%
Environment	F	5%
Total		**100%**

A cost effectiveness and practicability scores have been determined as the sum of each of the ratings for each parameter multiplied by its weighting factor.

9.1.3 Results of cost-effectiveness/practicability assessment

The mitigation options are compared in terms of the cost-effectiveness and practicability in Figure 9.1. Of the options that relate to the application of a veneer or water to the surface of the wagons, veneering at the mine site is likely to provide the most cost-effective and practical solution. Retrofitted and designed lids have relatively low scores for practicability and cost-effectiveness. However, given the strong interest in this as a solution from various areas and the fact that lids are likely to be very effective in reducing overall dust emissions, this solution has been investigated further.

Further discussion and assessment of the following mitigation measures is undertaken below:

- Veneering of wagon surfaces at the mine site
- Wagon loading improvements and load profiling
- Wagon washing
- Wagon unloading, and
- Wagon lids

Due to low scores in terms of practicability and/or cost-effectiveness, realignment of coal corridors, limiting corridor capacity and the use of conveyors to transport coal through communities have been eliminated from further consideration.

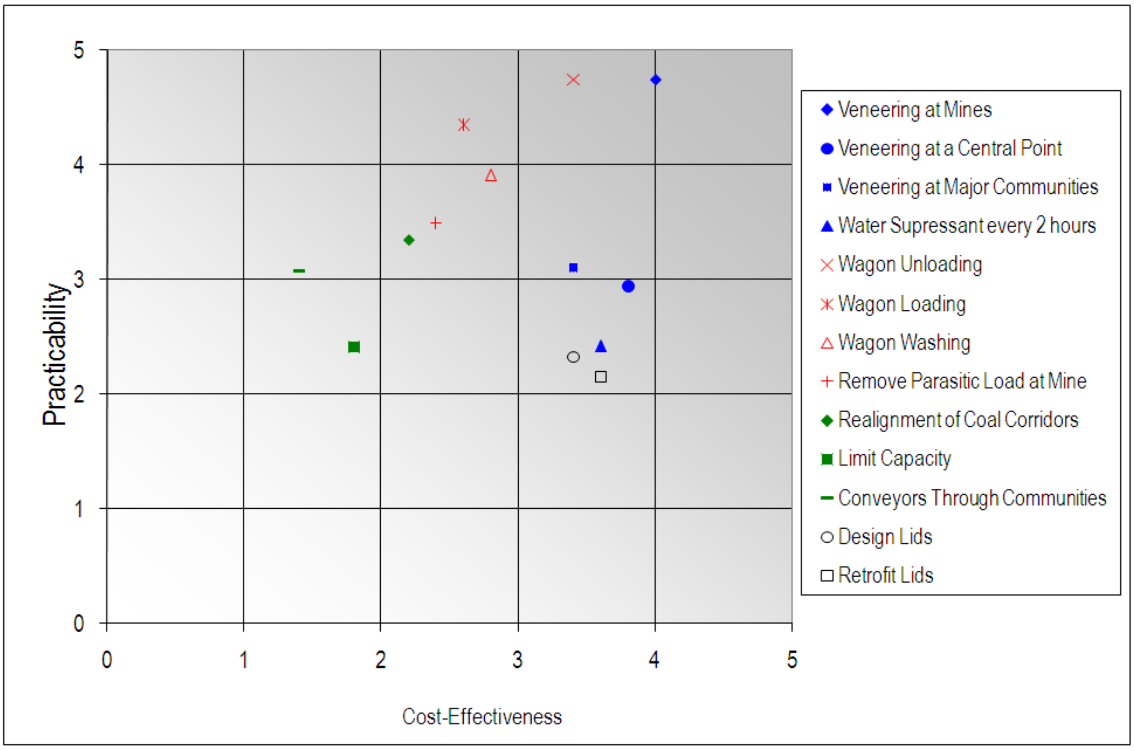

Figure 9.1 Comparison of mitigation options in terms of cost-effectiveness and practicability

9.2 Mitigation options submitted to detailed assessment within Environmental Evaluation

9.2.1 Veneering of coal surface of wagons

Suppressants have been used as a surface veneer to control coal dust emissions from wagons carrying coal from several mines (eg. South Walker, Callide, Boundary Hill and Ensham). The suppressants bind the particles together to provide a surface that is resistant to dust lift-off. Suppressants have been found to successfully reduce coal dust emissions from the tops of wagons. There are many suppressants on the market and whilst most are considered to be generally applicable to reducing coal dust emissions, the performance of each suppressant will depend upon the specific properties of the suppressant and the coal.

Data has been collected by many of the coal mines and the ports at Hay Point and Gladstone in recent years on the dustiness properties of coals from the Bowen and Callide Basins. Within this study, more detailed experiments have been undertaken to determine the extent of dust lift-off from the surface of coal wagons for typical coal types under simulated rail transport conditions. This work has utilised a specialised wind tunnel designed to quantify the dustiness moisture relationships of bulk materials and also the effectiveness of dust suppressant products.

This test program has investigated the performance of selected dust control products using the suppliers recommended solution strength and application rate, plus “equal cost” tests to evaluate performance against cost.

The suppressants can be applied to the surface of the loaded wagons using a relatively simple spray system installed immediately after the coal loading facility. The water used in the system can be recycled water or grey water, but must be of sufficient quality to ensure that the spray jets do not clog. The dust suppressant system takes signals from the coal load-out facility, enabling the system to be turned on and off for each wagon and to recognise and turn off for locomotives. The use of load profilers and continuous loading techniques will enhance the performance of the suppressants.

Laboratory test program of surface veneer treatments

A laboratory test program has been conducted to assess the likely performance and cost of five surface veneer chemicals when applied to seven typical coal types transported by QR Limited. The results of the test program are detailed in Appendix C. The literature review and test program indicate that reduction in coal lift-off from the surface of loaded wagons of at least 85% is achievable. The following conclusions were made as a result of this work (note that coal types and veneer chemicals are coded):

- All surface veneer products, when applied at the supplier's recommended application rate and solution strength, achieved a significant reduction in dust lift-off compared with nil treatment.
- All surface veneer products were applied at a common application rate of one litre per square metre. The solution strength varied according to the supplier's recommendation. All test samples were exposed to a wind speed of 20 metres per second (72 km/hr) under test conditions for a period of 8 hours. However due to very rapid dust lift-off, the untreated samples (Nil treatment) were removed from the wind tunnel after exposure to the test conditions for only 1 minute. This observation applied to all tested coal types.
- Although the surface treatment product C performed well on other tested coal types, it did not perform well when applied to the surface of coal type A1. This result was verified by observation of a similar result in a repeated test.
- The lowest total level of dust lift-off when applied to all seven coal types was achieved by surface treatment with product type D.
- When the wind tunnel is operated at a wind speed of 20 m/s (72 km/hr) a minor level of vibration is induced in the structure and the vibration is transferred to the test trays. This will, to some extent, simulate the effect of vibration transferred to the coal load in QR wagons during transport. This level of vibration was not observed to cause any slip failure in the contents of the sample trays at the typical coal angle of repose so the surface sealant remained intact for the test duration.
- As a coal surface slip failure during transport can disturb the surface sealant and expose un-protected coal, this feature will require further observation under operating conditions. It may be possible to conduct observations of the current Anglo Coal veneer treatment trials as part of the investigative process.
- Coal types selected for this study include some that have previously been observed to have a high dust emission tendency.
- As the satisfactory performance has been achieved on coal types that include some with a relatively high level of dustiness it is possible that a lower solution strength, and therefore lower cost, could be possible on some coal types.
- It is recommended that further laboratory tests and field trials be conducted on a larger range of coal types to explore the relevant treatment selection for each coal type and to refine the most cost effective approach to achieving an acceptable level of dust emission during rail transport from mine to port.

Generic veneering system

Connell Hatch has developed a generic veneering system design for application of dust suppressants to wagons, encompassing both capital investment and operational cost estimates. A full report of this work is included in Appendix F.

Successful trials of veneering systems in conjunction with noted improvements determine that a generic veneering system design that can assimilate effectively into continuous loading operations (that are prevalent throughout the Goonyella, Blackwater and Moura Systems) comprises of:

- Water and suppressant storage tanks and associated pumping systems
- Dosing system with adjustable control to achieve the desired solution strength
- Shower bar to apply suppressant to the coal profile
- Control system facilitating autonomous operation
- A shield to enclose the system to prevent infrastructure fouling

Site specific features that could alter the design and costs associated with installing, commissioning and operating the system include water availability, geometric constraints, topography, meteorological conditions, coal type and properties.

The system noted in this analysis rated high (4.0 out of 5) on the cost effectiveness rating guide noted in Section 9.1.3 of this report. This is compared with a high practicability score of 4.65 out of 5, indicating that this system would be easy to implement and have minimal effect upon operations across the coal chain.

9.2.2 Loading at the mine site and load profiling

Connell Hatch has conducted an analysis of wagon loading practices at the mines within the Goonyella, Blackwater and Moura Systems. The aim of this analysis is to examine the practicality and cost-effectiveness of improved loading techniques as a means of mitigation coal dust emissions. A full report of this work is included in Appendix G.

The loading arrangements with the above rail operator requires that the height of the load does not exceed a maximum height of 3950mm above rail and that 100mm freeboard is left around the edge of the wagon. The mines have various techniques to load trains ranging from front-end loaders, clamshell loaders and a variety of batch weighing hopper arrangements. The type of loading technique has implications for the ability of the mine to control the profile of coal in the wagon.

Clamshell and front-end loaders tend to produce uneven loads with multiple peaks with the loads relatively unstable and susceptible to spillage. Wind tunnel testing and CFD modelling has also shown that the uneven surface is subject to higher turbulent intensity and, hence, higher levels of coal dust lift-off. Improved loading techniques through the use of batch weighing systems can also reduce overloading and underloading of wagons and will improve the effectiveness of veneering treatments. Informal feedback from the coal mines suggests that there are few mines that currently operate with front-end loaders or clamshell loaders.

Wind tunnel testing and CFD modelling has shown that coal wagons with an uneven coal surface at the top are subject to higher turbulent intensity and, hence, higher levels of coal dust lift-off. Load profiling is the process of creating a consistent coal surface (both cross section and height above the sill) in a loaded coal wagon. A wagon that has a consistent coal surface will also improve the effectiveness of veneering treatments.

A summary of the wagon loading practices employed in the Goonyella, Blackwater and Moura Systems is tabulated in Table 9.4.

Table 9.4 Wagon Loading Practices in the Goonyella, Blackwater and Moura Systems (data supplied by QR Limited)

System	Stationary	Continuous				Total
		Batch Weighing		Volumetric Loading		
		Clamshell	Chute	Clamshell	Chute	
Goonyella	0	0	3	7	9	19
Blackwater	1	0	1	0	9	11
Moura	1	0	1	0	2	4
Total	**2**	**0**	**5**	**7**	**20**	**34**

Current best industry practice with respect to reducing coal emissions from loading includes:

- Inbound wagon identification system to determine class of wagon about to be loaded
- Inbound weighbridge to measure the tare weight of each incoming wagon
- Batch weighing system to load the correct amount of coal into each wagon
- Telescopic loading chute to profile the load in each wagon
- Outbound weighbridge to measure the gross weight of each outgoing wagon, and
- Volumetric scanning to measure the profile of each outgoing wagon

With the implementation of improved loading techniques at mines that currently use clamshell or front end loaders, a substantial reduction in excess spillage is expected. This technique is estimated to provide a reduction of about 500 tonnes of coal dust per year when used in conjunction with load profiling, based on estimates from 2006/07 coal data.

The system noted in this analysis rated medium (3.0 out of 5) on the cost effectiveness rating guide noted in Section 9.1.3 of this report. This is compared with a high practicability score of 4.5 out of 5, indicating that this system would be easy to implement and have minimal effect upon operations across the coal chain.

9.2.3 Wagon washing

Connell Hatch has conducted an analysis of wagon washing techniques. The aim of this analysis is to examine the practicality and cost-effectiveness of wagon washing as a means of mitigation coal dust emissions. A full report of this work is included in Appendix H.

As discussed in Section 4.4, it has been estimated that an average of 0.13 tonnes of coal, on average, remains inside each wagon after unloading. This coal will quickly dry and will be susceptible to leakage from the Kwik-Drop doors or can be emitted from the top of the wagons due to air currents induced by the movement of the train.

Washing each wagon will remove coal from within the wagons and this coal can be recovered and sent to the port. Wagon washing will also eliminate the parasitic load from the wagon exterior. The wagon washing facility will be designed to be an automated process that occurs immediately after the unloading facility. Water can be recycled within the system minimising water usage. This technique is estimated to provide a reduction of about 100 tonnes of coal dust per year, based on 2006/07 estimates. However, there may be adverse impacts on rolling stock due to washing that will need to be considered carefully.

Whilst the capital investment is relatively large for this mitigation strategy, each of the coal ports is located within communities that are sensitised to coal dust impacts. Tracking and deposition of coal dust within the corridor in the rail loop from the unloading facilities is a potential source of coal dust emission that could be substantially eliminated.

The system noted in this analysis rated medium (2.8 out of 5) on the cost effectiveness rating guide noted in Section 9.1.3 of this report. This rating does not fully take into account the fact that the improvements occur close to the ports in areas where population density is higher and other sources of coal dust are also present. Consequently, the cost-effectiveness rating may underestimate the benefit in relation to population exposure. This technique has a medium practicability score of 3.92 out of 5, indicating that this system would be relatively easy to implement and have minimal effect upon operations across the coal chain.

9.2.4 Wagon unloading

Connell Hatch has conducted an analysis of wagon unloading practices at the ports in the Goonyella, Blackwater and Moura Systems. The aim of this analysis is to examine the practicality and cost-effectiveness of improved unloading techniques as a means of mitigation coal dust emissions. A full report of this work is included in Appendix I.

Analysis of the wagon unloading practices identified many factors and circumstances that contribute to coal dust emissions form the sources of residual coal in unloaded wagons and parasitic load on the wagon exterior. The following factors were identified to be the most influential factors with respect to contributing to coal dust emissions:

- Coal ploughing
- Carry-back
- Grate height
- Wagon vibrators, and
- Automation

Coal ploughing is defined as the overfilling of the hopper at a wagon unloading station to the extent that the coal is ploughed by the wagon framework and bogies as they travel across the top of the hopper. Coal ploughing results in parasitic load on the wagon exterior and can contribute to residual coal within the wagons in some instances.

Hopper overfilling occurs as a result of a differential between wagon unloading rates and hopper unloading rates. This differential produces a net gain of coal in the hopper, and if this gain is maintained over time, the hopper will overfill. Consequently, overfilling can be controlled by either reducing wagon unloading rates (by reducing train speed) or increasing hopper unloading rates (if possible).

The mitigation strategies proposed to reduce the coal dust emissions from these sources include:

- Lowering the grate height
- Installing automatic wagon vibrators, and
- Increasing the level of automation

The system noted in this analysis rated medium (3.4 out of 5) on the cost effectiveness rating guide noted in Section 9.1.3 of this report. This rating does not fully take into account the fact that the improvements occur close to the ports in areas where population density is higher and other sources of coal dust are also present. Consequently, the cost-effectiveness rating may underestimate the benefit in relation to population exposure. This is compared with a very high practicability score of 4.7 out of 5, indicating that this system would be easy to implement and have minimal effect upon operations across the coal chain.

Wagon unloading and wagon washing address the same coal dust emission sources. Accordingly, a comparison between the two shows that wagon unloading is a more practical and cost-effective mitigation strategy than wagon washing. This is primarily due to the significantly higher capital investment and operating costs associated with washing. Furthermore, while washing could produce a more effective reduction of coal dust from the identified sources, the sources do not constitute the primary coal dust emission source.

9.2.5 Wagon lids

Connell Hatch has conducted an analysis of the feasibility, practicability and cost-effectiveness of either retrofitting wagon lids to the existing fleet or redesigning wagons to incorporate a lid for application across the Goonyella, Blackwater and Moura Systems. The aim of this analysis is to:

- Determine the advantages and disadvantages associated with implementing wagon lids
- Consider the impact of lid failures to the industry
- Estimate the capital investment and operational cost associated with wagon lids, and
- Assess the mitigation strategy for practicability and cost-effectiveness

A full report of this work is included in Appendix J.

Wagon lids have been advocated by some as a feasible method to control coal dust emissions. Wagon lids are used in the transport of some materials in northern Queensland and in the transport of coal in North America where very cold conditions, snow and ice can adversely affect the coal.

Fibreglass, flexible and bi-directional wagon lids can be retrofitted to wagons. These are likely to prevent the majority of coal loss from the surface of coal wagons and provide an estimated 20% reduction in aerodynamic drag. However, the lids result in a reduction in payload of each wagon and modifications will be required of all loading and unloading systems. Maintenance of lids when they fail will cause reductions in the capacity of the network.

Alternatively, wagon lids could be incorporated into the design of all new wagons. Such a design is not currently available and would take some time and research to develop into a workable solution. The additional cost of a new wagon would not be substantially changed by the inclusion of a lid.

Connell Hatch's assessment concludes that the major advantages associated with implementing wagon lids include:

  - 99% reduction in coal dust emissions from the top of wagons, the major coal dust emission source
  - Potential to completely seal the wagons doors
  - Reduction in aerodynamic drag, and
  - Environmentally friendly solution

The reduction in aerodynamic drag had been reported to be in the order of 20% based on trials conducted in the US (diesel haul). Due to varying conditions between the US trials and what would be experienced in the Goonyella, Blackwater and Moura Systems, this figure cannot be applied with confidence. Considering that the majority of the network is electrified, the only feasible method of estimating the reduction in aerodynamic drag would be to conduct trials in the coal rail systems and measure the change in, and cost of, the energy savings.

Connell Hatch's assessment concludes that the major disadvantages associated with implementing wagons lids include:

  - Large operating cost (retrofitting only)
  - Modifications to all loading and unloading sites, and
  - Ramifications of lid failure

It was acknowledged that there are many potential operational impacts and costs associated with implementing wagon lids that cannot be estimated without a thorough detailed investigation which would need to consider the operational decisions, reliability of lids and facilities at very intricate level of detail. It is therefore considered prudent not to consider wagon lids as a potential mitigation strategy without undertaking the aforementioned course of action.

The system noted in this analysis rated high (3.6 out of 5) for retrofitted lids and medium (3.4 out of 5) for lids incorporated into the wagon design on the cost effectiveness rating guide noted in Section 9.1.3 of this report. This is compared with a low practicability score of 2.15 out of 5 for retrofitted lids and a low practicability score of 2.32 out of 5 for lids incorporated into the wagon design.

9.3 Mitigation option for further assessment following Environmental Evaluation - reduction in leakage from Kwik-Drop doors

Door leakage is known to occur during travel due to coal with a small particle size falling through the gap between the Kwik-Drop doors. The nominal door clearance for the wagon doors is 3 mm, but there is substantial variation in the gap between doors in practice. The coal that is transported by QR is, in some cases becoming finer with the reclamation of fines from settlement ponds.

It is proposed that bushes in the door mechanism could be replaced with polyurethane bushes in order to reduce the door gap to a nominal clearance of 0.5 mm. The doors cannot be completely sealed because they need to drain water from the wagons to avoid overloading the axles.

At this point it is difficult to accurately quantify the amount of coal lost through the Kwik-Drop doors and only a subset of this material will be transported outside of the rail corridor. In order to estimate more accurately how much coal is being lost through the wagon doors during travel, a Door Loss Measurement Mechanism (DLMM) was developed by Connell Hatch in conjunction with QR. A DLMM trial is scheduled to be conducted during April 2008 to quantify coal loss.

9.4 Code of Practice for Coal Dust from the Coal Supply Chain

It is acknowledged that the mitigation measures that are detailed above, in part fall outside of the direct control of QR Limited and will require either the mines or the ports to implement new infrastructure and an ongoing commitment from them to maintain and operate that infrastructure.

A code of practice should be developed in consultation with all relevant stakeholders for mine to port coal chain. A code of practice states the ways of achieving compliance with the general environmental duty for activities that cause or are likely to cause environmental harm. The code of practice should give clear guidance on measures that should be taken to prevent or minimise environmental harm. The code of practice should consider:

- Loading specifications: use of suppressants, loading and load profiling
- Wagon operation: door loss, door design, aerodynamic design
- Unloading specifications and procedures: eliminate coal ploughing, wagon washing
- Monitoring of coal dust, performance measures and triggers for remedial action

10. Conclusions

An Environmental Evaluation has been undertaken of fugitive coal dust emissions from trains travelling on the Moura, Blackwater and Goonyella coal transport systems in response to a Notice issued by the Queensland Environmental Protection Agency (EPA). The conclusions of the Environmental Evaluation are as follows:

- Demand for coal has increased significantly over the last decade due to its low cost and stable supply compared to other fossil fuels. Growth is expected to remain strong over the coming years leading to plans to expand most of the key coal terminals and the addition of a new coal terminal at Gladstone. Coal tonnages on the Moura, Blackwater and Goonyella Systems contained are projected to increase by 50% by 2014/15

- Coal dust can be emitted from the following sources in the coal rail system:

  – Coal surface of loaded wagons
  – Coal leakage from doors of loaded wagons
  – Wind erosion of spilled coal in corridor
  – Residual coal in unloaded wagons and leakage of residual coal from doors
  – Parasitic load on sills, shear plates and bogies of wagons

- The key factor that contributes to the emission rate of coal dust from wagons is the speed of the air passing over the coal surface. This is influenced by the train speed and the ambient wind speed. Other factors that are also found to contribute include:

  – Coal properties such as: dustiness, moisture content and particle size
  – Frequency of train movements
  – Vibration of the wagons
  – Profile of the coal load
  – Transport distance
  – Exposure to wind
  – Precipitation

- In 2006/07 the emission rate of coal as TSP is estimated to be in the order of 5416 tonnes per annum from the Blackwater, Moura and Goonyella Systems. This is estimated to increase to 7882 tonnes per annum in 2014/15.

- At least six ambient air quality monitoring studies have been undertaken since 1993 to specifically investigate and quantify concentrations of TSP, PM_{10} and dust deposition rates adjacent to rail lines carrying coal. These studies did not find the potential for health impacts inside or outside of the rail corridor as assessed against current air quality goals due to coal dust emissions from trains. These studies did not find the potential for amenity impacts outside the rail corridor due to coal dust emissions from trains when assessed against current air quality guidelines for nuisance.

- The current air quality goals may not provide an adequate basis to delineate nuisance associated with coal dust, particularly if those impacts occur over short-time periods. The current amenity goals are based on annual or one-month averages.

- We are unaware of any nuisance related air quality goals for coal dust that are for shorter time periods that are employed in Australia or in other countries. The recent approval for the Wiggins Island Coal Terminal in Queensland has incorporated objectives that are lower than the current goals that are implemented through legislation in Queensland. The basis of these objectives and their relevance, if any, to nuisance associated with coal dust is unclear. Consequently, these are cautiously applied in this study.

- Although atypical, observations and photographs taken by the study team and others show that visible dust is emitted by some trains and this dust has been observed to travel beyond the rail corridor. Such occurrences suggest that coal dust emissions are not under control in certain circumstances, leaving open the possibility that a claim could be made that QR Limited has breached the General Environmental Duty under The Act because QR Limited has not taken "…all reasonable and practical measures…" to minimise harm.

- From a review of resident complaints and other observations it has been noted that there exists a community perception that "nuisance" dust levels are generated from current coal train operations. Although the complaints may be due to a number of "peak" events rather than the general operation of coal trains, the community perception must be given serious consideration, particularly in view of the proposed substantial increase in coal transport volumes.

- Considering short-term averages the most recent studies conducted at Callemondah in 2007 and for this Environmental Evaluation at locations along the Moura, Goonyella and Blackwater Systems, indicate that the effect of coal dust emissions on ambient dust concentrations is measurable at 15 metres from the rail centreline and that coal from some mines may be consistently dustier than others.

- There is a low risk of adverse impacts on flora, fauna, crops and livestock due to emissions of TSP from coal wagons. Even within the rail corridor, dust deposition rates have been measured to be well below thresholds that have been shown in literature studies to have little or no effect on crops and livestock.

- Dispersion modelling of coal dust emissions from coal trains operating at Mount Larcom and Grasstree for current train movements and future projections suggests that ground-level concentrations of PM_{10} are unlikely to exceed the current EPP(Air) goal or NEPM(Air) standards at 10 metres from the tracks or at residential locations.

- Wind tunnel tests conducted at the University of Sydney using 1:50 scale models of typical QR coal wagons, typical loading profiles, 80 km/hour travel speed, and typical operating conditions indicate that wind speeds over the coal surface will exceed 20 metres per second (72 km per hour).

- Laboratory tests conducted at the University of Newcastle on 30 typical coal types transported by QR Limited indicate that major dust lift-off from the coal surface can occur from the majority of tested coal types when the wind speed over the coal surface is less than 40 km/hr.

- Laboratory tests conducted at the University of Newcastle on seven typical coal types transported by QR Limited and five veneer treatments indicate that all surface veneer products, when applied at the supplier's recommended application rate and solution strength, achieved a significant reduction in dust lift-off compared with nil treatment.

- All surface veneer products were applied at a common application rate of one litre per square metre. The solution strength varied according to the supplier's recommendation. All test samples were exposed to a wind speed of 20 metres per second (72 km/hr) under test conditions for a period of 8 hours. Due to very rapid dust lift-off, the untreated samples (Nil treatment) were removed from the wind tunnel after exposure to the test conditions for only 1 minute. This observation applied to all tested coal types and indicates a high potential for lift-off for untreated wagons under normal train speeds.

- A range of measures have been identified that show potential to reduce the risk being caused by coal dust emissions. The following techniques have been identified as being practical and cost-effective and could be implemented within the Goonyella, Blackwater and Moura rail systems:

- Coal surface veneering using chemical dust suppressants at the mine
- Improved coal loading techniques at the mine to reduce parasitic load on horizontal wagon surfaces and reduce over-filling and hence spillage during transport
- Load profiling to create a consistent surface of coal in each wagon. To be implemented at the mine, and
- Improved unloading techniques to minimise coal ploughing and parasitic load on wagons

- Whilst wagon lids are likely to substantially reduce coal dust emissions from wagons, this cannot be considered in isolation of other issues. It is acknowledged that there are many potential operational impacts and costs associated with implementing wagon lids that cannot be estimated without a thorough detailed investigation. Such an investigation would need to consider the operational decisions, reliability of lids and facilities at very intricate level of detail. It is therefore considered prudent not to consider wagon lids as a potential mitigation strategy without undertaking the aforementioned course of action. The preliminary work presented in the environmental evaluation suggests that wagon lids are unlikely to be a feasible solution.

- The major concerns with the introduction of lids is the untried nature of these in the coal industry, a harsh environment. The lids proposed as a retrofit are of an experimental nature, hence are not able to be tried with any certainty as to whether they are reliable, safe or effective. The lids which would be incorporated in any design are by definition untried, however QR Limited’s experience with this style of lids in other industries has proven that these are maintenance intensive, hence cannot be recommended without significant development work being undertaken.

11. Recommendations

The Environmental Evaluation makes the following recommendations to QR Limited:

- QR Limited should develop a coal dust management plan as a framework for the ongoing management of the coal dust issue. The coal dust management plan should detail short-, medium- and long-term strategies for minimising coal dust emissions from the key dust sources that are highlighted in this document. The coal dust management plan should incorporate the principle of continual environmental improvement. The coal dust management plan should incorporate the subsequent recommendations.

- Further works should be undertaken to provide a more reliable estimate of coal leakage from Kwik-Drop doors to assist the assessment of the benefits of control of coal leakage from doors.

- Further laboratory tests and field trials should be conducted to explore the effectiveness of veneering for a broader range of coal types and to investigate the potential impact of slip failures in the coal on the overall effectiveness in terms of dust control.

- Further laboratory tests should be conducted on all coal types to explore the relevant treatment selection for each coal type and to refine the most cost-effective surface veneer treatment approach to achieve an acceptable level of dust emission during rail transport from mine to port. The responsibility for the costs of conducting this work could be negotiated as part of the Code of Practice.

- Ongoing monitoring should be implemented at strategic points within the Goonyella, Blackwater and Moura Systems to augment the baseline information collected in the Environmental Evaluation and to quantify the improvement in coal dust emissions as mitigation measures are implemented. The measurement technique adopted needs to:

  – Provide a reliable measure of the magnitude of coal dust emitted from a coal train during transport
  – Be relatively simple to maintain, calibrate and operate, and
  – Link measurements of coal dust with specific trains in a transparent way

- A Code of Practice should be developed by QR Limited in consultation with, and agreement from, all relevant stakeholders in the mine to port coal chain with the aim of minimising coal dust emissions from the rail corridor. The code of practice could state the ways of achieving compliance with the General Environmental Duty for activities that cause or are likely to cause environmental harm. The Code of Practice could give clear guidance on measures that should be taken to prevent or minimise environmental harm. The Code of Practice could state the minimum level of performance of surface veneers in controlling dust and the information that needs to be generated to certify that this is achievable.

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Appendix A

Literature Review

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Environmental Evaluation
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Contents

Executive Summary

This supplementary report presents the particulars of a literature review that was undertaken by Connell Hatch with respect to the Environmental Evaluation commissioned by Queensland Rail Limited. The aim of the report is to collect and analyse publicly available literature pertaining to coal dust emissions from rollingstock transport globally and draw conclusions from a comparison to the Central Queensland Coal Industry. In accordance with the Terms of Reference for the Environmental Evaluation, the literature review should focus on the following topics:

a) Identifying potential sources of coal dust emissions from rollingstock transport
b) Identifying factors and circumstances that contribute to emissions from each source
c) Quantifying the extent of emissions from each source
d) Identifying mitigation strategies pertaining to each source
e) Assessing each mitigation strategy for practicability and cost-effectiveness

The outcomes of the literature review completed by Connell Hatch include:

- Sources of coal dust emissions in the Central Queensland Coal Industry are comparable to those experienced globally
- Factors and circumstances contributing to coal dust emissions in the Central Queensland Coal Industry are comparable to those experienced globally
- The extent of coal dust emissions is governed by a multitude of variables which are not consistent between coal rollingstock transport systems
- Quantification of coal dust emissions must be determined by conducting work (trials, testing, modelling etc), in or which replicate Central Queensland Coal Industry conditions
- Mitigation strategies pertaining to coal dust emissions are comparable to those suggested and investigated globally
- The practicability and cost-effectiveness of mitigation strategies must be assessed by conducting work (trials, testing, modelling etc), in or which replicate Central Queensland Coal Industry conditions

Glossary of terms

ACARP
Australian Coal Association Research Program

BNSF
Burlington Northern Santa Fe (USA)

CFD
Computational Fluid Dynamics

CQCI
Central Queensland Coal Industry – entire coal supply chain

CQCN
Central Queensland Coal Network – entire rail infrastructure network

CSIRO
Commonwealth Scientific and Industrial Research Organisation

EE
Environmental Evaluation

EPS
Environmental Protection Service (Canada)

NCTA
National Coal Transportation Authority (USA)

PSD
Particle Size Distribution

QR
Queensland Rail Limited

QRNA
Queensland Rail Network Access – below rail operator

QRN
Queensland Rail National – above rail operator

SWA
Simpson Weather Associates (USA)

1. Introduction

Queensland Rail Limited (QR) has appointed Connell Hatch, John Planner of Introspec Consulting and Katestone Environmental to prepare an Environmental Evaluation (EE) of coal dust emissions engendered from rollingstock in the Central Queensland Coal Industry (CQCI) in response to a Notice issued by the Queensland Environmental Protection Agency (EPA). The deliverables of the report have been stipulated by the Terms of Reference for the project which encompass:

a) *Identify all potential sources of coal dust emissions from QR trains in Central Queensland on land described as rail lines connecting coal mines in the Bowen and Callide Basins with ports at Dalrymple Bay, Hay Point and Gladstone*

b) *Quantify the potential risk of environmental harm posed by each dust source*

c) *Identify the factors and circumstances that contribute to dust emissions and/or impacts from each source. Consideration should be given to (but not limited to) issues such as coal type, coal properties and meteorological conditions.*

d) *Based on the findings from the above, identify locations within QR's Central Queensland operations where proximity of railway lines to communities may give rise to higher risk of environmental harm due to fugitive coal dust*

e) *Identify ways to reduce the risk being caused by coal dust emissions and assess each for practicability, effectiveness and cost, in relation to the mitigation of environmental impacts of fugitive coal dust emissions*

The sources of coal dust emissions that have been identified in the CCQI include emissions from:

- The coal surface of loaded wagons
- Coal leakage from the doors of loaded wagons
- Wind erosion of spilled coal in the rail corridor
- Residual coal in unloaded wagons and leakage of residual coal from the doors
- Parasitic load on sills, shear plates and bogies of wagons

The factors and circumstances that contribute to coal dust emissions that have been identified in the CCQI include:

- Coal properties
- Train speed and ambient wind speed
- Train passing a loaded train
- Train frequency or system throughput
- Train vibration
- Profile of coal load
- Transport distance
- Precipitation

Mitigation strategies pertaining to the coal dust emissions that have been identified in the CCQI include:

- Veneering the coal surface at the mine site
- Improved coal loading
- Load profiling
- Wagon washing
- Reduction in leakage through the doors

- Wagon lids

The aim of the literature review is to collect and analyse publicly available literature pertaining to coal dust emisson from rollingstock transport globally and draw conclusions from a comparison to the Central Queensland Coal Industry. Accordingly, the report should focus on addressing the Terms of Reference for the Environmental Evaluation and obtaining information which can be used to draw useful conclusions regarding coal dust emissions from rollingstock coal transport systems.

2. Coal loss

2.1 United States studies

Burlington Northern Santa Fe (BNSF) and Union Pacific railways are currently conducting a large ongoing study into the issues of coal dust emissions and ballast fouling on the joint line in the Southern Powder River Basin, United States of America. This study aims to quantify the effects of the coal dust emissions and determine solutions to the issue of ballast fouling. Information regarding this study is not publicly available, with minimal information sourced from BNSF presentations posted on the internet. Gaining access to information regarding this study would be beneficial for the outcomes of the literature review.

2.2 Wind characteristics and speed of transit

The problem of coal dust emissions strongly depends on wind flow characteristics, as observed in specific wind tunnel studies conducted on coal stockpiles. Experimental work by Ferreira et al (2003) showed that a semi-covered wagon releases about 0.001% of its nominal 60 tonne coal load (about 1.2 g/km/car) during 350 km of transport. This result is considerably smaller than other values indicated in available literature. It must however be considered that these results were for the case of a semi-covered wagon and only considered the coal dust emissions as a result of wind erosion. Additionally, this testing was performed in Portugal and the atmospheric conditions and coal characteristics are not comparable with those observed in Queensland conditions.

Wagon covers can be used to mitigate the effects of wind. Ferreira and Vaz (2004), in further scale model investigations of the previously mentioned full scale study, found that the use of a semi-cover system, despite the existence of a one metre wide gap along the upper part of the wagon, significantly reduced the amount of dust released and consequently the damaging environmental impacts. Compared to an open wagon, a semi-covered wagon reduced dust emissions in excess of 80%.

A study performed for Norfolk Southern Rail by Simpson Weather Associates (SWA) in Virginia found that coal dust emissions from wind erosion were approximately 280 g/km/car (SWA 1994). This is appreciably larger than the 1.2 g/km/car determined by Ferreira et al (2003). The purpose of the SWA study was to determine the possible environmental impact of coal dust emissions and consequently the coals used were specifically chosen on the condition they constituted the dustiest tenth of all coals transported by Norfolk Southern, consequently representing the worst case scenario. The location of the studies is also not comparable with other studies, breaking down the ability to compare the two investigations.

The quantity of coal dust emissions has been deemed to be non-linearly related to the speed of train travel (SWA 1993). The most extreme emission events occur when two trains pass, and in other cases where there is significant lateral wind stresses (in tunnels, rock cuts, trestles, etc). It has also been noted that the dust emission intensity and frequency were found to be significantly higher during acceleration through a speed, than deceleration through the same speed. This has been attributed to coal dust emissions during travel and the subsequent absence of surface particles for emission during deceleration (SWA 1993).

McGilvray (2006) modelled changing train speed and coal profile through Computational Fluid Dynamics (CFD) to determine the effects of these characteristics. Three train velocities (12.5, 18.75 and 25 m/s) and four coal profiles (100 mm below sill, flat, 200 mm and 400 mm above sill) were tested to quantify the impacts on coal mass loss. It was found that the mass emitted for every coal profile was reduced by approximately 90% with a reduction in speed from 25 m/s to 12.5 m/s (90 km/hr to 45 km/hr). This observed mass loss reduction was approximately 66% for the reduction in speed from 25 m/s to 18.75 m/s (90 km/hr to 67 km/hr).

Witt et al (1999) investigated the effects of changing wind speeds on dust emissions from conveyors. The results of the model predict a 63% reduction in dust emissions when the speed is reduced by

25%. This was considered consistent with the complementary experimental work that was performed in a wind tunnel, however it is not directly applicable because of the varying geometry between wagons and conveyers.

2.3 Atmospheric conditions

The atmospheric conditions of the region in which coal is transported can have a significant impact on the likelihood of coal dust lift off and wind erosion. The external temperature, humidity and rainfall level of the environment are all factors that contribute to this issue. The SWA investigation into the reduction of coal dust emissions from rail wagons found that the extent of wind erosion is strongly dependent on the atmospheric conditions and the corresponding coal surface temperature (SWA 1993). A coal that might emit frequent and intense emissions during daytime will be less prone to emissions during colder night time hours, however no quantitative relationship to this effect was developed.

2.4 Coal characteristics

Materials possessing a wide particle size distribution (PSD) experience a decrease in emitted mass flux over time as a result of wind erosion. This is attributable to the presence of coarse particles at the surface that are unable to dislodge because they possess a greater inertia than smaller particles. This cover of coarse particles is known as the pavement and is responsible for a decrease in emitted mass flux over time (Descamps et al 2003). Therefore the greater the percentage of coarse particles in the material, the less mass is lost. In addition, coal with larger sized particles may have less chance of leaving the wagon through the gap between the wagon and the doors.

The National Coal Transportation Authority (NCTA) has discovered through preliminary investigations that customer preferences for 2-inch coal lumps may also be contributing to ballast fouling due to an increased proportion of fine particles than 3-inch coal lumps. However, it was also shown that this analysis was not conclusive and more investigation would be required (Union Pacific Rail 2006).

2.5 Wagon design

A study in Western United States of America on BNSF railway coal carrying trains found that over a 925 km trip an average of 100 kg of coal was lost per car when not treated with a dust suppressant. Of this 100 kg, an average of 17 kg was lost through the bottom of each wagon with rapid discharge rail doors (NCTA 2007). It can be argued that the coal lost through the bottom of the car potentially contributes more to ballast fouling than coal lost from the top of the car since the leakage occurs much closer to the ballast and interacts more directly with it. It was noted that rapid discharge cars tend to lose more coal fines through the bottom gates than conventional gondolas (Union Pacific Rail 2006).

2.6 Unloading facilities

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) in conjunction with QR are currently working on a project titled “Reduction of Carry-Back and Coal Spillage in Rail Transport” funded by the Australian Coal Association Research Program (ACARP). In October 2007 a draft report (P2007/893) “Analysis of Carry-Back at the RG Tanna Coal Terminal” was released with preliminary results from a carry-back quantification experiment. The study used two laser scanners to reconstruct a three dimensional model of the interior of each passing wagon. The mean and maximum carry-back for each month of the trial is presented in Table 1. These results estimate that seven trains worth of coal is lost annually due to carry-back, the majority of which eventually constitutes fugitive coal loss.

Table 1 – Monthly Carry-back from RG Tanna Coal Terminal (Einicke et al 2006)

Month	Mean Carry Back	Maximum Carry Back
March 2007	0.094 t	1.20 t
April 2007	0.097 t	1.16 t
May 2007	0.130 t	1.59 t
June 2007	0.105 t	0.61 t

Coal Density of 800 kg/m^3

A pending outcome from the project is how to deal with 'sticky coal', that is coal deposits that remain inside a coal wagon after unloading. Sticky coal events can occur for a number of reasons, such as high train speeds, insufficient feed-out capacities, coal properties and the absence of wagon vibrating systems. The project scope includes enabling the carry-back analysis to quantify each case of sticky coal, and determine appropriate action based on the amount of sticky coal residing in each wagon. It is suggested that small deposits require the wagon to be washed, whereas larger sized deposits require the train to be reversed and manual vibration techniques employed to remove the coal. In extreme cases of sticky coal events, wagons are required to be shunted (removed) from the set of wagons and excavators utilised to manually remove the coal.

3. Coal loss preventive solutions

3.1 Loading facilities

A collaborative study between the National Coal Transportation Association (NCTA), Union Pacific, BNSF and mines in the United States reported that an improved coal loading chute was designed that distributes coal more evenly and produces a load with a lower profile above the side sills of the railcar. It was also reported that preliminary test results demonstrated a 30-60% reduction in coal dust blowing off the top of the car during the early portion of transport. More analysis is required on the longer-term impact of the redesigned chutes on actual coal dust mitigation (Union Pacific Rail 2006). Further access to information about the actual design of the chute was unavailable.

There are a number of solutions for coal dust losses that have been identified in the literature. Many of these solutions focus on the technique of veneering, where a chemical treatment is sprayed onto the surface of the coal, or load profiling, where coal is loaded into the wagon in a way that will minimise dust emissions. Load profiling acts to improve the effects of the veneering by ensuring a more even application of the dust suppressant and reduce the impact of settling.

McGilvray (2006) suggests two solutions for reducing coal dust lift off from rail wagons. The first suggested solution is to reduce the coal level below the top sill with higher wagon sides or load profiling and inherently protect the coal from the oncoming wind flow. The other suggested solution is to protect the last couple of wagons by spraying or adding additional train components (ie locomotives or dummy wagons) to the end of the consist, coinciding with regions where large vortices develop and dust emissions are suggested to be maximised.

The Norfolk Southern Rail study concluded that reducing the extent of coal dust emission would require critical evaluation of a solution including critical slope management of load top profiles and the use of chemical binders for veneering. This study by Simpson Weather Associates (1993) found that levelling the load or lowering the load below the sill appears to only have a minimal impact on reducing fugitive coal and does not act to decrease the frequency of severe dusting events. These severe dusting events are the result of turbulent flow caused by preceding wagons.

Work by the Environmental Protection Service (EPS) of Canada studied coal dust losses over the period from 1973-1985 to reduce dust emissions along the Fraser River rail corridor, from West Alberta to Vancouver, British Columbia. As a result of this study trains on this rail corridor were loaded below the wagon sill and a crust forming chemical treatment was applied. Although it was expected that with a crust retention rate of 85% there would be a corresponding 85% decrease in dust emissions it was found in subsequent investigations that this relationship did not necessarily hold and these emissions reductions were not achieved (SWA 1993).

3.2 Veneering

Numerous trials of veneering systems have been conducted at wagon loading facilities in the CQCI over the past few years. All of the trials have used similar basic mechanical components, with the veneering application achieved by means of the following components:

- Water and suppressant storage tanks
- Dosing system to achieve the desired solution strength
- Shower bar to apply suppressant to the coal profile (see Figure 1)
- Control system facilitating autonomous operation

In this way, it has been shown that the trialled veneering systems are compatible with continuous wagon loading systems, and consequently veneering applications can assimilate effectively into normal operations with minimal disruption to the supply chain.

Figure 1 – Trial Veneering System

Figure 2 – Veneering Trial Train

Initially three different suppressants were trialled at a wagon loading facility in the CQCI. The first half of each train was veneered with a suppressing agent, with the second half remaining untouched for comparative purposes. Figure 2 shows a photograph of a train participating in the trial which displays a noticeable increase in the dust cloud around the second half of the train. Some of the key issues and observations arising from the trials include:

- Water consumption - it was identified that the long-term sustainability of veneering applications would depend heavily on water usage
- Cost - it was noted that a small operating cost differential would result in a noteworthy overall cost if veneering was adopted throughout the CQCI
- Suppressant implications on rollingstock - some suppressing agents were sticky in nature and adhered to rollingstock during the trial, proving difficult to remove. This is not acceptable for rail operators as regular veneering applications may degrade the quality of the rollingstock resulting in long-term sustainability issues

The recommendation of the initial trials was that a year long trial be pursued with a chosen suppressing agent to perform thorough testing in varying weather conditions with varying coal types. The recommendation was adopted and a year-long trial was implemented which produced positive results.

4. Conclusion

Open literature is available to the affect of the major aspects that constitute the commissioned Environmental Evaluation. Literature relating to coal dust emissions from rollingstock transport is mainly concerned with wind engaging with coal surfaces and dislodging particles from the surface that possess relatively small inertias. Many studies have been undertaken with respect to wind erosion, particularly on coal wagons, coal stockpiles and coal conveyers. The quantification presented from these studies is not directly applicable to the Central Queensland Coal Industry due to varying:

- coal properties
- meteorological conditions
- wagon geometry
- transport speeds

However, there are relative relationships and observations which provide insight into the mechanics of coal dust emissions due to wind erosion will be valuable to the project, some of which include:

- reduction in coal dust emissions due to semi covered wagons
- empty wagons can produce more coal dust emissions then full wagons
- coal dust emissions are not linearly related to transport speed
- cases involving lateral wind events produce the worst case dust emissions
- lowering the coal profile below the sill reduces coal dust emissions

Information regarding coal dust emission mitigation strategies is limited to wagon load profiling and veneering applications. Consistent and below sill profiles are recommended for reducing coal dust emissions, however due to varying wagon geometry and payloads this may not be directly applicable to the Central Queensland Coal Industry. The majority of literature regarding veneering applications has been obtained through trials conducted by Queensland Rail Limited, a process which is continuing within the Environmental Evaluation.

Coal dust emissions, the mechanisms that generate these losses and mitigation strategies for coal dust emissions have been experienced, analysed and tested globally in relation to rollingstock transport activities. The dust emissions, mechanisms and strategies are comparable in process to those experienced within the Central Queensland Coal Industry, however due to varying conditions are not related quantitatively. Work (trials, testing, modelling etc) conducted in, or which simulate, local conditions are the only means of accurately measuring and defining coal dust emissions attributable to rollingstock transport, which will provide the impetus for analysing and justifying mitigation strategies.

Appendix A

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Appendix A

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Appendix B

Ambient air quality monitoring

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Contents

Glossary of terms

ACARP
Australian Coal Association Research Program

BNSF
Burlington Northern Santa Fe (USA)

CFD
Computational Fluid Dynamics

CQCI
Central Queensland Coal Industry – entire coal supply chain

CQCN
Central Queensland Coal Network – entire rail infrastructure network

CSIRO
Commonwealth Scientific and Industrial Research Organisation

EE
Environmental Evaluation

EPS
Environmental Protection Service (Canada)

NCTA
National Coal Transportation Authority (USA)

PSD
Particle Size Distribution

QR
Queensland Rail Limited

QRNA
Queensland Rail Network Access – below rail operator

QRN
Queensland Rail National – above rail operator

SWA
Simpson Weather Associates (USA)

1. Introduction

This report has been prepared by Katestone Environmental on behalf of Connell Hatch. Connell Hatch, Katestone Environmental and Mr John Planner have been commissioned by Queensland Rail to conduct an Environmental Evaluation of fugitive emissions of coal dust from trains. Under Sections 323 and 324 of the Environmental Protection Act 1994, the Queensland EPA has required the Environmental Evaluation to be undertaken.

The primary scope of the Environmental Evaluation is to:

(a) *Identify all potential sources of coal dust emissions from QR trains in Central Queensland on land described as rail lines connecting coal mines in the Bowen and Callide Basins with ports at Dalrymple Bay, Hap Point and Gladstone*
(b) *Quantify the potential risk of environmental harm posed by each dust source*
(c) *Identify the factors and circumstances that contribute to dust emissions and/or impacts from each source. Consideration should be given to (but not be limited to) issues such as coal type, coal properties and meteorological conditions*
(d) *Based on the findings from the above, identify locations within QR's Central Queensland operations where proximity of railway lines to communities may give rise to higher risk of environmental harm due to fugitive coal dust*
(e) *Identify ways to reduce the risk being caused by coal dust emissions and assess each for practicability, effectiveness and cost, in relation to the mitigation of environmental impacts of fugitive coal dust emissions*

Underlined above are the key aspects of the scope of the Environmental Evaluation that have been directly assessed through the dust monitoring program. This document outlines the objectives, methodology and results of a dust monitoring program.

2. Objectives of monitoring study

The objectives of the ambient air quality monitoring study are to:

(a) Quantify the coal dust concentration and deposition rate at the edge and outside of the rail corridor
(b) Correlate measurements of dust concentration with meteorological conditions
(c) Correlate measurements of dust concentration with trains passing
(d) Quantify contribution of coal trains to ambient concentrations of dust, and
(e) Provide measurements to assist in validating dust emissions and dispersion modelling

3. Methodology

3.1 Standard methods

The dust monitoring program has been conducted in accordance with the requirements of the EPA and in a manner that is consistent with the following Australian Standards:

- *AS 3580.9.8-2001, Method for sampling and analysis of ambient air - Determination of suspended particulate matter - PM_{10} continuous direct mass method using a tapered element oscillating microbalance analyser;*
- *AS/NZS 3580.9.9:2006, Methods for sampling and analysis of ambient air - Determination of suspended particulate matter - PM_{10} low volume sampler - Gravimetric method; and*
- *AS/NZS 3580.10.1:2003, Methods for sampling and analysis of ambient air - Determination of particulate matter - Deposited matter - Gravimetric method.*

3.2 Siting considerations

3.2.1 Dust monitoring equipment

Dust monitoring equipment has been sited as far as is possible in accordance with:

- *AS/NZS 3580.1.1:2007, Methods for sampling and analysis of ambient air - Guide to siting air monitoring equipment*

AS/NZS 3580.1.1 sets out general guidelines for siting monitoring equipment for the measurement of ambient air quality. Compliance with the Australian Standard will provide data that is most suitable for establishing the ambient concentration of dust. Key siting requirements include:

- Clear sky angle of 120° above sampling inlet
- Unrestricted airflow of 180° around sampling inlet
- 10 metres from the nearest object or the dripline of trees that are higher than 2 metres below the height of the sample inlet
- No extraneous sources nearby
- Greater than 50 metres from road

3.2.2 Meteorological monitoring equipment

Meteorological monitoring equipment has been sited as far as is possible in accordance with:

- *AS 2923-1987, Ambient air - Guide for measurement of horizontal wind for air quality applications*

The Australian Standard AS2923 sets out general guidelines for siting monitoring equipment for the measurement of meteorology. Compliance with the Australian Standard will provide data that is most suitable for characterising local wind conditions. Full compliance with this standard can be difficult to achieve, particularly in situations where the meteorological monitoring is not the primary objective. In relation to the dust monitoring program for QR, to meet the objectives of the dust monitoring program may conflict with some aspects of an ideal meteorological monitoring location. In such circumstances, it is important to minimise any inconsistencies with the Australian Standard.

In order to characterise the wind conditions over a horizontal scale that is consistent with the dispersion of dust, measurements of wind speed and wind direction should be made at a height of ten metres above ground level.

The specific location of the meteorological monitoring station should be chosen to meet the following conditions if possible:

- Generally flat area free of obstructions, and
- The anemometer should be separated from any obstruction by a distance of more than ten times the height of the obstruction.

4. Monitoring locations and results

4.1 Continuous monitoring

The continuous monitoring program consisted of 5 TEOMs, 2 collocated with Osiris devices (Earlsfield: Moura System and Boonal: Blackwater System) and 1 Topas unit (Mindi System) refer to the main report of the Environmental Evaluation. All continuous monitoring devices where positioned within 10 metres of the track (Figures 3.3.1, 3.3.5, 3.3.9, 3.3.13, 3.3.17, and 3.3.21) and on the predominantly downwind side of the rail corridor.

The TEOMs continuously monitored 5-minute average mass concentrations (TSP) at the edge of the rail corridor for a period of 2 to 3 months. The raw data was quality assured and 24-hour averages attained for TSP (Figures 3.3.3, 3.3.7, 3.3.11, 3.3.15, 3.3.19, and 3.3.23). Osiris and Topas data was received as 10-minute averages with a breakdown of TSP, PM10, PM2.5 and PM1 as well as wind speed and direction. These systems measure the light refraction from passing particulates to calculate mass and density. The benefits of such systems for continuous regulatory monitoring of TSP and its constituents is substantial as they are easily installed and operated, without the need to change filters and requiring minimal maintenance. In light of this, statistical comparisons of the collocated Osiris devices performance in relation to the TEOMs captured TSP was conducted (Section 2).

Correlation of train passing times with dust sampling periods proved a difficult task, no exact data is available of when trains passed the monitoring sites. At best, known train departure, arrival times, distance covered and average speed allowed for a good estimate of train locations in relation to the monitoring sites (refer to main text for detailed explanation). Meteorological data was recorded for all continuous monitoring sites for 5-minute average wind speed and direction. Wind direction was compared with TSP and represented as a wind/dust rose for each site (Figures 3.3.4, 3.3.8, 3.3.12, 3.3.16, 3.3.20, and 3.3.25). It appears that TSP production is greatest when the train is travelling head on into the wind (refer to section 5.1 in main text).

The raw and 24 hour average results for all sites is presented below, reference to the main text of the Environmental Evaluation is advised for detailed descriptions and commentary.

4.2 Moura System

The locations of the monitoring stations in the Moura System are shown in Figure 1.

Figure 2. Moura system and monitoring sites. The black lines mark the network of rail tracks in this region. Image courtesy of Google Earth 2008

4.2.1 TEOM results for Beecher, Gladstone: Moura System. November 11 to December 13 2007

The location of the Beecher TEOM is shown in Figure 2. The results of monitoring are shown in Figures 3, 4 and 5.

Figure 2. Site location of Beecher dust deposition gauge and TEOM 23°53'46.23"S 151°12'11.35"E. Image courtesy of Google Earth 2008

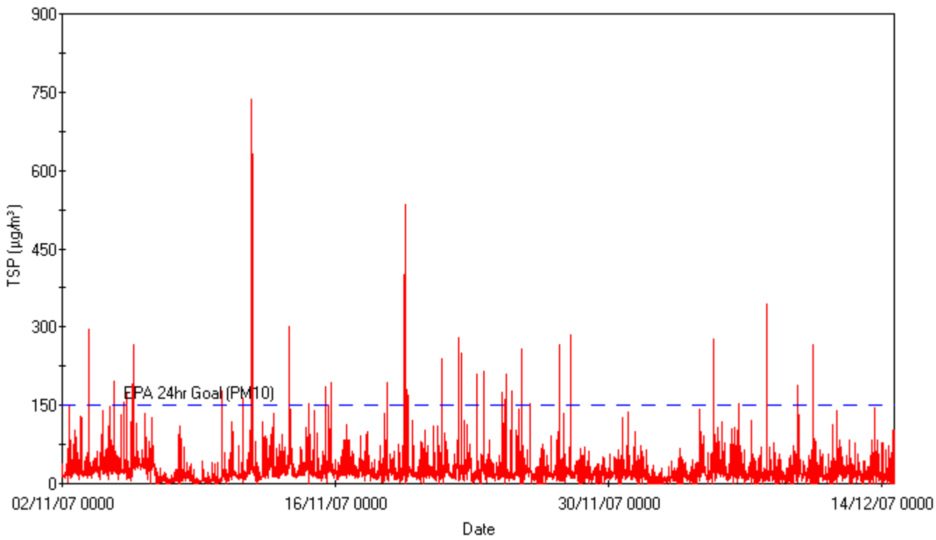

Figure 3. 5-minute average Mass Concentration of TSP (µg/m³) measured at 10 metres from the tracks at Beecher (November 11 to December 13 2007)

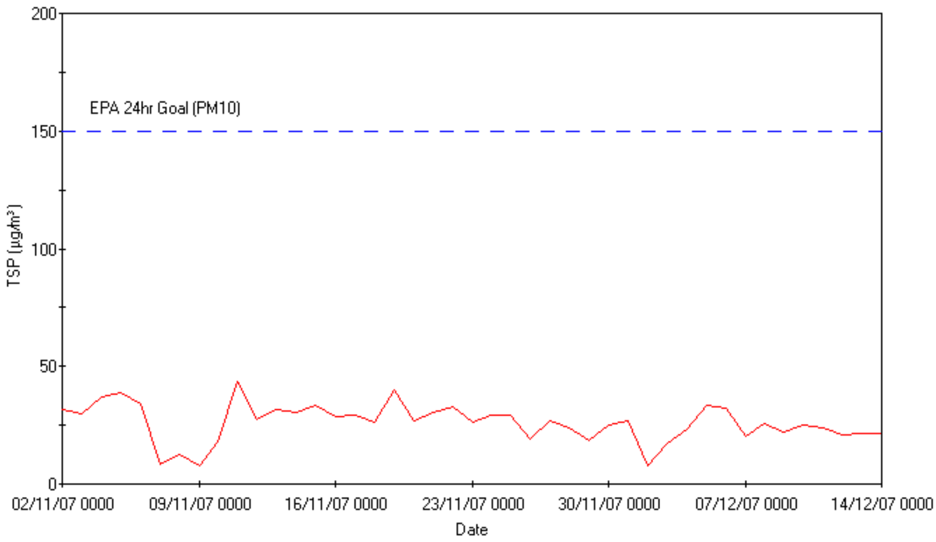

Figure 4. 24 hour average Mass Concentration of TSP (µg/m³) measured at 10 metres from the tracks at Beecher (November 11 to December 13 2007)

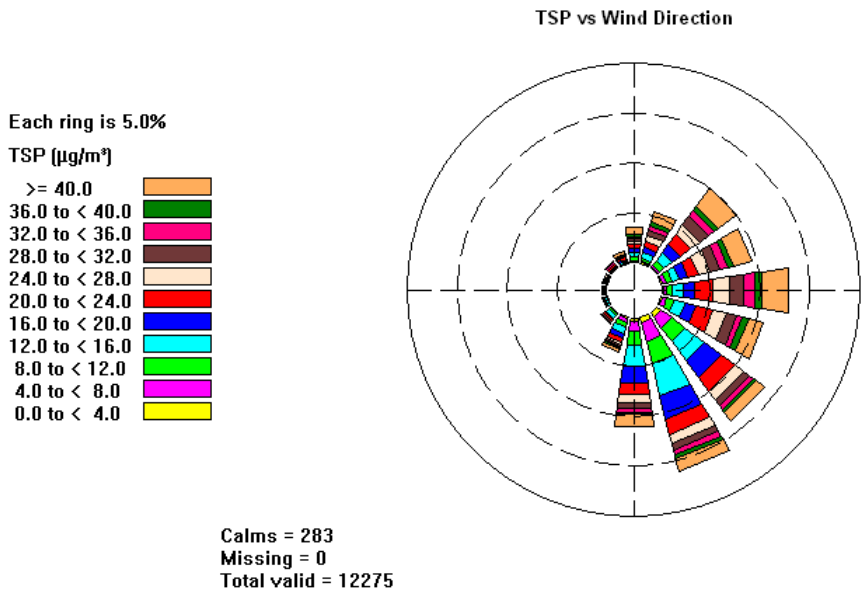

Figure 5. Wind/Dust rose of 5-mintue average wind direction and TSP (µg/m³) measured at 10 metres from the tracks at Beecher (November 11 to December 13 2007). The directional spread of the columns indicates a predominance of East to South East wind components; the coloured portion of the columns is TSP concentration

4.2.2 TEOM results for Earlsfield: Moura System. December 18 2007 to February 29 2008

The location of the Earlsfield TEOM is shown in Figure 6. The results of monitoring are shown in Figures 7, 8 and 9.

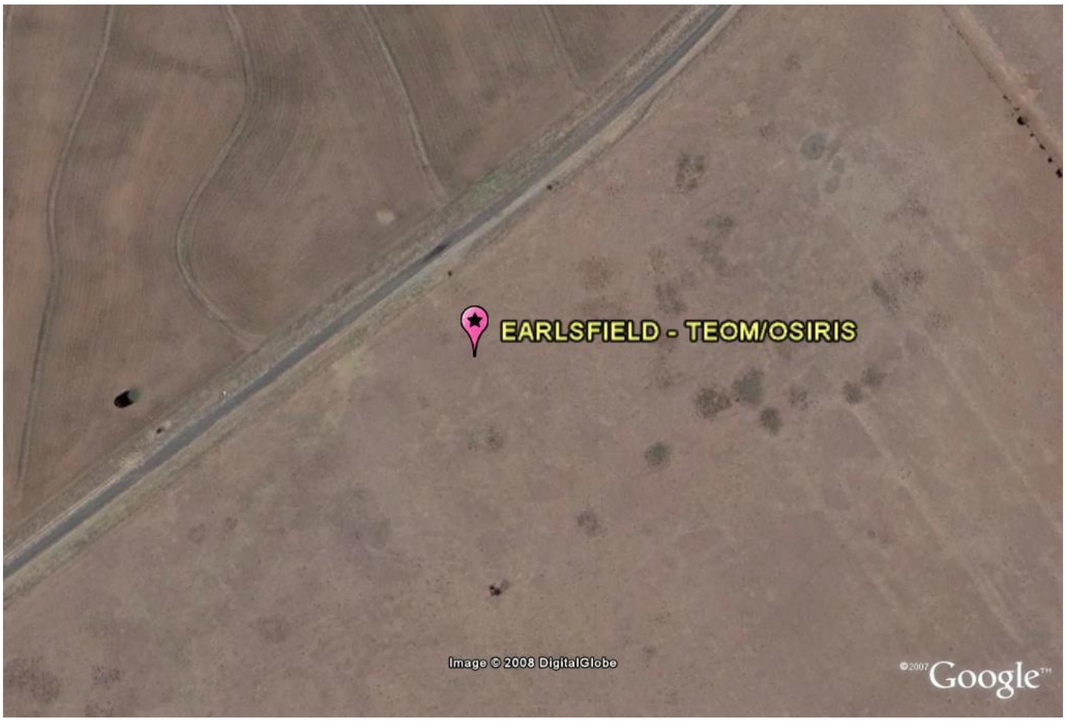

Figure 6. Site location of Earlsfield TEOM and Osiris 24°22'23.98"S 150°42'54.302"E. Image courtesy of Google Earth 2008

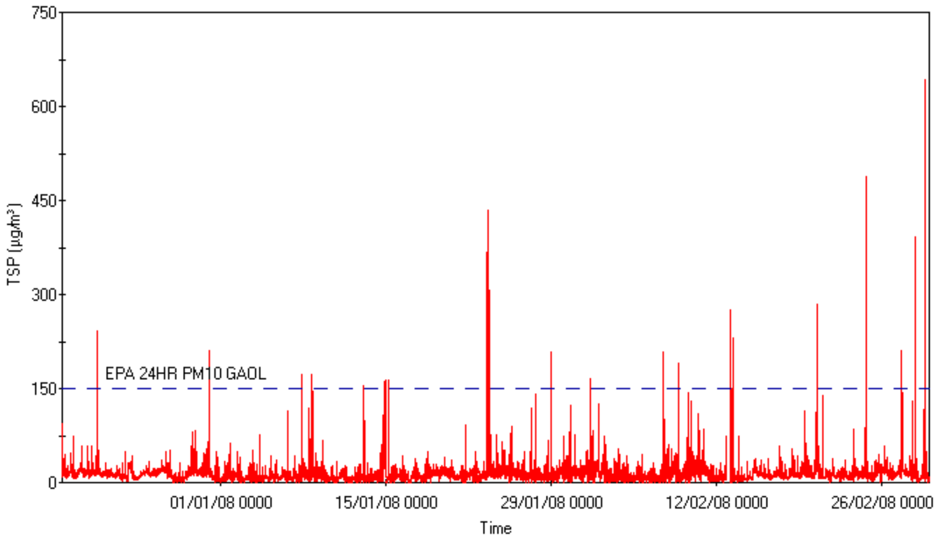

Figure 7. 5-minute average Mass Concentration of TSP (µg/m³) measured at 10 metres from the tracks at Earlsfield (December 18 2007 to February 29 2008)

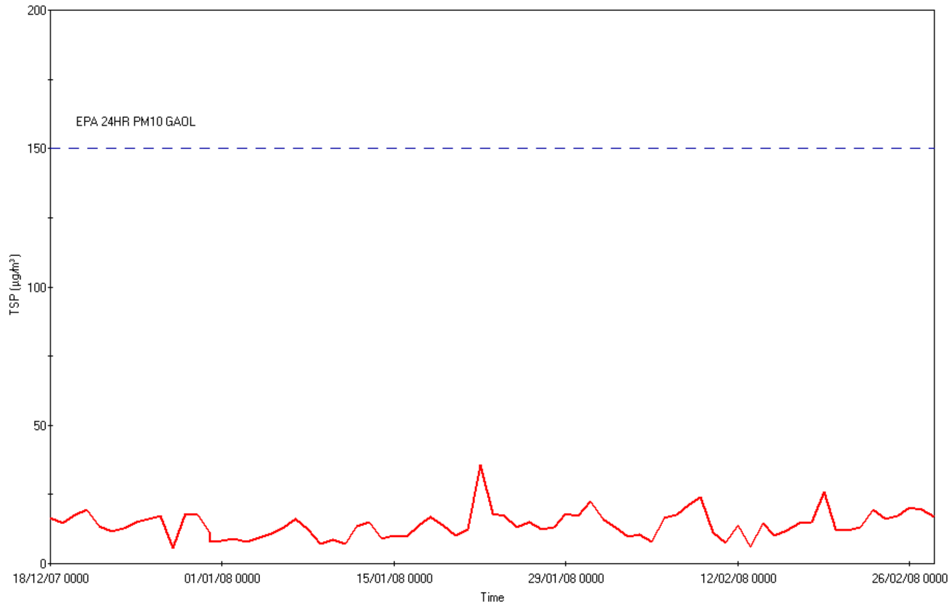

Figure 8. 24 hour average Mass Concentration of TSP (µg/m³) measured at 10 metres from the tracks at Earlsfield (December 18 2007 to February 29 2008)

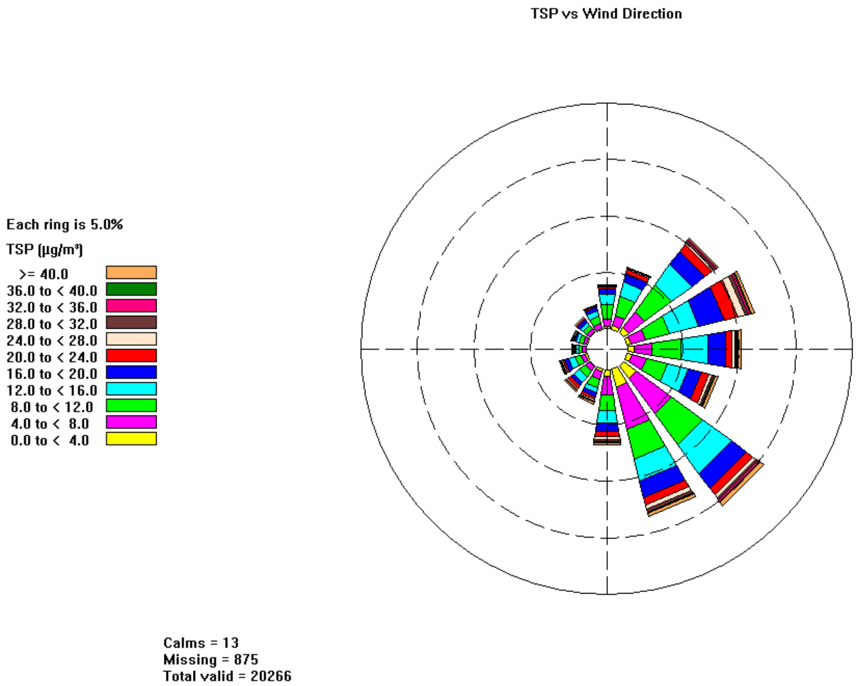

Figure 9. Wind/Dust rose of 5-mintue average wind direction and TSP (µg/m³) measured at 10 metres from the tracks at Earlsfield (December 18 2007 to February 29 2008). The directional spread of the columns indicates a predominance of East to South East wind components; the coloured portion of the columns is TSP concentration

4.3 Blackwater System

The locations of the monitoring stations in the Blackwater System are shown in Figure 10.

Figure 10. Blackwater system and monitoring sites. The black lines mark the network of rail tracks in this region. Image courtesy of Google Earth 2008

4.3.1 TEOM results for Raglan: Blackwater System. October 22 to December 13 2007

The location of the Raglan TEOM is shown in Figure 11. The results of monitoring are shown in Figures 12, 13 and 14.

Figure 11. Site location of Raglan TEOM 23°71'75.08"S 150°81'82.82"E. Image courtesy of Google Earth 2008

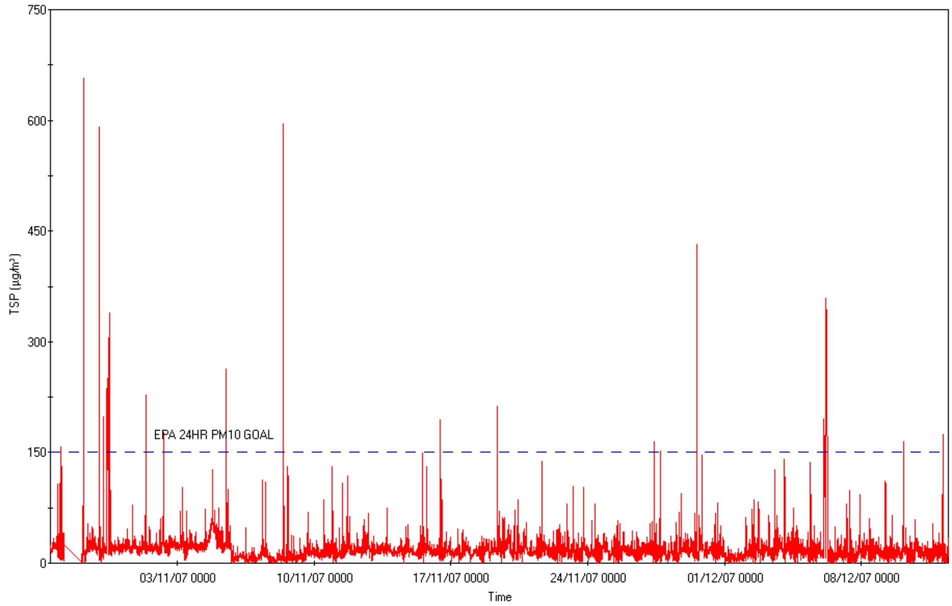

Figure 12. 5-minute average Concentration of TSP (µg/m³) measured at 10 metres from the tracks at Raglan (October 22 to December 13 2007)

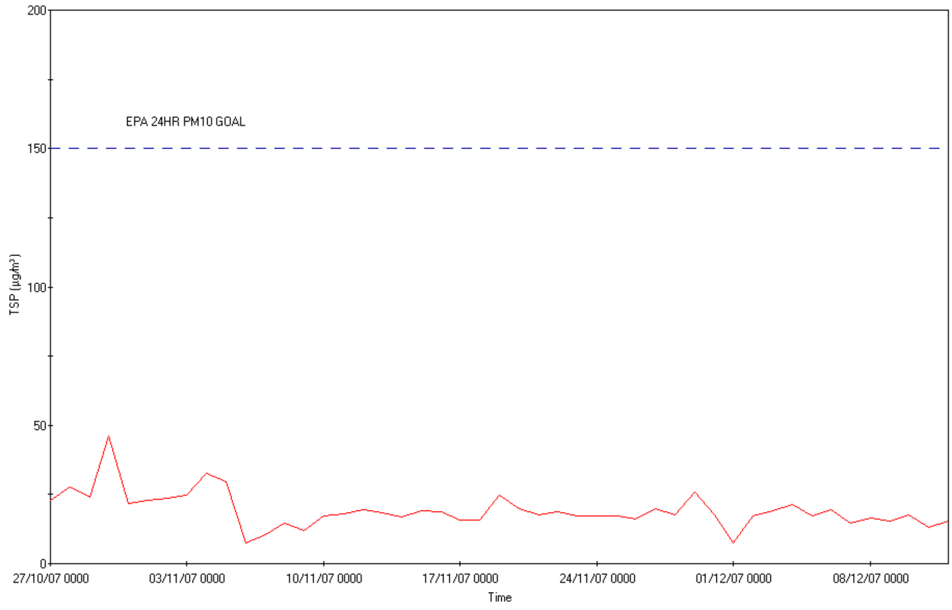

Figure 13. **24 hour average Concentration of TSP (µg/m³) measured at 10 metres from the tracks at Raglan (October 22 to December 13 2007)**

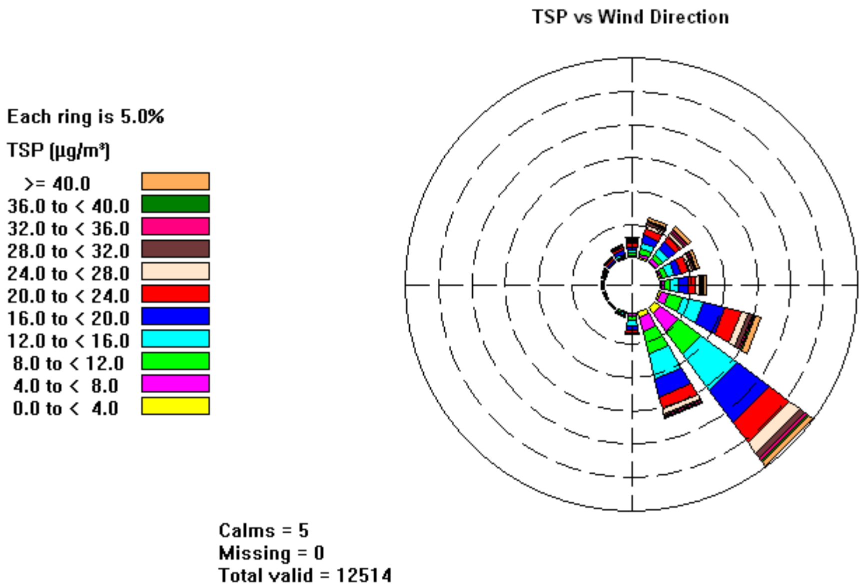

Figure 14. **Wind/Dust rose of 5-mintue average wind speed (m/s) and wind direction measured at 10 metres from the tracks at Raglan (October22 to December 13 2007). The directional spread of the columns indicates a predominance South East wind components; the coloured portion of the columns is TSP concentration**

4.3.2 TEOM results for Boonal: Blackwater System. December 31 2007 to March 6 2008

The location of the Boonal TEOM is shown in Figure 15. The results of monitoring are shown in Figures 16, 17 and 18.

Figure 15. Site location of Boonal TEOM and Osiris 23°88'94.33"S 150°41'50.849"E. Image courtesy of Google Earth 2008

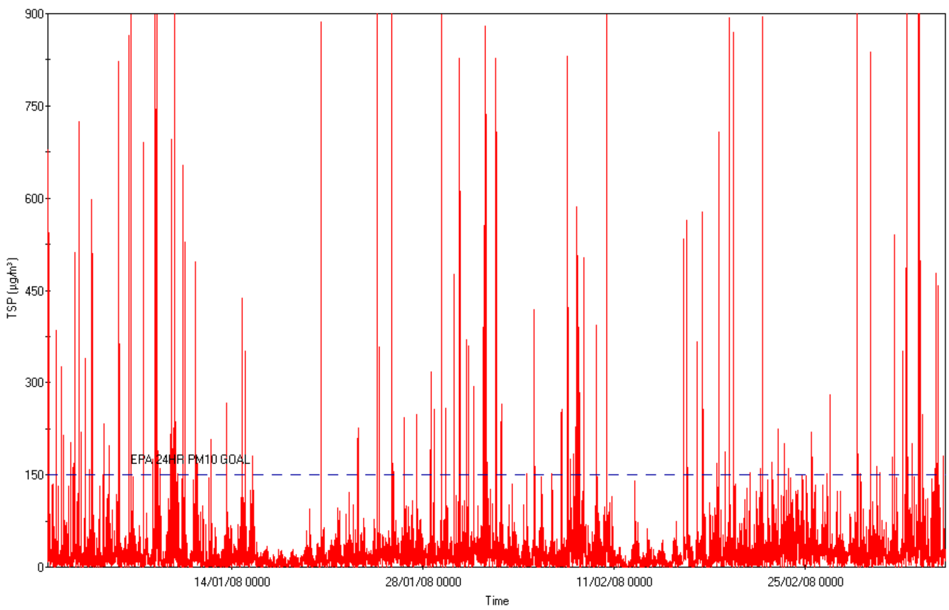

Figure 16. 5-minute average Concentration of TSP (µg/m³) measured at 10 metres from the tracks at Boonal (December 31 2007 to March 6 2008)

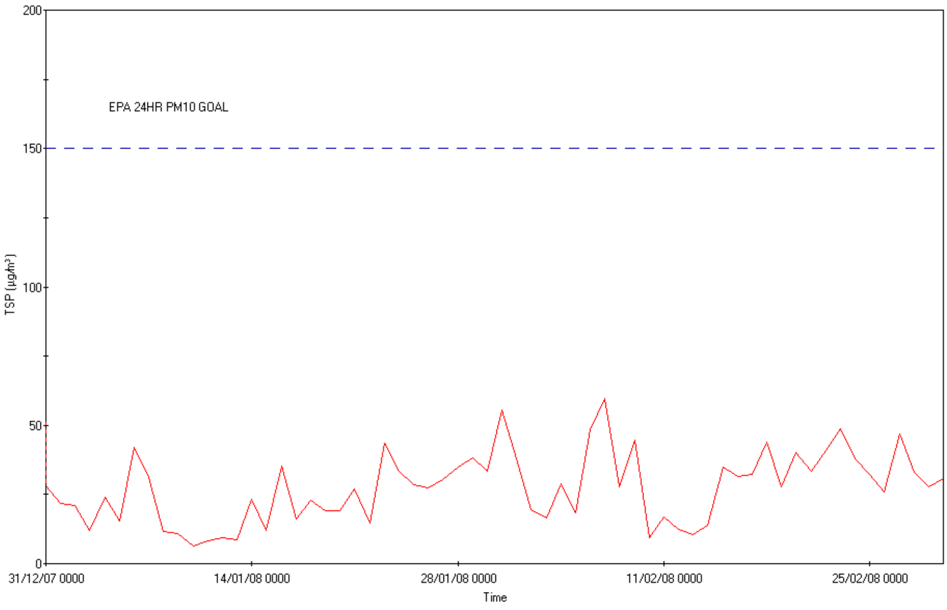

Figure 17. 24 hour average Concentration of TSP (µg/m³) measured at 10 metres from the tracks at Boonal (December 31 2007 to March 06 2008)

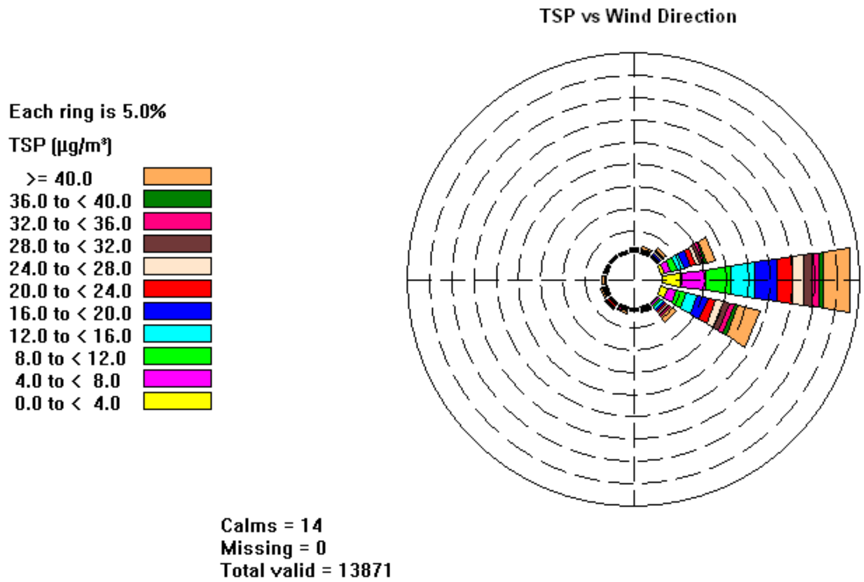

Figure 18. Wind rose of 5-mintue average wind speed (m/s) and wind direction measured at 10 metres from the tracks at Boonal (December 31 2007 to March 6 2008). The directional spread of the columns indicates a predominance of East wind components; the coloured portion of the columns is TSP concentration

4.4 Goonyella System

The locations of the monitoring stations in the Goonyella System are shown in Figure 19.

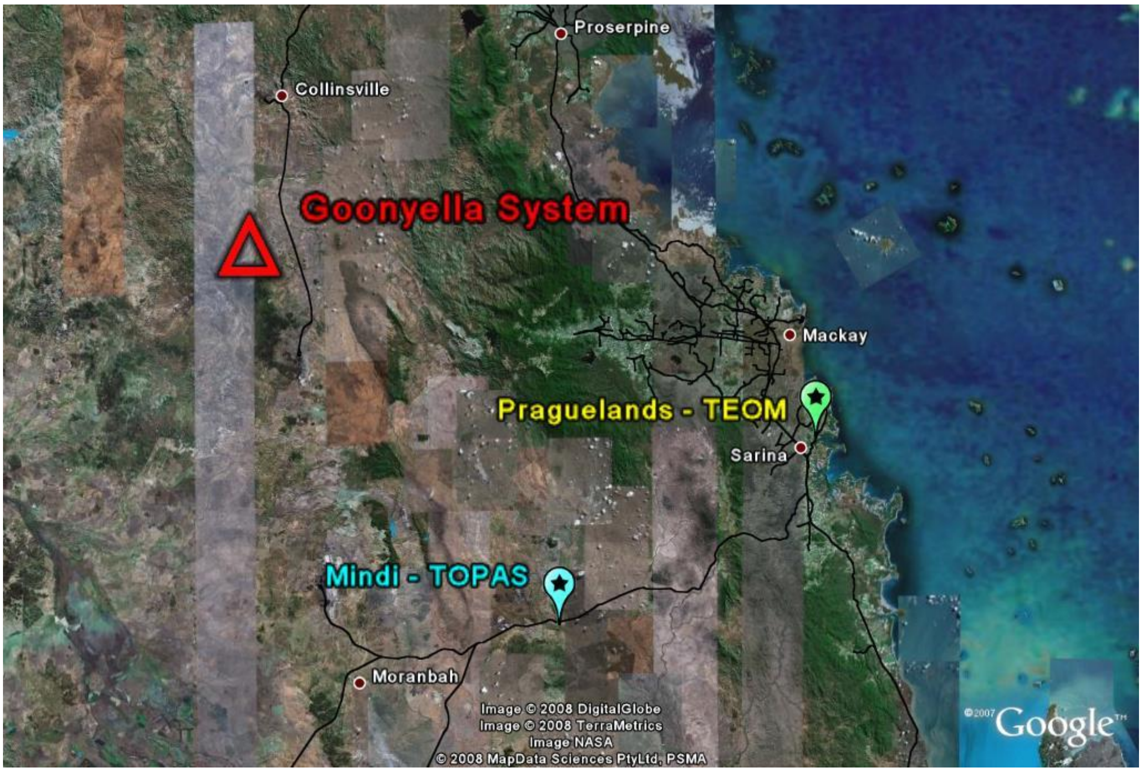

Figure 19. Goonyella system and monitoring sites. The black lines mark the network of rail tracks in this region. Image courtesy of Google Earth 2008

4.4.1 TEOM results for Praguelands: Goonyella System. November 11 2007 to February 29 2008

The location of the Praguelands TEOM is shown in Figure 20. The results of monitoring are shown in Figures 21, 22 and 23.

Figure 20. Site location of Praguelands TEOM 21°23'47.01"S 149°15'21.66"E. Image courtesy of Google Earth 2008

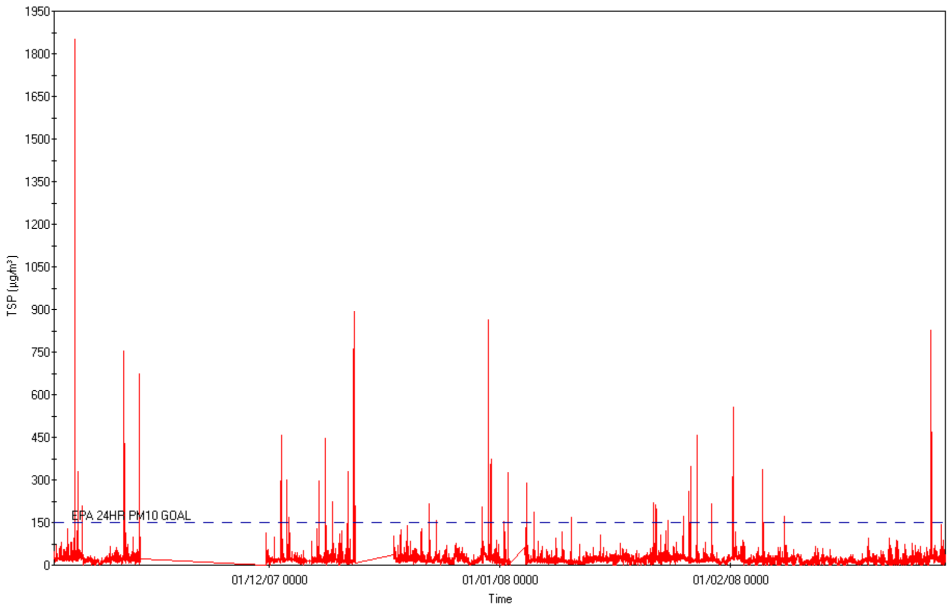

Figure 21. 5-minute average Concentration of TSP (µg/m³) measured at 10 metres from the tracks at Praguelands (November 11 2007 to February 29 2008)

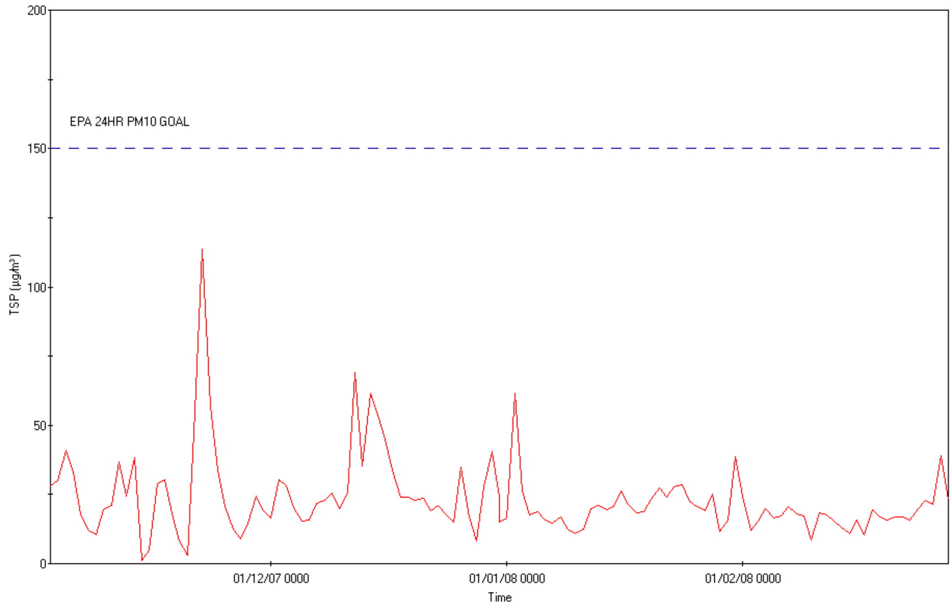

Figure 22. **24 hour average Concentration of TSP (µg/m³) measured at 10 metres from the tracks at Praguelands (November 11 2007 to February 29 2008)**

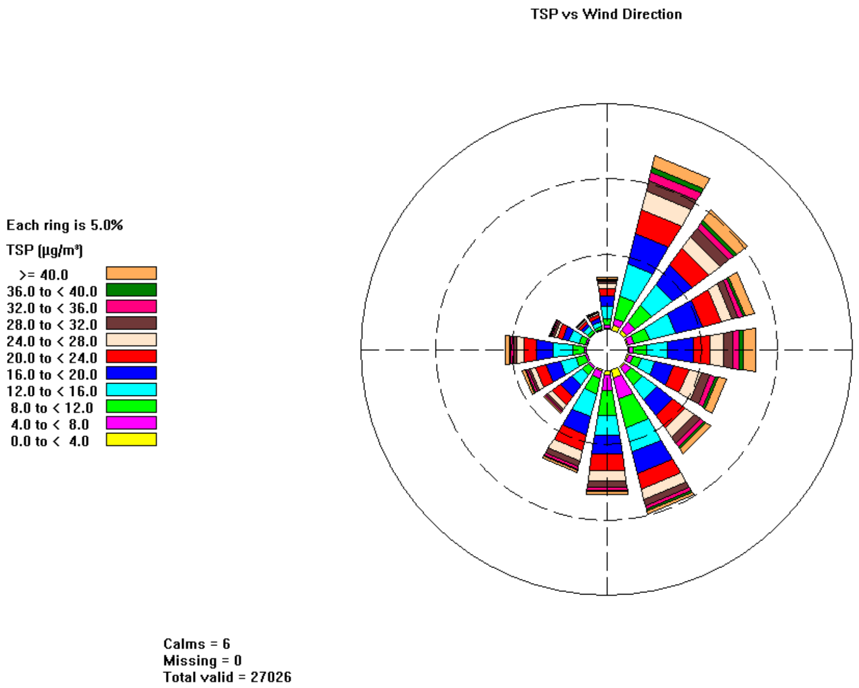

Figure 23. **Wind rose of 5-mintue average wind speed (m/s) and wind direction measured at 10 metres from the tracks at Praguelands (November 11 2007 to February 29 2008). The directional spread of the columns indicates a predominance of North East and South East wind components; the coloured portion of the columns is TSP concentration**

4.4.2 TOPAS results for Mindi: Goonyella System January 14 to February 26 2008

The location of the Praguelands TEOM is shown in Figure 24. The results of monitoring are shown in Figures 25, 26, 27 and 28.

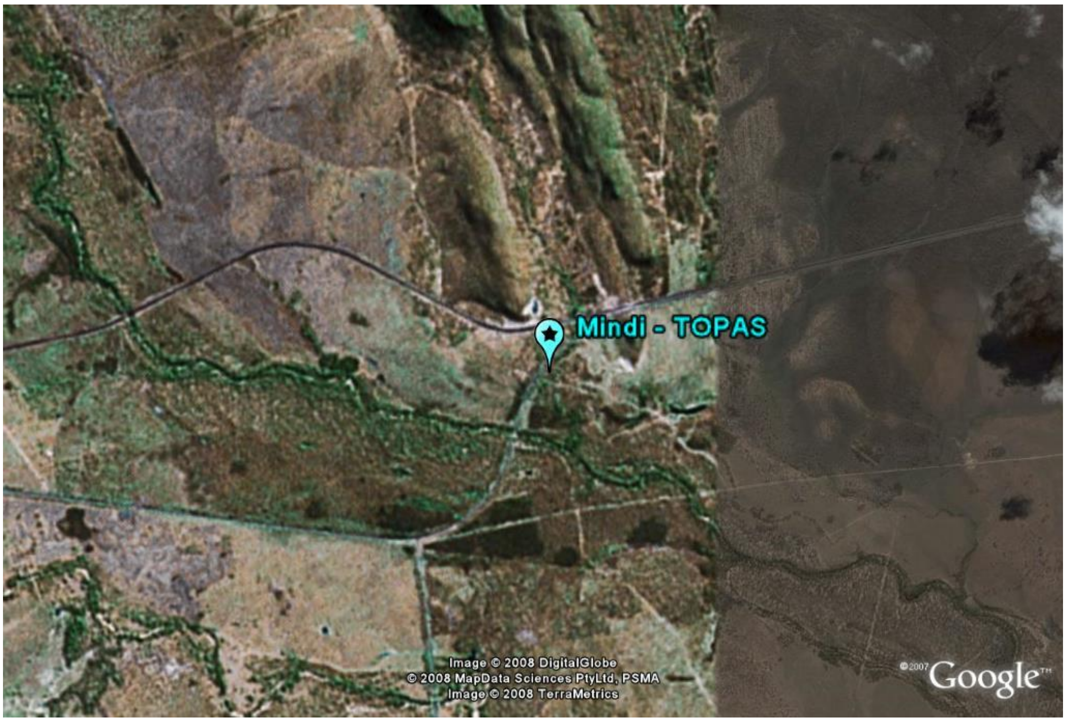

Figure 24. **Site location of Mindi TOPAS 21°51'26.09"S 148°34'37.82"E. Image courtesy of Google Earth 2008**

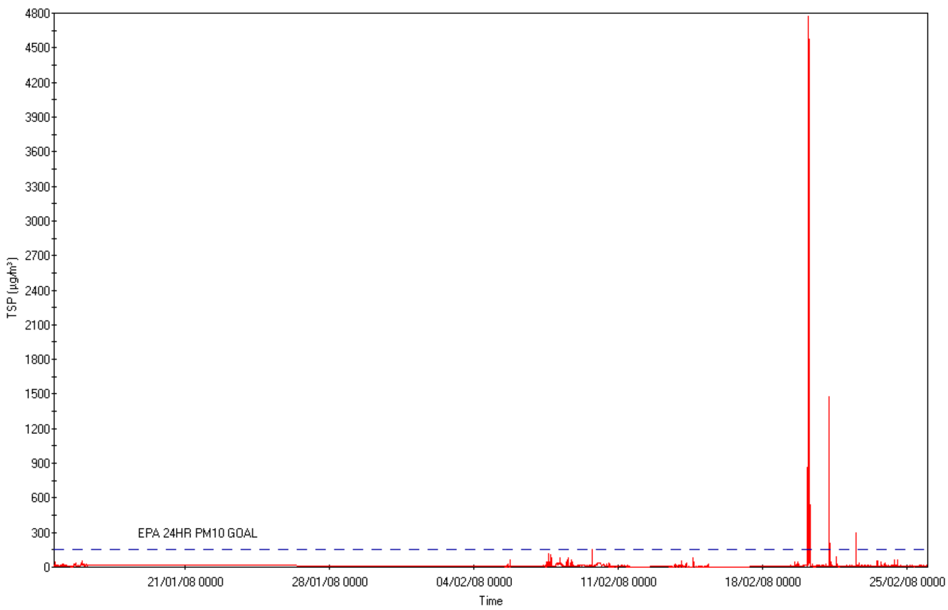

Figure 25. **5-minute average Concentration of TSP (µg/m³) measured at 10 metres from the tracks at Mindi (January 14 to February 26 2008)**

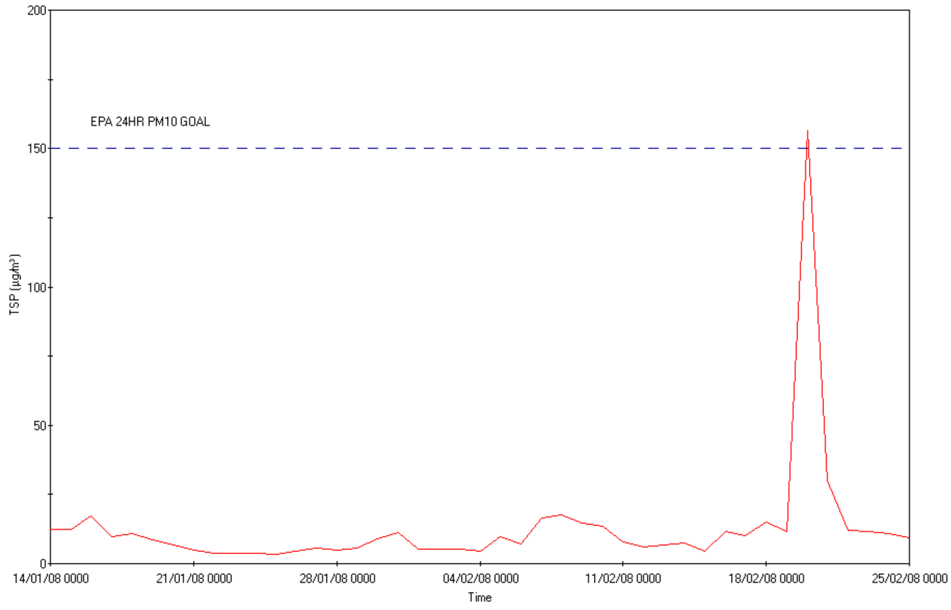

Figure 26. **24 hour average Concentration of TSP (µg/m³) measured at 10 metres from the tracks at Mindi (January 14 to February 26 2008)**

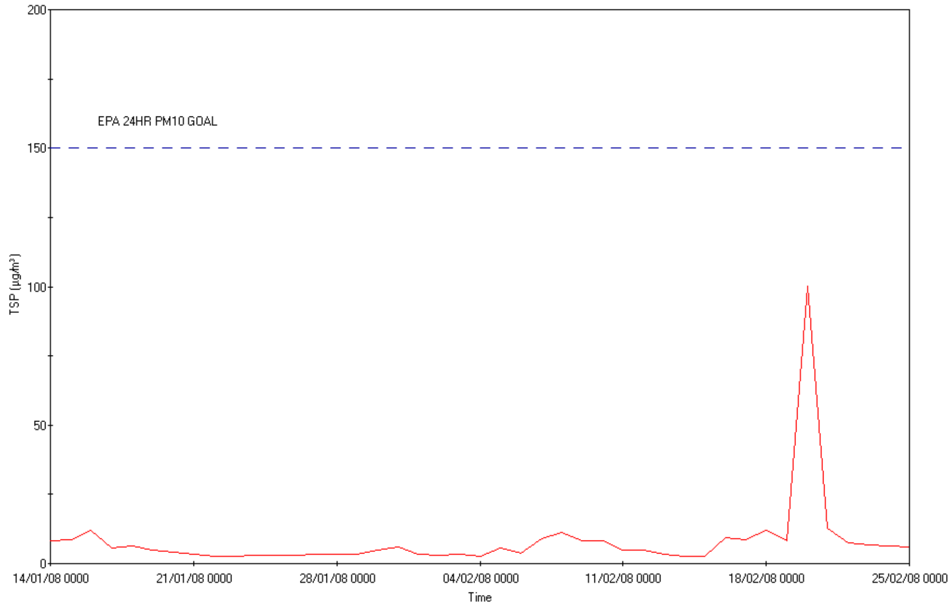

Figure 27. **24 hour average Concentration of PM10 (µg/m³) measured at 10 metres from the tracks at Mindi (January 14 to February 26 2008)**

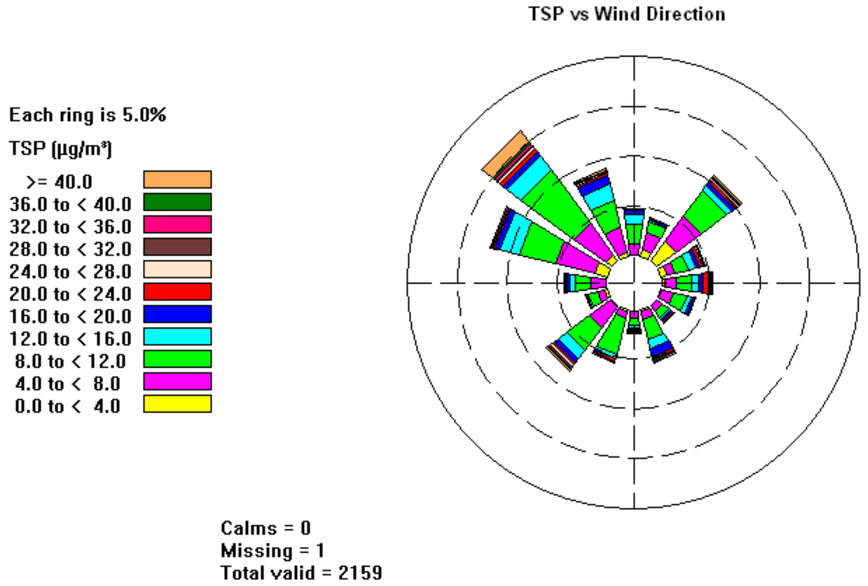

Figure 28. **Wind/Dust rose of 5-mintue average wind speed (m/s) and wind direction measured at 10 metres from the tracks at Mindi (January 14 to February 26 2008). The directional spread of the columns indicates a predominance of North West wind components; the coloured portion of the columns is TSP concentration**

4.5 Osiris vs. TEOM Results

To ascertain the reliability of Osiris data in relation to TEOM data, a statistical analysis was undertaken consisting of quantile to quantile comparisons and regression analysis. The raw TEOM data was converted into a 10 minute rolling average, allowing for direct comparison with the Osiris measurements. Results indicate that the Osiris tends to oversample high TSP periods and undersample low TSP periods (Figures 29 and 38), however when 24 hour averages are calculated a good correlation between the two units is realized. This is exemplified by the significant increase in R values for the 24 hour regression analysis (Figures 33 and 38).

4.5.1 Results for Boonal TEOM versus Osiris: December 31 2007 to March 6 2008

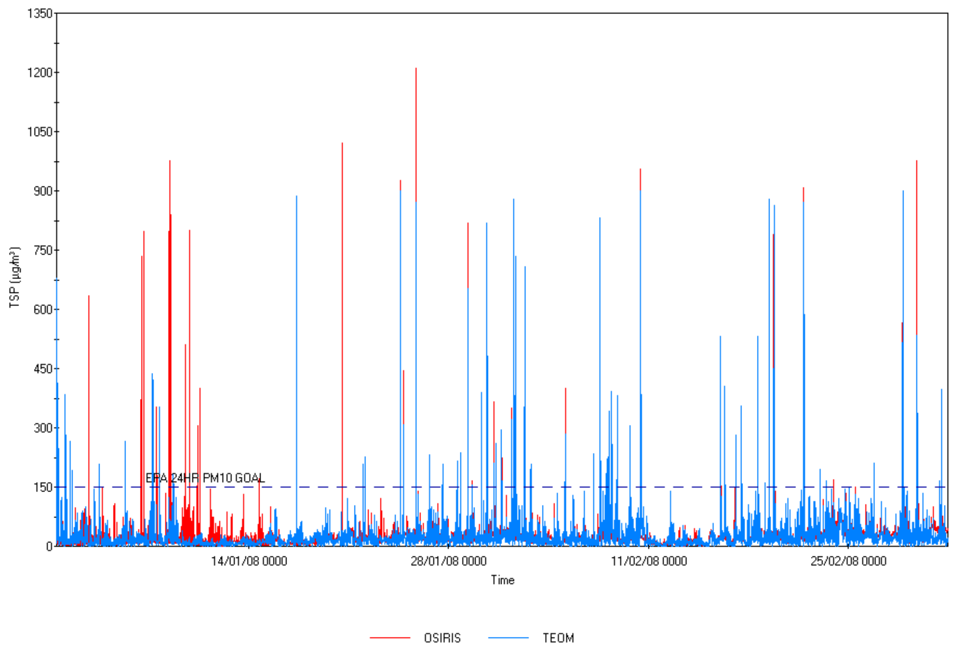

Figure 29. **10 minute average concentration of TSP (µg/m³) measured at 10 metres from the tracks at Boonal for the time period December 31 2007 to March 6 2008. The blue line represents the TEOM and the red line is the Osiris**

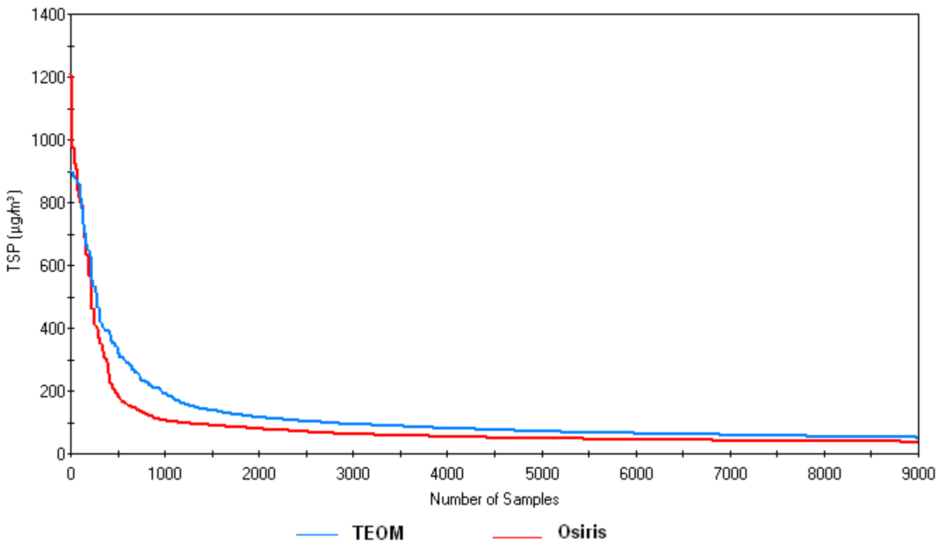

Figure 30. **Quantile – quantile plot of TEOM (blue) and Osiris (red) for 10 minute average concentrations at Boonal for the time period December 31 2007 to March 6 2008**

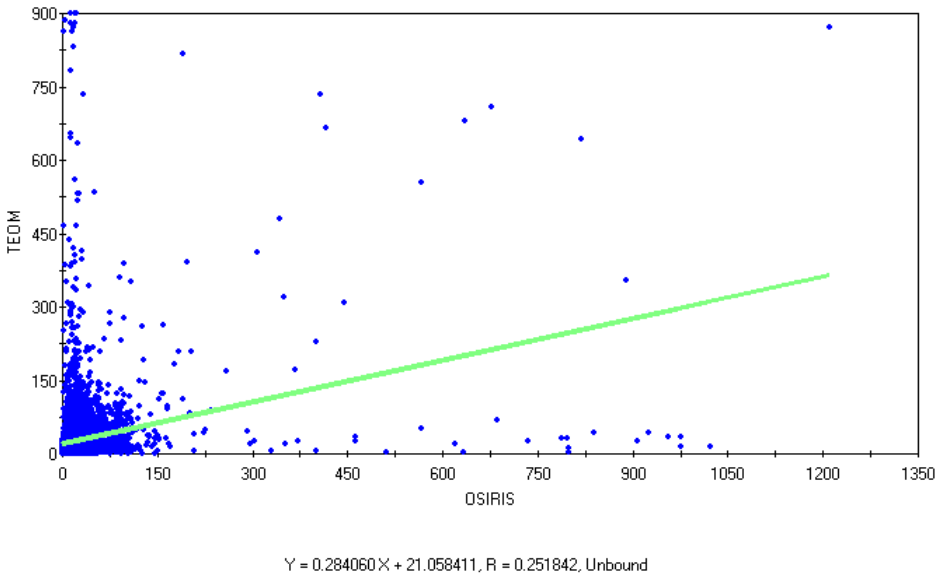

Figure 31. **Regression analysis of TEOM versus Osiris 24 hour average TSP (µg/m³) with an R value of 0.25 for Boonal during the time period December 31 2007 to March 6 2008**

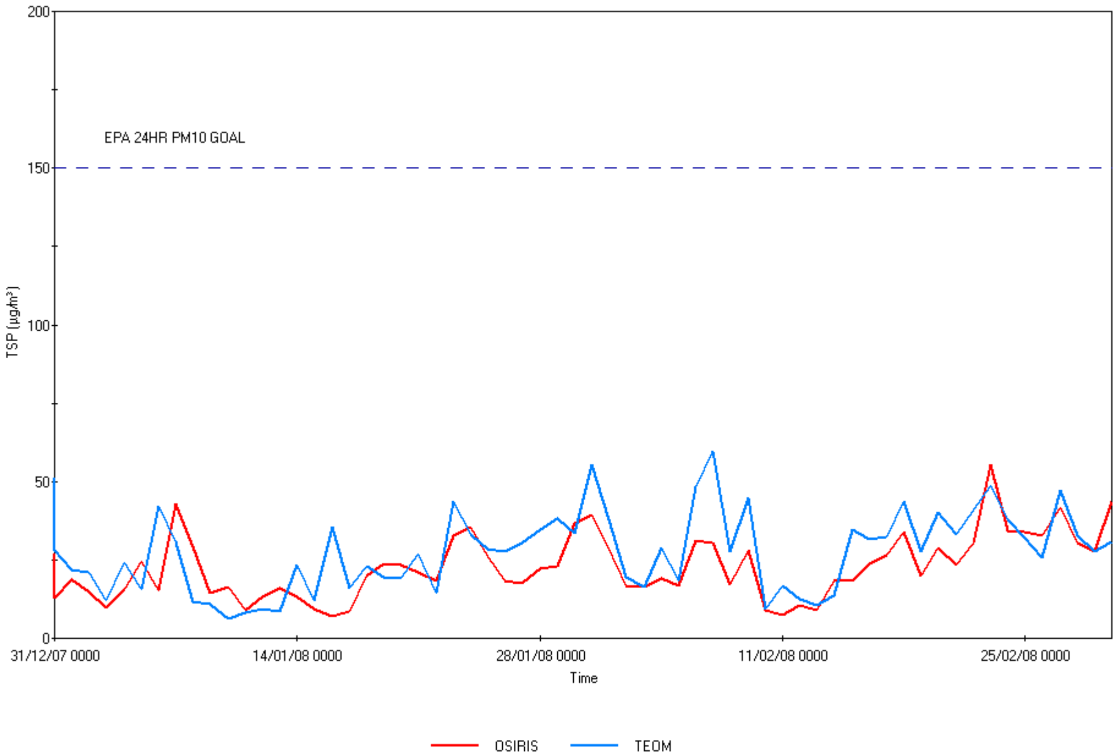

Figure 32. **24 hour average Concentration of TSP (µg/m³) measured at 10 metres from the tracks at Boonal for the time period December 31 2007 to March 6 2008. The blue line represents the TEOM and the red line is the Osiris**

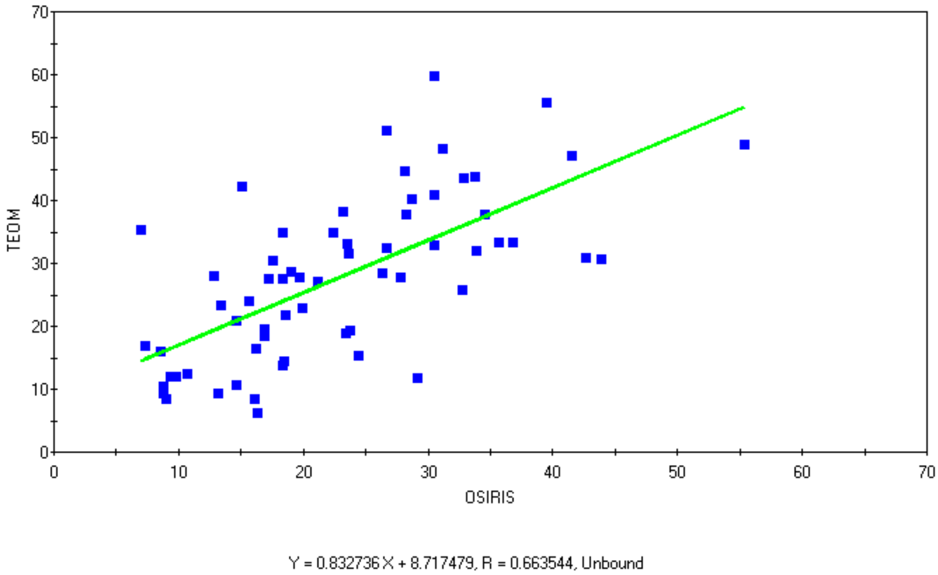

Figure 33. Regression analysis of TEOM versus Osiris 24 hour average TSP (µg/m³) with an R value of 0.66 for Boonal during the time period December 31 2007 to March 6 2008

4.5.2 Results for Earlsfield TEOM versus Osiris: December 18 2007 to February 29 2008

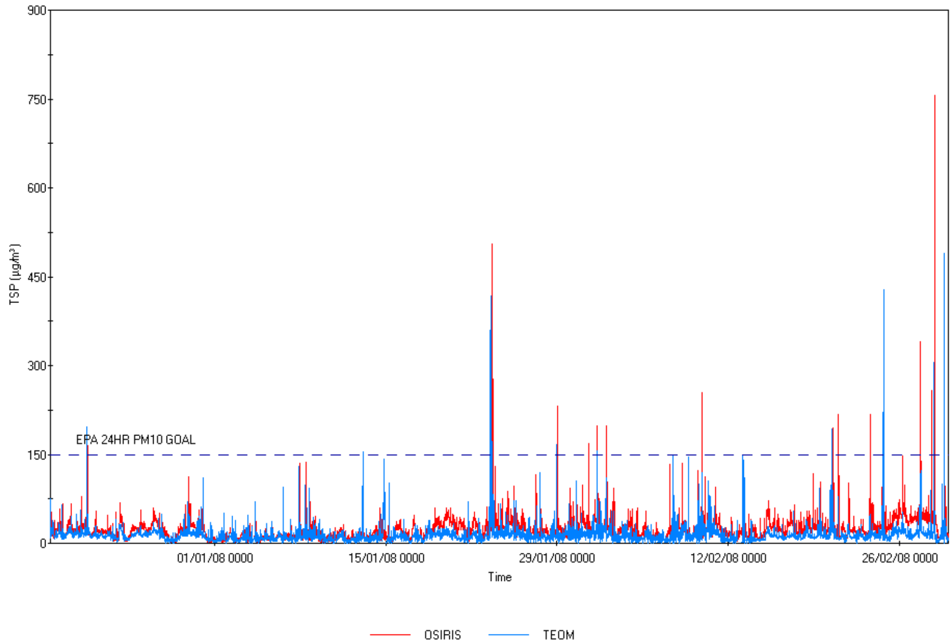

Figure 34. 10 minute average concentration of TSP (µg/m³) measured at 10 metres from the tracks at Earlsfield for the time period December 18 2007 to February 29 2008. The blue line represents the TEOM and the red line is the Osiris

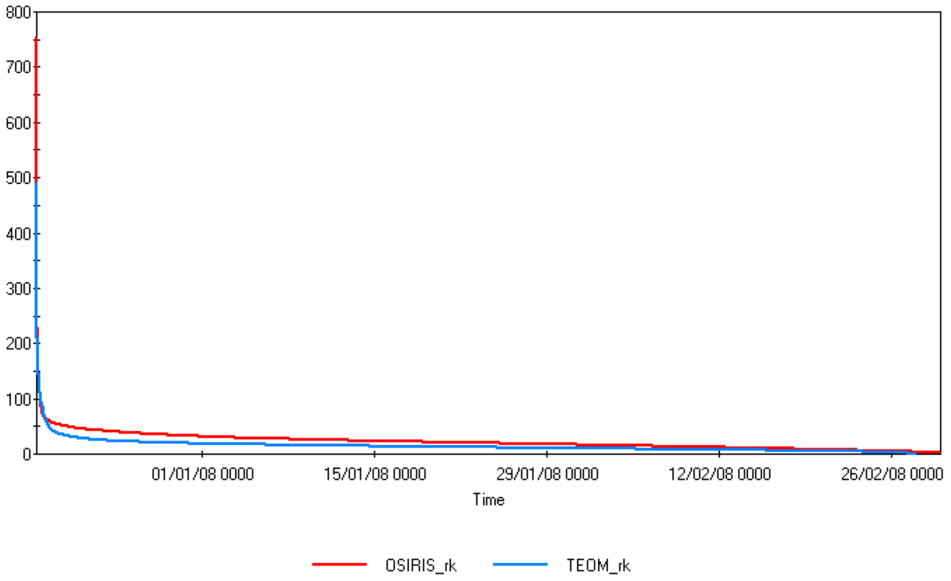

Figure 35. **Quantile – quantile plot of TEOM (blue) and Osiris (red) for 10 minute average concentrations for Earlsfield during the time period December 18 2007 to February 29 2008**

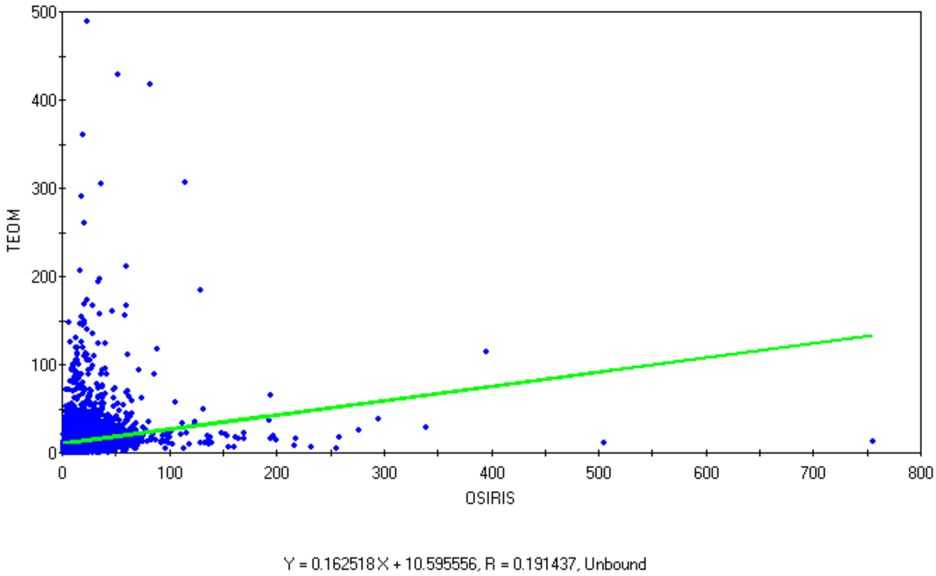

Figure 36. **Regression analysis of TEOM versus Osiris 10 minute average TSP (µg/m³) with an R value of 0.19 for Earlsfield during the time period December 18 2007 to February 29 2008**

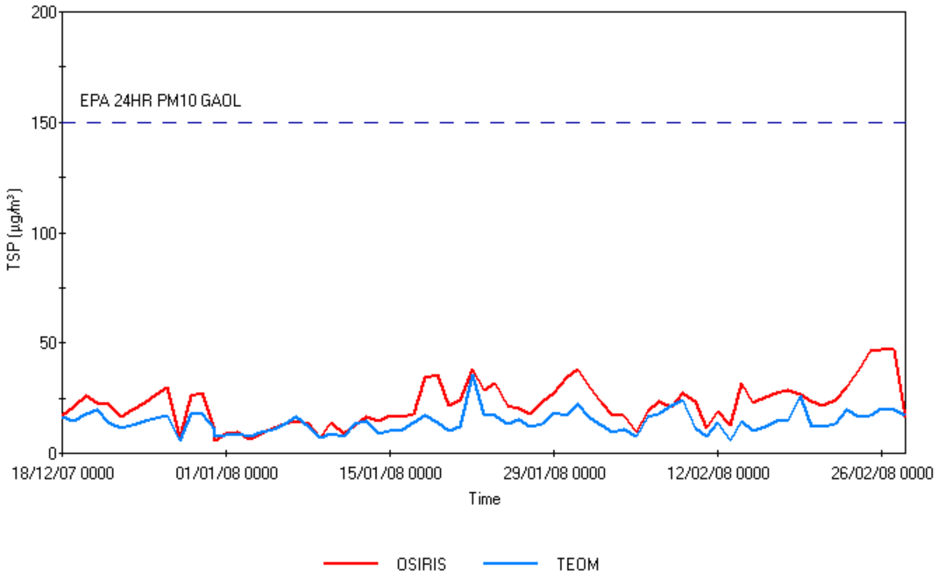

Figure 37. **24 hour average Concentration of TSP (µg/m³) measured at 10 metres from the tracks at Earlsfield for the time period December 18 2007 to February 29 2008. The blue line represents the TEOM and the red line is the Osiris**

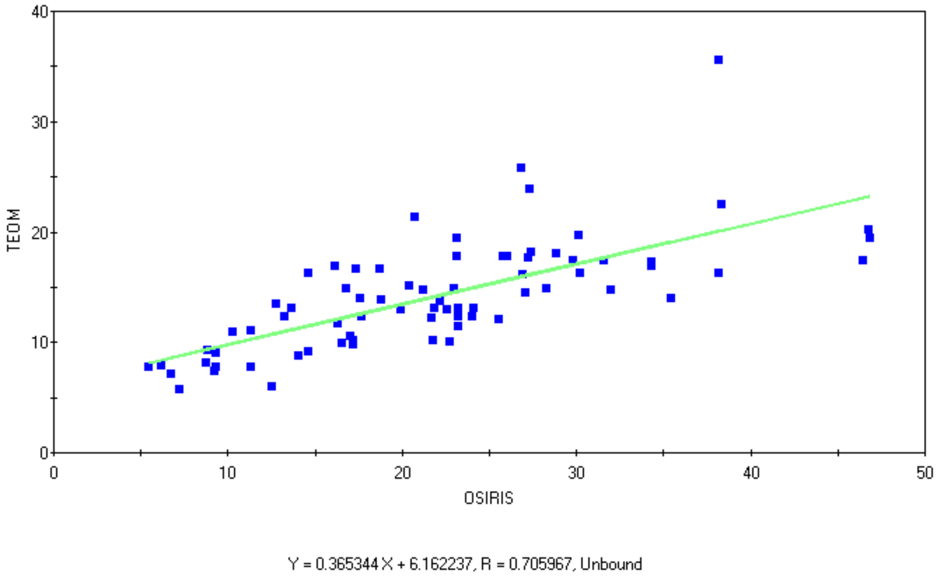

Figure 38. **Regression analysis of TEOM versus Osiris 24 hour average TSP (µg/m³) with an R value of 0.70 for Earlsfield during the time period December 18 2007 to February 29 2008**

4.6 Discreet residential monitoring program

The discreet residential monitoring program consisted of seven model 2000 Rupprecht and Patashnick Partisol samplers fitted with TSP sampling heads. The Partisol units were positioned in residential areas where known complaints of potential high coal dust events have been received. The monitoring took place over a period of four months (October 2007 to February 2008) ranging from 5 to 26 discreet 24 hour sampling periods at each locations. TSP statistics and number of discreet sampling periods are presented in Table 1. The highest 24 hour TSP measurement was recorded at Hay Point Rd (96 µg/m³) during the day of the 10 to 11 February 2008. The next highest measurement was recorded at Horsborough Rd. (89 µg/m³) during the day of the 27 to 28 February 2008. For individual results of each site and sampling period refer to the attached Simtars reports oe101866f1 – 4, 6 – 8, 10 and 12.

Table 1. Results of the discreet 24 hour residential monitoring program

Location	Equipment	Max TSP (µg/m³)	Min TSP (µg/m³)	Avg TSP (µg/m³)	Numer of Samples	Invalid
Off Lane, Gladstone	Partisol	30	19	23	5	2
Side Street, Gladstone	Partisol	52	13	27	6	0
Raglan Street, Mt. Larcom	Partisol	54	20	31	6	0
Kin Kora Caravan Park, Hay Point	Partisol	30	19	22	8	2
Hay Point Road, Hay Point	Partisol	96	1	15	26	0
Horsborough Road, Hay Point	Partisol	89	8	27	13	3
Grasstree Beach Road, Sarina	Partisol	50	9	21	16	0

4.7 Mineralogical Characterization

Partisol, dust deposition gauge (DDG) and ACCU filters were subjected to a multi-stage microscopic characterisation to determine the amount of coal dust contained in the sample. DDG monitoring was conducted at one month intervals covering November 2007 to February 2008, individual results for each site are available in the attached Simtars reports oe101866f5, 9, 11 and 12. The filters were checked for particle distribution and structure by stereomicroscopy and images produced for each filter by Polarised Light Microscopy (PLM). Subsamples of the filters were examined by Scanning Electron Microscopy with Energy Dispersive XRay Analysis (SEM/EDS) and combined with the PLM observations to quantify the mineralogical constituents of each DDG filter. Special emphasis was placed on determining the percentage of coal present.

The results of the multi-stage microscopic investigation are summarised below (Table 2) refer to the attached UniQuest reports 15346 SJ01 and SJ02 for images and detailed mineralogical breakdown. The highest concentration of coal dust (60%) was measured at the DDG site 15 metres downwind of the Dawson Highway for the period January 02 to 31 2008. The majority of the residential Partisol and DDG sites recorded coal dust percentages between 15 and 5 % with the exception of the Off Lane DDG site which recorded 25 % and 20 % coal dust during both 1 month sampling periods (December 04 2007 to January 02 2008 and January 02 to 31 2008) and the Shaw St DDG site (40%) for the sampling period November 16 to December 17 2007.

The ACCU filters formed part of the Boonal and Beecher monitoring program. Five 24 hour sampling periods were recorded by the ACCU filters with maximum coal dust percentages occurring on January 08 2008 (65%) for Boonal and November 21 2008 (10%) for Beecher. The results indicate that Boonal had the highest overall average percentage of coal dust in comparison to all other sites (45%). This result should be treated with caution however, as differences in monitoring equipment, sampling periods and the number of samples taken does not allow direct inter-site comparisons to be made (Table 2).

Table 2. Coal dust statistics for Partisol, Dust Deposition Gauge filters and ACCU filters at residential and corridor sites.

Location	Equipment	Max % Coal Dust	Min % Coal Dust	Avg % Coal Dust	Number of Samples
Off Lane, Gladstone	Partisol	15	5	8.3	3
Off Lane, Gladstone	DDG	25	15	20.0	15
Side Street, Gladstone	Partisol	10	5	5.8	6
Side Street, Gladstone	DDG	15	3	7.7	3
Raglan Street, Mt. Larcom	Partisol	5	5	5.0	6
Raglan Street, Mt. Larcom	DDG	15	5	10.0	2
Kin Kora Caravan Park, Hay Point	Partisol	5	5	5.0	6
Kin Kora Caravan Park, Hay Point	DDG	5	5	5.0	3
Hay Point Road, Hay Point	Partisol	20	5	7.8	18
Horsborough Road, Hay Point	Partisol	15	5	8.8	4
Grasstree Beach Road, Sarina	Partisol	10	5	5.8	6
Dawson Hwy 5m U/Wind	DDG	40	5	16.7	3
Dawson Hwy 5m D/Wind	DDG	30	5	28.3	3
Dawson Hwy 15m D/Wind	DDG	60	15	30.0	3
Dawson Hwy 25m D/Wind	DDG	35	1	13.7	3
Shaw St	DDG	40	5	16.7	3
Whitney St	DDG	20	3	11.0	3
Bradford St	DDG	10	5	10.0	3
Boonal	ACCU	65	5	45.0	5
Beecher	ACCU	10	5	6.0	5

Appendix A

Laboratory reports

Occupational Hygiene, Environment & Chemistry Centre

Simtars
Queensland Government
A business unit of the Department of Natural Resources and Mines

REPORT NO:OE101866F1

Laboratory Test Report

Report Number	**OE101866F1**
Issue Date	23 January 2007
Report To	Mr Simon Welshman Katestone Environmental
Client Reference	Purchase Order KE0710021
Job Description	Suspended particulate monitoring by Partisol (TSP) - Results for period October 2007 to January 2008
Responsibility for Sampling	Sampling conducted by Connell Wagner Pty Ltd
Reviewed	
Approved Signatory	**Mark Curtis** **Senior Health, Safety and Environmental Scientist**

Introduction

Simtars supplied Rupprecht and Patashnick Partisol samplers to Katestone Environmental for use in a coal dust monitoring program for Queensland Rail. The Model 2000 samplers were fitted with TSP sampling heads. Simtars provided initial setup of the samplers and training in their use and continues to provide a filter preparation and weighing service for the project.

Field operations are conducted by Connell Wagner Pty Ltd in Gladstone

The data are attached in Table 1.

REPORT NO:OE101866F1

Table 1 – Total Suspended Particulates (TSP)

Lab Number	Filter Number	Sampling Site	Property	Start	End	Sample Period (hrs)	Total Volume (m^3 STP*)	Particulates (μgm^{-3} STP*)
oe101866-102	E2197	7 Off Lane	Brian & Dawn Riddiford	23-Oct-07	24-Oct-07	22:55	11.4 (temperature sensor problem)	Invalid
oe101866-103	E3244	Mt Larcom 4 Raglan St	Tracey Shepard	23-Oct-07	24-Oct-07	24:00	22.2	24
oe101866-100	E2195	5/5 Side St	Ms Pye	29-Oct-07	30-Oct-07	Invalid time displayed. Volume appears correct	21.9	52
oe101866-101	E2196	Mt Larcom 4 Raglan St	Tracey Shepard	29-Oct-07	30-Oct-07	24:00	21.9	27
oe101866-104	E4249	5/5 Side St	Ms Pye	04-Nov-07	05-Nov-07	Invalid time displayed. Volume appears correct	21.5	24
oe101866-105	E4250	Mt Larcom 4 Raglan St	Tracey Shepard	04-Nov-07	05-Nov-07	24:00	21.9	32
No sample	E4248	7 Off Lane	Brian & Dawn Riddiford	04-Nov-07	05-Nov-07	24:00	22.0	Water in filter holder. Filter torn (invalid)
oe101866-109	E4013	Mt Larcom 4 Raglan St	Tracey Shepard	10-Nov-07	11-Nov-07	24:00	22.3	29
oe101866-108	E4012	5/5 Side St	Ms Pye	10-Nov-07	11-Nov-07	Invalid time displayed. Volume appears correct	22.0	13

REPORT NO:OE101866F1

Lab Number	Filter Number	Sampling Site	Property	Start	End	Sample Period (hrs)	Total Volume (m^3 STP*)	Particulates (μgm^{-3} STP*)
oe101866-107	E4011	7 Off Lane	Brian & Dawn Riddiford	10-Nov-07	11-Nov-07	24:00	22.2	19
oe101866-106	E4009	Mt Larcom 4 Raglan St	Tracey Shepard	16-Nov-07	17-Nov-07	24:00	22.1	20
oe101866-112	E4017	7 Off Lane	Brian & Dawn Riddiford	16-Nov-07	17-Nov-07	24:00	22.2	30
oe101866-110	E4015	7 Off Lane	Brian & Dawn Riddiford	23-Nov-07	24-Nov-07	24:00	22.0	19
oe101866-111	E4016	Mt Larcom 4 Raglan St	Tracey Shepard	23-Nov-07	24-Nov-07	24:00	22.0	54
oe101866-154	E4260	952 Hay Point Rd Saron's HI	Paul & Pat Saron	13-Dec-07	14-Dec-07	24:00	21.9	10
oe101866-155	E4259	952 Hay Point Rd Saron's HI	Paul & Pat Saron	18-Dec-07	19-Dec-07	24:00	21.9	6
oe101866-156	E4258	952 Hay Point Rd Saron's HI	Paul & Pat Saron	21-Dec-07	22-Dec-07	24:00	21.9	8
oe101866-157	E4257	952 Hay Point Rd Saron's HI	Paul & Pat Saron	25-Dec-07	26-Dec-07	24:00	22.0	5
oe101866-158	E4256	952 Hay Point Rd Saron's HI	Paul & Pat Saron	28-Dec-07	29-Dec-07	24:00	22.2	1
oe101866-159	E5153	952 Hay Point Rd Saron's HI	Paul & Pat Saron	31-Dec-07	01-Jan-08	24:00	21.8	12
oe101866-160	E5152	952 Hay Point Rd Saron's HI	Paul & Pat Saron	02-Jan-08	03-Jan-08	24:00	21.8	5

*STP- corrected to standard conditions of 0°C at 101.325 kpa

Laboratory Test Report

Report Number	**OE101866F2**
Issue Date	23 January 2007
Report To	Mr Simon Welshman Katestone Environmental
Client Reference	Purchase Order KE0710021
Job Description	Dust deposition monitoring Results for period 5 Nov to 4 Dec 2007
Responsibility for Sampling	Sampling conducted by Connell Wagner Pty Ltd
Reviewed	
Approved Signatory	

Mark Curtis
Senior Health, Safety and Environmental Scientist

Introduction

Simtars supplied dust deposition gauges to Katestone Environmental for use in a coal dust monitoring program for Queensland Rail. Simtars provided initial setup of the samplers and training in their use and continues to provide an analysis service for the project.

Field operations are conducted by Connell Wagner Pty Ltd in Gladstone

The data are attached in Table 1.

REPORT NO:OE101866F2

Table 1 – Dust Deposition Results for November/December 2007

Lab Number	Sampling Site	Start	End	Sample Period (days)	Total Solids ($mgm^{-2}d^{-1}$)	Insoluble Solids ($mgm^{-2}d^{-1}$)	Ash Solids ($mgm^{-2}d^{-1}$)	Soluble Solids ($mgm^{-2}d^{-1}$)	Combustible Solids ($mgm^{-2}d^{-1}$)
oe101866-113	7 Off Lane Gladstone	5-Nov-07	4-Dec-07	29	NA	42	37	NA	6
oe101866-114	5/5 Side St Gladstone	5-Nov-07	4-Dec-07	29	NA	42	36	NA	6
oe101866-115	Beecher 5 m upwind	5-Nov-07	4-Dec-07	29	71	70	34	<1	36
oe101866-116	Beecher 5 m downwind	5-Nov-07	4-Dec-07	29	NA	59	23	NA	36
oe101866-117	Beecher 25 m downwind	5-Nov-07	4-Dec-07	29	NA	39	21	NA	18
oe101866-118	4 Raglan St Mt Larcom	5-Nov-07	4-Dec-07	29	NA	26	16	NA	10
oe101866-119	Beecher 15 m downwind	5-Nov-07	4-Dec-07	29	NA	65	30	NA	36

Note: The dust gauges for samples oe101866-113, 114 and 116 to 119 overflowed due to excess rainfall.
Total and soluble deposition data are consequently not valid. Simtars testing shows that overflow does not significantly affect the insoluble solids result, however such testing does not meet AS/NZS 3580.10.1:2003.

Laboratory Test Report

Report Number	**OE101866F3**
Issue Date	25 January 2007
Report To	Mr Simon Welshman Katestone Environmental
Client Reference	Purchase Order KE0710021
Job Description	Suspended particulate monitoring by Partisol (TSP) - Results for period November to December 2007
Responsibility for Sampling	Sampling conducted by Connell Wagner Pty Ltd
Approved Signatory	Mark Curtis

Mark Curtis
Senior Health, Safety and Environmental Scientist

Introduction

Simtars supplied Rupprecht and Patashnick Partisol samplers to Katestone Environmental for use in a coal dust monitoring program for Queensland Rail. The Model 2000 samplers were fitted with TSP sampling heads. Simtars provided initial setup of the samplers and training in their use and continues to provide a filter preparation and weighing service for the project.

Field operations are conducted by Connell Wagner Pty Ltd in Gladstone.

The data are attached in Table 1.

Occupational Hygiene, Environment & Chemistry Centre

Simtars
Queensland Government
A business unit of the Department of Natural Resources and Mines

REPORT NO:OE101866F3

Table 1 – Total Suspended Particulates (TSP)

Lab Number	Filter Number	Sampling Site	Property	Start	End	Sample Period (hrs)	Total Volume (m^3 STP*)	Particulates (μgm^{-3} STP*)
oe101866-221	E4014	Kinkora Van Park	Mr Monty Olsen	23-Nov-07	24-Nov-07	9:59	9.2	Invalid
oe101866-220	E4002	Kinkora Van Park	Mr Monty Olsen	29-Nov-07	30-Nov-07	12:41 (likely power failure)	11.9	30
oe101866-219	E3999	Kinkora Van Park	Mr Monty Olsen	16-Dec-07 (assumed)	17-Dec-07 (assumed as field sheet states 16-dec-07)	24:00	21.9	20
oe101866-222	E4247	Kinkora Van Park	Mr Monty Olsen	19-Dec-07	20-Dec-07	24:00	21.9	19
oe101866-218	E4255	Kinkora Van Park	Mr Monty Olsen	22-Dec-07	23-Dec-07	21:57	21.9	21 (qualitative only due to temperature sensor problem)
oe101866-217	E4246	Side Street	Ms Dye	22-Dec-07	23-Dec-07	24:00	21.8	24
oe101866-216	E4008	Kinkora Van Park	Mr Monty Olsen	27-Dec-07	28-Dec-07	24:00	21.3	21 (qualitative only due to temperature sensor problem)
oe101866-215	E4007	Side Street	Ms Dye	27-Dec-07	28-Dec-07	24:00	22.2	21
oe101866-213	E4005	Kinkora Van Park	Mr Monty Olsen	29-Dec-07	30-Dec-07	14:39	12.3	Invalid (Sampler failed with temperature error)
oe101866-214	E4006	Side Street	Ms Dye	29-Dec-07	30-Dec-07	24:00	22.0	29

*STP- corrected to standard conditions of 0°C at 101.325 kpa

Occupational Hygiene, Environment & Chemistry Centre

Simtars
Queensland Government
A business unit of the Department of Natural Resources and Mines

REPORT NO:OE101866F4

Laboratory Test Report

Report Number	**OE101866F4**
Issue Date	30 January 2008
Report To	Mr Simon Welshman Katestone Environmental
Client Reference	Purchase Order KE0710021
Job Description	Suspended particulate monitoring by Partisol (TSP) - Results for January 2008
Responsibility for Sampling	Sampling conducted by Connell Wagner Pty Ltd

Reviewed

J. Franklin

Joel Franklin

Approved Signatory

Mark Curtis

Mark Curtis
Senior Health, Safety and Environmental Scientist

Introduction

Simtars supplied Rupprecht and Patashnick Partisol samplers to Katestone Environmental for use in a coal dust monitoring program for Queensland Rail. The Model 2000 samplers were fitted with TSP sampling heads. Simtars provided initial setup of the samplers and training in their use and continues to provide a filter preparation and weighing service for the project.

Field operations are conducted by Connell Wagner Pty Ltd in Gladstone. The samplers are run for a 24-hour period from midnight to midnight.

The data are attached in Table 1.

Occupational Hygiene, Environment
& Chemistry Centre

Simtars
Queensland Government
A business unit of the Department of
Natural Resources and Mines

REPORT NO:OE101866F4

Table 1 – Total Suspended Particulates (TSP) for January 2008

Lab Number	Filter Number	Sampling Site	Property	Start	End	Sample Period (hrs)	Total Volume (m^3 STP*)	Particulates (μgm^{-3} STP*)
oe101866-228	E5151	952 Hay Point Rd, HI- Saron	Paul & Pat Saron	05-Jan-08	06-Jan-08	24:00	21.7	7
oe101866-227	E5150	952 Hay Point Rd, HI- Saron	Paul & Pat Saron	09-Jan-08	10-Jan-08	24:00	21.7	9
oe101866-226	E5147	952 Hay Point Rd, HI- Saron	Paul & Pat Saron	12-Jan-08	13-Jan-08	24:00	21.8	2
oe101866-225	E5146	952 Hay Point Rd, HI- Saron	Paul & Pat Saron	17-Jan-08	18-Jan-08	24:00	21.6	18
oe101866-224	E5145	Grasstree Beach Rd Location B	David Pickworth	17-Jan-08	18-Jan-08	24:00	21.5	25
oe101866-223	E5144	952 Hay Point Rd, HI- Saron	Paul & Pat Saron	19-Jan-08	20-Jan-08	24:00	21.8	11
oe101866-231	E5477	Grasstree Beach Rd Location B	David Pickworth	19-Jan-08	20-Jan-08	24:00	21.8	12 (qualitative only, water penetrated temperature sensor)
oe101866-230	E5476	952 Hay Point Rd, HI- Saron	Paul & Pat Saron	22-Jan-08	23-Jan-08	24:00	21.9	10
oe101866-229	E5475	Grasstree Beach Rd Location B	David Pickworth	22-Jan-08	23-Jan-08	24:00	21.7	22 (qualitative only, water penetrated temperature sensor)

*STP- corrected to standard conditions of 0°C at 101.325 kpa

Occupational Hygiene, Environment
& Chemistry Centre

Simtars
Queensland Government
A business unit of the Department of
Natural Resources and Mines

REPORT NO:OE101866F5

Laboratory Test Report

Report Number **OE101866F5**

Issue Date 31 January 2008

Report To Mr Simon Welshman
Katestone Environmental

Client Reference Purchase Order KE0710021

Job Description Dust deposition monitoring
Results for period 16 Nov 07 to 21 Jan 08

Responsibility for Sampling Sampling conducted by Connell Wagner Pty Ltd

Reviewed

Approved Signatory

Mark Curtis
Senior Health, Safety and Environmental Scientist

REPORT NO:OE101866F5

Introduction

Simtars supplied dust deposition gauges to Katestone Environmental for use in a coal dust monitoring program for Queensland Rail. Simtars provided initial setup of the samplers and training in their use and continues to provide an analysis service for the project.

Field operations are conducted by Connell Wagner Pty Ltd in Gladstone

The data are attached in Table 1.

REPORT NO:OE101866F5

Table 1 – Dust Deposition Results for November 2007 / January 2008

Lab Number	Sampling Site	Start	End	Sample Period (days)	Total Solids ($mgm^{-2}d^{-1}$)	Insoluble Solids ($mgm^{-2}d^{-1}$)	Ash Solids ($mgm^{-2}d^{-1}$)	Soluble Solids ($mgm^{-2}d^{-1}$)	Combustible Solids ($mgm^{-2}d^{-1}$)
oe101866-143	Dawson Highway Beeches 5m U/Wind	4-Dec-07	2-Jan-08	29	597	140	33	457	107
oe101866-144	Dawson Highway Beeches 5m D/Wind	4-Dec-07	2-Jan-08	29	58	49	23	9	26
oe101866-145	Dawson Highway Beeches 25m D/Wind	4-Dec-07	2-Jan-08	29	113	60	29	53	31
oe101866-146	Dawson Highway Beeches 15m D/Wind	4-Dec-07	2-Jan-08	29	80	62	33	18	30
oe101866-147	7 Off Lane	4-Dec-07	2-Jan-08	29	59	26	17	32	9
oe101866-148	4 Raglan St	4-Dec-07	2-Jan-08	29	33	12	8	21	4
oe101866-149	5/5 Side St	4-Dec-07	2-Jan-08	29	67	36	24	31	12
oe101866-150	Kin Kora Van Pk	22-Nov-07	21-Dec-07	29	27	20	14	8	6
oe101866-151	Shaw St	16-Nov-07	17-Dec-07	31	38	24	14	14	10
oe101866-152	Witney St	16-Nov-07	17-Dec-07	31	44	17	9	28	7
oe101866-153	Bradford St	16-Nov-07	17-Dec-07	31	133	94	33	39	61
oe101866-209	Shaw St	17-Dec-07	18-Jan-08	32	19	18	7	<1	12
oe101866-210	Whitney St	17-Dec-07	18-Jan-08	32	40	34	15	6	19
oe101866-211	Bradford Rd	17-Dec-07	18-Jan-08	32	27	18	10	8	9
oe101866-212	Kin Kora Village Caravan Park	21-Dec-07	21-Jan-08	31	26	18	11	8	7

REPORT NO: oe101866f6

Laboratory Test Report

Report Number	oe101866f6
Issue Date	7 February 2008
Report To	Mr Simon Welchman, Katestone Environmental PO Box 2217 Milton Qld 4064
Client Reference	Purchase Order KE0710021
Job Description	Suspended particulate monitoring (TSP) by Partisol sampler Results for January 2008 24 – 31 January 2008
Responsibility for Sampling	Sampling conducted by Connell Wagner Pty Ltd
Approved Signatory	**Mark Curtis** **Senior Health, Safety and Environmental Scientist**

Mark Curtis

REPORT NO: oe101866f6

Introduction

Simtars supplied Rupprecht and Patashnick Partisol samplers to Katestone Environmental for use in a coal dust monitoring program for Queensland Rail. The Model 2000 samplers were fitted with TSP sampling heads. Simtars provided initial setup of the samplers and training in their use and continues to provide a filter preparation and weighing service for the project.

Field operations are conducted by Connell Wagner Pty Ltd in Gladstone.

The data are attached in Table 1.

REPORT NO: oe101866f6

Table 1 – Total Suspended Particulates (TSP)

Lab Number	Filter Number	Sampling Site	Property	Start	End	Sample Period (hrs)	Total Volume (m^3 STP*)	Particulates (μgm^{-3} STP*)
oe101866-232	E5473	952 Hay Point Rd, HI- Saron	Paul & Pat Saron	24-Jan-08	25-Jan-08	24:00	22.0	13
oe101866-233	E5467	Grasstree Beach Rd Location B	David Pickworth	24-Jan-08	25-Jan-08	24:00	21.9	27
oe101866-234	E5474	Horsburgh Rd Location A	Hodgson	24-Jan-08	25-Jan-08	24:00	21.9	31
oe101866-235	E5155	952 Hay Point Rd, HI- Saron	Paul & Pat Saron	26-Jan-08	27-Jan-08	24:00	22.0	14
oe101866-236	E5154	Grasstree Beach Rd Location B	David Pickworth	26-Jan-08	27-Jan-08	24:00	21.9	27
oe101866-237	E5156	Horsburgh Rd Location A	Hodgson	26-Jan-08	27-Jan-08	24:00	21.9	14
oe101866-238	E5158	952 Hay Point Rd, HI- Saron	Paul & Pat Saron	30-Jan-08	31-Jan-08	24:00	22.1	5
oe101866-239	E5466	Grasstree Beach Rd Location B	David Pickworth	30-Jan-08	31-Jan-08	23:19 Sampler probably shut down due to rainfall	22.1	10 (Qualitative result. Filter distorted, likely was wet)
oe101866-240	E5157	Horsburgh Rd Location A	Hodgson	30-Jan-08	31-Jan-08	23:09 Power outage at 07:30, 30 Jan 08	21.3	10

*STP- corrected to standard conditions of 0^oC at 101.325 kpa

REPORT NO: oe101866f7

Laboratory Test Report

Report Number	oe101866f7
Issue Date	12 February 2008
Report To	Mr Simon Welchman, Katestone Environmental
Client Reference	Purchase Order KE0710021
Job Description	Dust deposition monitoring Results for period 02–31 Jan 08
Responsibility for Sampling	Sampling conducted by Connell Wagner Pty Ltd
Approved Signatory	**Mark Curtis** **Senior Health, Safety and Environmental Scientist**

REPORT NO: oe101866f7

Introduction

Simtars supplied dust deposition gauges to Katestone Environmental for use in a coal dust monitoring program for Queensland Rail. Simtars provided initial setup of the samplers and training in their use and continues to provide an analysis service for the project.

Field operations are conducted by Connell Wagner Pty Ltd in Gladstone

The data are attached in Table 1.

REPORT NO: oe101866f7

Table 1 – Dust Deposition Results for January 2008

Lab Number	Sampling Site	Start	End	Sample Period (days)	Total Solids ($mgm^{-2}d^{-1}$)	Insoluble Solids ($mgm^{-2}d^{-1}$)	Ash Solids ($mgm^{-2}d^{-1}$)	Soluble Solids ($mgm^{-2}d^{-1}$)	Combustible Solids ($mgm^{-2}d^{-1}$)
oe101866-241	7 Off Lane	2-Jan-08	31-Jan-08	29	24	23	21	<1	3
oe101866-242	5/5 Side St	2-Jan-08	31-Jan-08	29	50	44	33	6	11
oe101866-243	4 Raglan St Mt Larcom	2-Jan-08	31-Jan-08	29	41	18	10	23	8
oe101866-244	Dawson Highway Beecher 5m U/Wind	2-Jan-08	31-Jan-08	29	74	56	35	19	21
oe101866-245	Dawson Highway Beecher 5m D/Wind	2-Jan-08	31-Jan-08	29	191	124	48	68	75
oe101866-246	Dawson Highway Beecher 15m D/Wind	2-Jan-08	31-Jan-08	29	90	37	16	53	21
oe101866-247	Dawson Highway Beecher 25m D/Wind	2-Jan-08	31-Jan-08	29	39	27	16	13	10

Occupational Hygiene, Environment & Chemistry Centre

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Simtars Queensland Government
A business unit of the Department of **Mines and Energy**

Laboratory Test Report

Report Number	oe101866f8
Issue Date	20 February 2008
Report To	Mr Simon Welchman, Katestone Environmental PO Box 2217 Milton Qld 4064
Client Reference	Purchase Order KE0710021
Job Description	Suspended particulate monitoring (TSP) by Partisol sampler Results for 1–8 February 2008
Responsibility for Sampling	Sampling conducted by Connell Wagner Pty Ltd
Approved Signatory	**Mark Curtis** **Senior Health, Safety and Environmental Scientist**

Occupational Hygiene, Environment
& Chemistry Centre

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Introduction

Simtars supplied Rupprecht and Patashnick Partisol samplers to Katestone Environmental for use in a coal dust monitoring program for Queensland Rail. The Model 2000 samplers were fitted with TSP sampling heads. Simtars provided initial setup of the samplers and training in their use and continues to provide a filter preparation and weighing service for the project.

Field operations are conducted by Connell Wagner Pty Ltd in Gladstone.

The data are attached in Table 1.

REPORT NO: oe101866f8

Table 1 – Total Suspended Particulates (TSP)

Lab Number	Filter Number	Sampling Site	Property	Start	End	Sample Period (hrs)	Total Volume (m^3 STP*)	Particulates (μgm^{-3} STP*)
oe101866-248	E5160	Horsburgh Rd Location A	Hodgson	01-Feb-08	02-Feb-08	24:00	21.8	27
oe101866-249	E5159	952 Hay Point Rd, HI- Saron	Paul & Pat Saron	01-Feb-08	02-Feb-08	24:00	21.9	18
oe101866-250	E5465	Grasstree Beach Rd Location B	David Pickworth	01-Feb-08	02-Feb-08	23:57	21.5	27
oe101866-251	E5464	Horsburgh Rd Location A	Hodgson	05-Feb-08	06-Feb-08	24:00	21.8	8
oe101866-252	E5463	952 Hay Point Rd, HI- Saron	Paul & Pat Saron	05-Feb-08	06-Feb-08	24:00	21.8	4
oe101866-253	E5161	Grasstree Beach Rd Location B	David Pickworth	05-Feb-08	06-Feb-08	24:00	21.8	12
oe101866-254	E5162	Horsburgh Rd Location A	Hodgson	07-Feb-08	08-Feb-08	24:00	21.6	12
oe101866-255	E5163	952 Hay Point Rd, HI- Saron	Paul & Pat Saron	07-Feb-08	08-Feb-08	24:00	21.6	8
oe101866-256	E5472	Grasstree Beach Rd Location B	David Pickworth	07-Feb-08	08-Feb-08	23:58	21.5	11

*STP- corrected to standard conditions of 0^oC at 101.325 kpa

Occupational Hygiene, Environment & Chemistry Centre

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Simtars
Queensland Government
A business unit of the Department of
Mines and Energy

Laboratory Test Report

Report Number	oe101866f9
Issue Date	25 February 2008
Report To	Mr Simon Welchman, Katestone Environmental PO Box 2217 Milton Qld 4064
Client Reference	Purchase Order KE0710021
Job Description	Suspended particulate monitoring (TSP) by Partisol sampler Results for 10–15 February 2008
Responsibility for Sampling	Sampling conducted by Connell Wagner Pty Ltd
Approved Signatory	Mark Curtis **Mark Curtis** **Senior Health, Safety and Environmental Scientist**

Occupational Hygiene, Environment
& Chemistry Centre

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ABN 98 628 485 885

Introduction

Simtars supplied Rupprecht and Patashnick Partisol samplers to Katestone Environmental for use in a coal dust monitoring program for Queensland Rail. The Model 2000 samplers were fitted with TSP sampling heads. Simtars provided initial setup of the samplers and training in their use and continues to provide a filter preparation and weighing service for the project.

Field operations are conducted by Connell Wagner Pty Ltd in Gladstone.

The data are attached in Table 1.

REPORT NO: oe101866f9

Table 1 – Total Suspended Particulates (TSP)

Lab Number	Filter Number	Sampling Site	Property	Start	End	Sample Period (hrs)	Total Volume (m^3 STP*)	Particulates ($\mu g m^{-3}$ STP*)
oe101866-257	E5471	Horsburgh Rd Location A	Hodgson	10-Feb-08	11-Feb-08	24:00	21.8	24
oe101866-258	E5470	952 Hay Point Rd, HI- Saron	Paul & Pat Saron	10-Feb-08	11-Feb-08	24:00	21.9	96
oe101866-259	E5469	Grasstree Beach Rd Location B	David Pickworth	10-Feb-08	11-Feb-08	24:00	22.0	9
oe101866-260	E7039	Horsburgh Rd Location A	Hodgson	12-Feb-08	13-Feb-08	24:00	21.6	24
oe101866-261	E7038	952 Hay Point Rd, HI- Saron	Paul & Pat Saron	12-Feb-08	13-Feb-08	24:00	21.6	16
oe101866-262	E7037	Grasstree Beach Rd Location B	David Pickworth	12-Feb-08	13-Feb-08	24:00	21.8	14
oe101866-263	E7036	Horsburgh Rd Location A	Hodgson	14-Feb-08	15-Feb-08	24:00	21.7	33
oe101866-264	E7035	952 Hay Point Rd, HI- Saron	Paul & Pat Saron	14-Feb-08	15-Feb-08	24:00	22.0	4
oe101866-265	E7034	Grasstree Beach Rd Location B	David Pickworth	14-Feb-08	15-Feb-08	23:59	21.7	12

*STP- corrected to standard conditions of 0°C at 101.325 kpa

Occupational Hygiene, Environment & Chemistry Centre

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Simtars
Queensland Government
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Mines and Energy

Laboratory Test Report

Report Number	oe101866f10
Issue Date	5 March 2008
Report To	Mr Simon Welchman, Katestone Environmental PO Box 2217 Milton Qld 4064
Client Reference	Purchase Order KE0710021
Job Description	Suspended particulate monitoring (TSP) by Partisol sampler Results for 1 January–25 February 2008
Responsibility for Sampling	Sampling conducted by Connell Wagner Pty Ltd
Approved Signatory	**Mark Curtis** **Senior Health, Safety and Environmental Scientist**

Occupational Hygiene, Environment & Chemistry Centre

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Introduction

Simtars supplied Rupprecht and Patashnick Partisol samplers to Katestone Environmental for use in a coal dust monitoring program for Queensland Rail. The Model 2000 samplers were fitted with TSP sampling heads. Simtars provided initial setup of the samplers and training in their use and continues to provide a filter preparation and weighing service for the project.

Field operations are conducted by Connell Wagner Pty Ltd in Gladstone.

The data (for each batch of samples received) are attached in *Table 1*, *2* and *3*.

Table 1 – Total Suspended Particulates (TSP) at Gladstone

Lab Number	Filter Number	Sampling Site	Property	Start	End	Sample Period (hrs)	Total Volume (m^3 STP*)	Particulates (μgm^{-3} STP*)
oe101866-270	E5460	Kin Kora Village	Mr Olsen	01-Jan-08	02-Jan-08	24:00	21.9	24
oe101866-271	E4004	Kin Kora Van Park	Mr Olsen	03-Jan-08	Run failed	24:00	NA	NA
oe101866-272	E4254	Side St	Mrs Dye	03-Jan-08	04-Jan-08	24:00	21.8	8
oe101866-273	E4253	Side St	Mrs Dye	11-Jan-08	12-Jan-08	24:00	22.0	17
oe101866-274	E4251	Side St	Mrs Georgie Dye	13-Jan-08	14-Jan-08	24:00	21.7	12
oe101866-275	E4252	Side St	Mrs Georgie Dye	15-Jan-08	16-Jan-08	24:00	21.8	28
oe101866-276	E5462	Side St	Mrs Georgie Dye	19-Jan-08	20-Jan-08	24:00	19.5	40[A]
oe101866-277	E5461	Kin Kora Village	Mr Olsen	23-Jan-08	24-Jan-08	24:00	22.0	24[B]
oe101866-278	E5459	Kin Kora Village	Mr Olsen	06-Feb-08	07-Feb-08	24:00	21.9	8
oe101866-279	E5458	Kin Kora Village	Mr Olsen	10-Feb-08	11-Feb-08	24:00	21.7	39

*STP- corrected to standard conditions of 0^oC at 101.325 kpa
A - Possible blackout, Partisol screen disrupted and pump operating but laboured, filter wet
B – Filter appeared wet

Table 2 – Total Suspended Particulates (TSP) near Mackay

Lab Number	Filter Number	Sampling Site	Property	Start	End	Sample Period (hrs)	Total Volume (m^3 STP*)	Particulates (μgm^{-3} STP*)
oe101866-280	E7074	Horsburgh Rd	Hodgson	19-Feb-08	20-Feb-08	Run Failed	NA	NA
oe101866-281	E7073	952 Hay Point Rd	Paul & Pat Saron	19-Feb-08	20-Feb-08	24:00	21.9	7
oe101866-282	E7072	Grasstree Beach Rd	Pickworths	19-Feb-08	20-Feb-08	24:00	21.1	21
oe101866-283	E5468	Horsburgh Rd	Hodgson	21-Feb-08	22-Feb-08	Run Failed	NA	NA
oe101866-284	E7071	952 Hay Point Rd	Paul & Pat Saron	21-Feb-08	22-Feb-08	24:00	21.9	16
oe101866-285	E7070	Grasstree Beach Rd	Pickworth	21-Feb-08	22-Feb-08	24:00	22.0	30
oe101866-286	E7079	Horsburgh Rd	Hodgson	24-Feb-08	25-Feb-08	Run Failed	NA	NA
oe101866-287	E7078	952 Hay Point Rd	Paul & Pat Saron	24-Feb-08	25-Feb-08	24:00	21.8	57
oe101866-288	E7077	Grasstree Beach Rd	Pickworth	24-Feb-08	25-Feb-08	24:00	21.9	34

*STP- corrected to standard conditions of 0^oC at 101.325 kpa

Table 3 – Total Suspended Particulates (TSP) near Mackay

Lab Number	Filter Number	Sampling Site	Property	Start	End	Sample Period (hrs)	Total Volume (m^3 STP*)	Particulates (μgm^{-3} STP*)
oe101866-289	E7069	Grasstree Beach Rd	Pickworths	27-Feb-08	28-Feb-08	24:00	22.2	50
oe101866-290	E7075	952 Hay Point Rd	Paul & Pat Saron	27-Feb-08	28-Feb-08	24:00	22.0	17
oe101866-291	E7076	Horsburgh Rd	Hodgson	27-Feb-08	28-Feb-08	24:00	21.9	89

*STP- corrected to standard conditions of 0^oC at 101.325 kpa

Simtars
Queensland Government

Reference: 50/003/0010/18/66
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A business unit of the Department of
Mines and Energy

11 March 2008

smart health, safety and environmental **solutions**

Mr Simon Welchman
Katestone Environmental
PO Box 2217
Milton Qld 4064

Dear Mr Welchman

Report for Queensland Rail Project

Please find enclosed final report 0e101866f11 on dust deposition monitoring during the period 18 January – 20 February 2008 for the Queensland Rail coal dust project.

Yours sincerely

Darren Brady
A/Manager
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Occupational Hygiene, Environment
& Chemistry Centre

Simtars
Queensland Government
A business unit of the Department of
Mines and Energy

Laboratory Test Report

Report Number	oe101866f11
Issue Date	11 March 2008
Report To	Mr Simon Welchman, Katestone Environmental
Client Reference	Purchase Order KE0710021
Job Description	Dust deposition monitoring Results for period 18 Jan–20 Feb 08
Date Received	26 February 2008
Date Conducted/Completed	27 Feb 2008
Responsibility for Sampling	Sampling conducted by Connell Wagner Pty Ltd
Approved Signatory	**Mark Curtis** **Senior Health, Safety and Environmental Scientist**

Mark Curtis

Occupational Hygiene, Environment
& Chemistry Centre

REPORT NO: oe101866f11

Introduction

Simtars supplied dust deposition gauges to Katestone Environmental for use in a coal dust monitoring program for Queensland Rail. Simtars provided initial setup of the samplers and training in their use and continues to provide an analysis service for the project.

Field operations are conducted by Connell Wagner Pty Ltd in Gladstone

The data are attached in Table 1.

REPORT NO: oe101866f11

Table 1 – Dust Deposition Results for January 2008

Lab Number	Sampling Site	Start	End	Sample Period (days)	Total Solids ($mgm^{-2}d^{-1}$)	Insoluble Solids ($mgm^{-2}d^{-1}$)	Ash Solids ($mgm^{-2}d^{-1}$)	Soluble Solids ($mgm^{-2}d^{-1}$)	Combustible Solids ($mgm^{-2}d^{-1}$)
oe101866-266	Kin Kora	21-Jan-08	20-Feb-08	30	10	3	3	6	<1
oe101866-267	Shaw St	18-Jan-08	20-Feb-08	33	20	12	5	8	7
oe101866-268	Witney St	18-Jan-08	20-Feb-08	33	28	21	15	6	7
oe101866-269	Bradford St	18-Jan-08	20-Feb-08	33	38	7	5	31	1

REPORT NO: oe101866f12

Laboratory Test Report

Report Number	oe101866f12
Issue Date	19 March 2008
Report To	Mr Simon Welchman, Katestone Environmental
Client Reference	Purchase Order KE0710021
Job Description	Dust deposition monitoring results (31 Jan–07 Mar 08) and Suspended particulate monitoring (TSP) results (21–22 Feb 08)
Date Received	10 and 18 March 2008
Date Conducted	10 and 19 March 2008
Responsibility for Sampling	Sampling conducted by Connell Wagner Pty Ltd
Approved Signatory	**Mark Curtis** **Senior Health, Safety and Environmental Scientist**

REPORT NO: oe101866f12

Introduction

Dust deposition gauges and Rupprecht and Patashnick Partisol suspended particulates samplers were supplied by Simtars to Katestone Environmental for use in a Queensland Rail coal dust monitoring program. The Model 2000 particulate samplers were fitted with TSP sampling heads. Simtars provided initial setup and training and continues to provide a dust deposition analysis and filter preparation/weighing service for the project. Field operations are conducted by Connell Wagner Pty Ltd in Gladstone

The dust deposition and suspended particulate TSP data are attached, respectively, as *Table 1* and *Table 2*.

Note: 451 mm of rainfall was recorded during February 2008 at the Bureau of Meteorology Gladstone Radar Station site. This represents three times the long-term February average for the site. It is likely that all the dust deposition bottles overflowed substantially during the sampling period as the capacity of the collection bottles is approximately 230 mm. The Australian Standard *AS/NZ 3580.10.1:2003* states “Where a gauge has overflowed soluble matter cannot be determined.” (This also means that the total deposition cannot be determined.) The standard also states “For routine monitoring programs, the period of exposure is typically 30 + or - 2 days.” The samples from Beecher were exposed for 36 days.

REPORT NO: oe101866f12

Table 1 – Dust Deposition Results for February 2008

Lab Number	Sampling Site	Start	End	Sample Period (days)	Total Solids ($mgm^{-2}d^{-1}$)	Insoluble Solids ($mgm^{-2}d^{-1}$)	Ash Solids ($mgm^{-2}d^{-1}$)	Soluble Solids ($mgm^{-2}d^{-1}$)	Combustible Solids ($mgm^{-2}d^{-1}$)
oe101866-293	Beecher 5 m up wind	31-Jan-08	7-Mar-08	36	ND	35	20	ND	15
oe101866-294	Beecher 5 m down wind	31-Jan-08	7-Mar-08	36	ND	93	33	ND	60
oe101866-295	Beecher 15 m down wind	31-Jan-08	7-Mar-08	36	ND	33	15	ND	18
oe101866-296	Beecher 25 m down wind	31-Jan-08	7-Mar-08	36	ND	26	11	ND	15
oe101866-297	Raglan St Mt Larcom	31-Jan-08	3-Mar-08	32	ND	16	9	ND	8
oe101866-298	Side St Gladstone	31-Jan-08	3-Mar-08	32	ND	149	140	ND	9
oe101866-299	Off Lane - Gladstone	31-Jan-08	3-Mar-08	32	ND	44	29	ND	15

ND – Not Determined because dust deposition gauges overflowed

Table 2 – Total Suspended Particulates (TSP)

Lab Number	Filter Number	Sampling Site	Property	Start	End	Sample Period (hrs)	Total Volume (m^3 STP*)	Particulates (μgm^{-3} STP*)
oe101866-300	E7023	Kinkora Village	Mr Monty Olsen	21-Feb-08	22-Feb-08	24:00	21.9	24

*STP- corrected to standard conditions of 0^oC at 101.325 kpa

MICROSCOPY OBSERVATIONS ON DUST SAMPLES MARCH 2008.

Sample	% COAL	MAJOR	MINOR	TRACE
266	5	Mineral Dust (60%)	Insect & Plant Debris P/s slime	Coal Misc fibres (mainly cellulose) Black rubber dust
267	5	Mineral Dust (35%) P/s slime + copper sludge(45%)	Insect Debris	Coal Plant Debris Misc fibres (mainly cellulose)
268	20	Coal (20%) Mineral Dust (45%) Insect & Plant Debris (25%)	P/s slime + copper sludge	Misc fibres (mainly cellulose) Black rubber dust
269	15	Mineral Dust (70%)	Insect Debris Coal	P/s slime + copper sludge Plant Debris Misc fibres (mainly cellulose) Black rubber dust
293	35	P/s slime + copper sludge (25%) Coal (35%)	Insect & Plant Debris Mineral Dust	Plant Debris Misc fibres (mainly cellulose)
294	40	P/s slime + copper sludge(20%) Mineral Dust (20%) Coal (40%)	Insect Debris	Plant Debris Misc fibres (mainly cellulose) Black rubber dust
295	15	Mineral Dust (20%) Insect & Plant Debris (40%)	P/s slime + copper sludge	Coal Misc fibres (mainly cellulose) Black rubber dust
296	5	Insect & plantdebris (55%) P/s slime + copper sludge (20%)	Misc fibres	Coal Mineral Dust

Sample	% COAL	MAJOR	MINOR	TRACE
297	5	Mineral Dust, including significant amounts of alumina (70%)	Insect debris	Plant Debris Coal P/s slime + copper sludge Misc fibres (mainly cellulose) Black rubber dust
298	3	Mineral Dust, including significant amounts of alumina (50%) P/s slime + copper sludge (30%)	Insect debris	Plant Debris Coal Misc fibres (mainly cellulose) Black rubber dust
299	15	Mineral Dust, including significant amounts of alumina (60%)	Coal Insect debris P/s slime + copper sludge	Plant Debris Misc fibres (mainly cellulose) Black rubber dust

LEGEND / EXPLANATORY NOTES:

Major

This indicates that the constituent is present at the highest percentage, on a projected area basis, of those seen. For complex samples a number of joint major constituents may be listed and this would indicate that several constituents of roughly equal proportions make up the bulk of the sample. In this case, a major constituent which is one of three or four may constitute only 20-30% of the sample.

Minor

Constituents which would be present in the 5-40% range.

Trace

Constituents which would be present in the range 5% to 'just detectable'.

Coal dust	Black, equant, sharp angled grains. Some glossy; some edges dark brown translucent. SEM/EDA used to check for carbon and ash elements (Al, Si, S, Ca, Ti, Fe, O)
Mineral matter	Usually equant siliceous appearance and typically colourless to brown, transparent to translucent, euhedral, rounded grains. Sometimes clays as very fine particles. Other constituents of siliceous appearance, sand etc. Some commercial mineral products (alumina, magnesia, etc) included in this category unless noted.
P/s slime	Polysaccharide slime. This extra-cellular bio-polymeric material may have different sources which might include microbiological growth, vertebrate excreta, decomposing biological matter, etc. Sometimes seen in these samples as a stringy gel binding other particles together. Sometimes fungal hyphae associated with the gel.
Copper sludge	Some well-developed turquoise crystal growths occasionally found, but usually subhedral to euhedral grains. Sometimes as blue highlights on a greenish caked material. This is probably copper salts precipitated from the copper sulfate algaecide solution as the hydroxide, with or without sulfate and or phosphorous inclusion.
Cement dust	Particles seen to consist primarily of calcium, silicon and oxygen with some aluminium at times. Calcium determinations have been used to underpin the microscopy results.
Red Rubber Dust	A fairly common constituent of some samples in these surveys - almost certainly from the rubber stoppers used in the sampling apparatus.

Black Rubber Dust	Another fairly common constituent of some samples in these surveys - likely sources are rubber tyres and conveyor belts.
Insect parts	Includes arachnids. Present as crushed body fragments, trichomes, wing scales, etc.
Plant Debris/ Plant char	Usually as trichomes, fragmented tissue and reproductive products and structures, eg pollen, stamens. Sometimes found as charred particles from, presumably, grass or bush fires.
Fly ash particles	Appear as spheroidal particles - colourless, milky or black
Wood dust/Cellulose	While a few stray fibres may be introduced by sampling and preparation, large numbers, especially as damaged fibres and torn fibre bundles confirm an ambient source, eg. wood chip.
Spores/pollen	General spherical but ay be distinctive shapes, sometimes textured or otherwise marked. When high counts of fungal spores are present some hyphal material may also be present.
Soot	Black glossy spherical to botryoidal aggregates, typically hollow or lacy. Usual source is incompletely burnt organic liquids, eg. fuel oils, and in port locations may be shipping, heavy equipment or truck origins.

Appendix C

Wind Tunnel Program to Determine the Extent of Dust Lift-Off From the Surface of Typical Coal Types When Treated With Surface Veneer Chemicals Under Simulated Rail Transport Operations

QUEENSLAND RAIL
CLMP STUDY

APPENDIX C

WIND TUNNEL PROGRAM TO DETERMINE THE EXTENT OF DUST LIFT-OFF FROM THE SURFACE OF TYPICAL COAL TYPES WHEN TREATED WITH SURFACE VENEER CHEMICALS UNDER SIMULATED RAIL TRANSPORT OPERATIONS

1. INTRODUCTION

A laboratory test program has been conducted to assess the likely performance and cost of five surface veneer chemicals when applied to seven typical coal types transported by Queensland Rail (QR).

It was shown in a study conducted on dust emission reduction from coal trains in Canada that surface treatment was found to be the most effective and cost efficient option. Surface veneer treatment is being adopted for use on coal stockpiles at major Australian port terminals.

As the mass of dust removed from the coal surface by wind erosion is related to wind speed, wind tunnel tests on scale models of typical QR coal wagons were conducted to develop an understanding of the pattern of wind movement over the surface under typical train travel speeds. The outcomes from that wind tunnel test program were then verified by the CFD modelling investigation, all shown in Appendix D.

From those outcomes it has been determined that treated coal samples used in the surface veneer performance wind tunnel program should be tested when exposed to a wind speed of 20 metres per second (72 km per hour).

A series of laboratory tests had been previously conducted on samples of over thirty typical coal types to determine the wind speed at which dust lift-off is observed. The predicted wind speed over the coal surface under typical train travel speeds is higher than the observed wind speed at which major dust lift-off occurred from all coal types tested under laboratory conditions, designed to simulate typical coal stockpiles.

As the coal surface in wagons during extended rail travel times is expected to lose moisture at a greater rate than the laboratory stockpile simulated conditions, dust lift-off could be expected to occur at even lower speeds relative to the wind speed over the coal surface predicted under normal rail operations.

The program to evaluate the performance of surface treatment options to minimise dust lift-off from wagons has been conducted using the supplier’s recommended solution strength and application rate to evaluate performance against cost.

The major objective of the program is to verify the principle of surface veneer treatment rather than the selection of a particular product, a process which will require more extensive investigation over a larger range of coal types.

2 SURFACE VENEER PRODUCTS AND COAL TYPES INCLUDED IN THE TEST PROGRAM

2.1 Surface Veneer Products

Surface veneer chemicals used in the program were selected from products which have a previously demonstrated ability to minimise dust lift-off from the surface of coal stockpiles under adverse weather conditions, including high wind speed. Although performance was the major selection requirement, cost effectiveness is also an important factor.

Based on the above criteria selected organisations were invited to nominate a product that met the requirements also supported by provision of the following information;

- MSDS Data
- Previous application to coal stockpiles in operational use, laboratory tests, or field trials
- Recommended solution strength
- Recommended application rate
- Typical supply cost
- Effect on coal properties
- Effect on residential or rural environments

The following companies were selected to provide a product for inclusion in the test program;

- Supplier A
- Supplier B
- Supplier C
- Supplier D
- Supplier E

2.2 Coal Types

The following coal types were selected to include products transported to Gladstone and to the Hay Point area. Coal types were also selected as being somewhat representative of coal types prone to dust lift-off;

Rail transport to Gladstone

- AC 1
- X 1
- AE 1

Rail transport to Dalrymple Bay, Hay Point

- A 1
- J 1
- T 1
- S 1

3 LABORATORY TEST FACILITIES AND PROCEDURE

3.1 Test Procedure

Dust lift-off tests were conducted using the wind tunnel shown in Figure C1. The wind tunnel is located in the laboratories of TUNRA Bulk Solids Research Associates, Newcastle.

The coal wagon situation was simulated by placing a sample of each coal type in a sample tray with dimensions 300mm x 230mm, depth 60mm were placed in the wind tunnel at an angle of 37 degrees, simulating typical angle of repose of coal.

Each sample was screened to remove any product greater than 6.3mm, to represent the sizing most vulnerable to dust lift-off and to increase consistency in the relatively small sample trays.

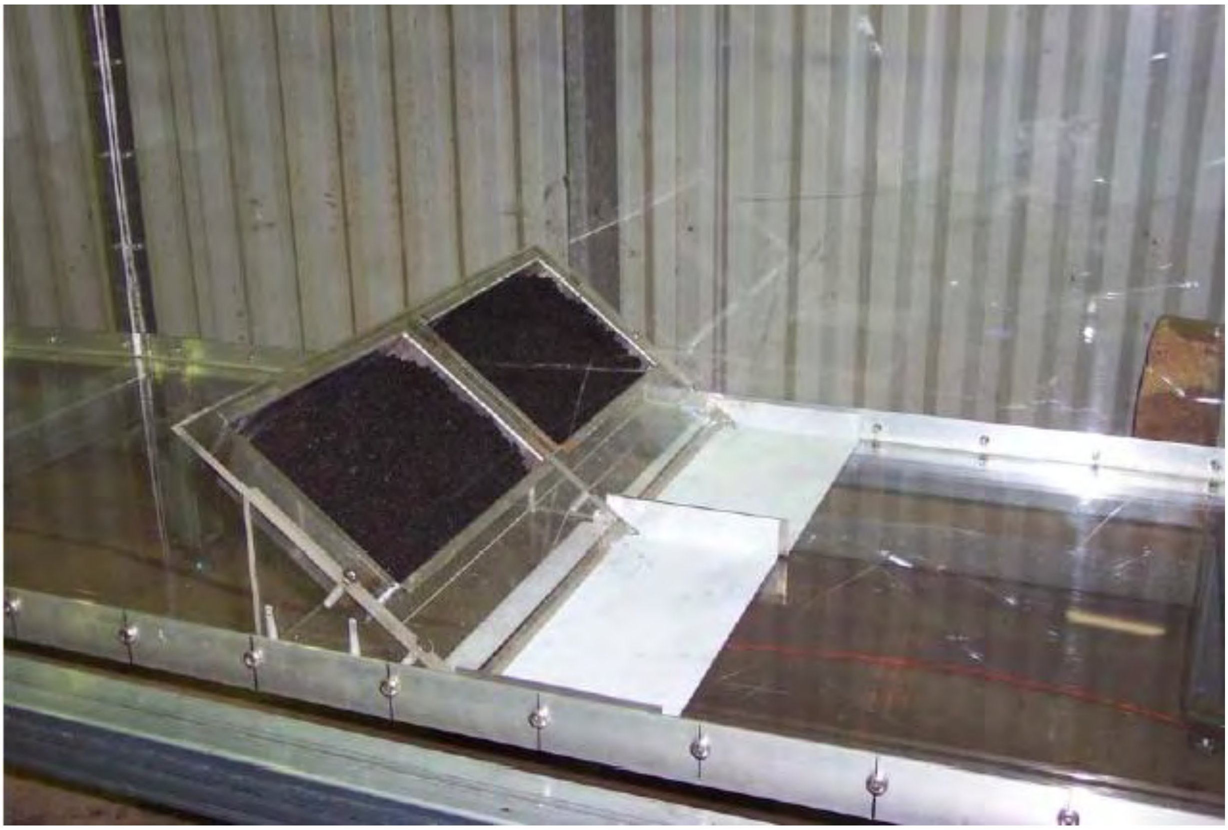

Figure C 1 Wind tunnel with two sample trays

The wagon typical operating conditions were simulated in accordance with the following procedure;

- Prepare samples at 75% DEM (Note 1)
- Apply one of the five nominated products at a rate of 1 litre per square metre
- Place trays in oven for 60 minutes at 35 degrees C (Note 2)
- Place test trays in wind tunnel at angle of 37 degrees
- Apply 20 metres per second (72 k/h) wind speed
- Test duration 8 hours
- Measure dust lift-off
- Record observations

Note 1: To simulate a typical moisture level for each coal type when placed in the wagon an allowance was made in the pre-test sample moisture level (75% DEM) for loss of moisture due to evaporation which may occur during stockpiling and handling operations between preparation at the mine site and loading to wagons.

Note 2: To allow for loss of moisture by evaporation from the surface of the loaded coal, after application of surface treatment and during transport, each sample was oven pre-dried for a period of 60minutes at 35ºC.

3.2 Dust Suppressant Veneer Products

The following products were tested at supplier's recommended solution strength;

- Product A - 3% solution
- Product B - 4% solution
- Product C - 5% solution
- Product D - 6% solution
- Product E - 3% solution

3.3 Wind Speed Pattern over the Surface of Sample Test Trays

The wind speed over the surface of the sample test trays was measured at wind tunnel wind speeds of 20 metres per second as shown in Figure C 2.

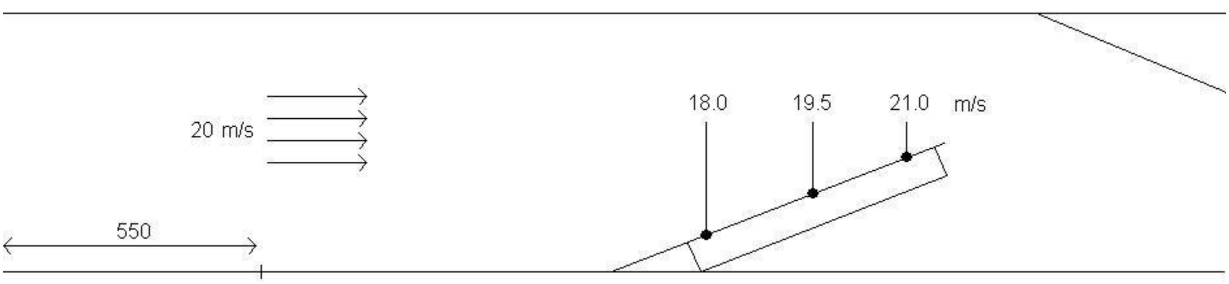

Figure C 2 Wind flow over test trays at 20 metres per second wind tunnel

4 TEST RESULTS

The following tables provide the test program results. Two samples were tested under parallel conditions each time but the pairings were changed for different coal types.

Sample preparation was consistent for all tests and the variable temperature and humidity conditions have been indicated. The test duration was 8 hours for all surface treatment options but was dramatically reduced for nil treatment due to the rapid rate of dust lift-off.

Table C 1 Dust lift-off (grams) from coal type A1 when exposed to 72 k/h wind speed following the application of alternative surface veneer treatment options or nil treatment

Treatment and dosage ratio	Duration	Dust Lift-Off (g)	Temp	Humidity
A @ 3 %	8 hours	8.11	27.0	55%
D @ 5 %	8 hours	8.66	27.0	55%
B @ 4 %	8 hours	16.14	28.0	50%
E @ 6 %	8 hours	13.47	28.0	50%
C @ 3 %	8 hours	462	23.0	76%
Nil	1 min	115	25.0	52%

Table C 2 Dust lift-off (grams) from coal type X1 when exposed to 72 k/h wind speed following the application of alternative surface veneer treatment options or nil treatment

Treatment and dosage ratio	Duration	Dust Lift-Off (g)	Temp	Humidity
A @ 3 %	8 hours	0.42	28.0	60%
C @ 3 %	8 hours	0.37	28.0	60%
B @ 4 %	8 hours	3.25	26.0	58%
E @ 6 %	8 hours	3.60	26.0	58%
D @ 5 %	8 hours	0.60	27.0	60%
Nil	1 min	221.50	27.0	60%

Table C 3 Dust lift-off (grams) from coal type AC1 when exposed to 72 k/h wind speed following the application of alternative surface veneer treatment options or nil treatment

Treatment and dosage ratio	Duration	Dust Lift-Off (g)	Temp	Humidity
A @ 3 %	8 hours	16.14	28.0	56%
C @ 3 %	8 hours	17.90	28.0	56%
B @ 4 %	8 hours	0.00	30.0	54%
E @ 6 %	8 hours	0.00	30.0	54%
D @ 5 %	8 hours	2.60	28.0	55%
Nil	1 min	136.20	28.0	55%

Table C 4 Dust lift-off (grams) from coal type AE1 when exposed to 72 k/h wind speed following the application of alternative surface veneer treatment options or nil treatment

Treatment and dosage ratio	Duration	Dust Lift-Off (g)	Temp	Humidity
A @ 3 %	8 hours	6.00	28.0	56%
C @ 3 %	8 hours	8.14	28.0	56%
B @ 4 %	8 hours	0.11	26.0	60%
E @ 6 %	8 hours	0.00	26.0	60%
D @ 5 %	8 hours	4.70	23.0	76%
Nil	1 min	51.80	23.0	76%

Table C 5 Dust lift-off (grams) from coal type T1 when exposed to 72 k/h wind speed following the application of alternative surface veneer treatment options or nil treatment

Treatment and dosage ratio	Duration	Dust Lift-Off (g)	Temp	Humidity
A @ 3 %	8 hours	4.20	24.0	60%
C @ 3 %	8 hours	7.10	24.0	60%
B @ 4 %	8 hours	3.60	24.0	50%
E @ 6 %	8 hours	5.80	24.0	50%
D @ 5 %	8 hours	4.50	25.0	55%
Nil	1 min	156	25.0	55%

Table C 6 Dust lift-off (grams) from coal type S1 when exposed to 72 k/h wind speed following the application of alternative surface veneer treatment options or nil treatment

Treatment and dosage ratio	Duration	Dust Lift-Off (g)	Temp	Humidity
A @ 3 %	8 hours	3.1	24.0	60%
C @ 3 %	8 hours	6.33	24.0	60%
B @ 4 %	8 hours	2.60	24.0	55%
E @ 6 %	8 hours	3.86	24.0	55%
D @ 5 %	8 hours	3.40	25.0	55%
Nil	1 min	110.0	25	55%

Table C 7 Dust lift-off (grams) from coal type J1 when exposed to 72 k/h wind speed following the application of alternative surface veneer treatment options or nil treatment

Treatment and dosage ratio	Duration	Dust Lift-Off (g)	Temp	Humidity
A @ 3 %	8 hours	5.30	27.0	65%
C @ 3 %	8 hours	6.20	27.0	65%
B @ 4 %	8 hours	5.50	26.0	56%
E @ 6 %	8 hours	7.50	26.0	56%
D @ 5 %	8 hours	4.13	25.0	55%
Nil	1 min	154.80	25.0	55%

5 OBSERVATIONS AND RECOMMENDATIONS

All surface veneer products, when applied at the supplier's recommended application rate and solution strength, achieved a significant reduction in dust lift-off compared with nil treatment.

All surface veneer products were applied at a common application rate of one litre per square metre. The solution strength varied according to the supplier's recommendation. All test samples were exposed to a wind speed of 20 metres per second (72 k/h).

All treated samples exposed to 72 k/h wind speed remained in the wind tunnel under test conditions for a period of 8 hours. However due to very rapid dust lift-off the untreated samples (Nil treatment) were removed from the wind tunnel after exposure to the test conditions for only 1 minute. This observation applied to all tested coal types.

Although the surface treatment product C performed well on other tested coal types, it did not perform well when applied to the surface of coal type A1. This result was verified by observation of a similar result in a repeated test.

The lowest total level of dust lift-off when applied to all seven coal types was achieved by surface treatment with product type D.

When the wind tunnel is operated at a wind speed of 20 m/s (72 k/h) a minor level of vibration is induced in the structure and the vibration is transferred to the test trays. This will to some extent simulate the effect of vibration transferred to the coal load in QR wagons during transport. This level of vibration was not observed to cause any slip failure in the contents of the sample trays at the typical coal angle of repose so the surface sealant remained intact for the test duration.

As a coal surface slip failure during transport can disturb the surface sealant and expose un-protected coal, this feature will require further observation under operating conditions. It may be possible to conduct observations of the current Anglo Coal veneer treatment trials as part of the investigative process.

Coal types selected for this study include some that have previously been observed to have a high dust emission tendency.

A review has been conducted of the relevant cost of the five surface treatment options. Although it is appropriate to treat the information as "commercial in confidence", it is concluded that at least one product can achieve a satisfactory performance at a cost not exceeding $0.08 per litre.

As the satisfactory performance has been achieved on coal types which include some with a relatively high level of dustiness it is possible that a lower solution strength, and therefore lower cost, could be possible on some coal types.

It is recommended that surface veneer treatment be considered as a cost effective means of reducing dust emission during QR coal transport.

It is also recommended that further laboratory tests and field trials be conducted on a larger range of coal types to explore the relevant treatment selection for each coal type and to refine the most cost effective approach to achieving an acceptable level of dust emission during rail transport from mine to port.

Appendix D

Wagon and load profiling wind tunnel – University of Sydney and Computational Fluid Dynamics

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CFD Analysis
Coal Erosion
Queensland Rail

15 February 2008
Reference H327578-N00
Revision 3

Document Control

Connell Wagner

Document ID: P:\H327578-N00\ADMIN\REP\AK101217AK COAL EROSION CFD REPORT_HM_1.DOC

Rev No	Date	Revision Details	Typist	Author	Verifier	Approver
0	10 December 2007		AK/HM	AK/HM	AK/HM	NCM
1	17 December 2007	Draft	AK/HM/BM	AK/HM/BM	NCM	NCM
2	20 December 2007	Original	AK/HM/BM	AK/HM/BM	NCM	NCM
3	15 February 2008	Revision 1	HM	AK/HM/BM	NCM	NCM

Contents

1. Introduction

Erosion of coal from wagons during transport leads to significant environmental and financial costs and therefore mitigation measures should be investigated. This report details the results of the Computational Fluid Dynamics (CFD) analysis conducted by Connell Wagner on several loading configurations of the Queensland Rail (QR) Coal wagons. This study was commissioned by QR in order to determine the effect of train geometry and coal loading configurations on the flow patterns and velocities around the train. This analysis has been conducted on the 106 tonne Class VSAL coal wagon, the geometry of the wagon can be seen in Appendix A.

A CFD package called PHOENICS was used to numerically simulate the flow of air around the train and across the coal face and allowed graphical representation of the properties of the flow of air. Over a discretized grid (mesh) the program predicts the properties of the flow by solving the Navier–Stokes equations.

Once the properties of the air flow over the coal face are predicted in this investigation, the results can then be compared with information regarding the critical properties which dictate the rate of coal erosion (determined elsewhere).

Validation of the CFD simulation is required; therefore the results from the simulation are to be compared to the results from experiments conducted by Connell Wagner in the wind tunnel at The University of Sydney.

This report will detail predicted values of velocity and turbulence intensity across the coal face. Values reported, unless otherwise stated, represent the magnitude at a height of approximately 150 mm above the coal face. This height has been used since it was the closest practicable height that measurements could be taken in The University of Sydney's wind tunnel (approximately 3 mm at 1:50 scale)

2. References

1) AS 1170.2:2002 Structural Design Actions – Wind Actions
2) AS1170.2:1989 Minimum Design Loads on Structures (known as the SAA Loading Code) – Wind Loads
3) Queensland Rail 106 Tonne Class VSAL Coal Wagon Drawings
4) http://www.railpictures.net/showphotos.php?railroad=Queensland%20Rail

3. Assumptions

- Steady state flow.
- Working fluid: air at standard temperature and pressure (STP) (20°C and one atm).
- Thermal effects negligible.
- Incompressible flow.
- Simplified coal and wagon geometry used.
- All surfaces fully rough with user specified roughness:
  - Ground: 20 mm
  - Wagon: 1 mm
  - Coal: 2 mm
- Flow volume boundaries (not including the ground) sufficiently far away from the wagon and coal such that they had no effect.
- A turbulence intensity of 5% was applied to the entire inlet; no wind profile was used.
- Ground velocity is equal to mean air velocity

4. Wagon Geometry and Scenarios Modelled

Isometric views of the coal and wagon geometry can be seen in Appendix A. The wheels and undercarriage of the wagons were simplified to cube shapes in order to decrease computational time, under the assumption that this geometry is not expected to have a significant influence on fluid flow over the top of the wagon and hence the coal face. All of the models that will be described below with the exception of Model 4 were analysed in both the case where the train was travelling at 80 km/h with no cross wind and also with cross wind of 18 km/h.

4.1 Model 1 – Unmodified Wagon and Garden Bed Coal Configuration

The first scenario modelled consisted of six inline wagons with a garden bed (flat) coal loading configuration. This configuration had a 100 mm gutter around the cant rail, with a 600 mm front and rear gutter, with the height of the garden bed being approximately 250 mm above the cant rail. The geometrical features and dimensions are best described by Figure 1.

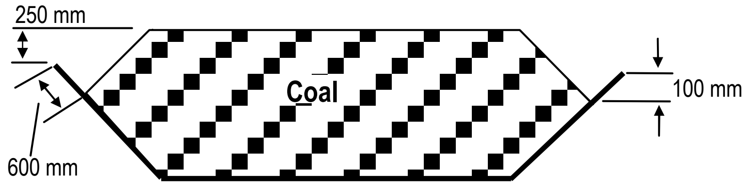


Figure 1 Model 1 Dimensions

4.2 Model 2 – Unmodified Wagon and Three Mound Coal Configuration

The second scenario modeled also consisted of six inline train wagons but with a 'clamshell' or three mound coal loading configuration with a significant proportion of the geometry being similar to that of Model 1. The geometrical features and dimensions are best described by Figure 2.

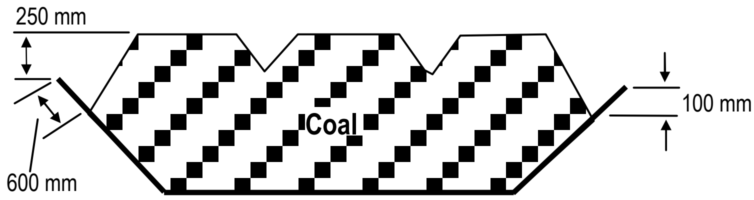


Figure 2 Dimensions of three mound ('clamshell') coal configuration

4.3 Model 3 – Wagon with Hungry Board

The third scenario tested consisted of the train with a 300 mm hungry board around the cant rail on the front and sides of the wagon. The garden bed and three mound coal configuration with the same geometrical characteristics were simulated with the new train geometry. Figure 3 shows an isometric view of the coal wagon and the positioning of the hungry boards (black).

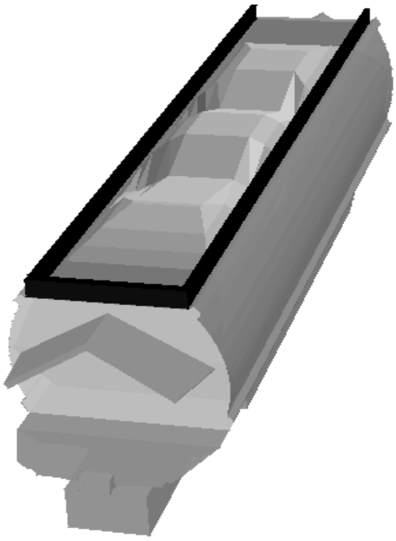


Figure 3 Isometric view of train with hungry board and three mound coal loading

4.4 Model 4 – 100 Inline Wagons

The length of a 100 inline wagons was approximately 1.5 km, resulting in significant computational expense due to the size of the domain. Hence in order to decrease computational time a two dimensional analysis in the YZ cutting plane (length wise) (as shown in Figure 4) was conducted. This analysis was conducted assuming the trains would only experience the wind opposing the direction of travel. Due to the 2D simulation, a cross wind case was unable to be modelled; it is expected that the cross wind effect will be unchanged with the additional length.

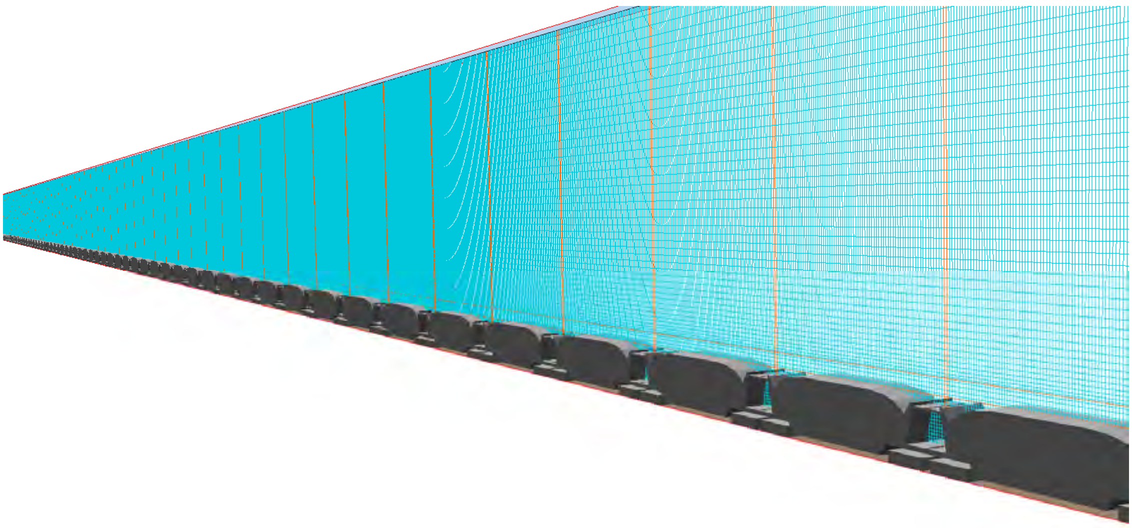


Figure 4 Isometric view of 100 Inline wagons 2D analysis.

4.5 Model 5 – Low Loading Case

Another simulation which may be of interest is a low loading case where there is a 200 mm gutter around the coal (as opposed to 100 mm in the standard case). It is expected that results from this simulation will be similar to the addition of small hungry boards around the cant rail. To minimise computation time, this simulation has not been conducted, results can be extrapolated from the hungry board case.

4.6 Model 6 – Tee Pee Load

This simulation involves an alternate loading case where the wagon is essentially filled to capacity. There is no gutter between the wagon and the coal face. To allow comparison between this case and the base case the total height of the coal has been maintained to the same height as the base case.

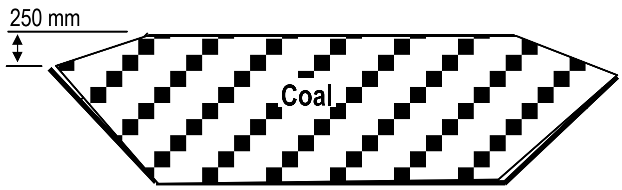


Figure 5 Tee Pee Load

4.7 Modelling Domain

The modelling domain for the six inline wagon run with no cross wind is shown in Figure 6. The flow inlet and outlets are represented by the areas shaded purple and blue respectively. The length of the domain past the last wagon was sufficiently large so as to allow wake development. In addition a sufficient length has been kept at the start of the domain so as to allow for the flow to fully develop. In the scenario where a cross wind was input into the model, the X-domain length was increased to 20 m to allow for the wake development in that direction, and an outlet was added in the downstream Y-Z plane. An example of the mesh density can be seen in Figure 7.

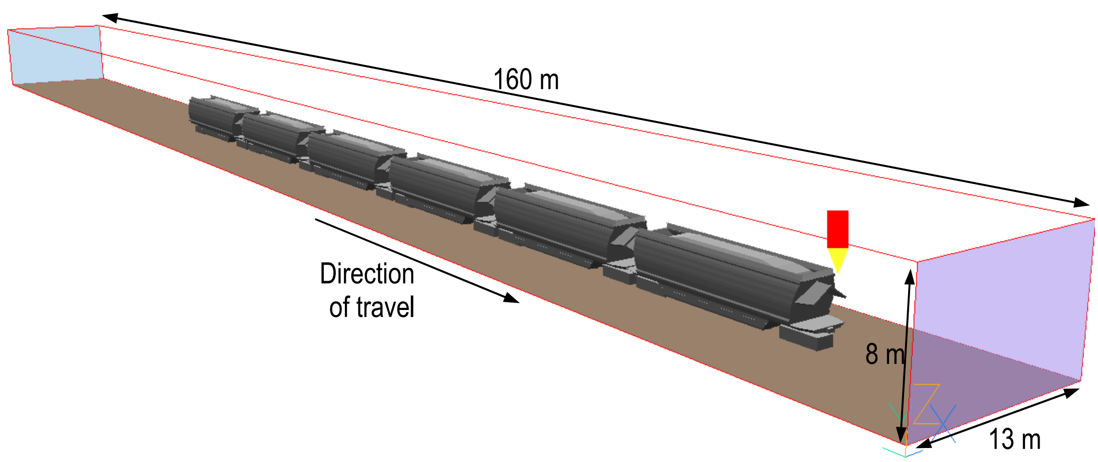


Figure 6 Modelling domain (No cross wind case)

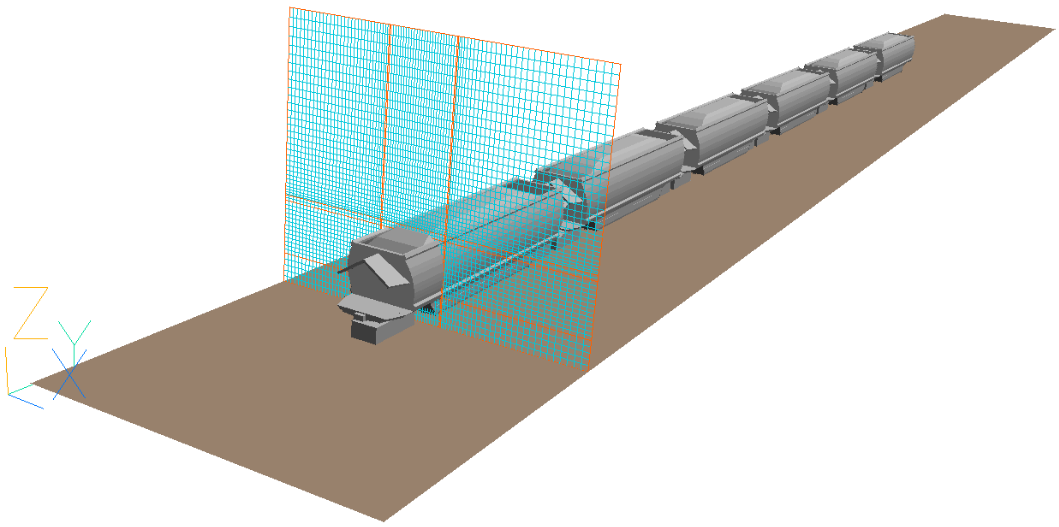


Figure 7 Mesh Density

5. Verification of Wind Tunnel Results

The train models used in the wind tunnel section of this study were constructed at 1:50 scale in order to see the cumulative effects of several wagons. The University of Sydney wind tunnel is calibrated to 1:400 scale. Simulations were conducted at terrain category (TC) TC2 and TC3 in the wind tunnel; velocity profiles were recorded, however turbulence intensity profiles were not. The effect of scaling the wind profile is discussed in this section.

The Queensland Rail wagons which were modelled in the wind tunnel have an approximate (real) height of 5 m, measurements of velocity and turbulence intensity were measured approximately 2 mm above the coal face of the model (approximately 100 mm from the ground at 1:50 scale). However, the wind profile generated by the wind tunnel is calibrated to a 1:400 scale, therefore the 100 mm measurement height does not represent 5 m, but rather 40 m above the ground.

A wind profile is inherently created in the wind tunnel due to roughness generated by the ground. A terrain category of 2 (at 1:400 scale) is achieved with carpet on the ground of the wind tunnel. This is the minimum level of turbulence that can be simulated. Increasing the roughness by adding calibrated blocks to the ground and turbulence inducing spires generates Terrain Category 3.

AS1170.2 gives the following definitions for terrain categories:

Category 1 – Exposed open terrain with few or no obstructions and water surfaces at serviceability wind speeds
Category 2 – Water surfaces, open terrain, grassland with few, well–scattered obstructions having heights generally from 1.5 m to 10 m.
Category 3 – Terrain with numerous closely spaced obstructions 3 m to 5 m high such as areas of suburban housing
Category 4 – Terrain with numerous large, high (10 m to 30 m high) and closely spaced obstructions such as large city centres and well developed industrial complexes.

A wind profile associated with terrain category 2 is representative of wind blowing over a still train in "open terrain". Frictional losses associated with small obstructions such as grass etc lead to lower velocities and higher turbulence intensities closer to the ground. However, a train travelling into still air will not be subjected to the same wind profile conditions, and therefore will be exposed to lower levels of turbulence. Simulation of a train moving into still air is not able to be conducted in the wind tunnel due to the inherent wind profile generated by losses associated with the wind tunnel walls and floor. Therefore a high turbulence CFD model has been generated to validate the wind tunnel simulation, however, a low turbulence case is likely to more closely simulate real life.

The Australian Wind Code AS1170.2 gives values of turbulence intensities with respect to height and terrain category. The measurement location (40 m at TC3) indicates a turbulence intensity of 19.5%. A turbulence intensity of 19.5% is good correlation for a height of 5 m at TC 2. To verify the wind tunnel results, an inlet turbulence intensity of 19.5% has been applied to the inlet of the CFD model.

Figure 8 shows the comparison of the wind profiles provided in AS1170.2 scaled to 1:50 and 1:400.

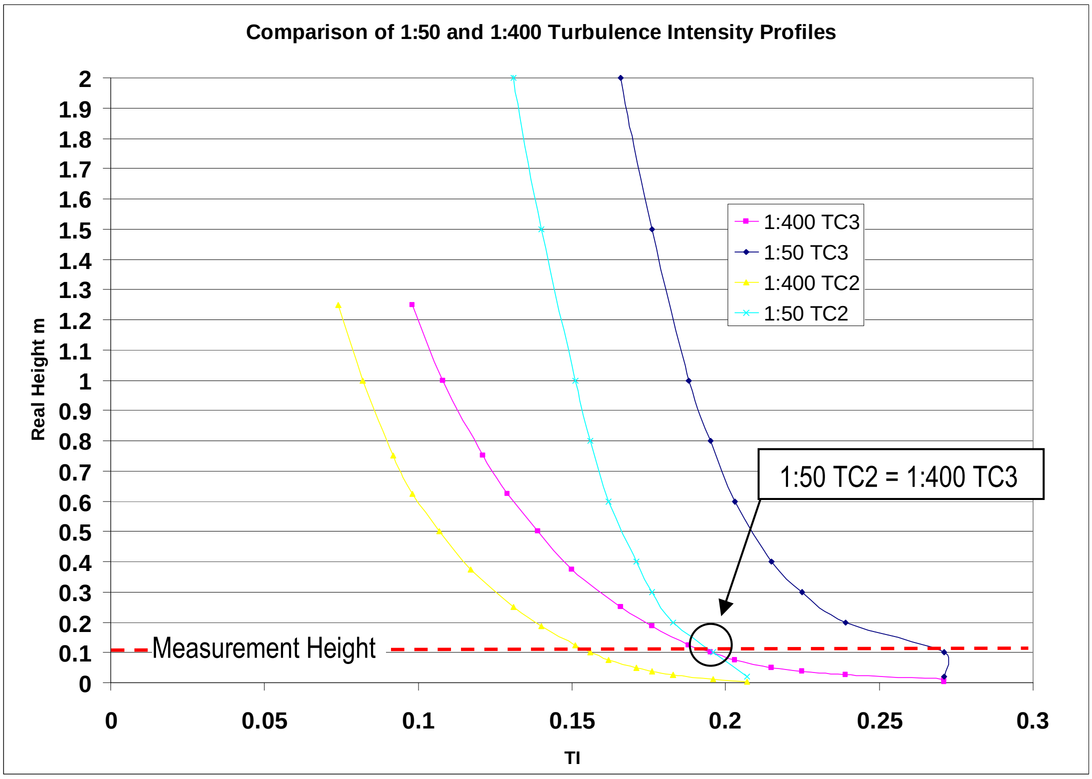
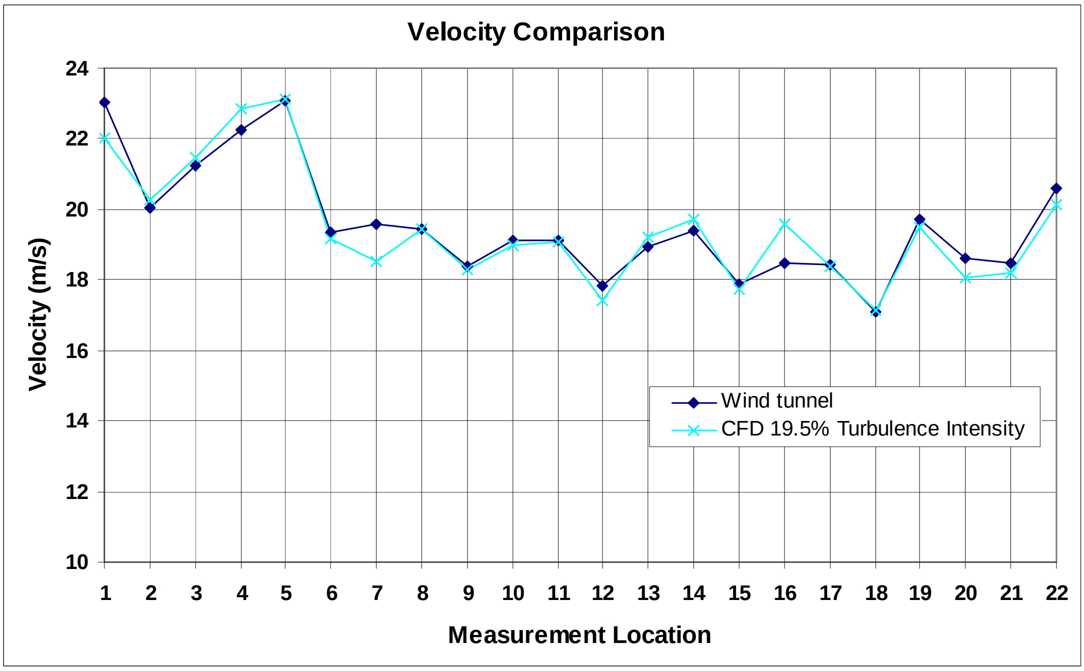


Figure 8 Turbulence Intensity Profiles (Source: AS1170.2)

CFD work conducted, and documented in this report was conducted with an inlet turbulence intensity of 5% and a ground roughness of 0.02 m. This ground roughness is representative of TC 2. This is seen to be an accurate representation of a train traversing an open field where the train is travelling through still air. Wind profiles of cross winds have been deemed negligable.

Achieving 5% inlet turbulence intensity was not able to be conducted in the wind tunnel due to the inherent roughness of the wind tunnel producing turbulence greater than 5% at the measurement height. It is therefore unable to simulate a train travelling through still air. However, results of the wind tunnel have been used to confirm the accuracy of the simulation conducted in Phoenics.

The following figures show the verification of the wind tunnel results with the CFD.



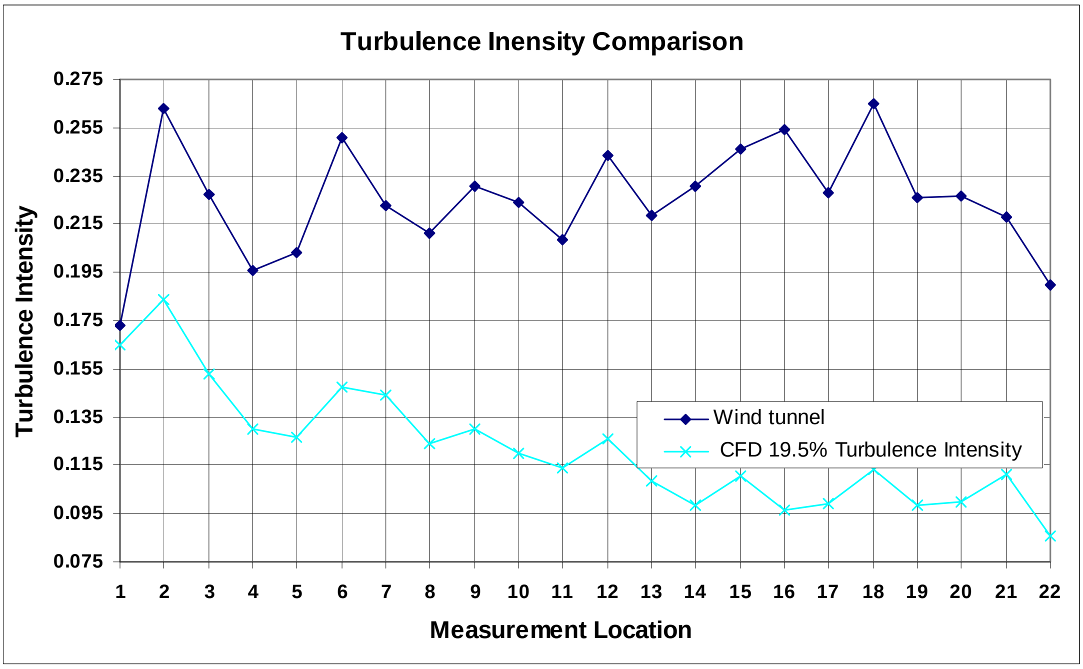


Figure 9 Verification of Results

There is very good correlation between the velocity profile of the wind tunnel and the CFD results. However, it can be seen that small inconsistencies are present between the velocity profiles recorded in the wind tunnel results and the CFD results at some measurement locations. There are several reasons behind the inconsistencies:

- The hot wire used in the wind tunnel is approximately 5 mm long. Therefore the values measured in the wind tunnel are an average over that 5 mm which equates to a 250 mm at 1:50 scale, or 2 m at 1:400 scale. This is however the most accurate measuring device available at The University of Sydney. Spot measurements taken in the CFD simulation are an average value over the computational element and therefore are also not a precise spot measurement, however the averaging area is much smaller (dependent on mesh size). Discrepancies in the averaging area may lead to small errors.
- Measurements in the wind tunnel were taken by hand using the hot wire on a stand. It is therefore possible that differences in the measurement heights and positions have lead to results that are not characteristic of the flow at a single height. At a 1:50 scale, a 1 mm change in height is equivalent to 50 mm – a change which close to the coal face may yield quite different results in velocity and turbulence intensity due to boundary layer effects caused by coal roughness.

Generally, there is good correlation between the trends in turbulence intensity values measured in the CFD and wind tunnel. However it can be seen that the magnitude of the values predicted in the CFD are significantly lower than those measured in the wind tunnel:

- It can be seen that the inlet turbulence intensity (measured at location 1) correlate well. After location 1, the magnitude of the turbulence intensity measured in the CFD simulation drops off significantly. This is because the CFD model allows the input of ground velocity. As the ground is moving at the same velocity as the air in the CFD model, there is no turbulence being generated by the ground. This means that turbulence will be dissipated over the domain length, leading to lower levels of turbulence intensity. The ground of the wind tunnel was stationary, and hence frictional losses lead to the generation of a turbulent wind profile. The generation of the turbulent wind profile over a non-moving ground can be seen in Figure 10.
- Simulation of a moving train was not able to be conducted at The University of Sydney, as the wind tunnel does not have the functionality of a moving ground. The simulation conducted in the wind tunnel represents a still train with an 80 km/hr wind blowing over it. While this gives an accurate representation of the velocity profile of the flow around the train, the turbulence is inaccurately modelled due to the wind profile.
- Simulation conducted in CFD allows more accurate turbulence predictions than the wind tunnel since the movement of the train with respect to the ground can be simulated. The simulation conducted in CFD represents the train moving at 80km/hr with respect to the ground into still air, therefore a wind profile is not generated (hence the losses in turbulence intensity)

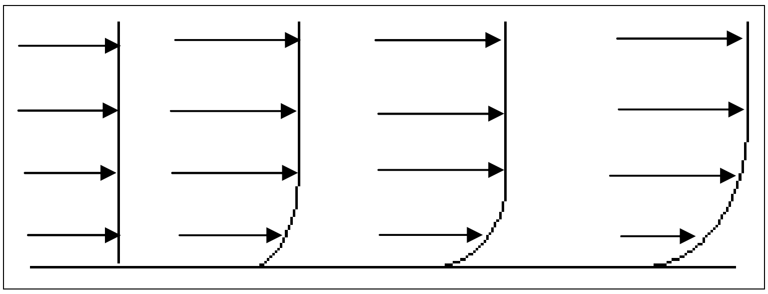


Figure 10 Generation of Wind Profile in Wind Tunnel

6. CFD Results

PHOENICS has the ability to provide a large amount of information regarding the properties of the flow. The velocity, pressure and kinetic energy of the flow are typical examples of information that can be output.

For this study, the variables that are presented are velocity and turbulence intensity. Presenting these variables allows direct comparison with results achieved in wind tunnel testing. It is proposed that analysing these variables will provide an indication of the likelihood of coal erosion (thought to be predominantly dependent on the velocity of the air directly above the coal and the level of turbulence in the flow).

The train is assumed to be travelling into still air at a speed of 80 km/hr over Terrain Category 2 (open grassland with well–scattered obstructions. A wind profile has not been used, however a ground roughness of 0.02 m (equivalent to TC2) and 5% turbulence intensity has been included.

The CFD analysis allows the addition of ground velocity to be included in the simulation. In all cases, the ground has a velocity equal to the velocity of the train (80 km/hr). For this reason, it is expected that the CFD results will provide results more representative of real life than the wind tunnel results.

6.1 Velocity Contours

The velocity data was obtained directly from the program output. The following contour plots graphically represent the magnitute of the velocity for each case analysed.

6.1.1 No Cross Wind Case

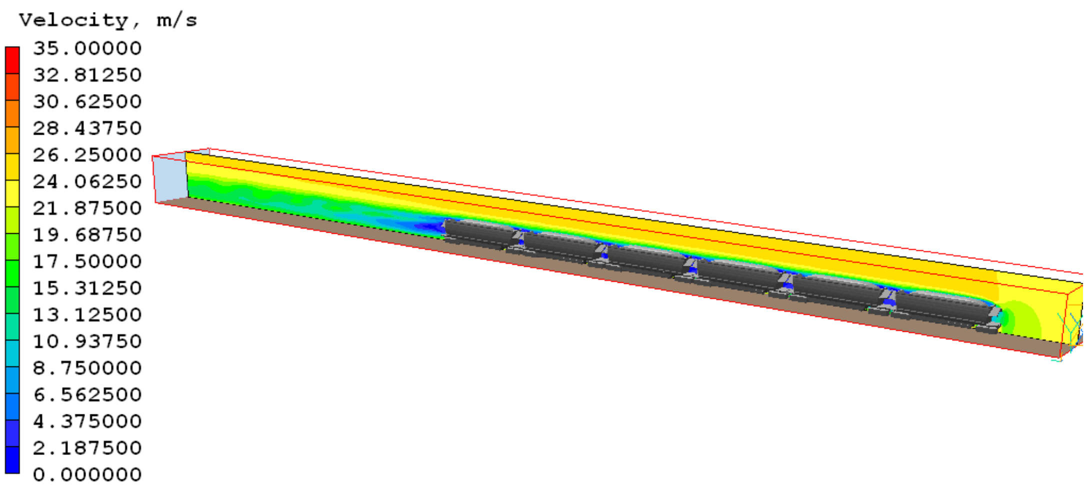


Figure 6.1.1a Model 1 – Unmodified wagon and single mound coal configuration velocity contour isometric

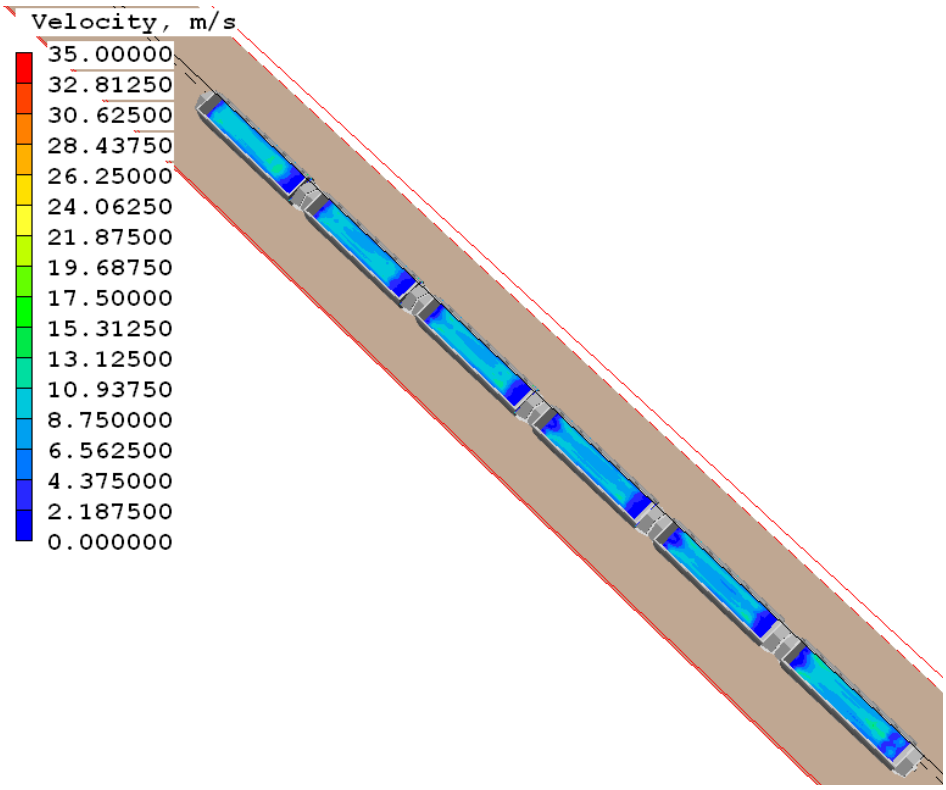


Figure 6.1.1b Model 1 – Unmodified wagon and single mound coal configuration contour coal surface velocity

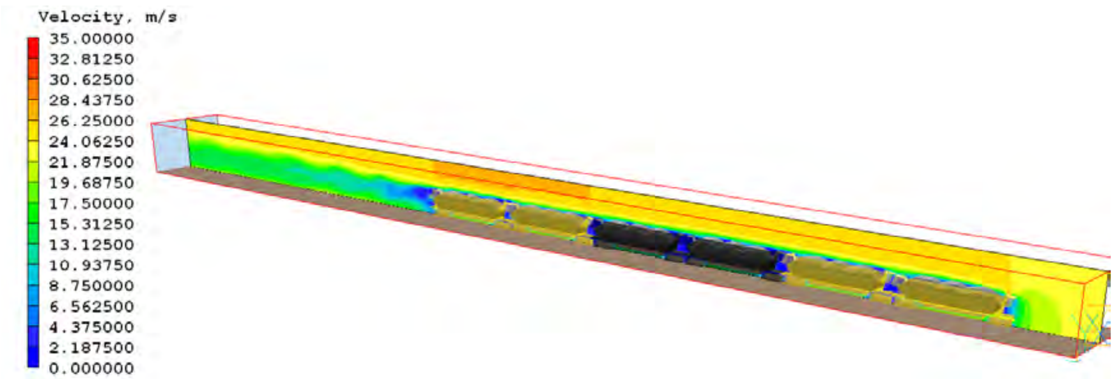


Figure 6.1.1c Model 2 – Unmodified wagon and three mound coal configuration velocity contour isometric

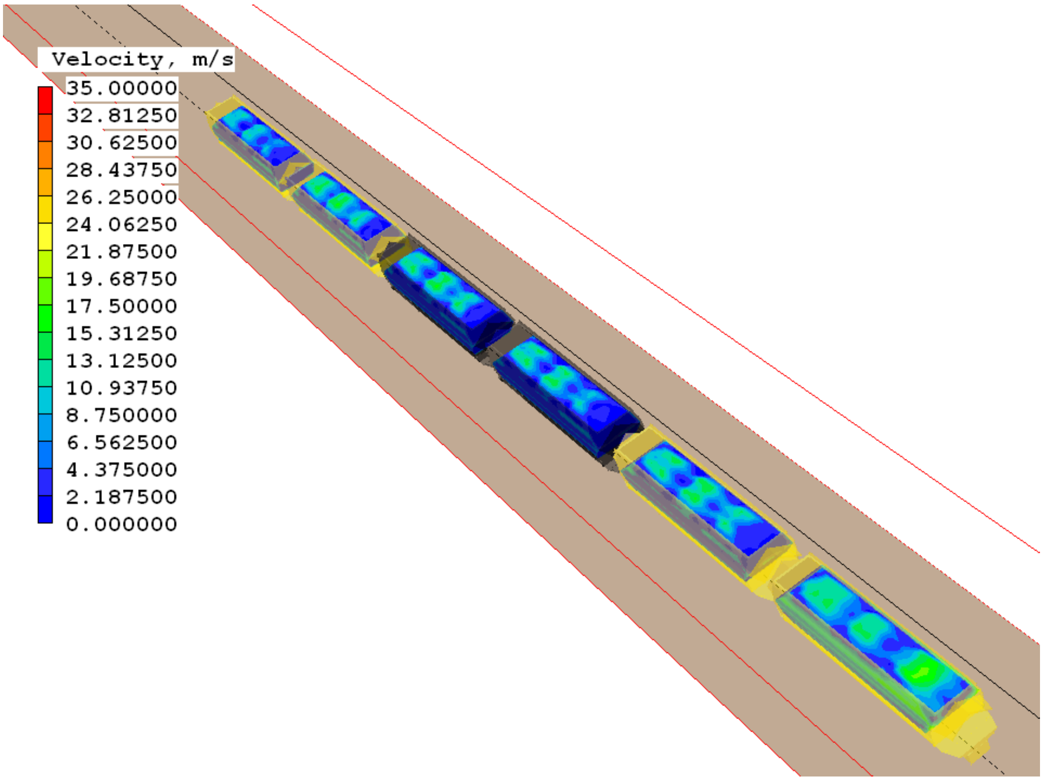


Figure 6.1.1d Model 2 – Unmodified wagon and three mound coal configuration velocity contour coal surface velocity

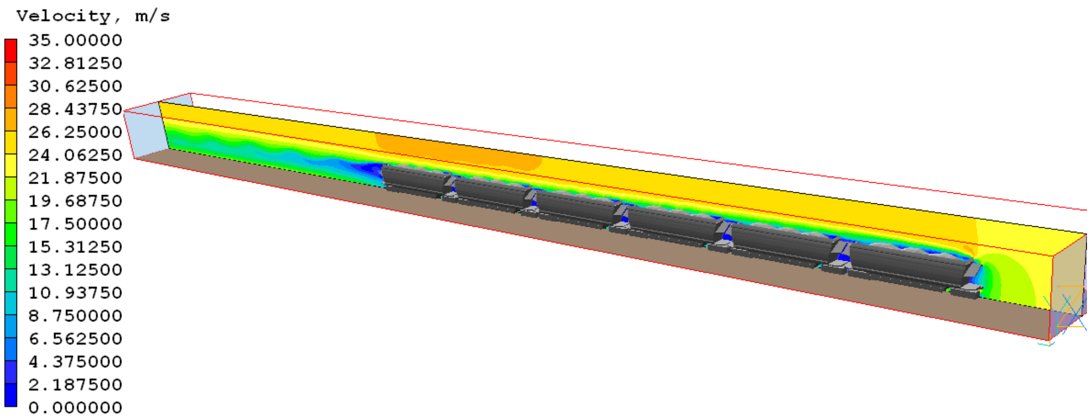


Figure 6.1.1e Model 3 – Wagon with 300 mm hungry board and three mound coal configuration velocity contour isometric

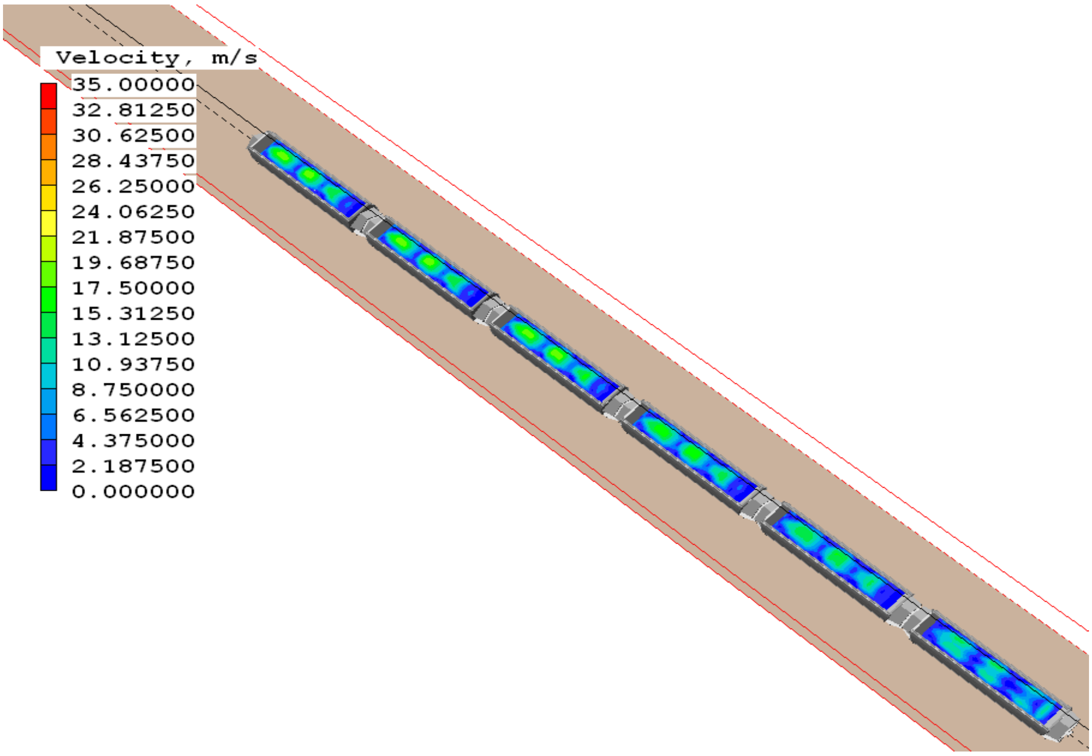


Figure 6.1.1f Model 3 – Wagon with 300 mm hungry board and three mound coal configuration velocity contour coal surface velocity

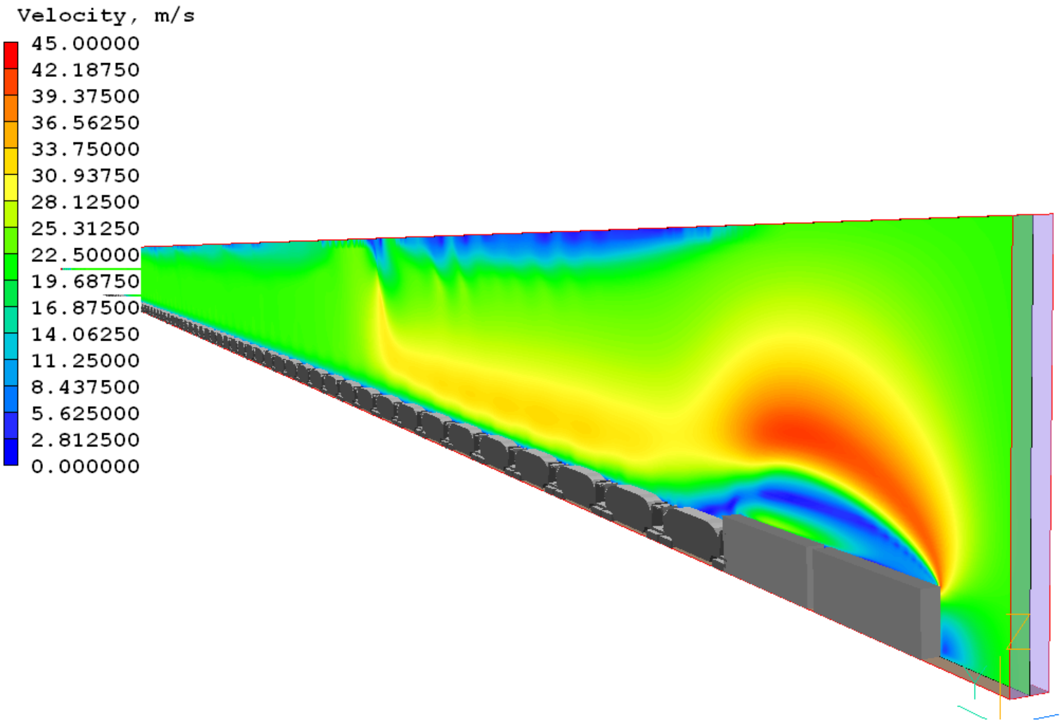


Figure 6.1.1g Model 4 – Unmodified wagon and single mound coal configuration velocity contour isometric with addition of locomotive

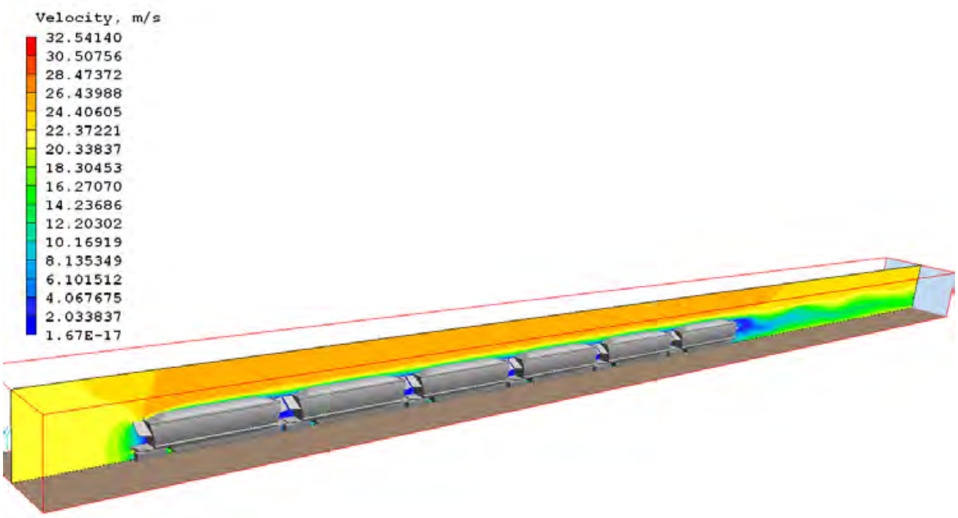


Figure 6.1.1h Model 6 – Unmodified wagon and Tee Pee Load mound coal configuration velocity contour isometric

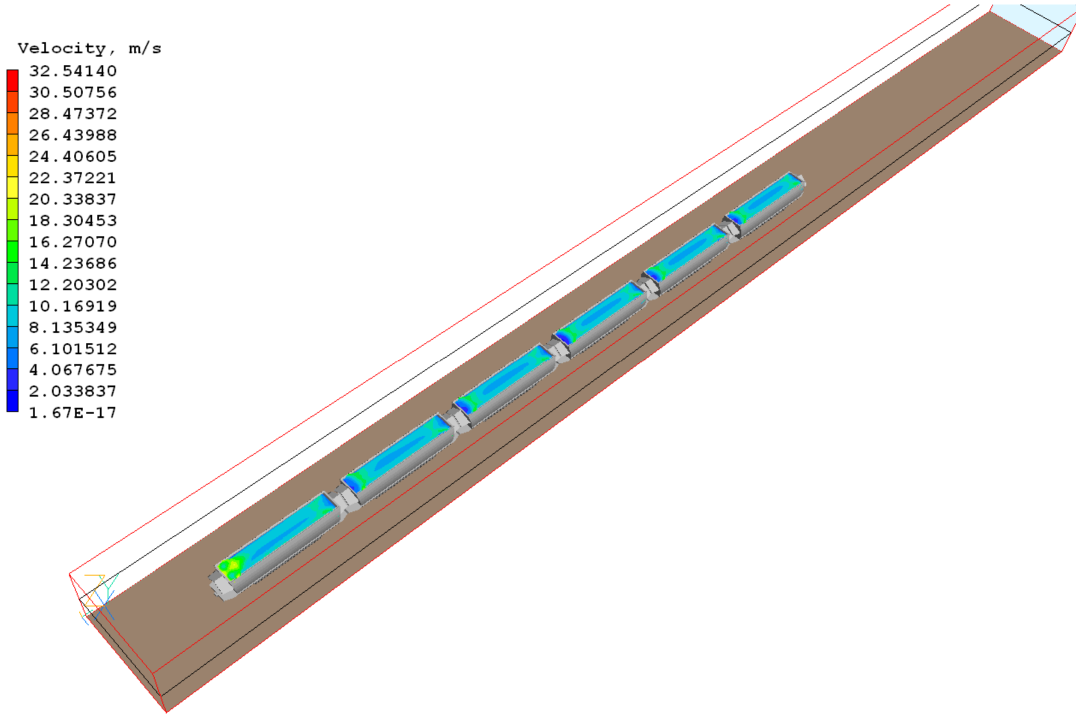


Figure 6.1.1i Model 6 – Unmodified Wagon and Tee Pee Load coal configuration velocity contour coal surface velocity

6.1.2 Cross Wind Case

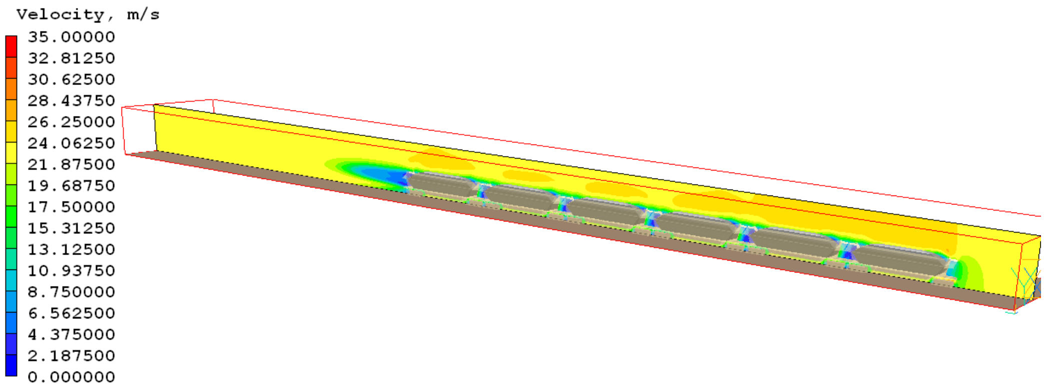


Figure 6.1.2a Model 1 – Unmodified wagon and single mound coal configuration velocity contour isometric

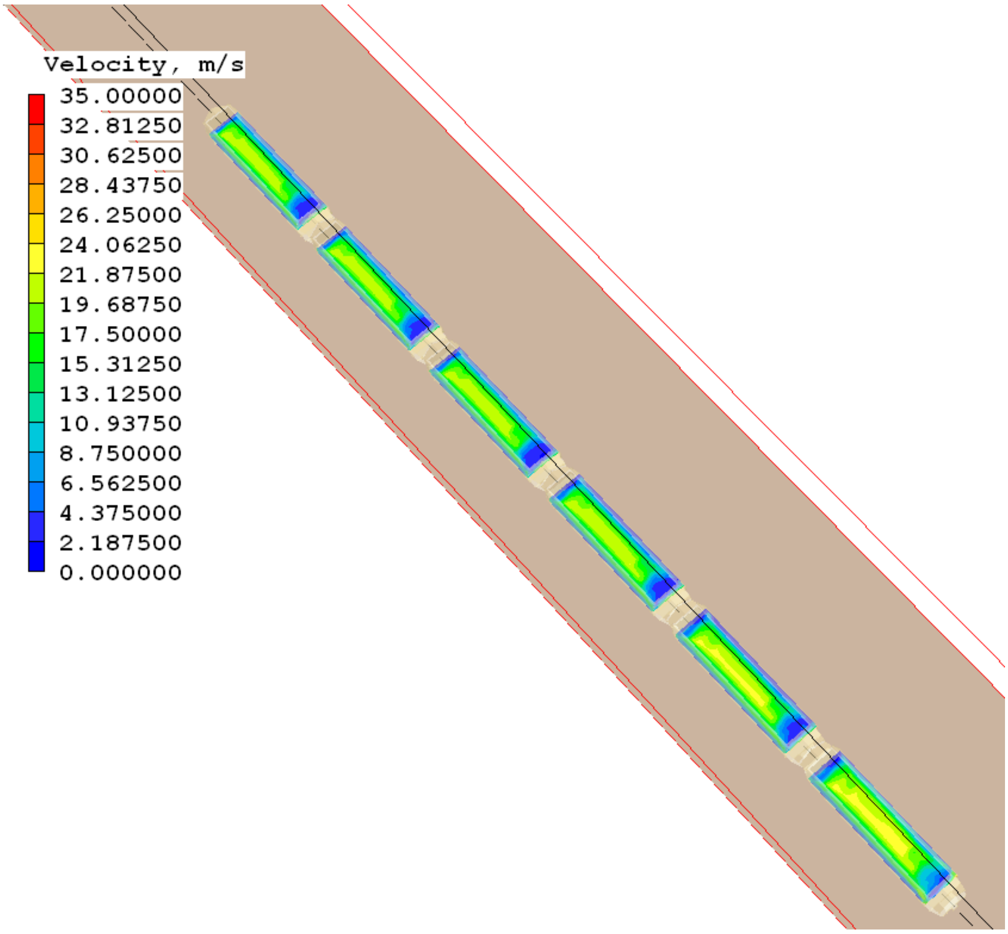


Figure 6.1.2b Model 1 – Unmodified wagon and single mound coal configuration contour coal surface velocity

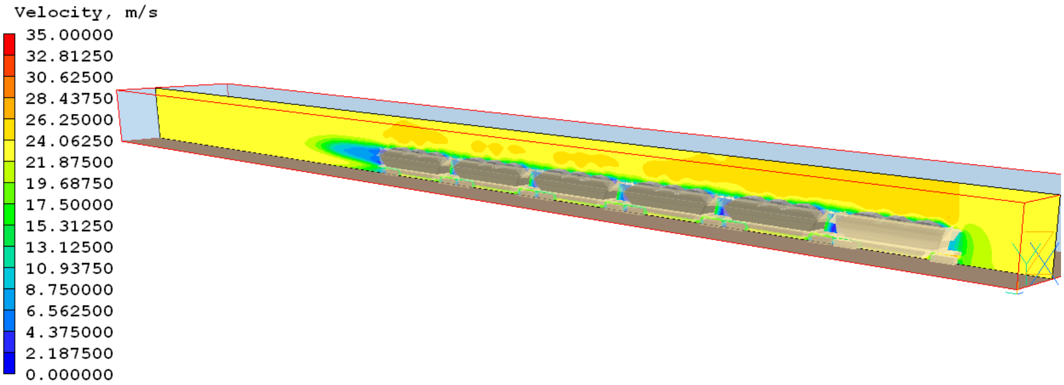


Figure 6.1.2c Model 2 – Unmodified wagon and three mound coal configuration velocity contour isometric

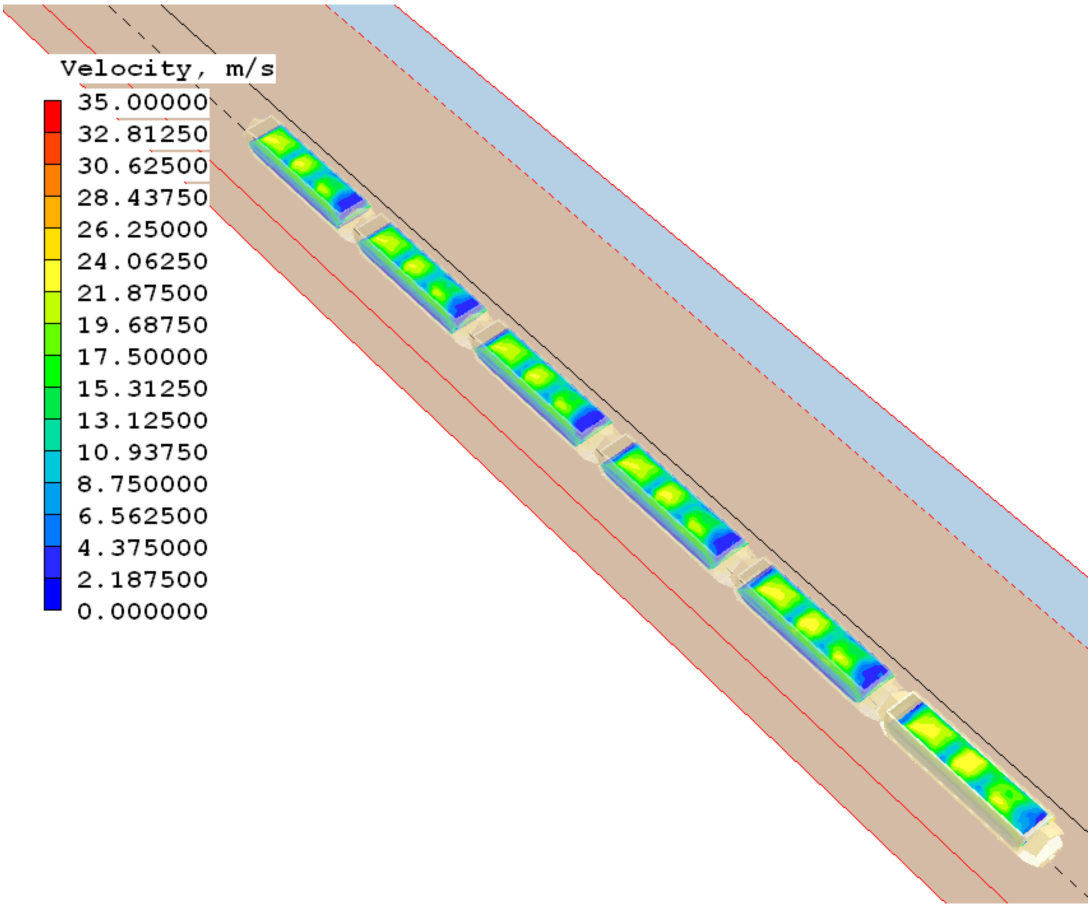


Figure 6.1.2d Model 2 – Unmodified wagon and three mound coal configuration velocity contour coal surface velocity

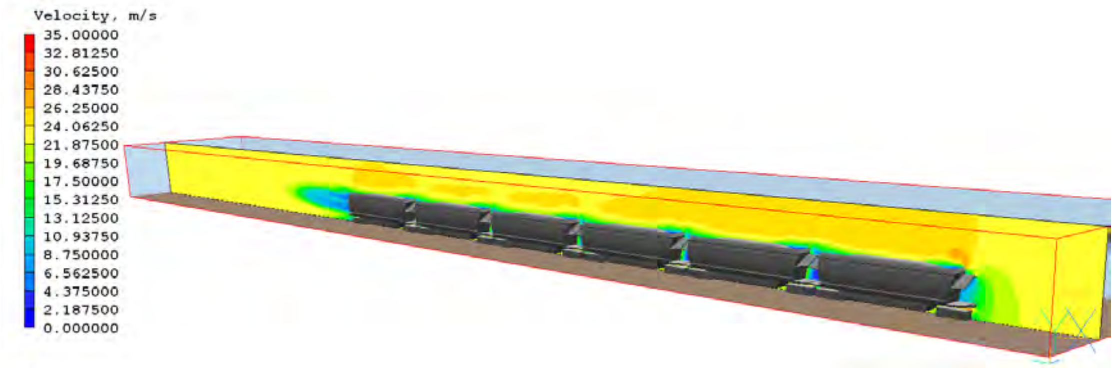


Figure 6.1.2e Model 3 – Wagon with 300 mm hungry baord and single mound coal configuration velocity contour isometric

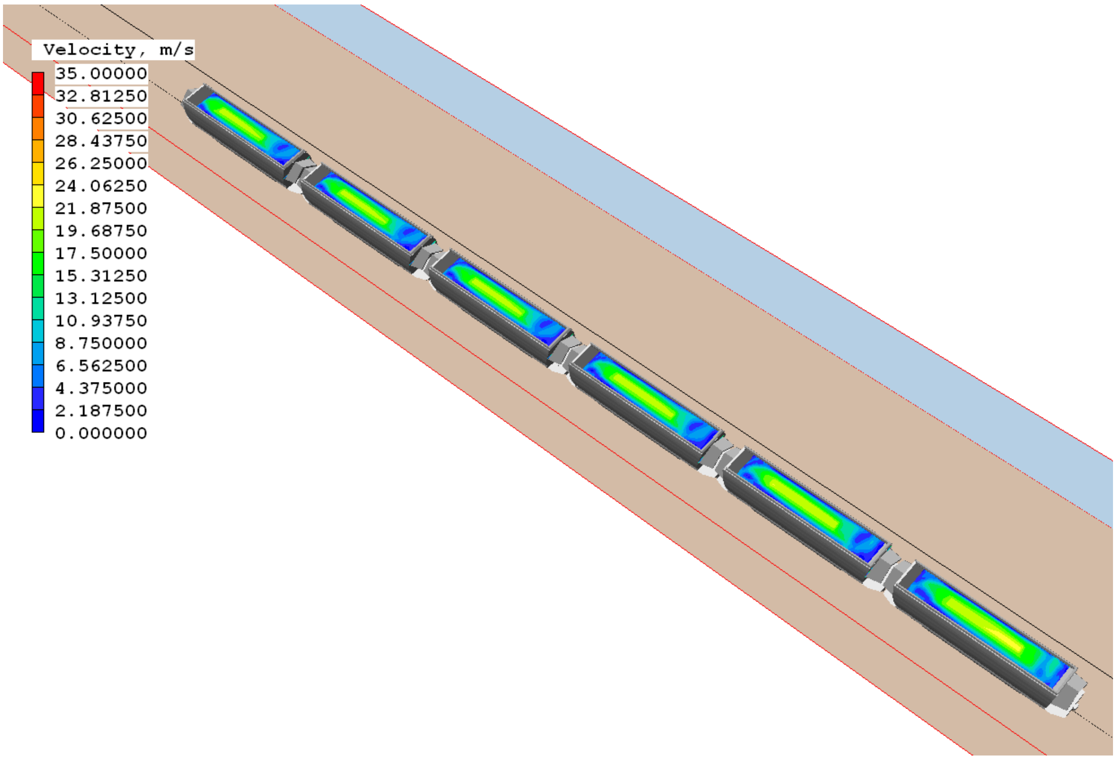


Figure 6.1.2f Model 3 – Wagon with 300 mm hungry baord and single mound coal configuration velocity contour coal surface velocity

6.2 Data Comparison Graphs

After the verification of the wind tunnel and CFD results, it was apparent that there were some height discrepancies in the wind tunnel results. This occurred due to the measurement probe being positioned slightly lower or higher in some locations. In order to accurately represent the wind tunnel velocity profile with the CFD results, the measurement heights at some locations needed to be raised or lowered in the CFD simulation. This change in height may have lead to trends in the velocity profiles which are not characteristic of the air flow at a single height. The results presented represent the velocity profiles of the train at a single height of 150 mm above the coal face in the centerline of the six wagons. Documenting results at a single height provides more accurate information on the air velocity profile.

The first and last wagons had five measurements locations; the middle four wagons each had three measurement locations. The first and last probe locations on each wagon were above the gutter between the carriage lip and the coal mound. The probe locations were equally spaced along the length of each particular carriage. The measurement locations can be seen in Figure 11. This measurement technique was used to correlate data with the measurements taken in the wind tunnel.

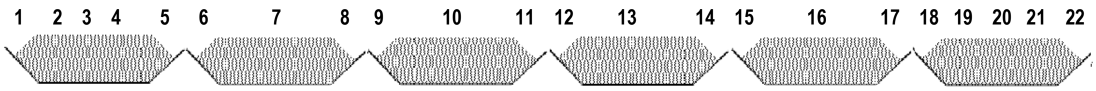


Figure 11 Velocity probe locations

Turbulence intensity has been used to assess the amount of turbulence that is present in the flow at any particular measurement position.

PHOENICS can not directly output turbulence intensity, therefore, unlike the velocity data that was directly obtained from the program output, the turbulence intensity was calculated by post processing the velocity and the kinetic energy results using the following relationship at each of the measurement points:

$$\text{Turbulence Intensity} = \frac{\sqrt{\text{Total Kinetic Energy}}}{\text{Mean Velocity}}$$

Turbulence intensity can alternatively be calculated by taking the ratio of the variance in a velocity measurement and the mean velocity at a point. Variance in the velocity at a point is not able to be calculated in the CFD program, and therefore the Total Kinetic Energy method was used.

With reference to the graphs below, the first train carriage (first five data points) is subject to direct oncoming air. In practice, this would not be the case, as there will always be another carriage, or locomotive in front. In the case of the carriages located directly behind the locomotive, they will be subject to lower velocities across the coal surface not typical the other carriages (refer to figure 4.1.1g) due to the wake generated by the locomotive.

6.2.1 No Cross Wind Case

1. Single Mound Coal Configuration – Comparison with and without hungry boards

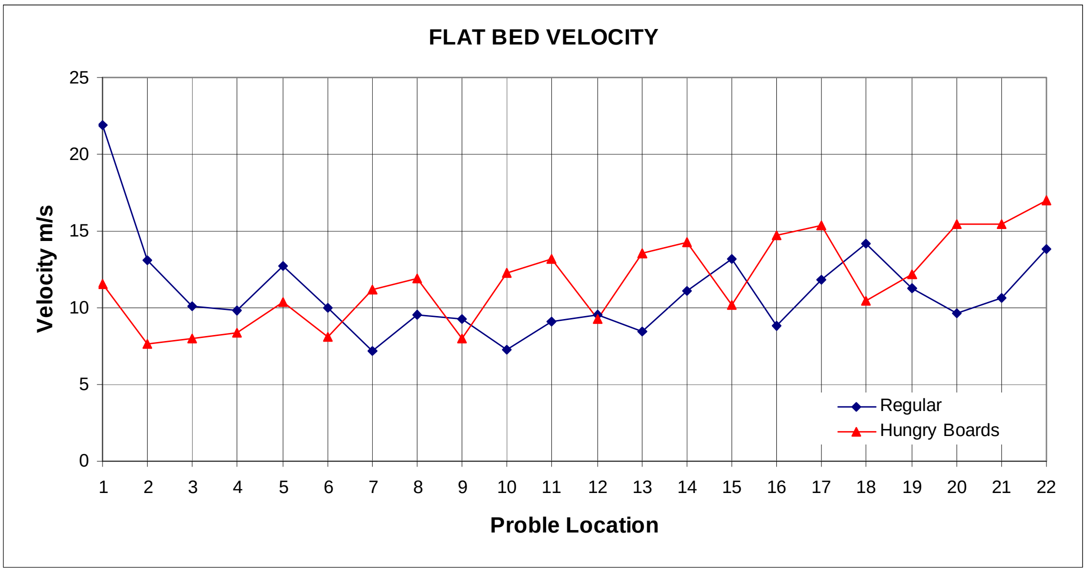


Figure 6.2.1a Velocity profile – single mound case

Refering to figure 6.2.1a, it can be seen that the common trend for each train without hungry boards is to have the highest velocity at the front of each train carraige. When the 300 mm hungry boards are introduced, this measurement point now reads the lowest velocity. This is expected, as the hungry boards would divert air around this point. The data set for the case with the hungry boards does however exhibit a higher average velocity over the coal face, with the greatest variance in velocity compared with the case without hungry boards in the middle measurement location. In both cases, with and without hungry boards, there is a general trend of increasing velocity towards the back of the train.

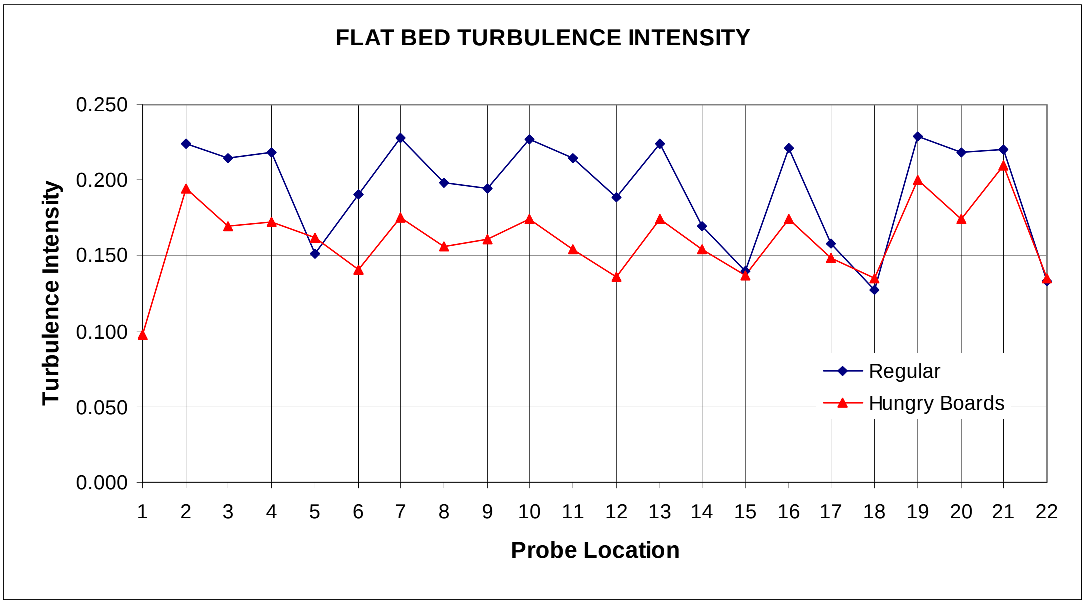


Figure 6.2.1b Turbulence intensity profile – single mound case

Refering to figure 6.2.1b, it can be seen that the common trend for each wagon without hungry boards is to have the highest turbulence intensity at the front of each wagon. This first measurement location exhibits the highest value for each individual wagon, with a decrease in turbulence intensity down each train carriage the common trend. When the 300 mm hungry boards are introduced, this front measurement point on each wagon now exhibits the lowest turbulence intensity.

2. Three Mound Coal Configuration – Comparison with and without hungry boards

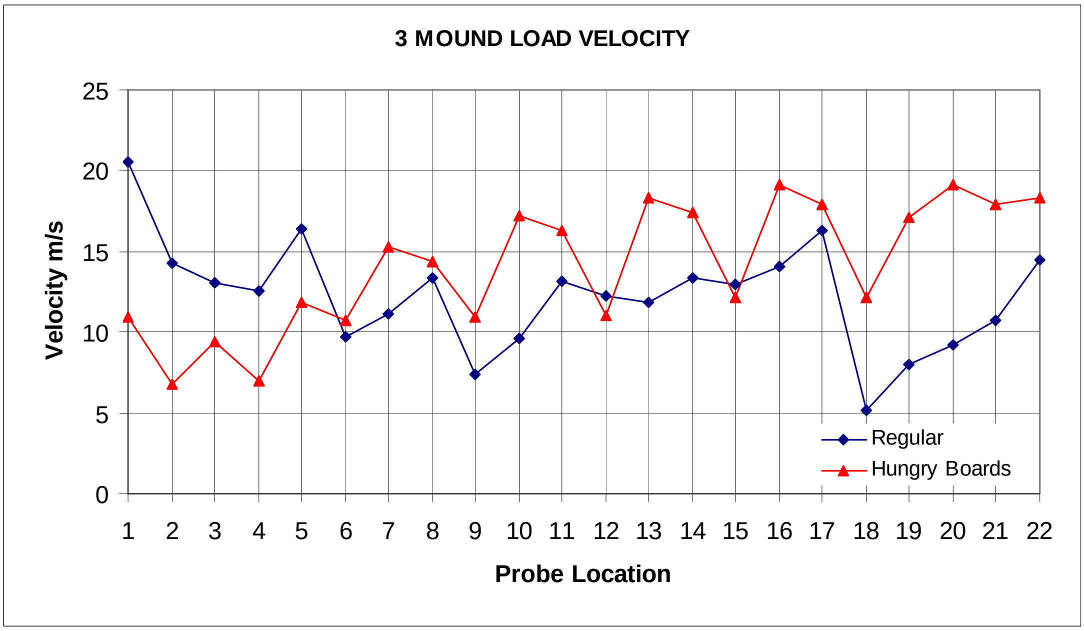


Figure 6.2.1c Velocity profile – 3 mound case

Refering to figure 6.2.1c, it can be seen that the common trend for each wagon without hungry boards is to have the lowest velocity at the front of each wagon. This first measurement location exhibits the lowest value for each individual wagon, with an increase in velocity down each wagon the common trend. When the 300 mm hungry boards are introduced, the maximum velocity for each wagon can be seen in the middle measurement point.

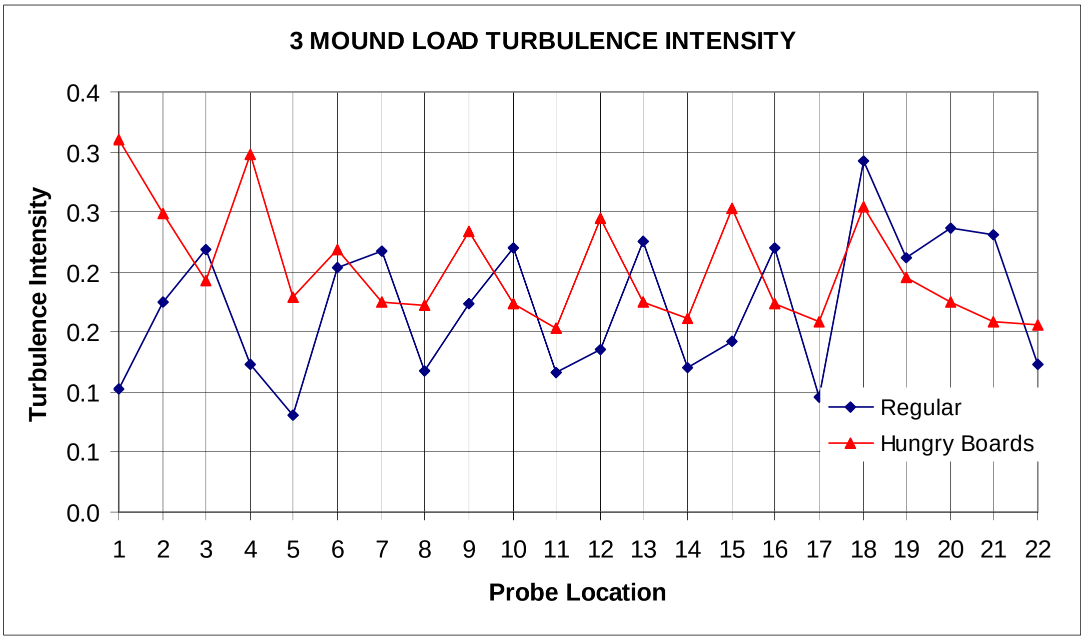


Figure 6.2.1d Turbulence intensity profile – 3 mound case

Refering to figure 6.2.1d, it can be seen that the common trend for each wagon without hungry boards is to have the lowest turbulence intensity at the back of each wagon. In this case, the peak turbulence intensity for each wagon can be seen in the middle measurement point. When the 300 mm hungry boards are introduced, the higest value of turbulence intensity can be seen at the front of each wagon with a general trend of decreasing turbulence intensisty towards the back of each wagon.

3. Tee Pee Load Coal Configuration – Comparison with base case

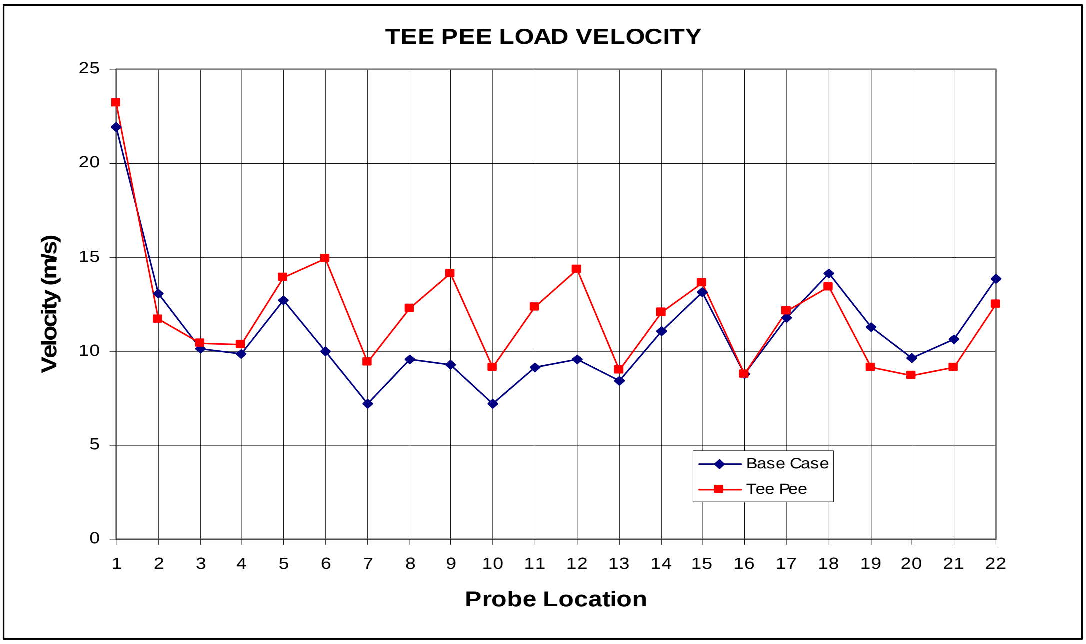


Figure 6.2.1e Velocity profile – Tee Pee Load case

Figure 6.2.1e shows similar trends between the base case and the tee pee loading case, however it can be seen that there are some regions of higher velocities, particularly across the middle three wagons.

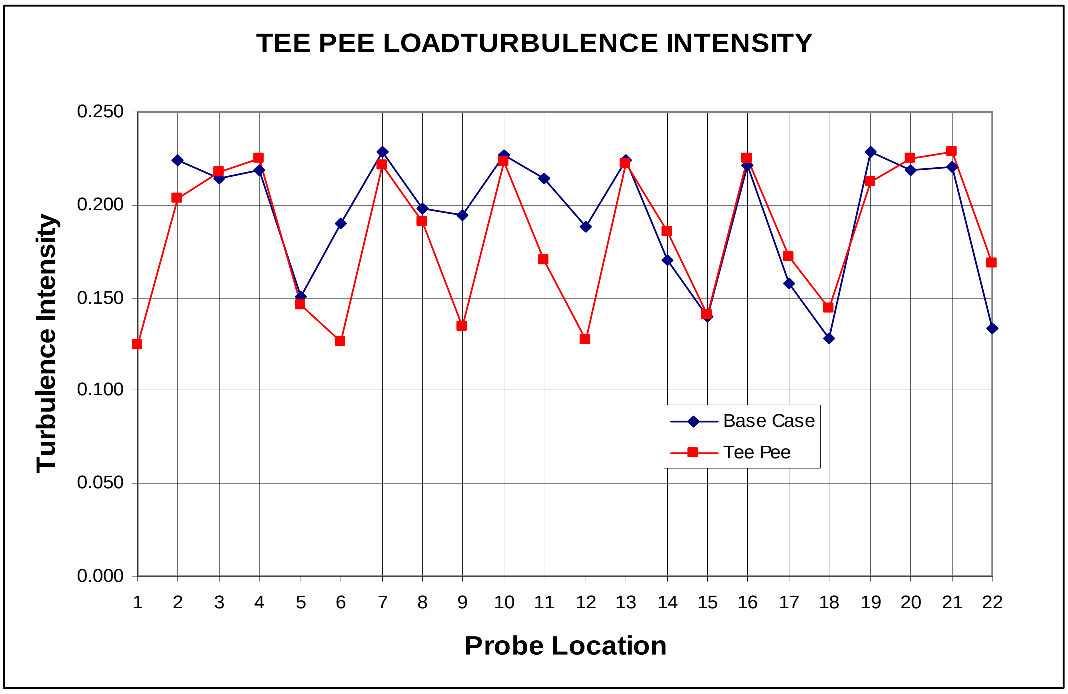


Figure 4.2.1f Turbulence Intensity profile – Tee Pee Load case

The Tee Pee loading case shows slightly higher velocities across the coal face, and slightly lower turbulence intensities at the front of each wagon. Less turbulence is generated because the gutter, (the sharp edge at the front of the wagon) has been filled with coal leading to an overall smoother profile.

6.2.2 Cross Wind Case

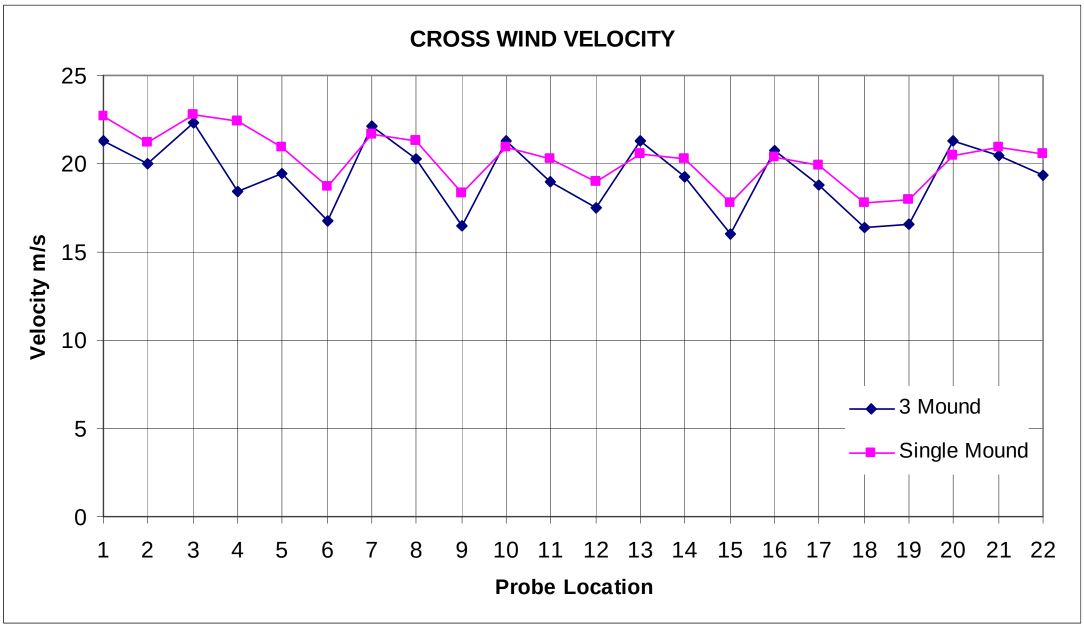


Figure 6.2.2a Velocity profile – cross wind case

Figure 4.2.2a shows very similar trends for the velocity profile in both the single and three mound cases. The single mound case however, exhibits a slightly higher average velocity over each wagon, but the three mound case as a slightly higher peak.

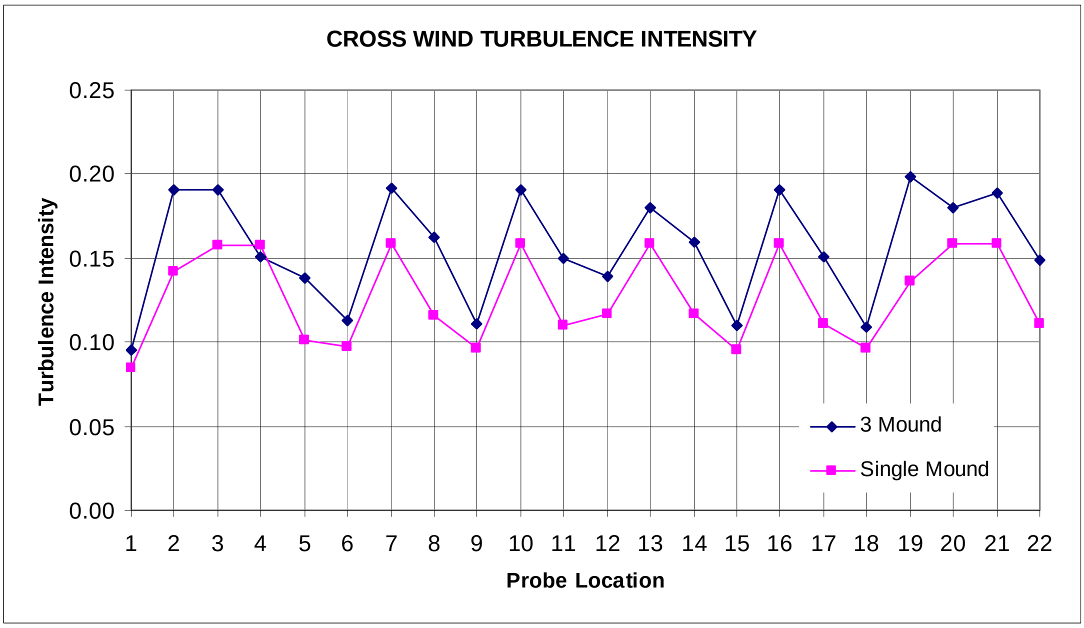


Figure 6.2.2b Turbulence intensity profile – cross wind case

Figure 4.2.2b shows very similar trends for the turbulence intensity profile in both the single and three mound cases. The three mound case however, exhibits much higher turbulence intensity values along the length of each wagon with the exception of the first measurement point on each wagon.

6.3 Velocity and Turbulence Intensity Profiles

Figure 12 shows the velocity profile generated above the coal face due to the roughness of the coal for a flat coal profile and straight wind direction case. Measurements were taken at the centre location of each of the six wagons. It can be seen that there is little difference in the profiles for the six different wagons. The resolution of the mesh in the CFD model restricts the accuracy of the measurements closer to the coal face, however it can be seen that there is a characteristic wind profile generated buy the coal roughness (assumed to be 2 mm particle size). The CFD model assumes a conservation of mass flow rate through the domain, therefore due to the reduction of velocity closer to the coal face, a higher velocity is recorded further from the coal than the assumed free stream velocity (22.22 m/s). The velocity profiles can also be seen in Figure 13.

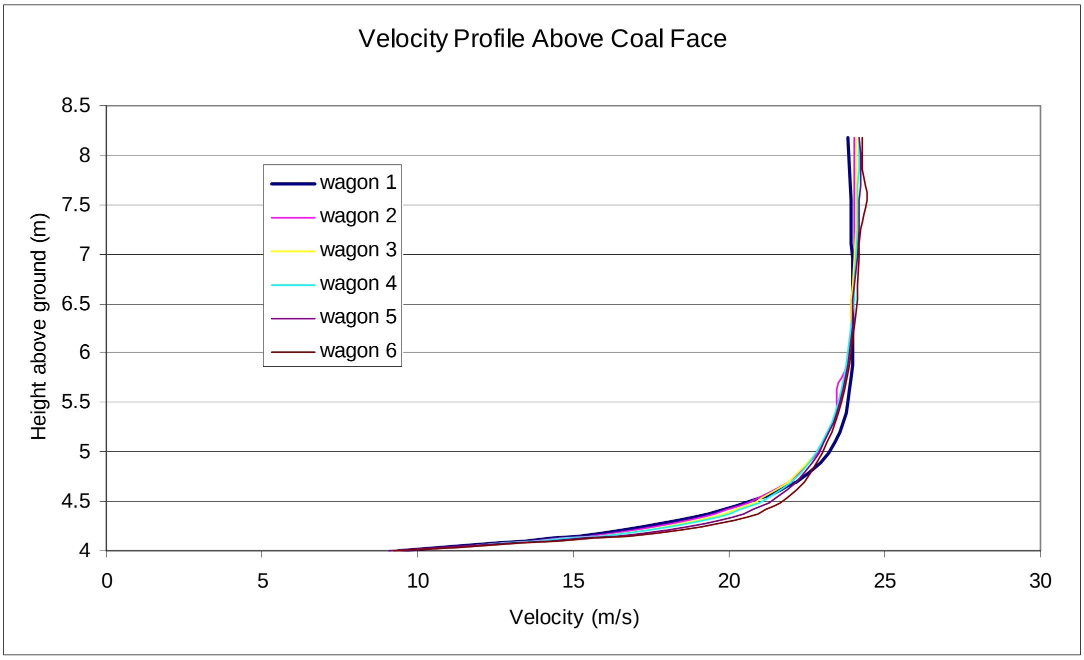


Figure 12 Velocity Profiles

Considering that there is very little difference between the velocity profiles across the 6 wagons, it appears unlikely that there would be a case where there is a higher amount of coal loss from the rear wagons assuming that the erosion is dependant on velocity alone.

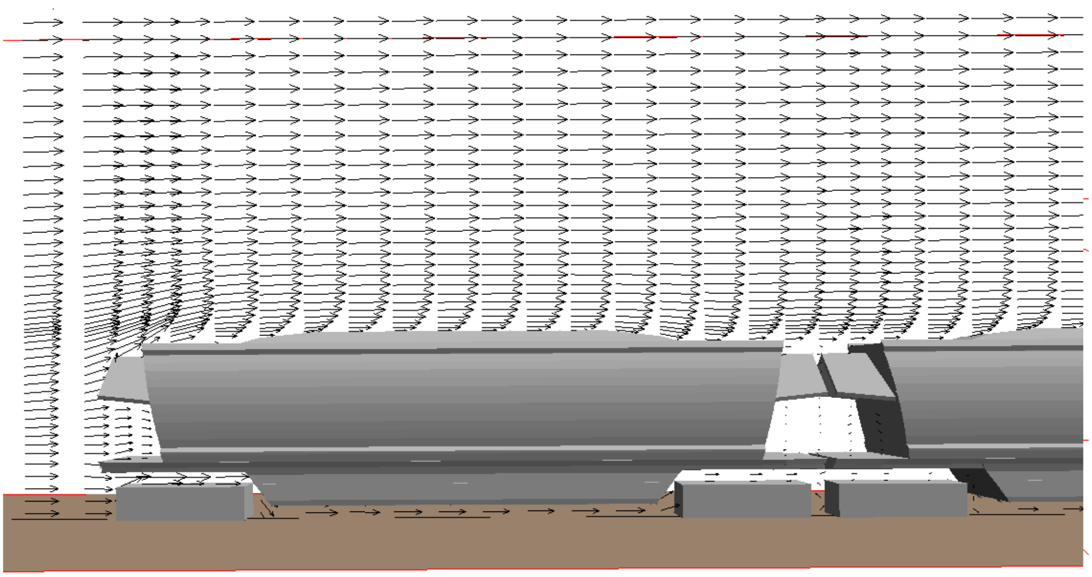


Figure 13 Wind Profile

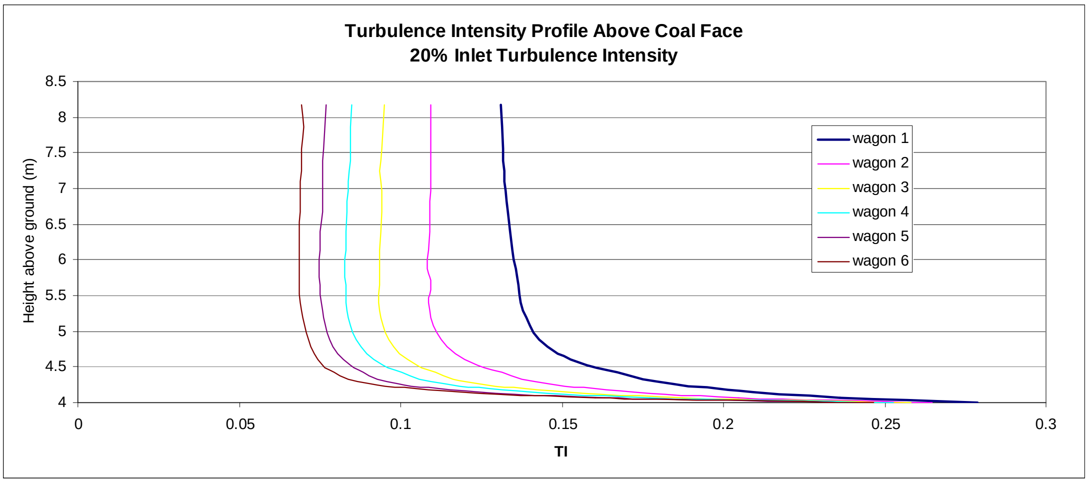


Figure 14 Turbulence Intensity Profiles

It can be seen that the free stream turbulence intensity is decreasing along the length of the train. This is to be expected in the CFD model, without the generation of turbulence from the ground roughness (since the ground is moving). It is expected that a higher level of turbulence intensity would lead to higher amounts of coal erosion, therefore it appears that there is no reason to expect higher amounts of erosion on later wagons. Turbulence intensity levels close to the coal face are comparable for all wagons.

7. Discussion

In relation to the CFD analysis that has been undertaken, it is apparent that while the 300 mm hungry boards create a localized lower velocity immediately behind them, they create a region of higher velocity for the remainder of the wagon. However, preliminary results have indicated that increasing the size of the hungry boards will serve in extending the length of the localized low velocity behind the hungry boards. It is understood that there are practical limits to the size that these boards can be made before other factors start arising, such as increased aerodynamic drag of the train and obstruction of the coal loading process.

It appears that the addition of hungry boards to the wagons generally reduces the turbulence intensity recorded across the coal face in the no cross wind case. Study into the effects of coal erosion with respect to turbulence intensity has not been completed; however it is assumed that decreased velocity and turbulence intensity will lead to reduced coal erosion rates.

In general, the three mound cases exhibit slightly higher velocities and turbulence intensities in all comparable scenarios to the single mound (garden bed) loading configuration. The additional geometrical effects of the "lumpy" loading case create a scenario where the air has more resistance passing over the coal face, leading to turbulence, recirculation and reduced velocity.

The effect of the boundary layer was significant and lead to greatly reduced velocities and increased turbulence intensities close to the coal surface. Surface roughness of the coal reduced the velocity to less than half of the free stream velocity close to the coal face. The velocity profiles generated for the six wagons are extremely similar, indicating that there is unlikely to be higher losses from the rear wagons. Turbulence intensity profiles also indicate that higher rates of erosion at rear wagons are unlikely.

Appendix A

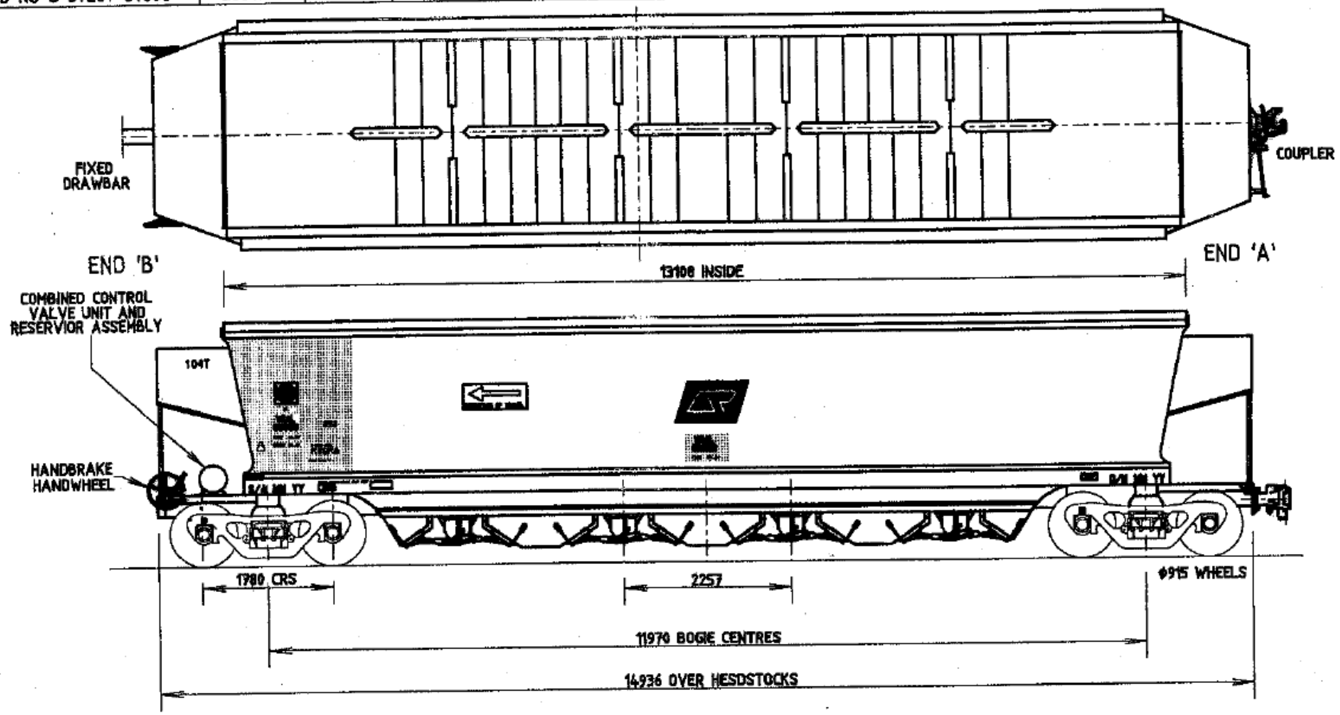
Coal Wagon Geometry

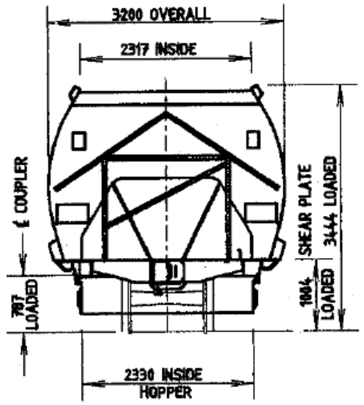
	YEAR BUILT	SPEC	MRE REF	DRG LIST	ARRGT DRG	BOGIES
ODD No's 49001-49499	1998/9/0	MRE 9711	6000/160	MRE137	AO-28989	QR 56
ODD No's 49501-50199	1998/9/0	MRE 9711	6000/158	MRE138	AO-31640	QR 56
ODD No's 50201-50549	1998/9/0	MRE 9711	6000/159	MRE138	AO-31640	QR 56
ODD No's 50551-50919	1998/9/0	MRE 9711	6000/161	MRE138	AO-31640	QR 56
ODD No's 50921-51019	2000/01	MRE 9711	6000/160	MRE137	AO-28989	QR 56
ODD No's 51021-51279	2002/03	ES0129	W 50167	MRE209	AO-36497	QR 56
ODD No's 51281-51539	2001/02	ES0133	W 50169	MRE211	AO-33774	QR 56

KWIK DROP DOORS FITTED
CONTINUOUS LOAD SENSING CHANGE OVER VALVE FITTED
SCR12 STEEL BODY WITH STEEL UNDERFRAME END UNITS

UNCONTROLLED WHEN PRINTED

NOMINAL TARE	20.4 t
MAX. CARRYING CAPACITY	85.6 t
MAX. GROSS CAPACITY	106.0 t
DRAFTGEAR TYPE	MINER TF880
DRAWGEAR CLASS	D1
LENGTH UNIT	15.9 m
MAINTENANCE CATEGORY	L1 & L3
CUBIC CAPACITY - WATER LEVEL	90.0 m3
C of G ABOVE RAIL (LOADED)	1995





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CURRENT REV	DRAWN / DATE	CHECKED / DATE	APPROVED / DATE
A	WJP 03-01-03	PS 3 JAN 03	RA 6-1-03

MRE W. THOMAS PER AEN

ROLLINGSTOCK ENGINEERING DIVISION

106t COAL WAGON CLASS VSAL

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DATE	18-12-98

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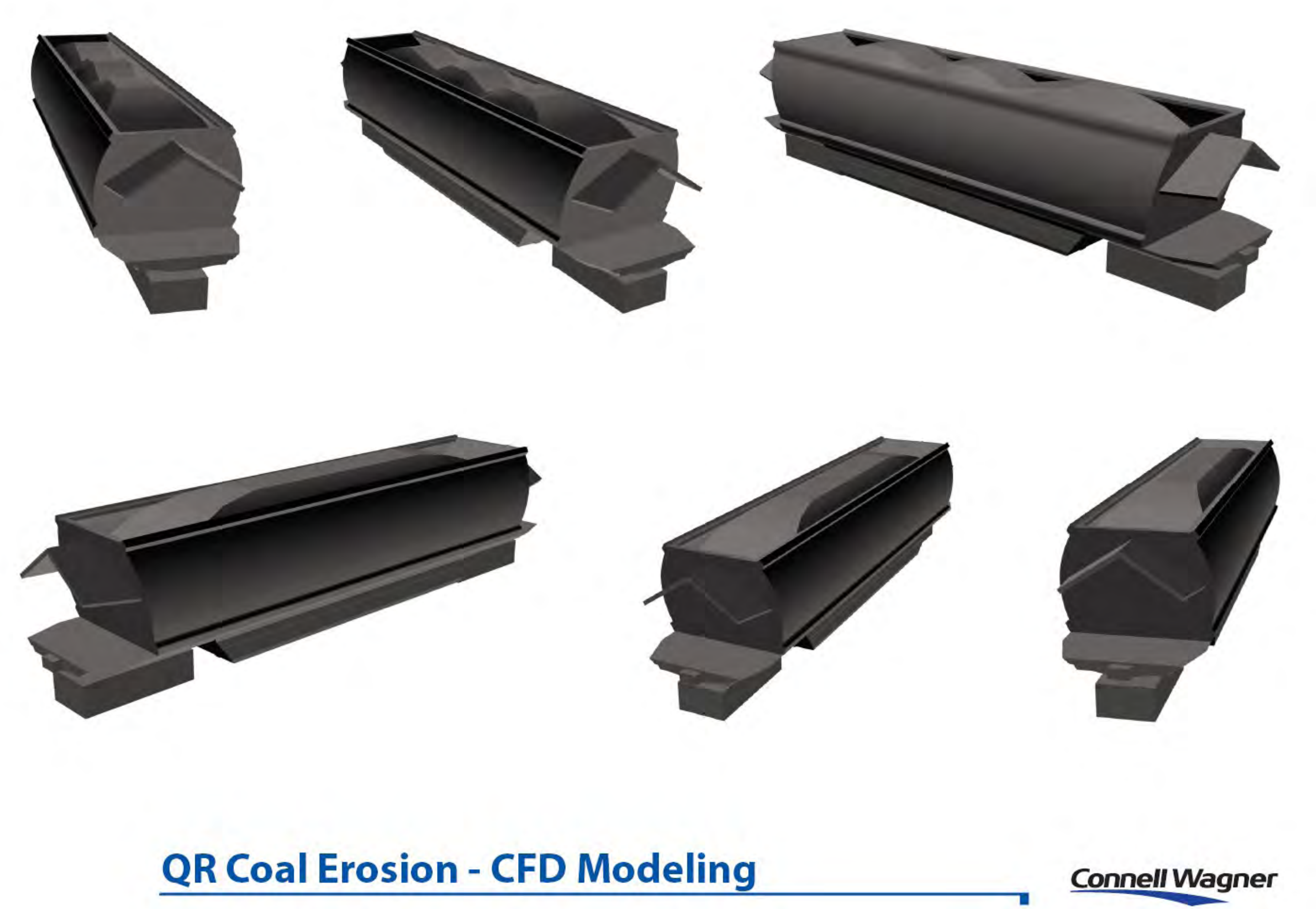
WAGON DIAGRAM P-526A


QR Coal Erosion - CFD Modeling

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Coal Erosion Wind Tunnel Testing
Queensland Rail Coal Erosion
Queensland Rail

15 February 2008
Reference H327578-N00
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Rev No	Date	Revision Details	Typist	Author	Verifier	Approver
0	20/11/07	DRAFT	HM	HM	NM	NM
1	15/02/08	ORIGINAL	HM	HM	NM	NM

Contents

1. Introduction

This report details the preliminary results from the wind tunnel testing conducted by Connell Wagner at the University of Sydney wind tunnel between 12 November and 15 November 2007

Connell Wagner was contracted by Queensland Rail to conduct a series of wind tunnel tests on scale models of coal wagons to determine the effect the train and coal geometry had on the flow patterns around the train and hence coal erosion rates.

Six wagons were modelled at a 1:50 scale, this scale was chosen as it allowed the effects of multiple wagons to be studied in the University of Sydney's wind tunnel.

Measurements were carried out using the atmospheric boundary layer wind tunnel at the University of Sydney. This tunnel has a cross-section of about 3 m, a turntable of diameter 2.4 m, and a development length of about 15 m. The turbulent boundary layer is established using a trip board, spires and roughness elements over a development length (or fetch).

The measured variable in the wind tunnel in this study is velocity, measured using a hot wire probe. From the variance in the velocity measurement, the turbulence intensity can be calculated which is an indication of the level of turbulence in the flow. It is proposed that the turbulence intensity and velocity be used as measures for the likelihood of coal erosion.

2. Scaling Laws

The fundamental concept is that the model of the structure and that of the wind should be at approximately the same scale.

- Geometric Scale : The **geometric scale was set as 1:50**, and affects the ratio of roughness length and integral scales of longitudinal turbulence:

$$L = \frac{(z_0)m}{(z_0)p} = \frac{(L_u)m}{(L_u)p} = 1:50$$

- Velocity Scale : The wind **tunnel reference mean velocity was chosen as about 13m/s** to maximise the sensitivity of the measurement instrumentation. The velocity scale for the simulation was (with a design wind speed of about 30m/s):

$$V = \frac{(Vref)m}{(Vref)p} = 0.5$$

The following scales are necessary to determine wind tunnel instrumentation sampling and frequency response characteristics:

- Time Scale: $T = L/V = t_m / t_p = 1:25$
- Frequency Scale : $F = 1/T = f_m / f_p = 25:1$

A **sampling rate of 1000Hz was used** for the following reasons:

- This rate corresponds to about 40Hz in full-scale, which will allow velocity fluctuations with frequencies up to about 20Hz (full-scale) to be determined without distortion or attenuation.

The sampling period of 10 seconds was used for the following reasons:

- It ensures measured maximum and minimum velocities provide representative estimates of peaks encountered during a full-scale interval of about 4 minutes, being the length of time takes for 100 carriages to pass.

AS1170.2 gives the following definitions for terrain categories:

Category 1 – Exposed open terrain with few or no obstructions and water surfaces at serviceability wind speeds
Category 2 – Water surfaces, open terrain, grassland with few, well–scattered obstructions having heights generally from 1.5 m to 10 m.
Category 3 – Terrain with numerous closely spaced obstructions 3 m to 5 m high such as areas of suburban housing
Category 4 – Terrain with numerous large, high (10 m to 30 m high) and closely spaced obstructions such as large city centres and well developed industrial complexes.

The Queensland Rail wagons have an approximate real height of 5 m when fully loaded. At a 1:50 scale, this relates to 0.1 m. The wind tunnel located at The University of Sydney is calibrated to 1:400 scale, leading to a discrepancy between the scale of the model and the wind tunnel. However, as illustrated in Figure 1, there is good correlation between Terrain Category 2 at 1:50 scale and Terrain Category 3 at 1:400 scale at the measurement height of 5 m.

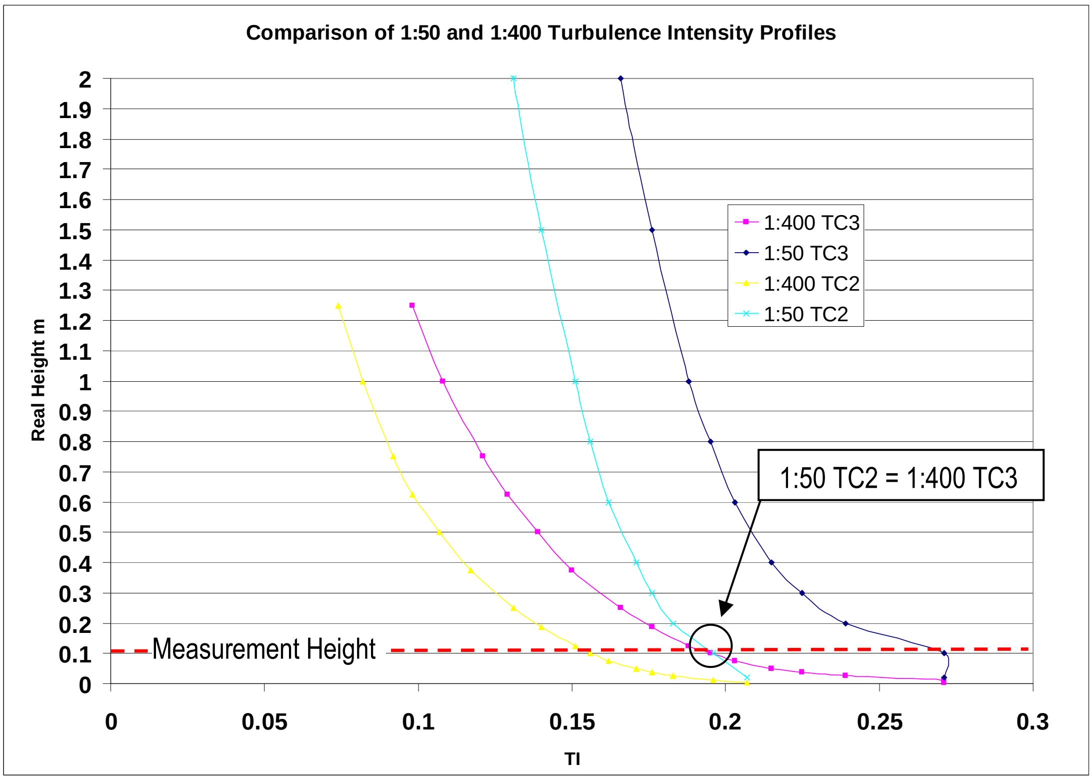


Figure 1 Comparison of Terrain Categories at 1:50 and 1:400

The measurements represent a still train with a wind profile blowing over it at the speed of the train. The wind tunnel does not have the functionality of a moving ground, therefore the measurements should be taken as a reference point for future work. Work conducted using computational fluid dynamics allows the modelling of a moving ground and may therefore in this case give a more accurate representation of real world vehicle dynamics. The simulations documented in this report will provide a comparison between different geometrical elements which may lead to different wind profiles being generated around the wagon.

3. Measurement Procedure

Several geometrical elements of the simulation could be modified; it was the intent of the tests to determine the effect each element had on the airflow around the train. The following geometrical effects were simulated:

3.1 Geometrical Simulations

3.1.1 Track Geometry

1) **Straight**: This simulates standard train operation on a flat, straight track
2) **Cutting**: This simulates a train travelling through a cutting 1.5 times the height of the train
3) **Raised**: This simulates the train travelling on a raised track 1.5 m high
4) **Curved Geometry**: This simulates the train travelling around a curved track. The agreed radius of curvature for this case was 500 m, which when scaled was not a feasible option to test in the wind tunnel

3.1.2 Fill Geometry

5) **Full**: Standard filling geometry, 450 mm above the line of the wagon, with a flat peak along the centreline of the wagon
6) **Uneven**: Uneven filling geometry as may be experienced when filling using non-standard techniques
7) **Empty**: Empty fill geometry as may be experienced when travelling with no load

3.1.3 Other

8) **Side by side**: This simulates two trains travelling side by side
9) **Locomotive**: Simulates the effect on the first four wagons behind two locomotives
10) **Roughness and turbulence**: simulates the effect of reducing surface roughness and turbulence of the surrounding environment (urban or rural environment)
11) **Cross wind**: This simulates a situation where there is a significant cross-wind component to the overall free stream wind velocity. The ratio of the cross to head wind was 1:2, ie a 40km/hr cross wind.
12) **Mitigation procedures**: This simulated the effect of the addition of "hungry boards" to the sides and front of the wagon

3.2 Procedure

For each geometrical simulation, the mean velocity profile, turbulence intensity and variance in velocity was measured at points along the train. Measurement of variance in the mean velocity is an indication of turbulence in the measurement position and allows the calculation of turbulence intensity (TI) (ratio of velocity variation (u') to mean velocity (U)).

$$TI = \frac{u'}{U}$$

A hot wire probe was positioned at each of 28 measurement positions along the train which allowed an overall mean velocity and turbulence profile for each simulation to be generated. Measurement points can be seen in Appendix A. The following nomenclature has been used where a number was not allocated:

F – Front
R – Rear
L – Low

The hot wire probe used a sampling frequency of 1000 Hz and took 10000 samples from which after passing through an anti-aliasing filter allowed mean velocity, variance in velocity and therefore turbulence intensity to be calculated.

Roughness effects of the coal have been omitted from this simulation, since the purpose was to simulate the overall geometrical effects of the coal train. Further investigation into localised effects on single wagons could include scaled roughness characteristics of the coal.

In order to test all simulations listed in Section 3.1the following testing schedule (Table 1) was carried out:

Table 1 Test Schedule

Test Number	Track Geometry	Fill Geometry	Other
1	Straight	Full	None
2	Cutting	Full	None
3	Straight	Full/Empty	Side-side
4	Straight	Empty	None
5	Straight	Uneven	None
6	Raised	Full	None
7	Straight	Full	Hungry Board
8	Straight	Full	Hungry Board + Locomotive
9	Straight	Full	Crosswind
10	Straight	Full	Rural

Smoke visualisation was used to observe the flow patterns across the train, but the turbulent flow across the wagons proved difficult to obtain observable streamlines. It did however give some insight into the turbulent region at the front of each wagon, and showed recirculation effects inside an empty wagon.

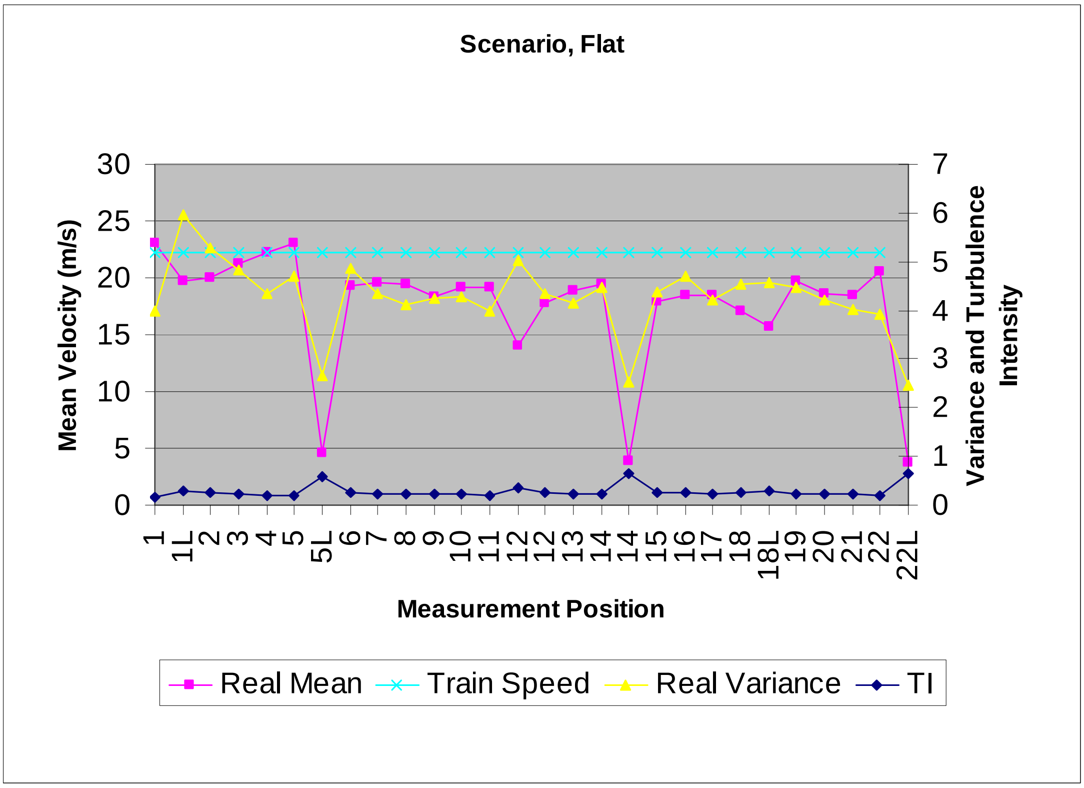
The use of a larger scale model may provide clearer results for localised turbulence effects using smoke visualisation.

4. Results

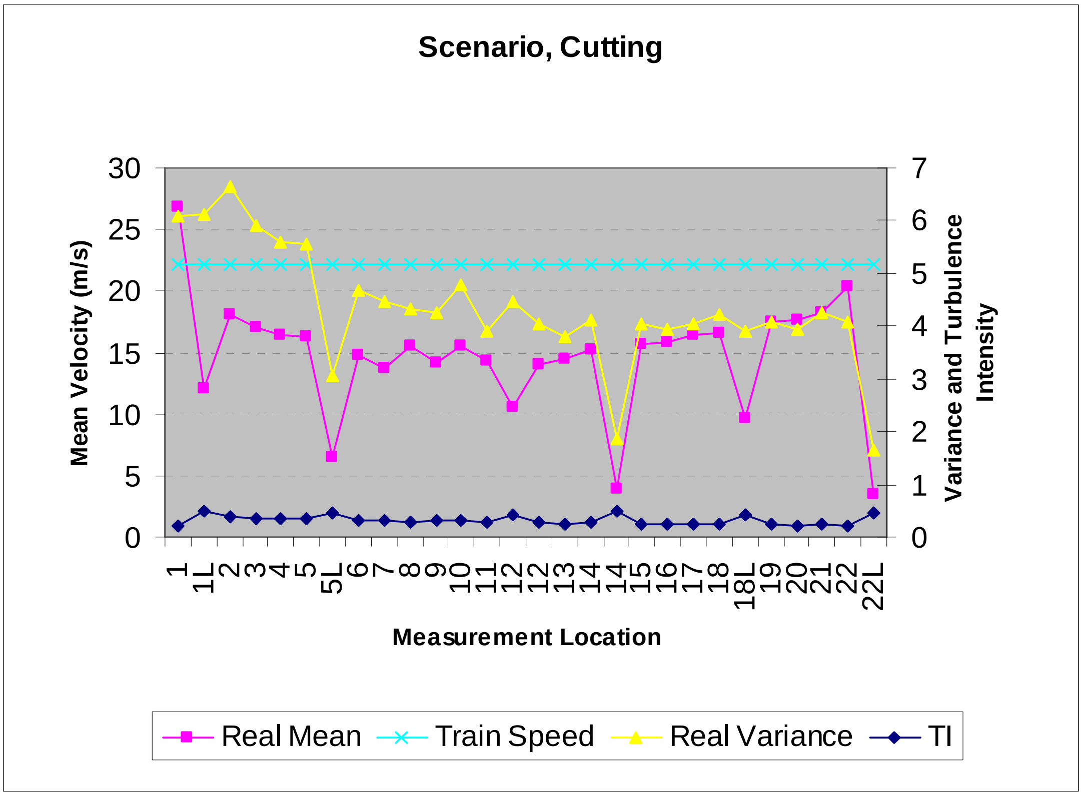
This section will detail the preliminary findings from each of the geometrical simulations.

4.1 Individual Train Results

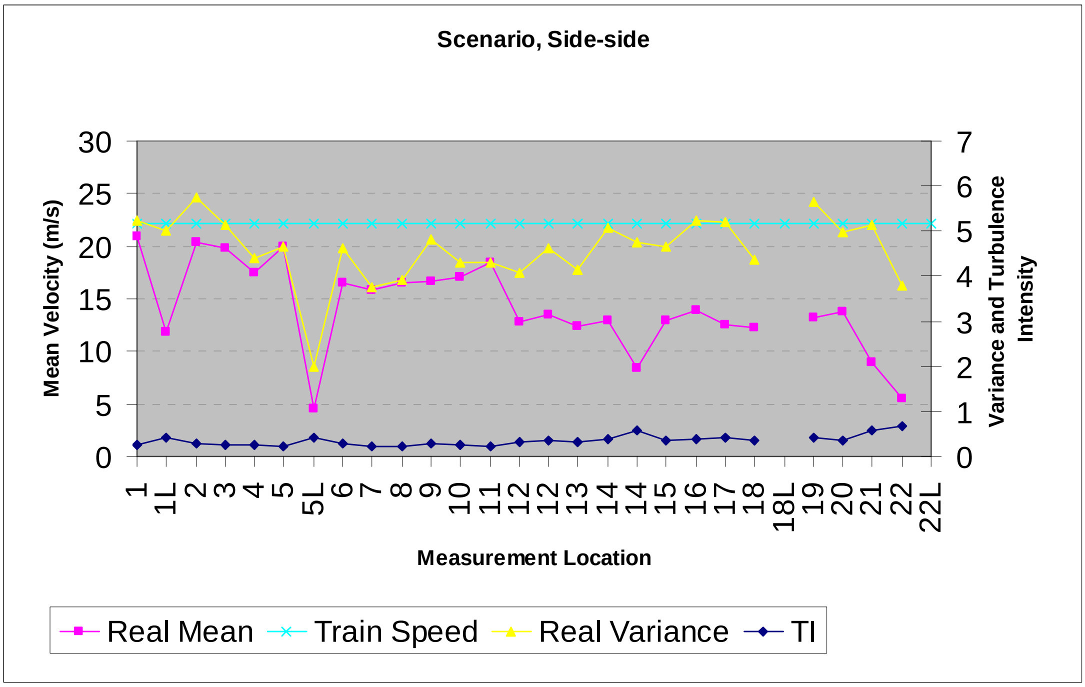
Simulation 1, Flat:



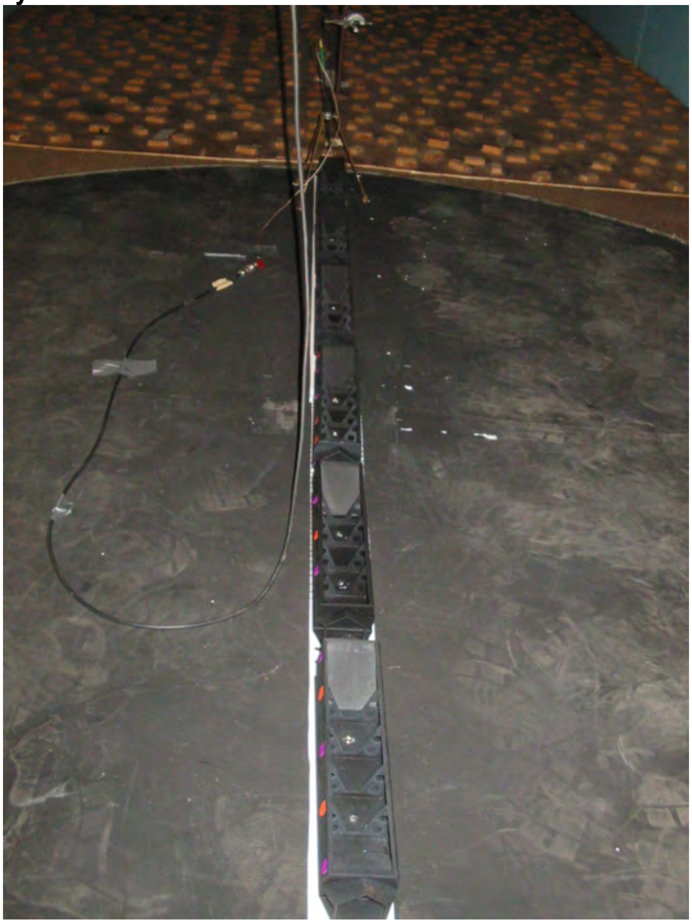
Simulation 2, Cutting:

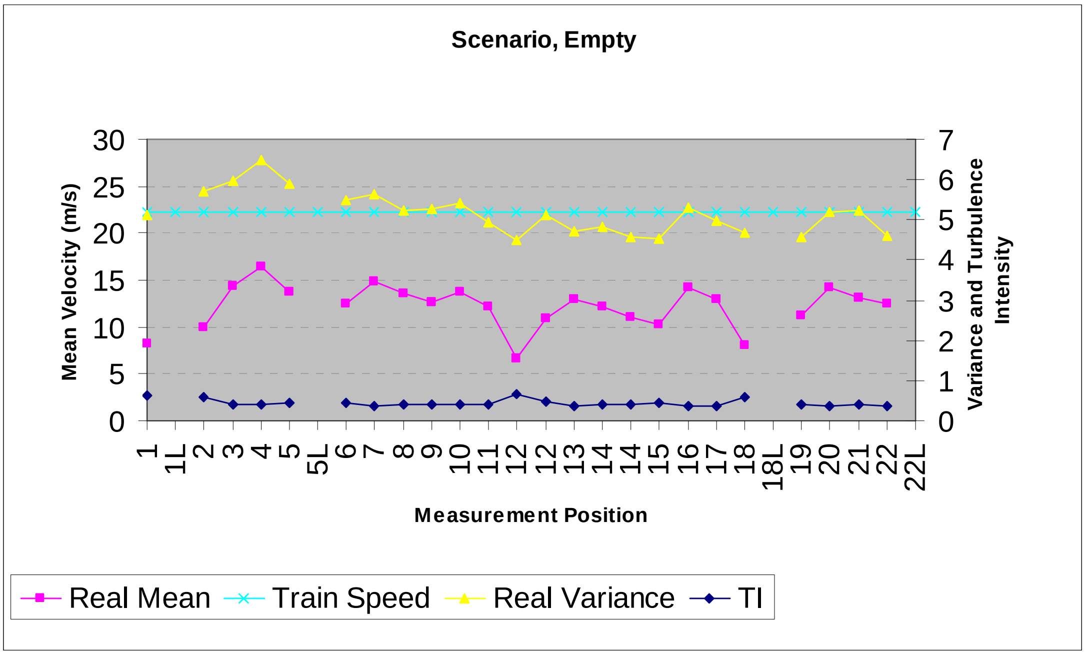


Simulation 3, Side-side:

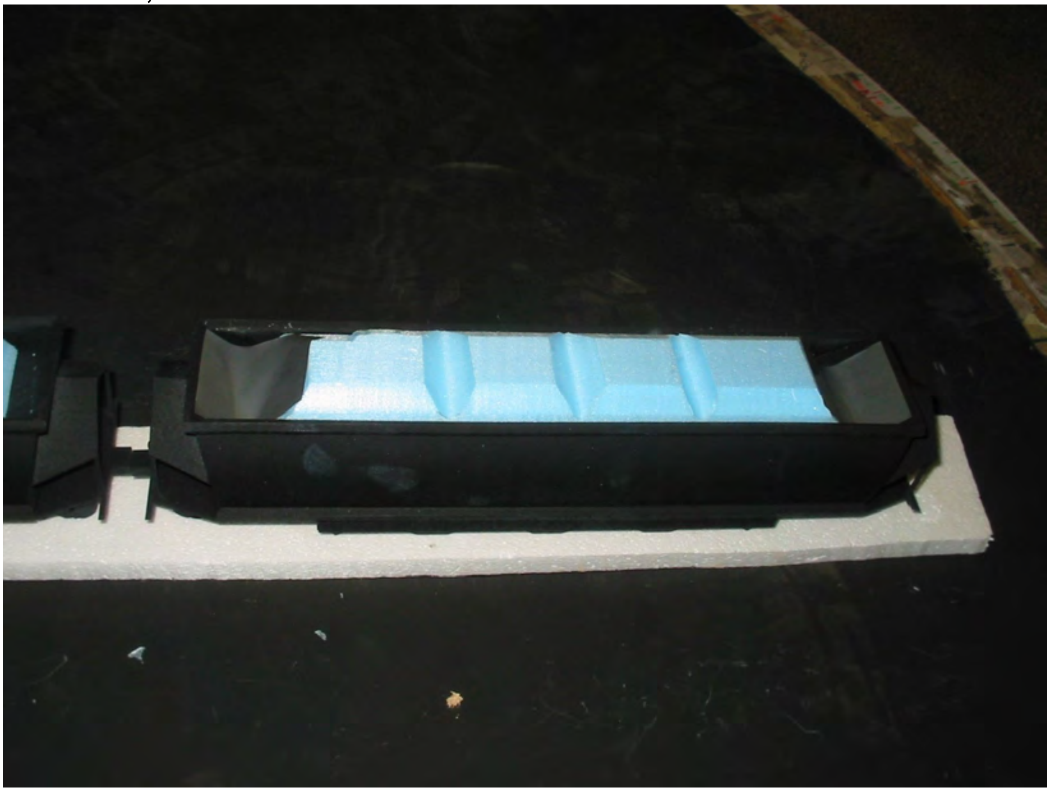


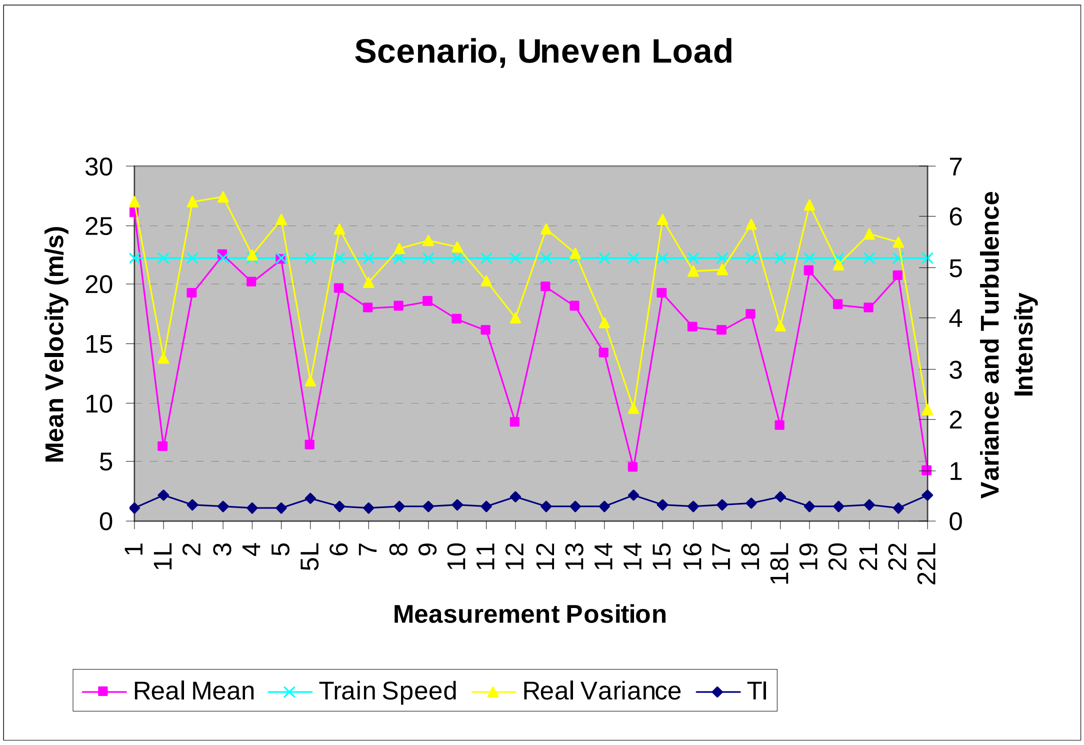
Simulation 4, Empty:



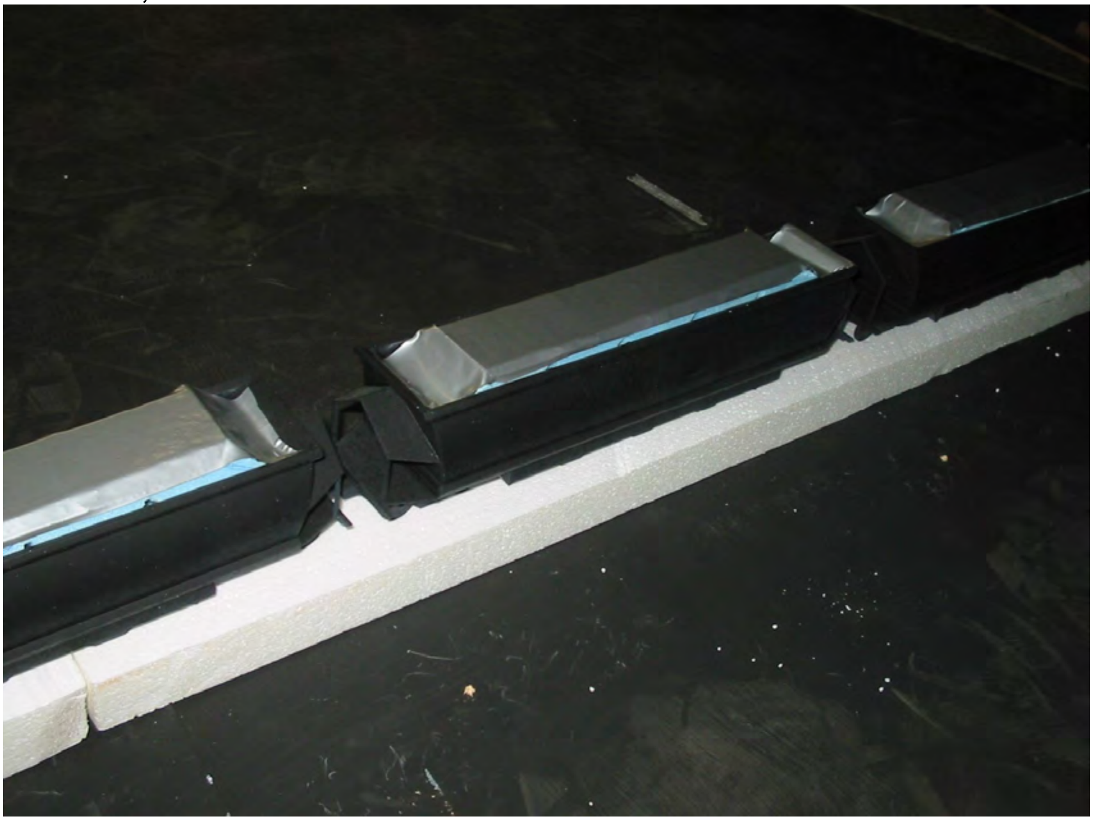


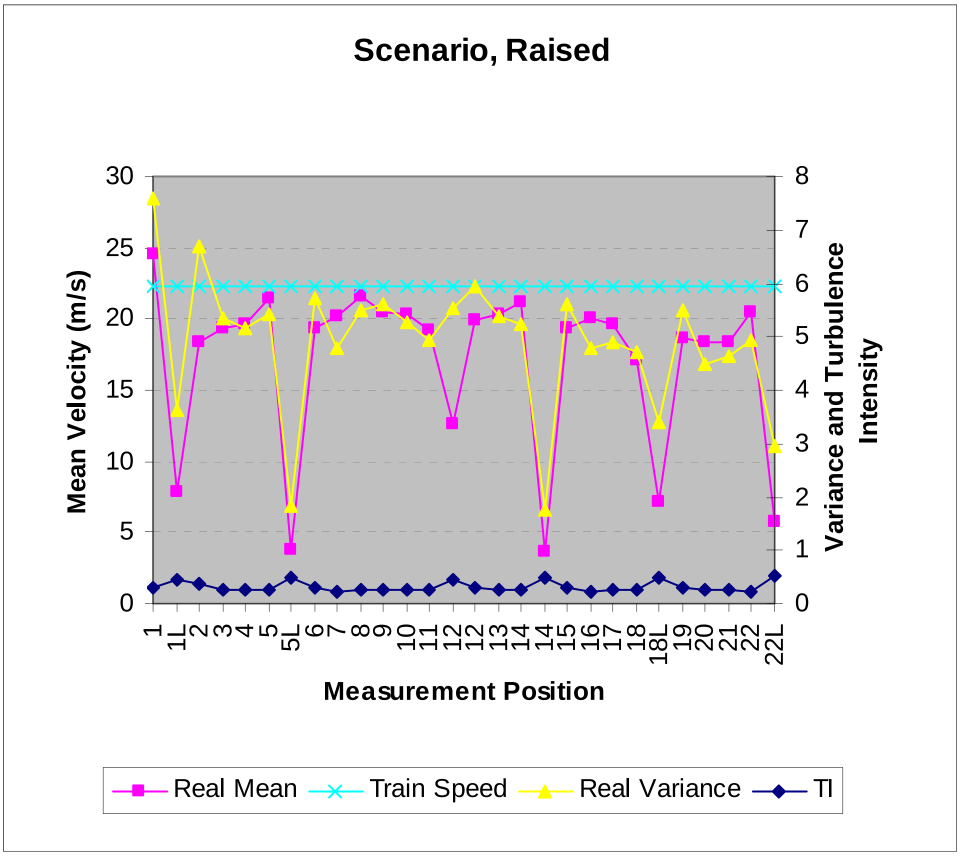
Simulation 5, Uneven Load:



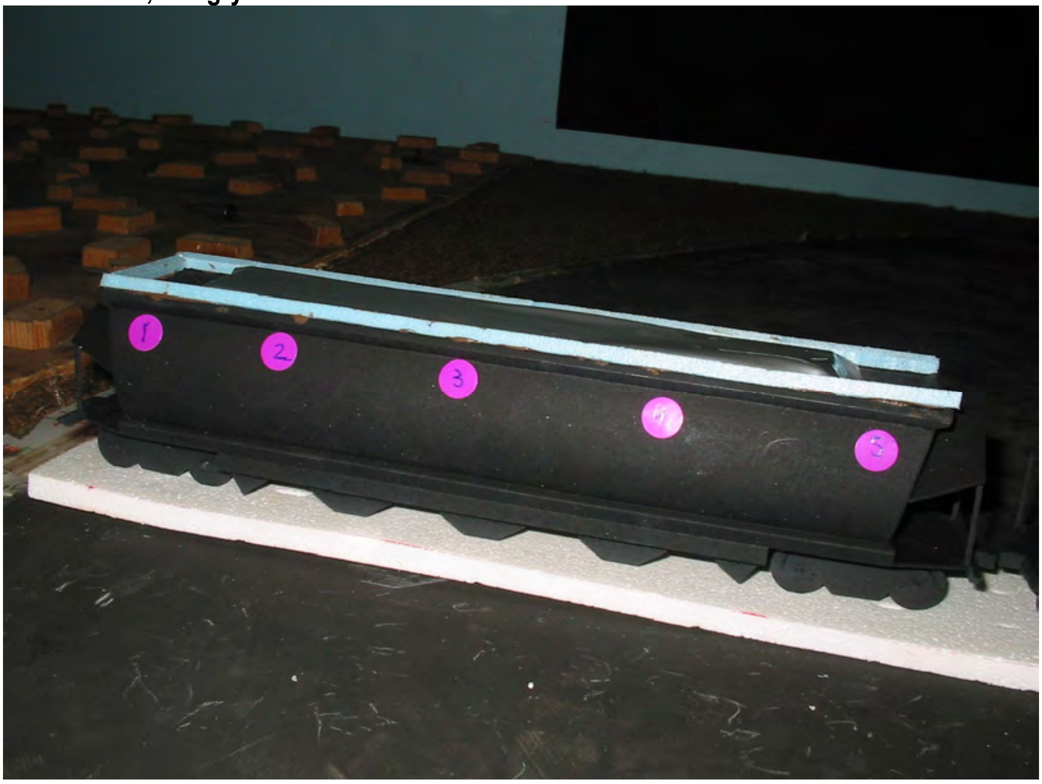


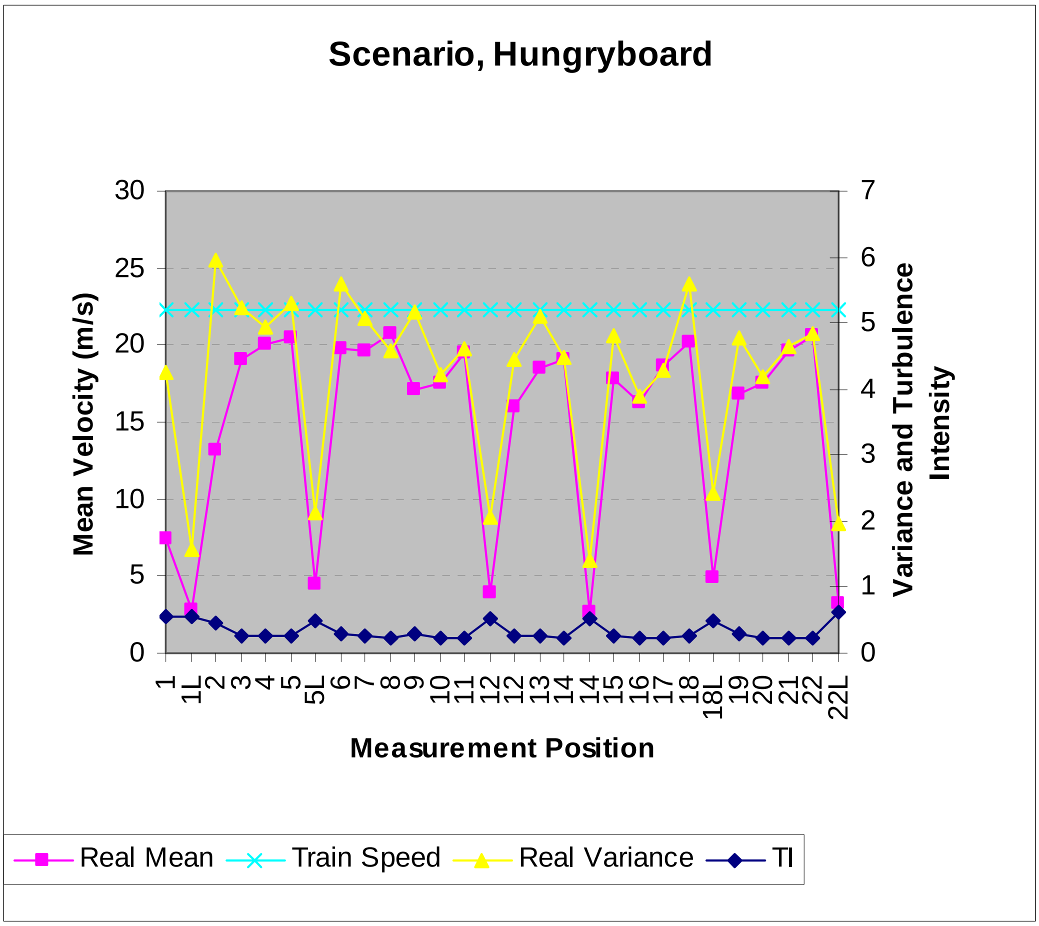
Simulation 6, Raised Track:



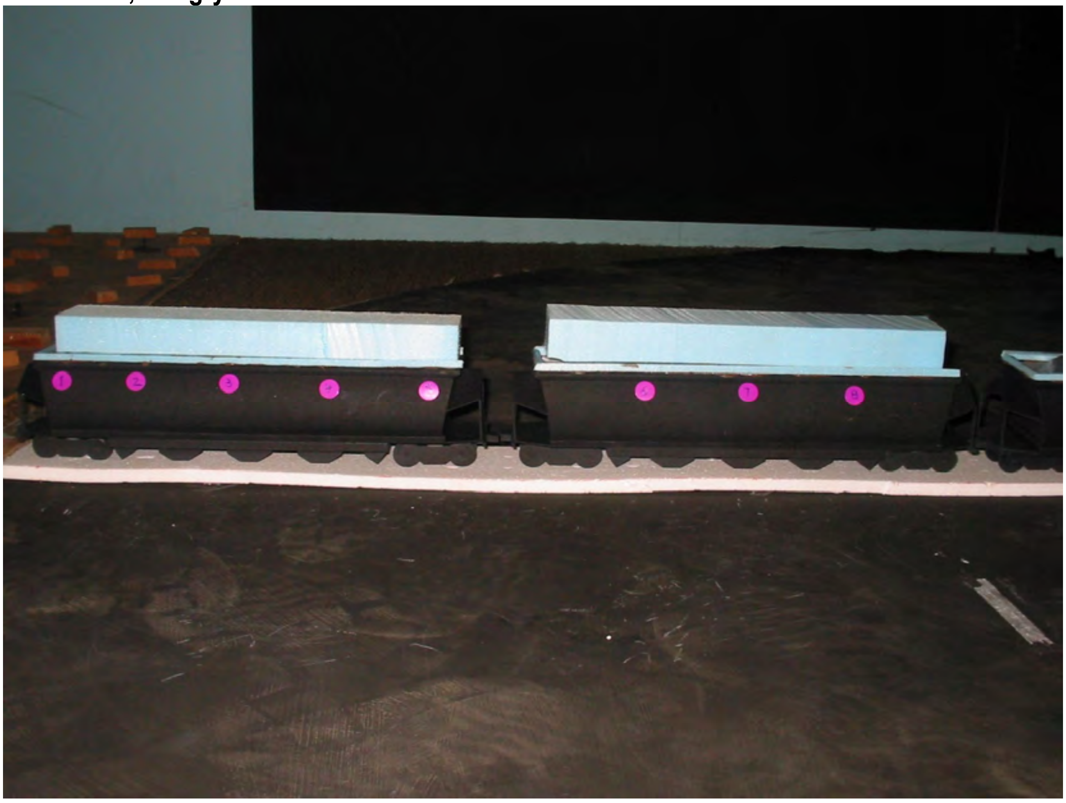


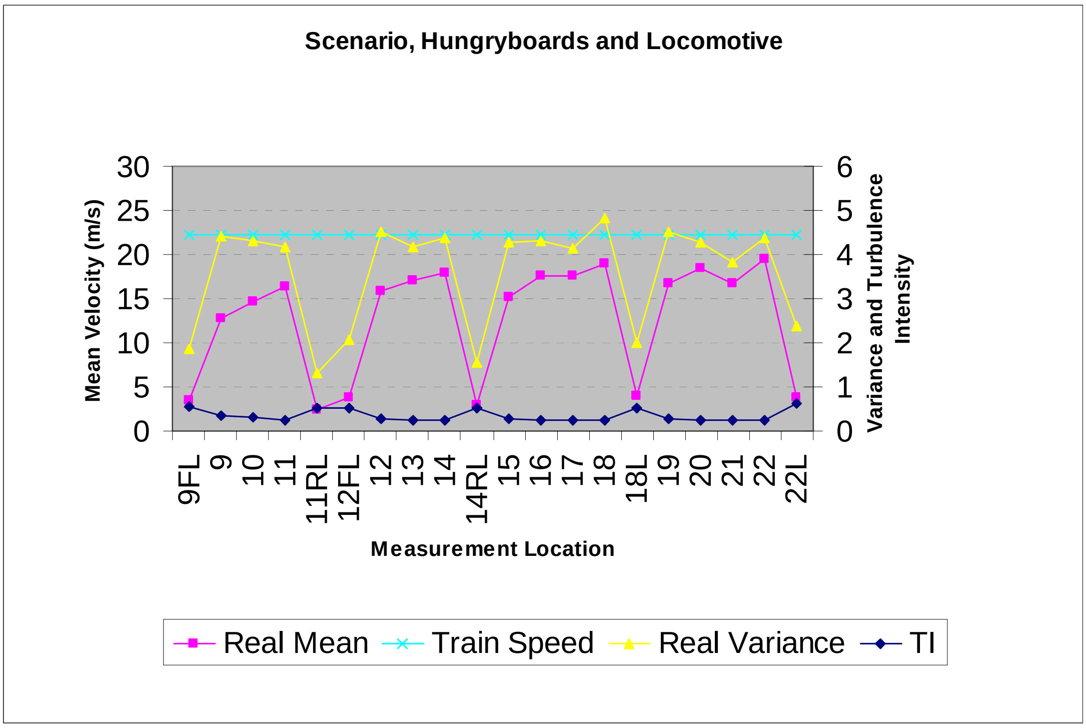
Simulation 7, Hungry Board:



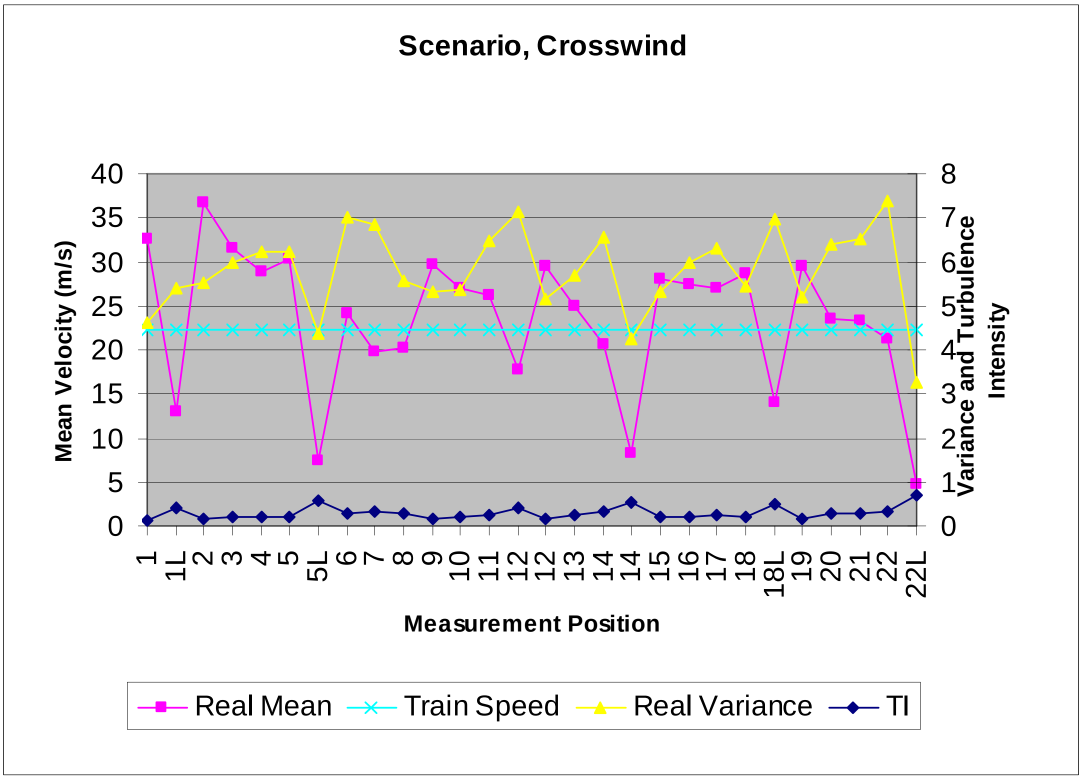


Simulation 8, Hungry Boards and Locomotive:

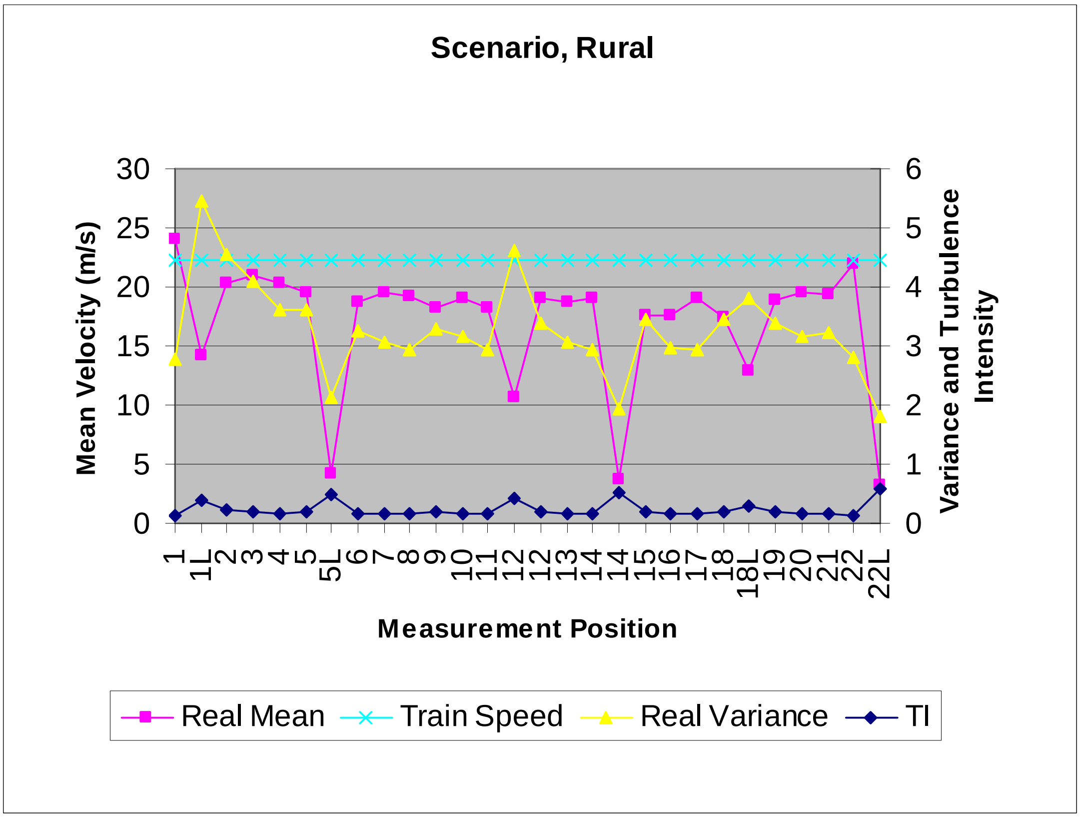




Simulation 9, Crosswind:



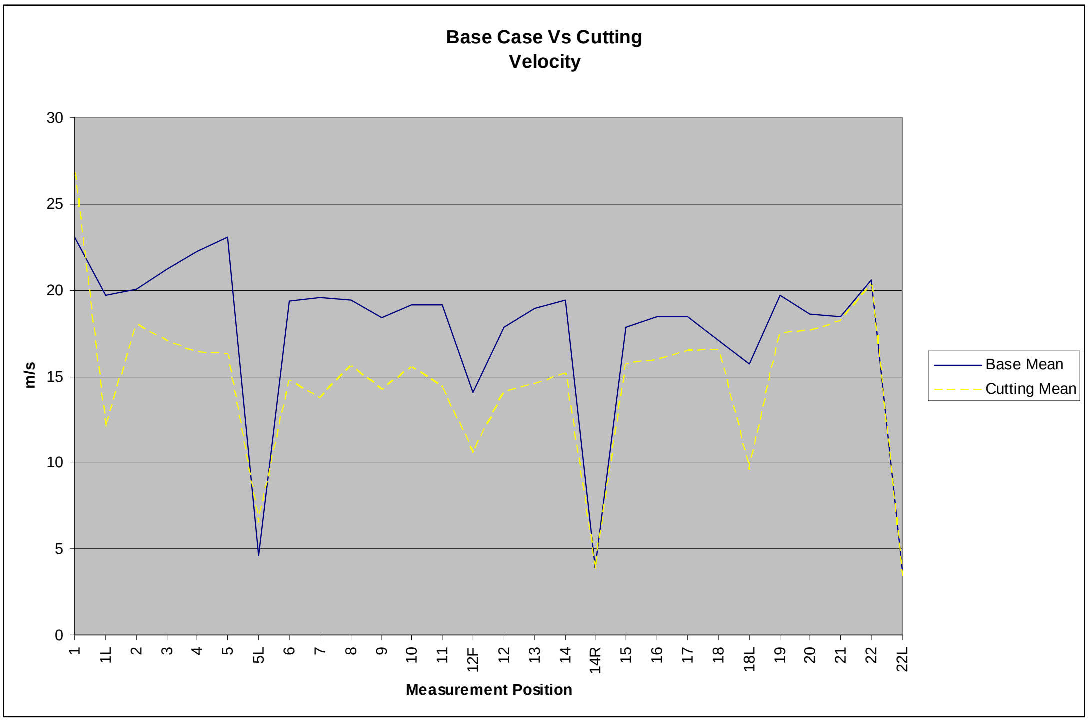
Simulation 10, Rural:

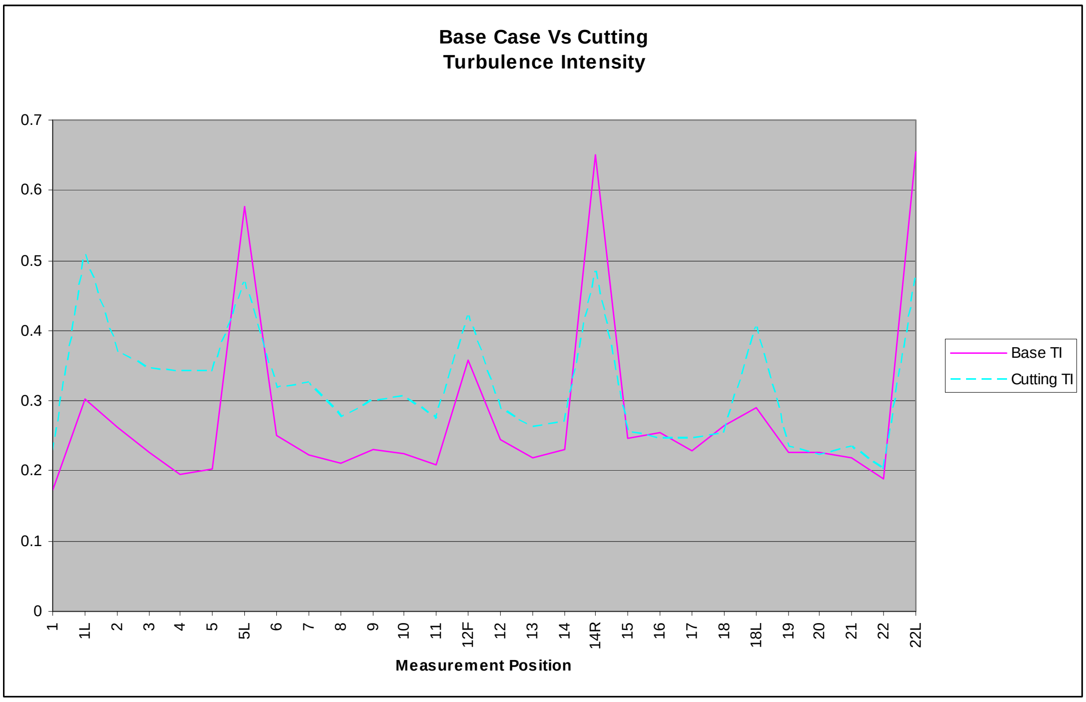


4.2 Comparative Results

The following graphs show a comparison of the test case with the base case (flat coal, no cross wind). The aim of the graphs is to show the effect of changing the geometrical elements of the simulation, therefore determining which is likely to have the largest impact on coal erosion.

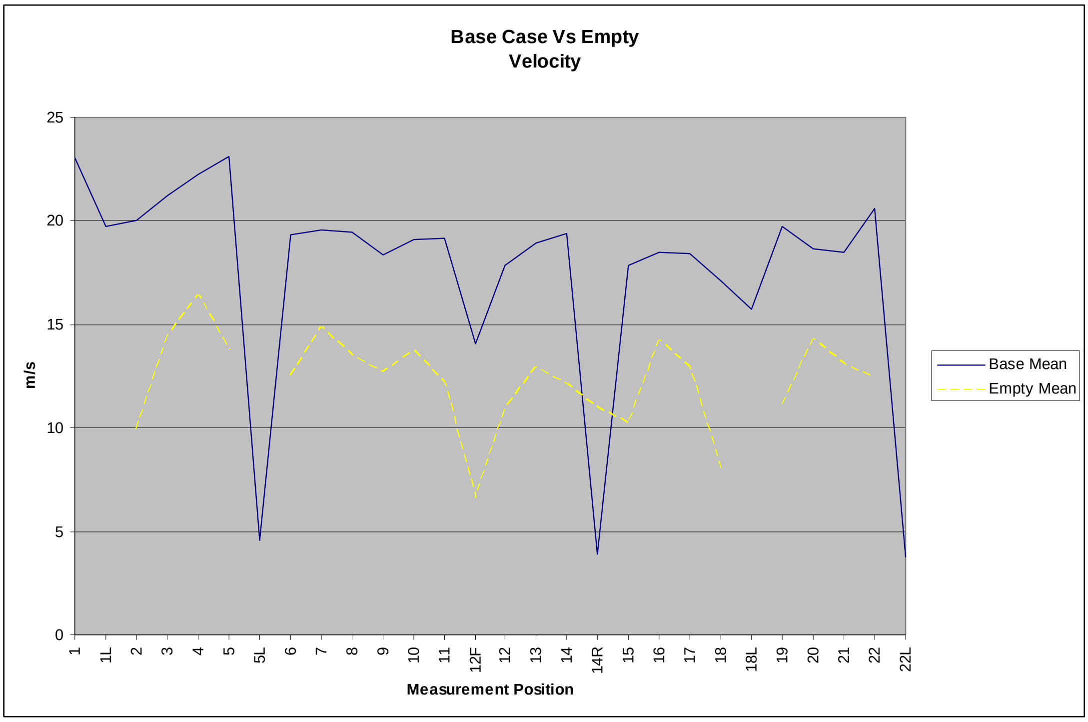
4.2.1 Cutting

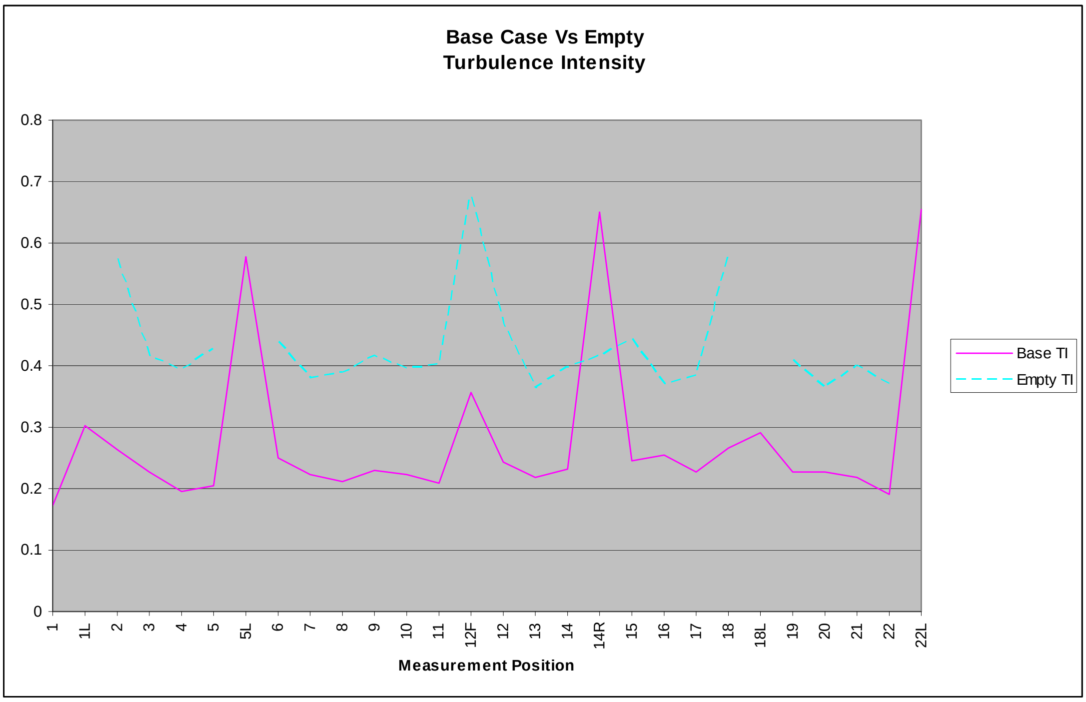




- It can be seen that the mean velocities measured in the cutting simulation are generally lower than those in the base case
- Cutting has generally higher turbulence intensity levels

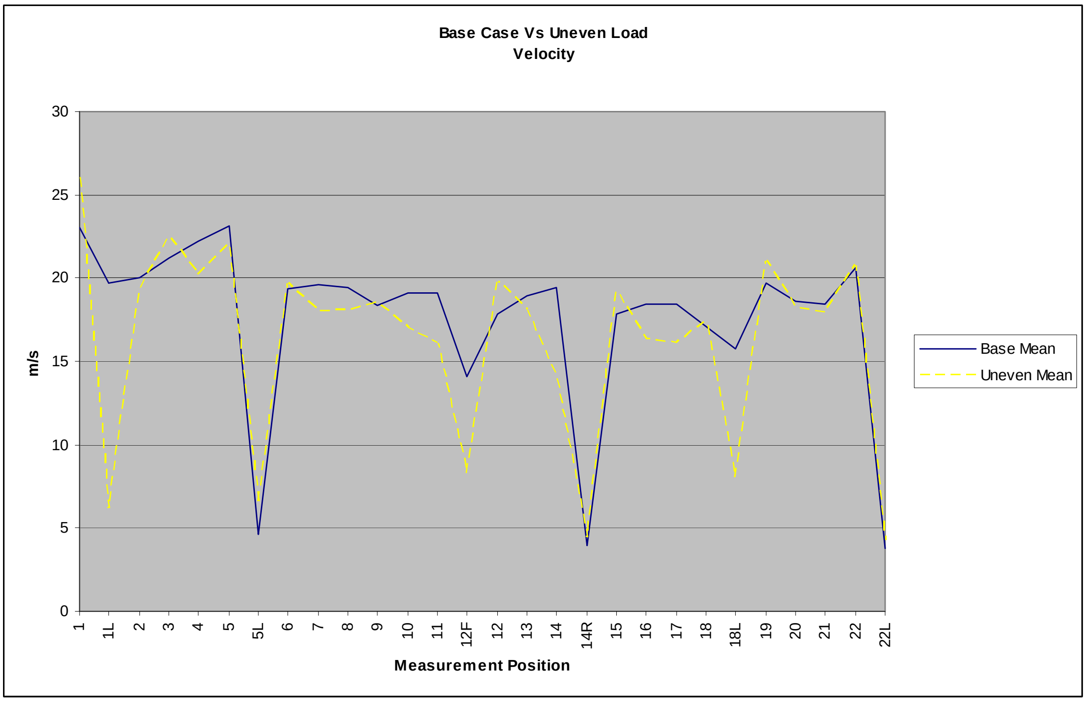
4.2.2 Empty Wagons

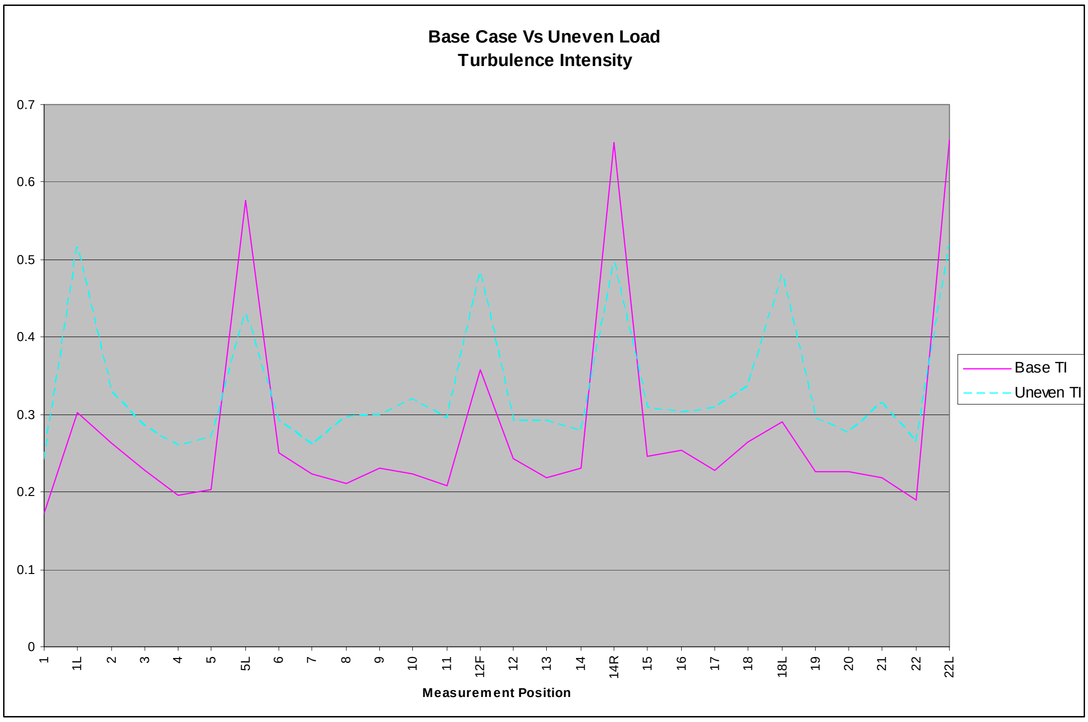




- Mean velocities of the empty case are generally much lower than the base case.
- Empty case has generally higher turbulence intensity levels.
- Has implications for lower loading levels; for example a half filled wagon will experience similar effects of reduced velocity and higher turbulence intensity, but possibly to a lesser extent

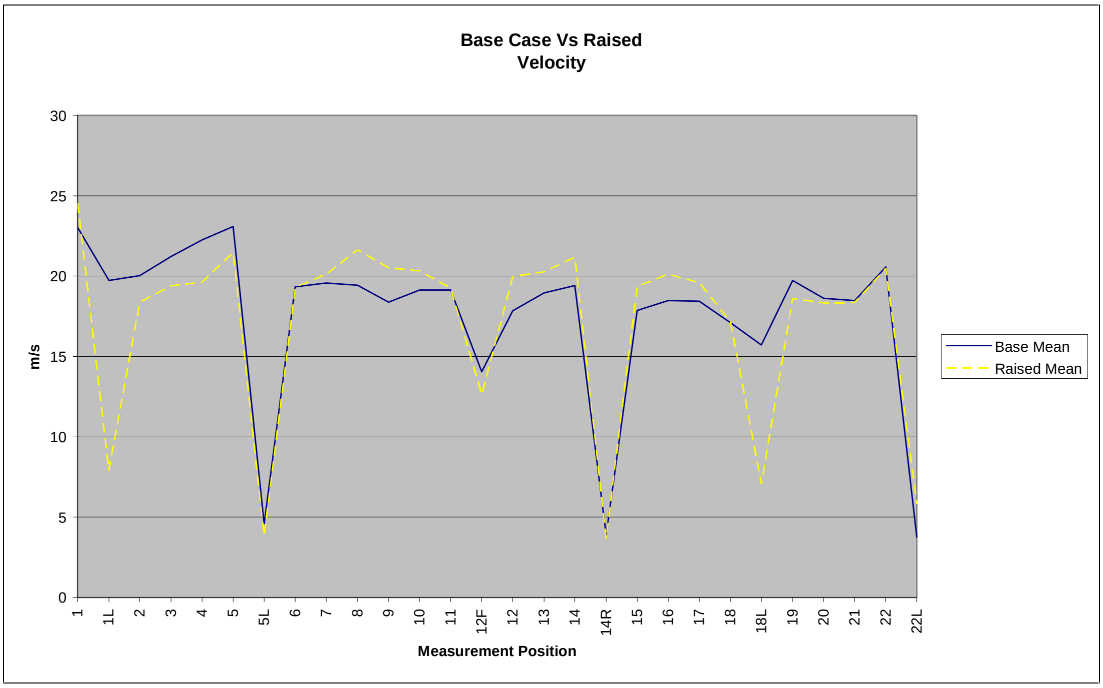
4.2.3 Uneven Load

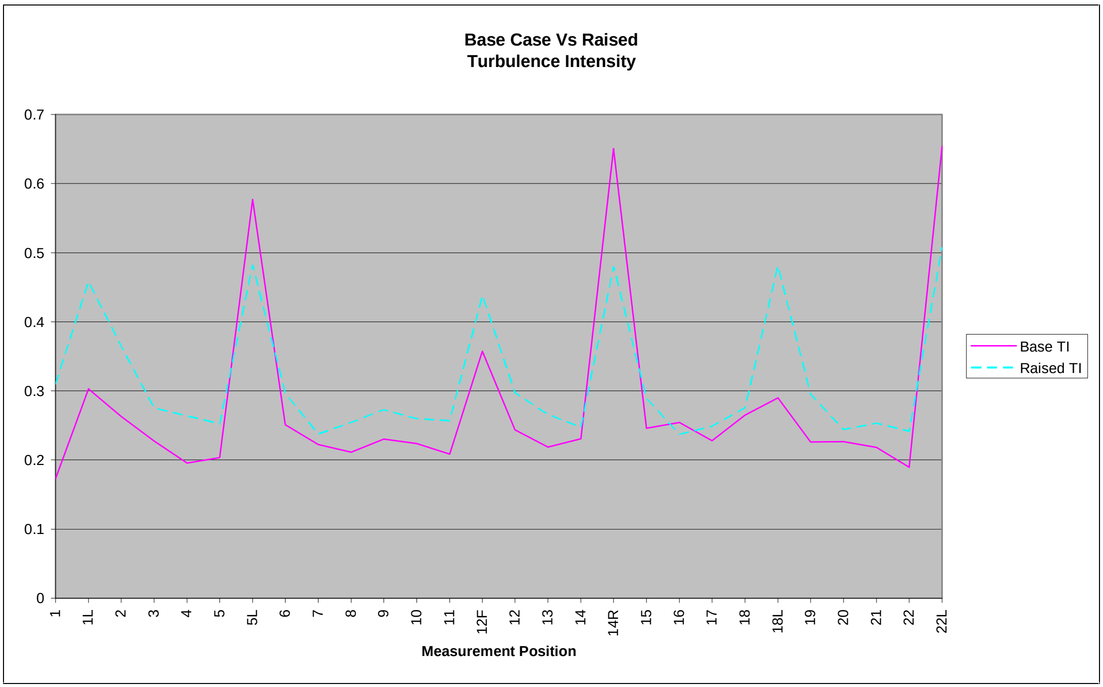




- Magnitude of mean velocity is generally similar.
- Turbulence intensity generally increased.
- Variation in the velocity profile can be seen from the base case due to the additional geometrical complexity of the coal face. The complex geometry also leads to the increased turbulence.

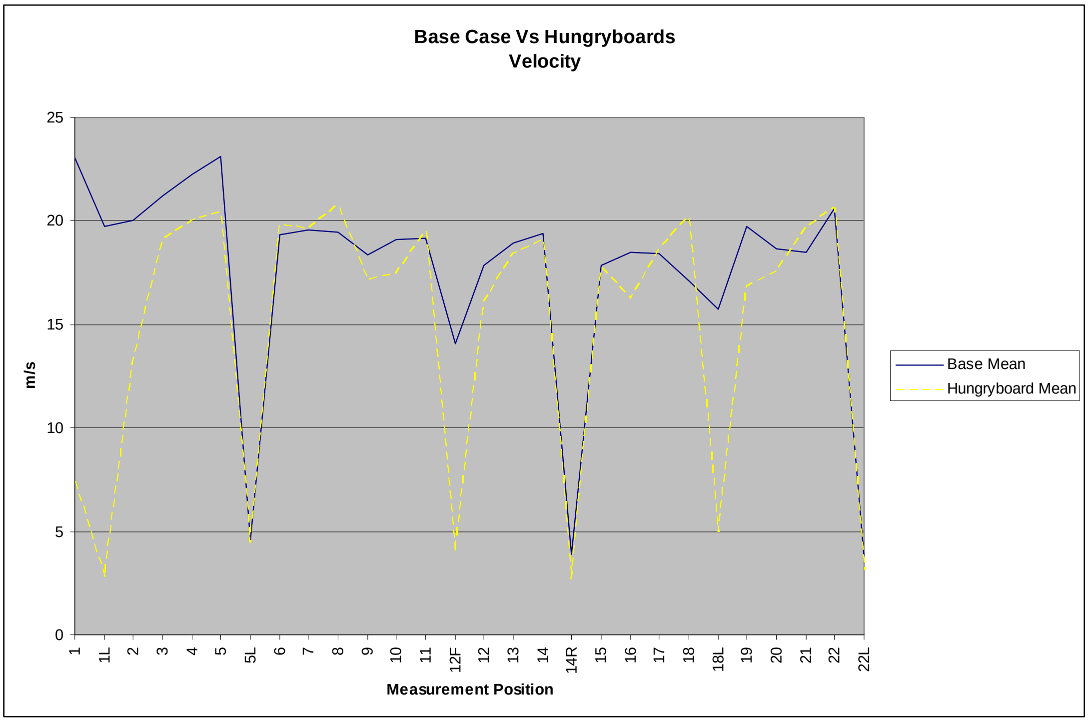
4.2.4 Raised Track Profile

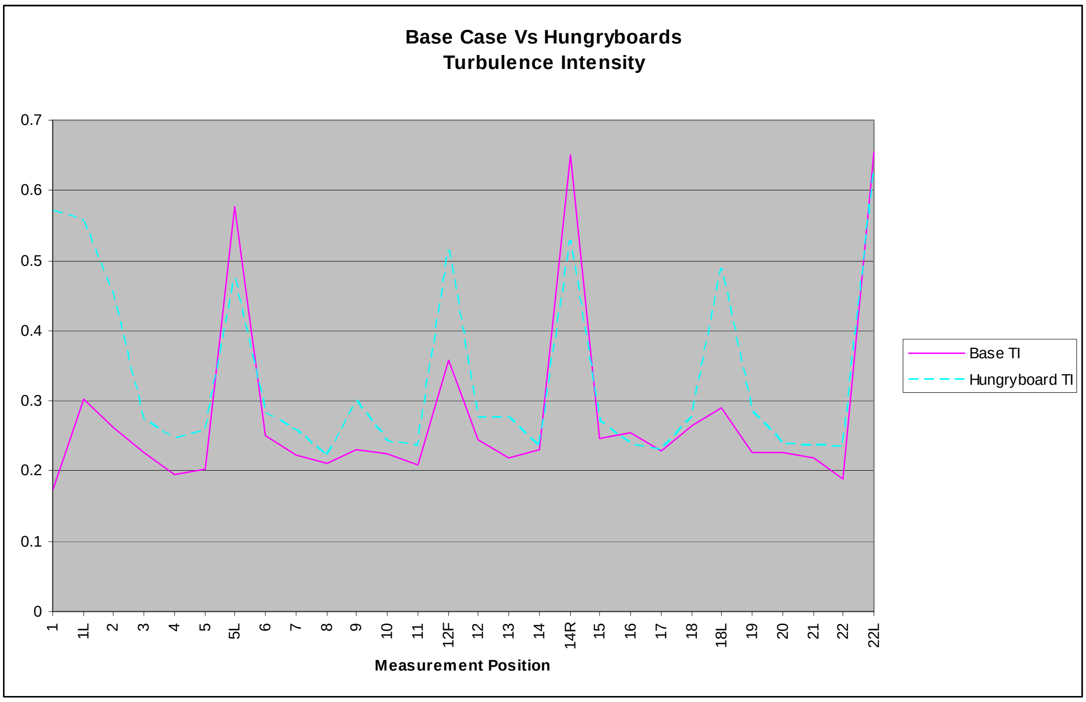




- Mean velocity increased slightly
- Turbulence intensity generally slightly increased
- As expected there is little difference between the base case and the raised case. Differences in mean velocity may be attributed to measurement location.

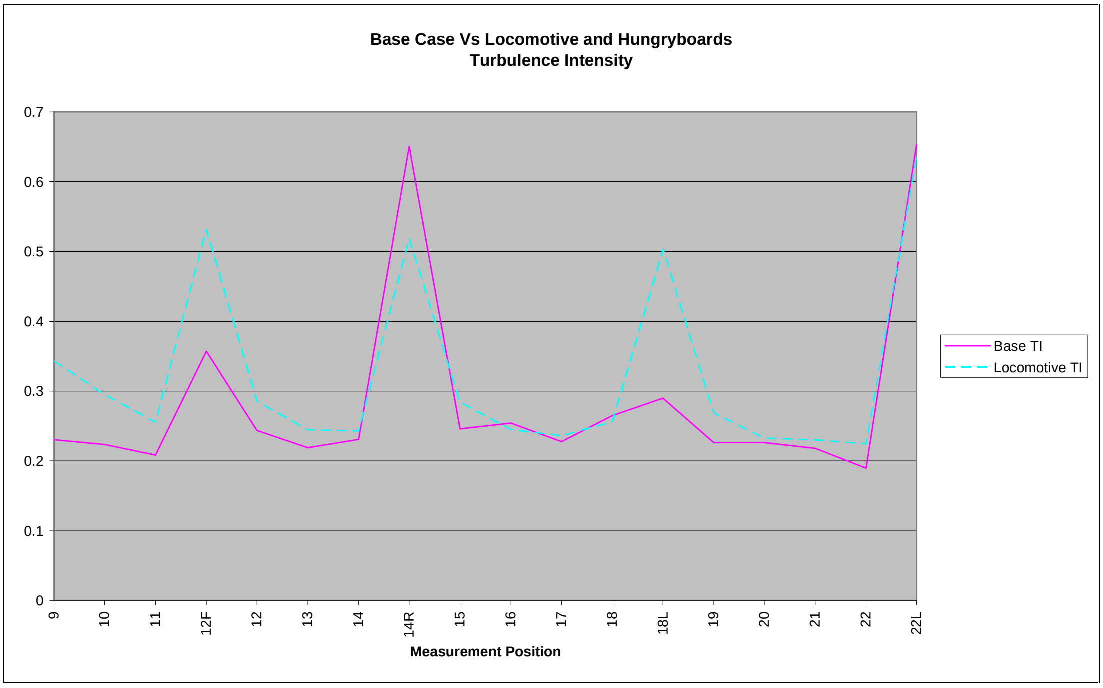
4.2.5 Hungryboards





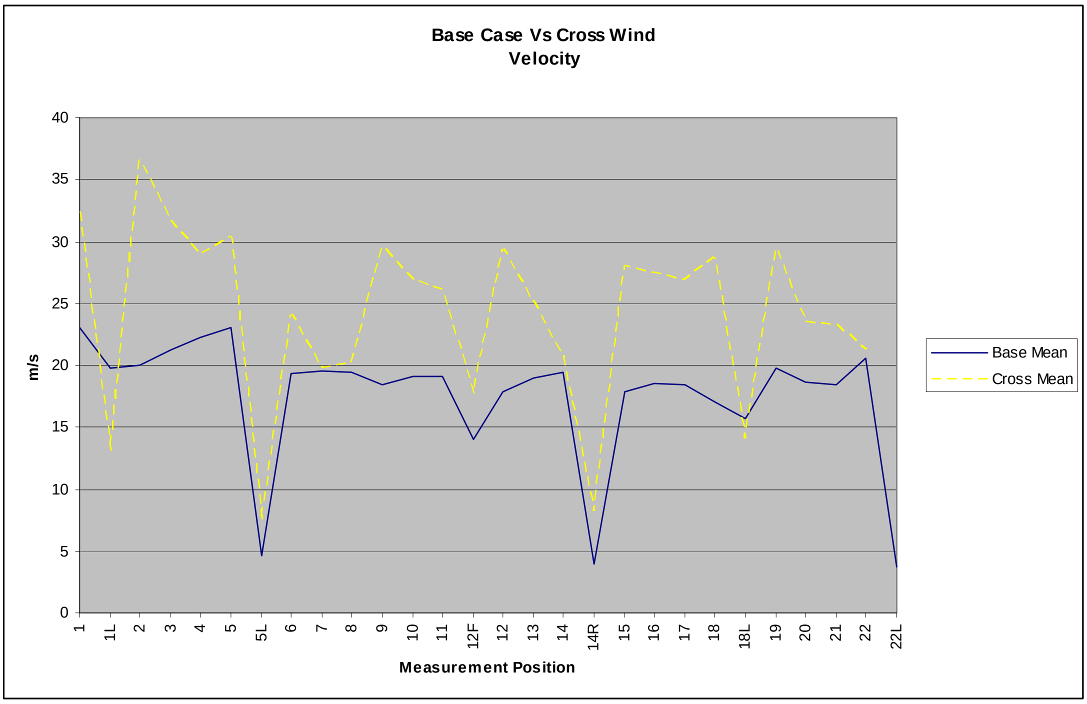
- It can be seen that there is a large discrepancy over the first wagon, with the hungryboard simulation having much lower mean velocity levels than the base case.
- The remainder of the wagons experience generally comparable mean velocity and turbulence intensity levels, except immediately after the hungryboards. Turbulence intensity levels are slightly increased, however there is not a significant difference.
- It appears that the reduction in velocity is quite localised behind the hungryboard and the effect is not noticed further down the wagon.

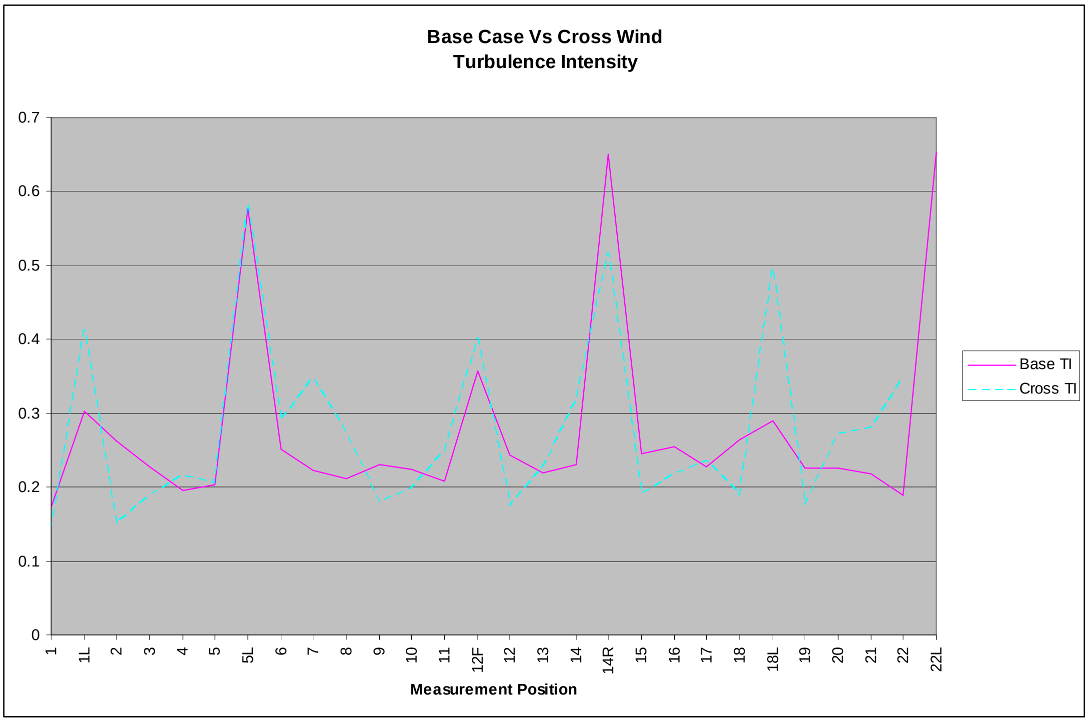
4.2.6 Locomotive and Hungryboards



- It can be seen that the first wagon after the locomotive (measurement position 9) has a dramatically reduced mean velocity, it is expected that this is due to shielding effects from the locomotive. Further back in the train, the levels return to comparable levels.
- Significant reduction in mean velocities occur immediately behind the hungry boards, which also leads to peaks in turbulence intensity.

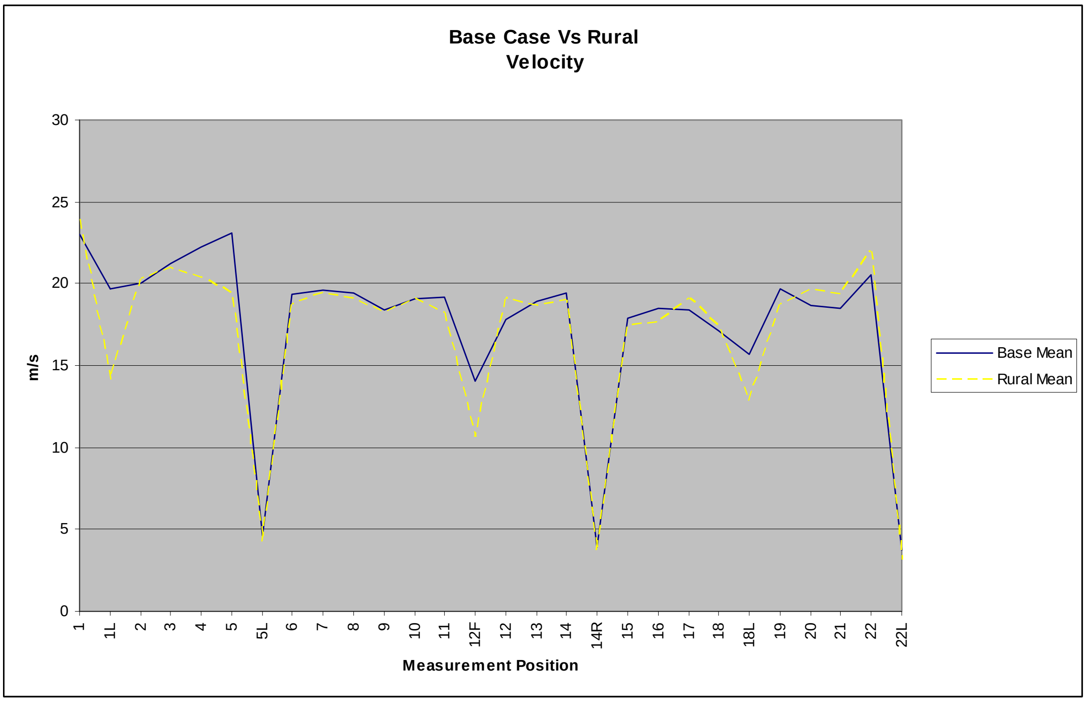
4.2.7 Cross Wind

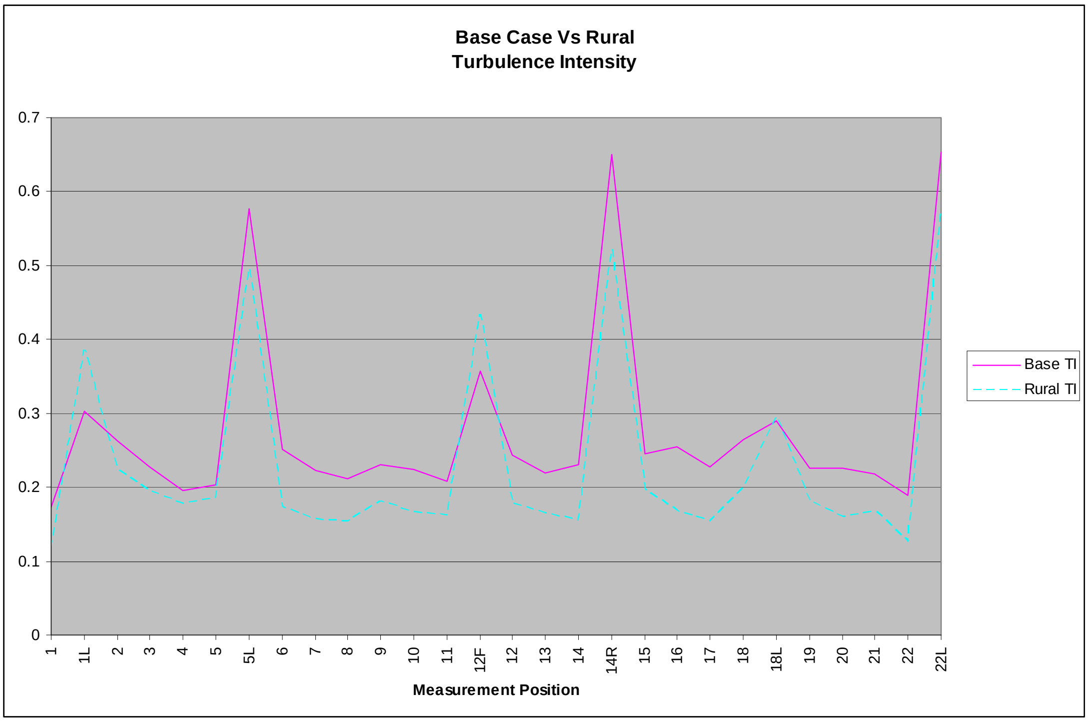




- The mean velocity is significantly increased. However, higher inlet velocity may be a major contributor to this increase. In this case, inlet velocity was set at 33 m/s (22 m/s straight + 11 m/s cross wind) hence the increase.
- Turbulence intensity profiles are quite different, but have generally similar magnitudes.

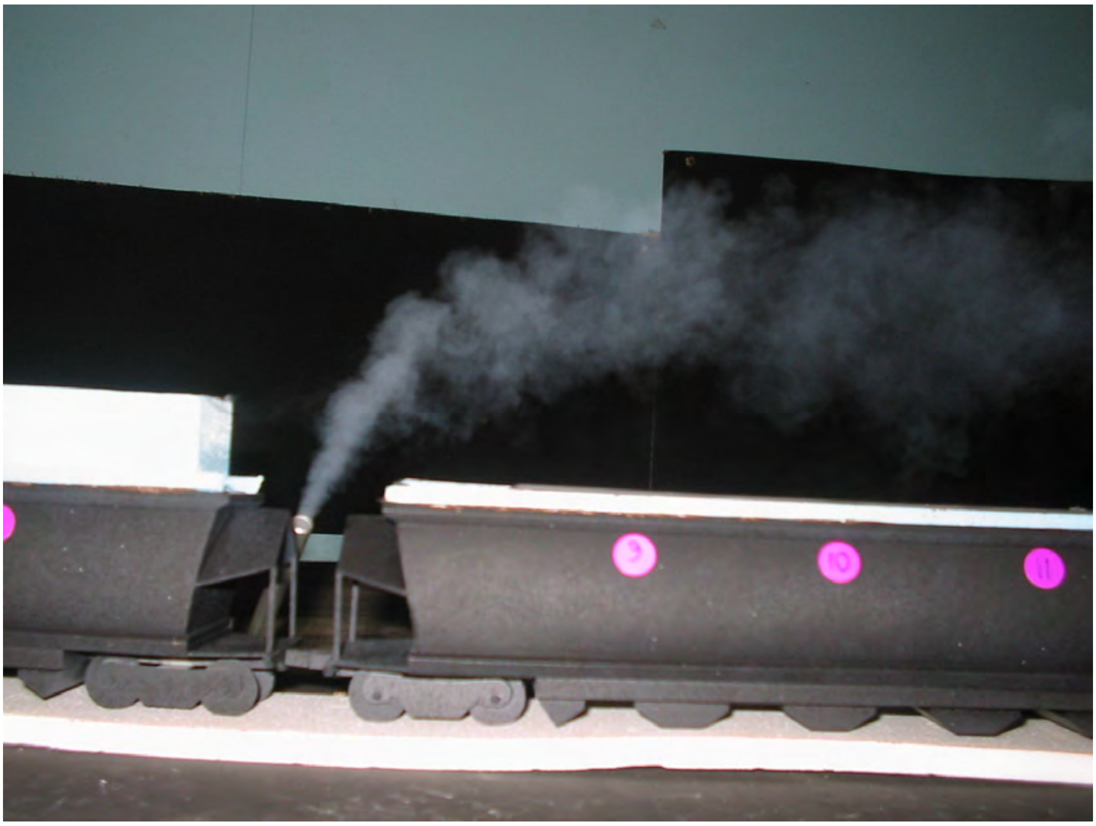
4.2.8 Rural Turbulence Intensity

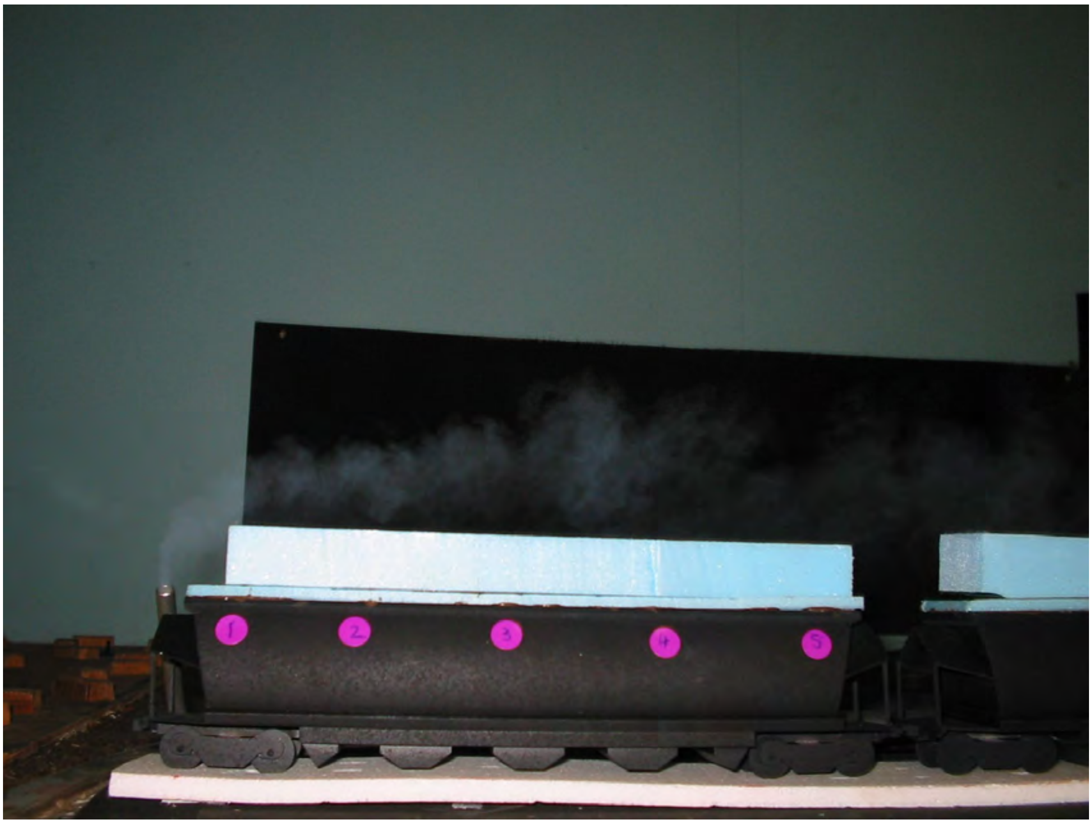


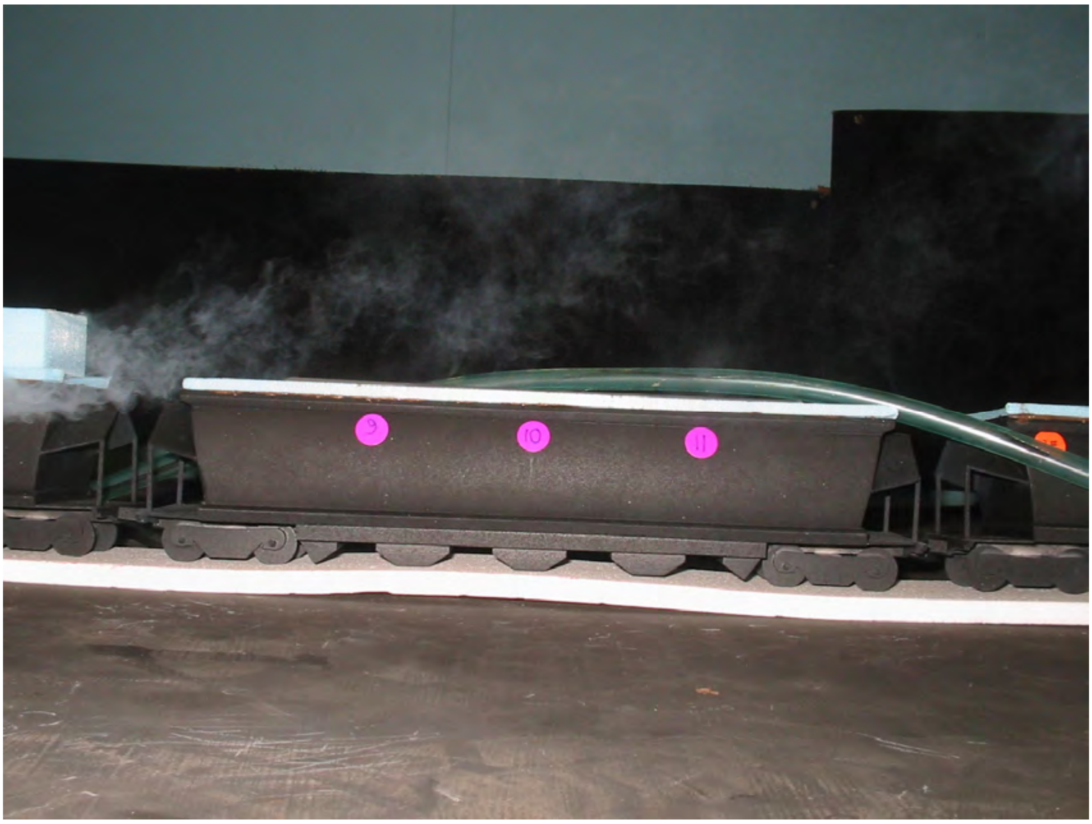


- Mean velocity levels for both cases are very similar
- The Rural case experiences generally lower turbulence intensity levels across the train. This is due to reduced inlet turbulence (terrain category 2 as opposed to terrain category 3).

4.3 Smoke Visualisation



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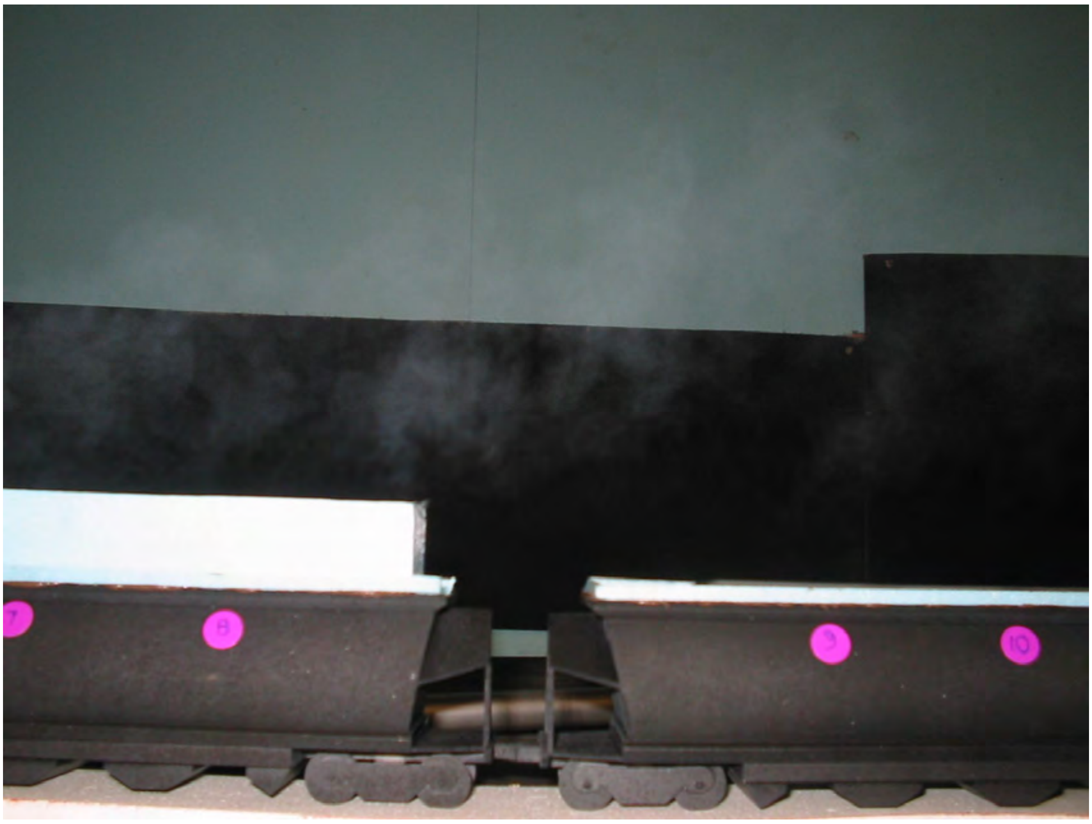
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5. Discussion

It is immediately obvious from all plots that there is a large turbulent region created by the leading edge of each carriage. This can be seen by the peak in turbulence intensity at measurement points 1L, 5L, 12F, 14R, 18L and 22L. This effect is well known and has been seen in previous studies.

For the comparisons between the cases, the flat, straight, full load case shall be taken as the base case to which the other scenarios are to be compared. Mean wind speeds across the coal is typically 15 to 20 m/s. This is a large reduction when compared to the free stream wind velocity of 22 m/s. Geometrical effects of the coal wagons are a significant contributor to the reduction in velocity, however boundary layer effects may have also lead to the generation of a wind profile above the coal face, causing a reduction in velocity close to the coal. The surface roughness of the coal has not been scaled in this study.

When compared to the base case, most simulations on average have reduced mean velocities and comparable or slightly increased turbulence intensity. Since turbulence intensity is inversely proportional to velocity, this is to be expected. The dependence of coal erosion on velocity compared to turbulence intensity has not been considered.

The exception is the cross wind case, where the mean velocity and variance are both generally increased. It is believed this is due to the turbulent region caused by air flowing across the side of the wagon not being slowed across the coal face. Higher inlet velocity (due to the 2:1 ratio) has lead to higher velocity readings.

Slightly higher turbulence levels were recorded in the hungry board simulation with generally comparable mean velocities. This indicates generally higher levels of turbulence after the addition of the hungry boards. It is thought that the sharp edges on the wagon walls increase the turbulent region.

Generally it appears that mean velocity reduces to a stable value further down the train, with the turbulence intensity staying relatively constant. It can be seen that generally the turbulence intensity is relatively constant across the length of the train. This appears to contradict previous studies which indicate that coal loss is elevated in wagons closer to the end of the train.

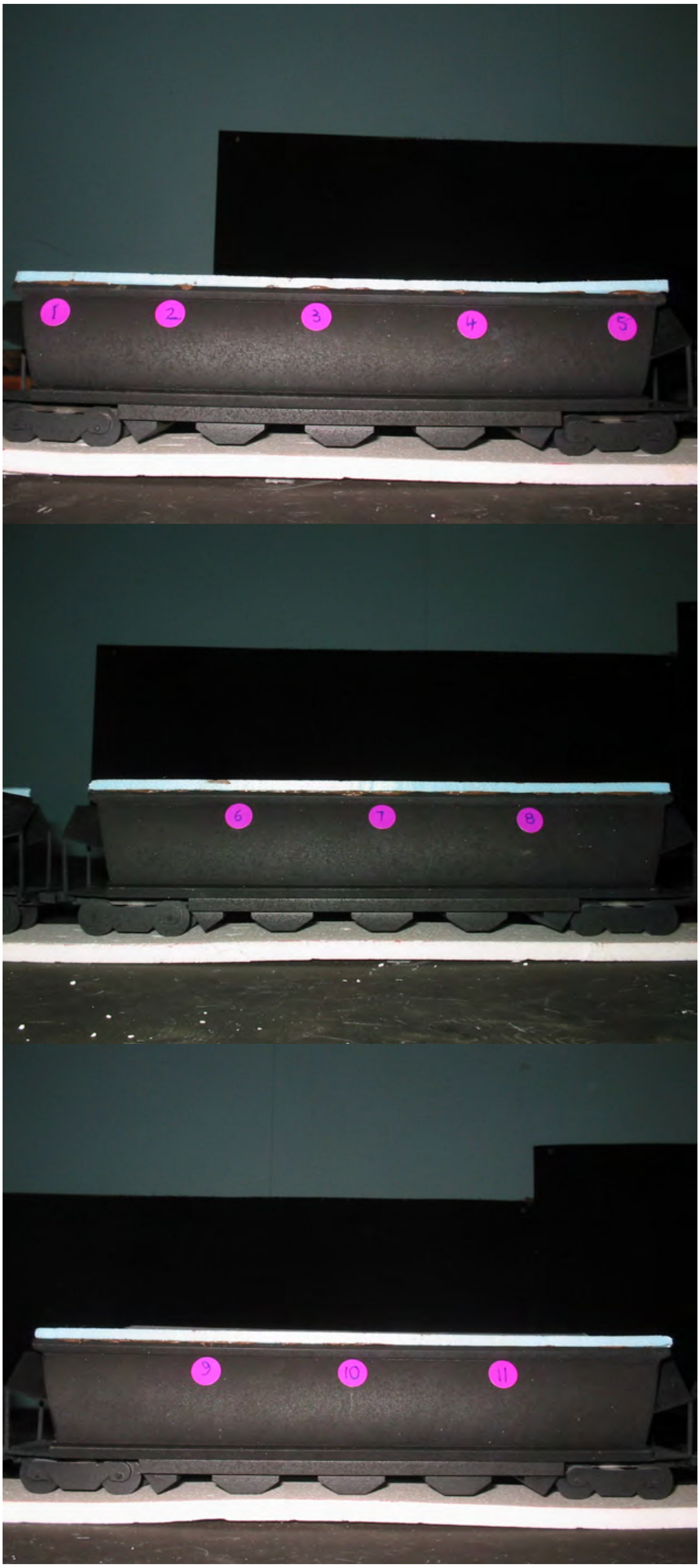
6. Recommendations

The following recommendations are made:

- Hungry boards on the sides of the train are likely to have a significant effect on cross-wind erosion velocities. The detached region of low velocity is unlikely to reattach over the cross sectional length of the wagon, however, cross wind velocities are significantly higher than would be expected in operation, therefore the effect would be less pronounced.
- Along-wind velocities are difficult to mitigate without significant height hungry boards at the front and along the length of the wagons. The hungry boards used in this experiment did not appear to have a significant impact on longitudinal velocity magnitudes.

Appendix A

Measurement Locations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Appendix E

Wind statistics for various locations within the study area

Emerald

Calms= 2.88%

EMR_WSpeed vs EMR_WDir

Sector	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
0.00 <= WS < 3.6	0.129613398	0.1445329	0.1659797	0.126816	0.1370732	0.0494209	0.0466235	0.0531508	0.0718002	0.0345014	0.0382313	0.0270416	0.0606106	0.0680703	0.0615431	0.0568807
3.6 <= WS < 7.2	0.441991011	0.4792898	0.616363	0.5893213	0.7898025	0.4046922	0.4140169	0.3552713	0.4606404	0.2918633	0.2443073	0.1967513	0.3515414	0.2237929	0.2023461	0.1976837
7.2<= WS < 10.8	1.023852595	1.2047519	1.7791537	2.0756793	3.1470879	1.7511796	1.5357789	1.5106022	1.8546838	0.8429533	0.6816359	0.5650771	0.6294176	0.3897727	0.3935025	0.4093545
10.8 <= WS < 14.4	1.089125529	1.4453293	2.5680237	2.968986	3.8837396	2.1707913	2.0346506	2.3675426	2.3377035	0.6573917	0.5604148	0.5268458	0.4345312	0.204211	0.2704164	0.378583
14.4 <= WS < 18	0.792599914	1.1898323	2.3013372	2.7256112	3.143358	1.4947502	1.7008262	2.1941031	1.6467429	0.3235673	0.4242741	0.4130844	0.2443073	0.1007068	0.1603849	0.2499021
18 <= WS < 21.6	0.522183473	0.7338543	1.5133996	2.0141363	2.3265139	0.9977434	1.3623394	1.8276422	0.8196416	0.1799668	0.2844035	0.2937282	0.1324108	0.0578132	0.0979094	0.1501277
21.6 <= WS < 25.2	0.194886332	0.3300946	0.759031	1.1264243	1.4462617	0.5548199	0.8653326	1.169318	0.4401261	0.1063016	0.2461722	0.1986162	0.0811249	0.0223793	0.031704	0.0708678
25.2 <= WS < 28.8	0.086719755	0.1445329	0.2918633	0.5259134	0.7478413	0.2004812	0.489547	0.6294176	0.2098059	0.0466235	0.1473303	0.1370732	0.0596781	0.0130546	0.0121221	0.0289066
28.8 <= WS < 32.4	0.041028701	0.0363663	0.1118965	0.1808993	0.2508346	0.0419612	0.1864941	0.2657541	0.0773951	0.0177169	0.0578132	0.0596781	0.0298391	0	0.0046624	0.0093247
32.4 <= WS < 36	0.012122116	0.0121221	0.0345014	0.0531508	0.0773951	0.0177169	0.0484885	0.1063016	0.0345014	0.0111896	0.0214468	0.0261092	0.0139871	0.0009325	0	0.0037299
WS >= 36	0.009324705	0.0018649	0.0083922	0.0167845	0.0289066	0.0065273	0.0261092	0.0372988	0.0214468	0.0102572	0.0149195	0.0111896	0.0130546	0.0018649	0	0.0046624
Total	4.34344753	5.7225714	10.149941	12.403722	15.978814	7.6900841	8.7102068	10.516402	7.9744876	2.5223327	2.7209489	2.4551948	2.0505026	1.0825982	1.2345909	1.5600231

Gladstone

Calms= 4.95%

WSpeed vs WDir

Sector	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
0.00 <= WS < 3.6	0.099277625	0.0666205	0.0849085	0.0940525	0.1045028	0.0653142	0.0979713	0.0901336	0.206393	0.2534192	0.1201782	0.0287383	0.0404948	0.027432	0.0418011	0.0352697
3.6 <= WS < 7.2	0.399723068	0.2233747	0.3278774	0.3814351	0.445443	0.4088671	0.7589513	0.6884119	1.0202082	1.1534492	0.5146761	0.2116181	0.1567541	0.0888273	0.1345473	0.197249
7.2<= WS < 10.8	0.945750003	0.6296291	0.7628702	0.8765169	0.9705694	0.8477787	2.5981999	3.5478688	3.3610701	3.8065131	1.9973091	0.4976944	0.339634	0.1750421	0.2547255	0.4049482
10.8 <= WS < 14.4	0.961425418	0.803365	1.0659282	1.1456115	1.3102034	1.0737659	3.3767455	3.5269682	2.0965867	2.6961713	1.5597037	0.3135083	0.2024741	0.0992776	0.1894113	0.3984168
14.4 <= WS < 18	0.608728593	0.7367445	1.6446122	1.7151516	1.794835	1.5923608	2.9535093	1.9842462	0.5956657	0.5930532	0.427155	0.1841861	0.1358536	0.0640079	0.0862148	0.3004454
18 <= WS < 21.6	0.340940264	0.5421081	1.3924993	1.7177642	2.2232963	1.8797434	2.1423066	0.6975559	0.1371599	0.0783771	0.0627017	0.0653142	0.0444137	0.0313508	0.036576	0.2325186
21.6 <= WS < 25.2	0.122790746	0.2429689	0.5133698	0.8686792	2.4231578	1.6720442	1.0959727	0.1894113	0.0195943	0.0130628	0.0143691	0.0326571	0.0156754	0.0039189	0.0222068	0.1306285
25.2 <= WS < 28.8	0.016981699	0.0352697	0.0587828	0.2534192	2.17627	1.436913	0.3918854	0.0483325	0.0052251	0	0.0039189	0.0052251	0.0117566	0.0078377	0.0039189	0.0339634
28.8 <= WS < 32.4	0.001306285	0.0013063	0.0039189	0.0169817	1.7007825	0.9535877	0.1227907	0	0.0039189	0.0013063	0	0	0	0.0026126	0	0.0013063
32.4 <= WS < 36	0	0	0	0	0.9588128	0.4611184	0.0339634	0	0	0	0	0	0	0	0	0
WS >= 36	0	0	0	0	0.2886889	0.1724296	0.0065314	0	0	0	0	0	0	0	0	0.0013063
Total	3.4969237	3.2813868	5.8547673	7.0696119	14.396562	10.563923	13.578828	10.772929	7.4458218	8.5953522	4.7000118	1.3389416	0.9470563	0.500307	0.7694016	1.7360521

Moranbah

Calms= 42.76%

WSpeed vs WDir

Sector	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
0.00 <= WS < 3.6	0.016675931	0	0	0.0055586	0.0389105	0.0055586	0.0277932	0	0.0111173	0	0	0	0	0	0	0
3.6 <= WS < 7.2	0.806003335	0.3668705	0.5947749	0.7226237	8.3435242	1.778766	1.2506948	0.2223457	0.4391329	0.250139	0.2946081	0.1612007	0.6670372	0.250139	0.4391329	0.3668705
7.2<= WS < 10.8	0.561423013	0.5002779	0.8226793	1.1728738	9.5997777	2.6459144	1.2062257	0.4168983	0.3446359	0.2779322	0.32796	0.2946081	0.5780989	0.4669261	0.4558088	0.4002223
10.8 <= WS < 14.4	0.289049472	0.233463	0.3613118	0.5836576	4.5580878	1.6564758	0.3446359	0.2001112	0.0611451	0.1111729	0.077821	0.1222902	0.2167871	0.1612007	0.3057254	0.2001112
14.4 <= WS < 18	0.072262368	0.077821	0.1222902	0.3779878	2.0455809	0.9338521	0.1056142	0.0500278	0.0333519	0.0444691	0.0333519	0.0667037	0.1111729	0.077821	0.0833797	0.1111729
18 <= WS < 21.6	0.050027793	0.0500278	0.172318	0.3335186	1.6787104	0.733741	0.1111729	0.0333519	0	0.0389105	0.0667037	0.0667037	0.077821	0.0555864	0.077821	0.0611451
21.6 <= WS < 25.2	0.005558644	0.0444691	0.0444691	0.1000556	0.639244	0.2279044	0.0166759	0.0277932	0.0055586	0	0.0222346	0.0222346	0.0277932	0.0444691	0.0333519	0.0500278
25.2 <= WS < 28.8	0.016675931	0.0111173	0.0277932	0.077821	0.3891051	0.1500834	0.0055586	0.0111173	0	0.0055586	0.0111173	0.0166759	0.0222346	0.0111173	0.0500278	0.0055586
28.8 <= WS < 32.4	0.005558644	0.0055586	0.0277932	0.0277932	0.1167315	0.0389105	0	0	0	0.0055586	0.0055586	0.0111173	0.0166759	0.0055586	0	0.0055586
32.4 <= WS < 36	0.005558644	0	0.0055586	0.0111173	0.0444691	0.0500278	0.0055586	0	0	0	0.0055586	0	0.0111173	0	0.0055586	0.0055586
WS >= 36	0.005558644	0	0	0.0055586	0.0667037	0.0055586	0	0	0	0.0055586	0.0055586	0	0.0111173	0.0055586	0.0055586	0.0055586
Total	1.834352418	1.2896053	2.1789883	3.4185659	27.520845	8.2267927	3.07393	0.9616454	0.8949416	0.7392996	0.8504725	0.7615342	1.7398555	1.0783769	1.4563646	1.2117843

Mackay

Calms= 4.33%

WSpeed vs WDir

Sector	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
0.00 <= WS < 3.6	0.040881274	0.0320761	0.0257867	0.0144657	0.0207551	0.0163525	0.0176104	0.0075473	0.0352208	0.0320761	0.0446549	0.0823915	0.20818	0.0647811	0.0289314	0.0352208
3.6 <= WS < 7.2	0.233337736	0.1364806	0.1044045	0.0729574	0.0924546	0.0496865	0.0534601	0.0503154	0.164783	0.1918275	0.3037793	0.6421505	1.5415385	0.4572413	0.1842802	0.1786197
7.2<= WS < 10.8	0.682402813	0.416989	0.4119575	0.2547218	0.4081838	0.2050353	0.154091	0.2163563	0.9188853	1.1264363	1.8258206	3.3145279	6.2340799	0.8075624	0.4000075	0.4075549
10.8 <= WS < 14.4	0.871085618	0.4735938	0.5534696	0.5742247	1.1924753	0.6402637	0.3748498	0.5446644	2.2396649	1.6000302	1.3874476	1.1553677	1.6981452	0.2459166	0.2345956	0.3673025
14.4 <= WS < 18	0.936495657	0.4157311	0.5062989	0.9478166	2.3553904	1.3258112	0.6308295	0.8679409	2.2660805	0.5018963	0.2157273	0.0955993	0.1383674	0.0591206	0.0974861	0.274219
18 <= WS < 21.6	0.92769046	0.4629018	0.4968647	1.108197	2.9604332	2.2767725	1.2012805	1.2188909	1.4541155	0.1119518	0.0666679	0.0452839	0.0238998	0.0119499	0.054718	0.2056643
21.6 <= WS < 25.2	0.866683019	0.4427756	0.3773656	0.6956106	2.4038189	3.1679843	1.9799116	1.1729781	0.7603917	0.0509444	0.0427681	0.0276735	0.0050315	0.0031447	0.022013	0.1622672
25.2 <= WS < 28.8	0.666679246	0.2616402	0.1270464	0.1704435	1.1893306	3.0277301	2.8296131	0.9723454	0.2993767	0.0201262	0.0232709	0.011321	0.011321	0.0037737	0.0132078	0.1125807
28.8 <= WS < 32.4	0.423907369	0.1031466	0.0157236	0.022013	0.5421486	2.3937559	2.8472235	0.7471839	0.0962282	0.010692	0.0132078	0.010692	0.0018868	0.0018868	0.0081763	0.0559759
32.4 <= WS < 36	0.193085404	0.0283024	0.0050315	0.0088052	0.2163563	1.415121	1.9327409	0.4773675	0.0301892	0.0006289	0.0037737	0.0031447	0	0.0006289	0.0018868	0.0213841
WS >= 36	0.137738448	0.0075473	0.0018868	0.0132078	0.1433989	0.8836645	1.2868167	0.2427719	0.0069184	0.0012579	0.0044026	0.0044026	0.0031447	0	0.0012579	0.0213841
Total	5.979987044	2.7811846	2.6258357	3.8824632	11.524746	15.402177	13.308427	6.518362	8.2718542	3.6478676	3.9315207	5.3925546	9.8655949	1.6560061	1.0465606	1.8421731

Thangool
Calms= 30.4%
WSpeed vs WDir

Sector	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
0.00 <= WS < 3.6	0.421312233	0.444433	0.7501413	2.0320608	2.6049427	1.4411961	0.7116066	0.3211221	0.1464317	0.1053281	0.1207419	0.1464317	0.113035	0.1798284	0.3493809	0.3776396
3.6 <= WS < 7.2	1.310178287	1.1817294	2.8798233	2.9517546	8.1410882	2.9003751	4.2593639	0.7732621	0.7501413	0.2440528	0.5086575	0.228639	0.4675538	0.3082772	1.114936	0.6165545
7.2<= WS < 10.8	0.382777578	0.7321585	1.2510918	0.8426245	1.2947644	1.4077994	3.0365309	0.8760212	0.2055182	0.2851565	0.3725017	0.110466	0.107897	0.1721215	0.5985716	0.2851565
10.8 <= WS < 14.4	0.053948518	0.3082772	0.4983815	0.6088476	0.1412937	0.8837281	0.9428146	0.5086575	0.0385347	0.2517597	0.1978112	0.1001901	0.0205518	0.1490007	0.4161743	0.3134152
14.4 <= WS < 18	0.161845553	0.4187433	0.7450033	0.6088476	0.3725017	1.227971	1.4000925	0.5189334	0.0513795	0.2646046	0.2106561	0.1361558	0.0179828	0.1027591	0.3236911	0.2646046
18 <= WS < 21.6	0.04367261	0.0385347	0.107897	0.1387248	0.0667934	0.3416739	0.333967	0.1053281	0.005138	0.0539485	0.0873452	0.002569	0.0077069	0.0462416	0.1361558	0.0590865
21.6 <= WS < 25.2	0.09505215	0.1695525	0.2877254	0.1541386	0.1387248	0.45214	0.5420542	0.0924832	0.0462416	0.0488106	0.0873452	0.0231208	0.002569	0.0333967	0.1284489	0.0796383
25.2 <= WS < 28.8	0.007706931	0.0333967	0.1027591	0.0822073	0.0539485	0.3802086	0.3057083	0.0513795	0.0077069	0.0488106	0.0796383	0.0154139	0.005138	0.0308277	0.0899142	0.0411036
28.8 <= WS < 32.4	0.002568977	0.0154139	0.0590865	0.0488106	0.0154139	0.1798284	0.1001901	0.0282587	0	0.0154139	0.0154139	0.0077069	0	0.0077069	0.0256898	0.0385347
32.4 <= WS < 36	0.007706931	0.0436726	0.0359657	0.0205518	0.0333967	0.1001901	0.1207419	0.0282587	0.0077069	0.0128449	0.0102759	0.0102759	0.002569	0.0102759	0.0128449	0.0128449
WS >= 36	0.007706931	0.0102759	0.0179828	0.0077069	0.0231208	0.0256898	0.0282587	0.005138	0.005138	0.005138	0.002569	0	0.002569	0.002569	0.002569	0.0128449
Total	2.494476699	3.3961876	6.7358578	7.496275	12.885989	9.3408005	11.781329	3.3088424	1.2639367	1.3358681	1.6929559	0.780969	0.7475723	1.0430047	3.1983764	2.1014232

Rockhampton
Calms= 9.3%
WSpeed vs WDir

Sector	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
0.00 <= WS < 3.6	0.201874472	0.0963614	0.0904398	0.0812881	0.1577313	0.1959528	0.2470944	0.2110261	0.2670126	0.1846479	0.1577313	0.134583	0.0968997	0.0629848	0.0554482	0.0818265
3.6 <= WS < 7.2	0.658918276	0.3601441	0.3073875	0.2772409	0.6330783	0.749358	1.008834	0.9264692	1.2198601	0.6626866	0.4893437	0.2950059	0.2880076	0.1690362	0.1997211	0.2745493
7.2<= WS < 10.8	1.677442277	0.9167793	0.6922949	0.7035998	1.9116167	3.2719814	3.8716832	2.1393311	2.0854979	0.7665847	0.5609419	0.3768323	0.4252822	0.2982359	0.3768323	0.4629655
10.8 <= WS < 14.4	1.536399313	1.0454406	0.7396681	0.9157026	2.8892274	5.6659435	5.1545282	1.1848686	0.7186731	0.4193606	0.3332275	0.2427877	0.2653976	0.2034895	0.2874692	0.4581205
14.4 <= WS < 18	0.939927541	1.0653589	0.7595863	1.0852772	3.5707557	4.3389553	3.2337599	0.4198989	0.2567843	0.4166689	0.3165392	0.1975678	0.1609612	0.0952848	0.1545013	0.3375341
18 <= WS < 21.6	0.522720299	0.8274162	0.6960632	0.7488197	2.8450842	2.8289343	1.4787978	0.1254313	0.1437346	0.3644507	0.2820859	0.1555779	0.1130497	0.0452199	0.0985147	0.2083345
21.6 <= WS < 25.2	0.199721144	0.4398172	0.3213842	0.2621676	1.2710017	1.6952072	0.6174667	0.0322999	0.0796731	0.265936	0.1798029	0.111973	0.0581398	0.0312233	0.0430666	0.1173564
25.2 <= WS < 28.8	0.078596461	0.1173564	0.0920548	0.0398366	0.3154625	0.7138281	0.1814179	0.0091516	0.0317616	0.1335063	0.0850564	0.0500649	0.0349916	0.014535	0.01615	0.0613698
28.8 <= WS < 32.4	0.03068492	0.0231483	0.0107666	0.00323	0.0715981	0.2164094	0.0290699	0.0043067	0.0118433	0.0543715	0.0301466	0.0139966	0.0269166	0.00646	0.0053833	0.0301466
32.4 <= WS < 36	0.003229992	0.00323	0.001615	0.0005383	0.0086133	0.0398366	0.0037683	0.0005383	0.0037683	0.0199183	0.0139966	0.0037683	0.0123816	0.0010767	0.0021533	0.0026917
WS >= 36	0.002153328	0	0.0005383	0	0.0053833	0.0043067	0.0005383	0.0005383	0.0010767	0.004845	0.0059217	0.0053833	0.00969	0.0005383	0.0005383	0.0026917
Total	5.851668021	4.8950522	3.7117986	4.1177009	13.679553	19.720713	15.826959	5.0538601	4.8196857	3.2929764	2.4547936	1.5875408	1.4917178	0.9280842	1.2397784	2.0375863

Appendix F

Generic Veneering System Proposal

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Generic Veneering System Proposal
Environmental Evaluation
Queensland Rail Limited

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Contents

Executive summary

This supplementary report presents the particulars of a design proposal for a generic veneering system which could be implemented throughout the Central Queensland Coal Industry that was undertaken by Connell Hatch with respect to the Environmental Evaluation commissioned by Queensland Rail Limited. Applying a suppressant to the coal profile of loaded coal wagons has been identified as a mitigation strategy to reduce coal dust emissions from the top of loaded coal wagons during transport. This report is concerned with the development of a generic veneering system design, encompassing both capital investment and operational cost estimates. Accordingly, the completion of this report aims to:

- Determine the most suitable method of applying a suppressant to loaded coal wagons that can be supported by, and assimilate effectively into, the Central Queensland Coal Industry
- In relation to the nominated method:
  – Determine the functional specifications
  – Detail a process flow diagram
  – Identify site specific and special conditions
  – Estimate the capital investment
  – Estimate the operational costs
- Assess the practicability and cost-effectiveness of the developed system

The outcomes achieved with respect to the aims of the report include:

- The most suitable method of applying a suppressant to loaded coal wagons that is similarly generic for the majority of the Central Queensland Coal Industry includes:
  – Water and suppressant storage tanks and associated pumping systems
  – Dosing system with adjustable control to achieve the desired solution strength
  – Shower bar to apply suppressant to the coal profile
  – Control system facilitating autonomous operation
  – A shield to enclose the system to prevent infrastructure fouling
- The most influential site specific factor is the availability and cost of water
- The estimated capital investment associated with the veneering system is \$50,000 – \$65,000 per wagon loading system
- The estimated operational cost associated with the veneering system is \$1.55 - \$3.06 per wagon trip
- Veneering rates very highly with respect to the weighted rating system, presenting the most practical and cost-effective short-term mitigation strategy to reduce coal dust emissions from the top of coal wagons

Glossary of terms

CFD
Computational Fluid Dynamics

CQCI
Central Queensland Coal Industry – entire coal supply chain

CQCN
Central Queensland Coal Network – entire rail infrastructure network

EE
Environmental Evaluation

EPA
Environmental Protection Agency

QR
Queensland Rail Limited

QRNA
Queensland Rail Network Access – below rail operator

QRN
Queensland Rail National – above rail operator

1. Introduction

Queensland Rail Limited (QR) has appointed Connell Hatch, John Planner of Introspec Consulting and Katestone Environmental to prepare an Environmental Evaluation (EE) of coal dust emissions engendered from rollingstock in the Central Queensland Coal Industry (CQCI) in response to a Notice issued by the Queensland Environmental Protection Agency (EPA). The deliverables of the report have been stipulated by the Terms of Reference for the project which encompass:

a) Identify all potential sources of coal dust emissions from QR trains in Central Queensland on land described as rail lines connecting coal mines in the Bowen and Callide Basins with ports at Dalrymple Bay, Hay Point and Gladstone

b) Quantify the potential risk of environmental harm posed by each dust source

c) Identify the factors and circumstances that contribute to dust emissions and/or impacts from each source. Consideration should be given to (but not limited to) issues such as coal type, coal properties and meteorological conditions.

d) Based on the findings from the above, identify locations within QR's Central Queensland operations where proximity of railway lines to communities may give rise to higher risk of environmental harm due to fugitive coal dust

e) Identify ways to reduce the risk being caused by coal dust emissions and assess each for practicability, effectiveness and cost, in relation to the mitigation of environmental impacts of fugitive coal dust emissions

The sources of coal dust emissions that have been identified in the CCQI include emissions from:

- The coal surface of loaded wagons
- Coal leakage from the doors of loaded wagons
- Wind erosion of spilled coal in the rail corridor
- Residual coal in unloaded wagons and leakage of residual coal from the doors
- Parasitic load on sills, shear plates and bogies of wagons

This supplementary report presents the particulars of a generic veneering system design which could be implemented to apply a suppressant to the coal profile of loaded coal wagons in the CQCI. Accordingly, the deliverables of the report include:

- Identifying the most suitable method of applying a suppressant to loaded coal wagons
- Determining the functional specifications and process flow diagrams for the system
- Identifying site specific factors which need to be considered with respect to the generic design
- Estimating the capital investment and operational cost of implementing the system
- Assessing the practicability and cost-effectiveness of the proposed system

Wind tunnel testing and Computational Fluid Dynamics (CFD) modelling conducted by John Planner will be utilised to develop generic functional specifications for the proposed veneering system. Establishing the functional specifications for the system will enable a design to be completed and capital investment and operating costs estimated.

2. Veneering

2.1 Definition

Veneering refers to the process of applying a suppressant to the coal profile of loaded coal wagons. Suppressing agents facilitate the agglomeration of coal particles on the exposed surface by forming a web over the coal profile, increasing the inertia of the exposed coal particles, subsequently reducing the probability that wind forces extricate these particles during transport.

2.2 Literature

Suppressing agents have been extensively investigated for suppressing coal dust from stockpiles at mine and port facilities. Differences in the factors and circumstances facilitating dust emissions from stockpiles and loaded coal wagons determine that no quantitative relationships can be drawn between the applications.

Burlington Northern Santa Fe (BNSF) and Union Pacific railways are currently conducting a large ongoing study into the issues of coal dust emissions and ballast fouling on the joint line in the Southern Powder River Basin, United States of America. Part of this study includes "… analyze and field test coal dust suppression alternatives[1]."

The report titled Coal Dust Emissions Literature Review that was undertaken with respect to the EE concluded that "Quantification of coal dust emissions must be determined by conducting work (trials, testing, modelling etc), in or which replicate Central Queensland Coal Industry conditions", infers that studies pertaining to veneering applications cannot be used to draw quantitative conclusions regarding suppressing loaded coal wagons in the CQCI.

2.3 Suppressants

There are numerous suppressing agents available that can be used for veneering applications, many of which have been developed and implemented for suppressing coal stockpiles. All suppressants achieve agglomeration of the coal profile, however their attributes vary appreciably. Consequently there are many suppressant characteristics which need to be considered, viz:

- Suppressant effectiveness (including lifespan)
- Suppressant and water availability, usage, shelf-life and cost
- Suppressant implications
  - Handleability
  - Rollingstock
  - Storage tanks and mechanical equipment and surrounding infrastructure
  - Persons
  - Environment
  - Customer

2.4 CQCI trials

Trials of veneering systems have been conducted at wagon loading facilities in the CQCI in past years. All of the trials have used similar basic mechanical components, with the veneering application achieved by means of the following components:

- Water and suppressant storage tanks and associated pumping systems
- Dosing system to achieve the desired solution strength
- Shower bar to apply suppressant to the coal profile (see Figure 1)
- Control system facilitating autonomous operation

[1] http://www.spp.org/publications/RSC_102405_KraemerPresnt.pdf

In this way, it has been shown that the trialled veneering systems are compatible with continuous wagon loading systems, and consequently veneering applications can assimilate effectively into normal operations with minimal disruption to the supply chain.

Figure 1 – Trial Veneering System

Figure 2 – Veneering Trial Train

Initially three different suppressants were trialled at a wagon loading facility in the CQCI. The first half of each train was veneered with a suppressing agent, with the second half remaining untouched for comparative purposes. Figure 2 shows a photograph of a train participating in the trial which displays a noticeable increase in the dust cloud around the second half of the train. Some of the key issues and observations arising from the trials include:

- Water consumption - it was identified that the long-term sustainability of veneering applications would depend heavily on water usage
- Cost - it was noted that a small operating cost differential would result in a noteworthy overall cost if veneering was adopted throughout the CQCI
- Suppressant implications on rollingstock - some suppressing agents were sticky in nature and adhered to rollingstock during the trial, proving difficult to remove. This is not acceptable for rail operators as regular veneering applications may degrade the quality of the rollingstock resulting in long-term sustainability issues

The recommendation of the initial trials was that a year long trial be pursued with a chosen suppressing agent to perform thorough testing in varying weather conditions with varying coal types. The recommendation was adopted and a year-long trial was implemented which produced positive results.

During the trial, damage occurred to the overhead insulators by means of fouling (see Figure 3). The prevailing winds at the mine blew the suppressant onto the insulators, facilitating the build-up of coal dust. Damage to infrastructure of this nature is unacceptable, therefore any proposed veneering system must detail a solution to avoid insulator fouling.

Figure 3 – Fouled Insulator

2.5 EE modelling and testing

John Planner conducted wind tunnel testing and CFD modelling to produce a testing regime and model to test the effectiveness of veneering applications for the EE. The testing regime implemented was developed to estimate the effectiveness of veneering applications in the CQCI. This was achieved by testing six typically dusty (high dust emission tendency) CQCI coal types at CQCI operating speeds, comparing five suppressing agents available for veneering applications in the CQCI against the nil suppressant option. The key outcomes with respect to the testing and this report include:

- A ‘garden-bed’ profile reduces turbulent air flow over the coal surface, reducing the probability that coal dust lift-off will occur at a given operating speed
- Veneering is an effective method of significantly reducing coal dust emissions from the top of loaded coal wagons during transport through the CQCI at nominal operating speed
- The effectiveness of a suppressing agent varies according to coal type and properties
- Coal profile slumping following veneering compromises the effectiveness of the suppressant
- The veneer application thickness required is 1 mm, equating to 1 L/m^2 of solution
- The solution strength required ranges from 1.5% – 6%

3. Veneering system

The generic system design consists of the following basic components:

- Water and suppressant storage tanks and associated pumping systems
- Dosing system with adjustable control to achieve the desired solution strength
- Shower bar to apply suppressant to the coal profile
- Control system facilitating autonomous operation
- A shield to enclose the system to prevent infrastructure fouling

The veneering systems used in the trials assimilated effectively into continuous loading operations, which constitute the vast majority of the wagon loading systems in the CQCI (see Table 1). The systems have proved to be an effective method of applying suppressant to the coal surface immediately following loading, which can operate independently of, and not interfere with other infrastructure and systems. System downtime does not impose delays to the train during loading. Accordingly, no critical changes have been made to previous trial veneering systems.

The insulator fouling that occurred has determined that shielding around the veneering application, which will vary in design by location (based on geometry, topography, meteorological conditions etc), is an essential feature of the generic veneering system design. This will help protect the surrounding infrastructure from the risk of fouling.

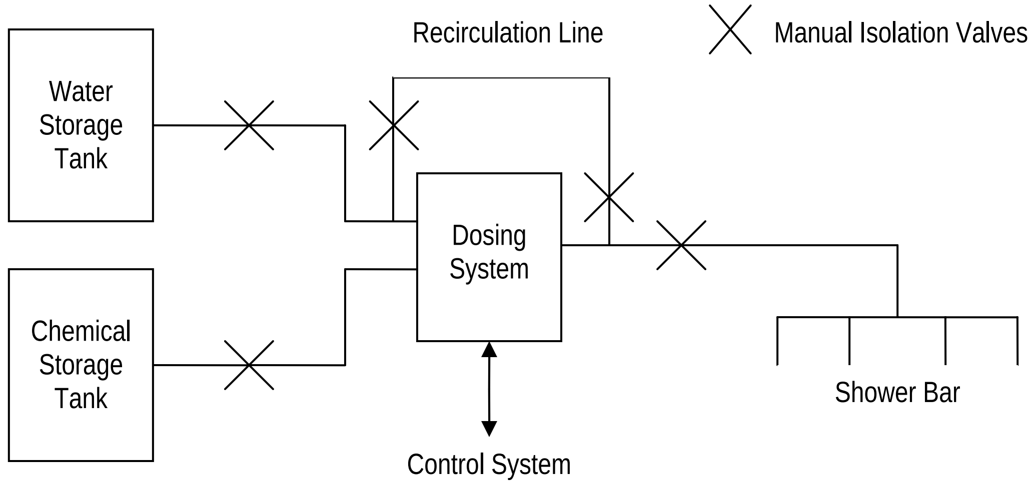
Table 1 details the number of stationary and continuous wagon loading practices currently operational in each system throughout the CQCI.

Table 1 – CQCI Wagon Loading Practices by System (#)

System	Stationary	Continuous	Total
Goonyella	0	19	19
Blackwater	1	10	11
Newlands	0	3	3
Moura	1	0	4
Total	2	35	37

QR Internal Data

3.1 Process flow diagram



3.2 Site specific requirements

3.2.1 Layout

The physical layout of the components is dependant on the layout of each wagon loading facility, thus consideration should be given to the following factors:

- Geometric constraints
- Accessibility
- Safety
- Interference with other equipment
- Water (location of supply, availability etc)
- Suitable chemical storage area

3.2.2 Control system

The control system required to autonomously operate a veneering system will depend upon the equipment and control system available at each mine. Some facilities may require the installation of additional inputs (sensory information) in order to gain sufficient information to completely automate the veneering process.

3.2.3 Shielding

The specific design of the shielding will be a site specific design based upon many factors including the location of surrounding infrastructure, topography, meteorological conditions etc.

3.2.4 Location

Slumping of the coal surface of a loaded wagon after veneering will cause the web that has formed over the coal surface to break down, as noted in Section 3.1 of the report titled Coal Dust Emission Literature Review. Accordingly, the effectiveness of veneering applications can be compromised if wagons are loaded with unstable coal profiles, generally attributable to overloading. It is therefore prudent, in the absence of improving loading techniques, to locate the veneering system after any manual profiling devices, the location and application of which are highly variable.

4. Functional requirements

4.1 Assumptions

Inline with the scope to develop a generic veneering system which could be implemented throughout the CQCI, the functional requirements will be derived from average results/trends noted through the trial work that has been undertaken by John Planner. The system is therefore independent of the suppressing agent, providing a generic but realistic representation of a veneering system that is suitable and appropriate for the conditions and coal types found in the CQCI. Accordingly, the two fundamental veneering variables are nominated to be:

- 1 L/m^2 of solution (suppressant suspended in water)
- 1.5 – 6% solution strength (suppressant percentage of total volume)

The generic design also determines that the system should be designed to account for the largest potential surface area, which occurs on the largest wagon, the VSA class. This decision is justifiable as the VSA wagon is the predominant wagon class in the CQCI fleet (see Table 2).

Table 2 – CQCI Wagon Numbers by Class and System (#)

System	Wagon Class			
	VSAS	VAZQ/VAZQB	VALKQ	VNLQ
	106 t	80 t	80 t	90 t
Moura	116	244	–	–
Blackwater	1832	150	502	–
Goonyella	2,110	–	–	550
Newlands	–	312	–	–
Total	4,058	706	502	550
Percentage	70%	12%	9%	9%

QR Internal Data

4.2 Calculations

$$Application\ Area\ (m^2) \approx Wagon\ Width\ (m) \times Wagon\ Length\ (m)$$

$$Application\ Area\ (m^2) \approx 13.1\ (m) \times 2.3\ (m)$$

$$Application\ Area\ (m^2) \approx 31\ m^2$$

$$Application\ Volume\ (L) = Application\ Area\ (m^2) \times Application\ Quantity\ (L/m^2)$$

$$Application\ Volume\ (L) = 31\ (m^2) \times 1\ (L/m^2)$$

$$Application\ Volume\ (L) = 31\ L$$

$$Application\ Rate\ (L/min) = \frac{Application\ Volume\ (L/wagon) \times Train\ Speed\ (km/min)}{Length\ (km/wagon)}$$

$$Application\ Rate\ (L/min) = \frac{31\ (L/wagon) \times 0.5 - 2.0\ (km/hr)}{0.013108\ (km/wagon) \times 60\ (min/hr)}$$

$$Application\ Rate\ (L/min) = 20 - 80\ L/min$$

4.3 Nominated factors

An operating pressure of 6 bar has been nominated as an average standard output pressure from a nozzle that would be suitable for a veneering application. This pressure could vary depending upon the type of nozzle chosen, which will be a function of many factors such as the spray distance, desired spray characteristics, solution properties etc.

Due to the variability in water facilities available at each mine throughout the CQCI, it will be assumed for the purposes of this report that the water will be supplied from a 20,000 L tank (minimum size), which will be filled as required by any nominated means. The storage and supply of the chemical required for veneering will be assumed to be supplied and suitably stored in a tank of a sufficient size by the suppressant client.

5. Capital investment

The estimated capital investment required for the installation of the generic veneering system design is detailed in Table 3. The cost estimate includes the basic mechanical, civil and electrical elements of the system as well as the labour required for the installation and commissioning of the system.

Table 3 – Capital Expenditure Estimate

Item	Quote	Estimate	Total
20,000 L water tank (including foundations)	✓		$3,000 – $15,000
Dosing system (pumps, valves, control panel)	✓		$6,750
Shower bar		✓	$1,000
Nozzles		✓	$100
Manual valves		✓	$1,250
Piping		✓	$1,000
Shielding*		✓	$2,000
Sensor and control system components		✓	$7,500
Labour		✓	$17,500
Contingency (25%)		✓	$10,000 – $13,000
Total			**$50,000 – $65,000**

** Static*

6. Operational cost

The estimated operational cost, on a per wagon trip basis, associated with the veneering system is dependant upon three main costs which are detailed in the following subsections.

6.1 Suppressant

$$Suppressant\ Cost\ Range\ (\$/m^2) = \$0.04 - \$0.08$$

$$Suppressant\ Cost\ (\$) = Application\ Area\ (m^2) \times Suppressant\ Cost\ (\$/m^2)$$
$$Suppressant\ Cost\ (\$) = 35\ (m^2) \times 0.04 - 0.08\ (\$/m^2)$$
$$Suppressant\ Cost\ (\$) = \$1.40 - \$2.80$$

6.2 Water

$$Water\ Application\ Volume\ (L/wagon) = 35 - 70$$

$$Water\ Cost\ (\$) = Application\ Volume\ (L) \times Water\ Cost\ (\$/L)$$
$$Water\ Cost\ (\$) = 35 - 70\ (L) \times 0.003\ (\$/L)$$
$$Water\ Cost\ (\$) = \$0.11 - \$0.21$$

6.3 Maintenance

$$Maintenance\ Cost\ (\$) = \frac{Capital\ Investment \times Maintenance\ Factor\ (\%)}{Wagon\ Trips\ (\#)}$$
$$Maintenance\ Cost\ (\$) = \frac{\$50{,}000 - \$65{,}000 \times 5\ (\%)}{85800000/85.25/19}$$

$$Maintenance\ Cost\ (\$) = \$0.04 - \$0.05$$

6.4 Total

The total estimated operational cost of the veneering system is \$1.55 – \$3.06 per wagon trip.

7. Assessment

7.1 Prelude

The practicability and cost-effectiveness of the proposed veneering system is determined by giving a weighted score to predetermined rating factors. The rating system has been developed in order to facilitate a weighted score for each mitigation strategy arising from the EE which has a generic comparable base. This was achieved by developing:

- A set of weighted rating factors which are relevant to the practicability and cost-effectiveness of a mitigation strategy, and
- A rating guide (see Appendix B) pertaining to various aspects of the rating factors which will highlight the differences between the different mitigation strategies

7.2 Veneering

Table 4 shows that veneering scores highly with respect to the rating factors for cost-effectiveness, scoring 4.0 out of 5, with 5 being the highest. Table 5 shows that veneering scores very highly with respect to the weighted rating factors for practicability, scoring 4.74 out of 5. The combination of these high scores determines that veneering is practical and cost-effective mitigation strategy to reduce coal dust emissions from the top of loaded coal wagons during transport in the CQCI.

Table 4 – Veneering Cost-Effectiveness Assessment

Factor	Rating Code	Weighting	Rating
Capital Investment	A	20%	4
Operational Cost	B	40%	4
Effectiveness	C	40%	4
Total		100%	4.0

Table 5 – Veneering Practicability Assessment

Factor	Rating Code	Weighting	Rating
Implementation			
Ease	D	8%	5
Time	E	8%	4
Resources	D	8%	4
Capacity Impact	G	35%	5
Maintainability	D	2%	5
Reliability	F	15%	5
Implementation Risk	G	14%	5
Safety	F	5%	5
Environmental	F	5%	3
Total		100%	4.74

7.3 Comparison

Appendix B contains a complete assessment including both practicability and cost-effectiveness for all of the identified mitigation strategies. Figure 4 shows that veneering is a much more practical and cost effective mitigation strategy than implementing wagon lids to reduce coal dust emissions from the top of loaded wagons. Furthermore veneering is a short term mitigation strategy whereas wagon lids are considered to be a long term strategy.

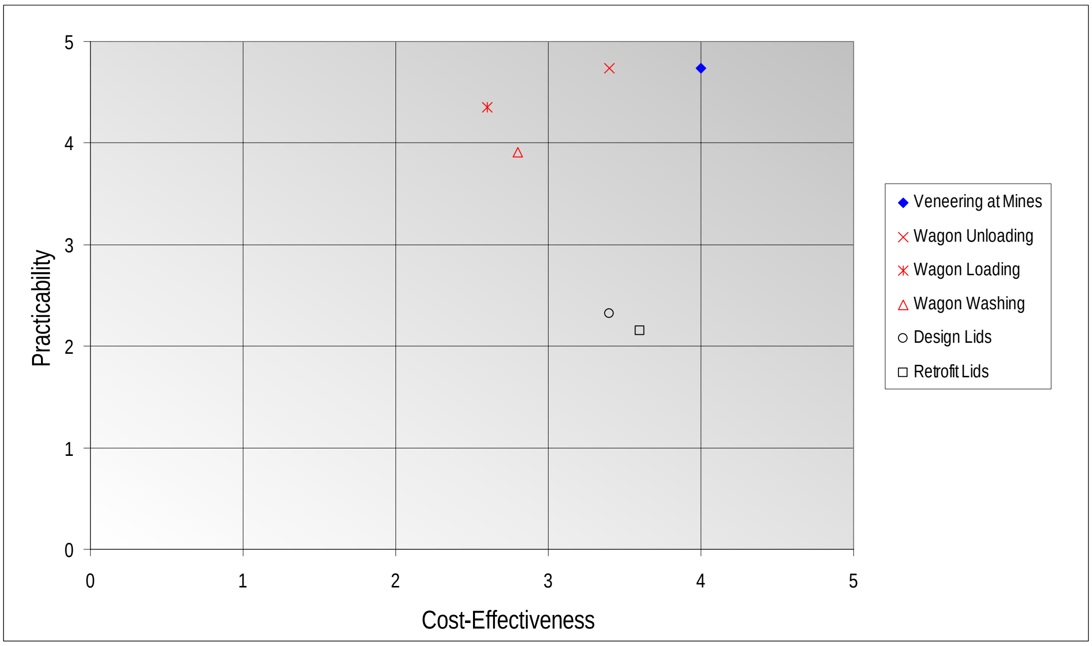


Figure 4 – Mitigation Strategies Assessment Summary

8. Conclusion

Successful trials of veneering systems in conjunction with noted improvements determine that a generic veneering system design which can assimilate effectively into continuous loading operations which are prevalent throughout the Central Queensland Coal Industry comprises of:

- Water and suppressant storage tanks and associated pumping systems
- Dosing system with adjustable control to achieve the desired solution strength
- Shower bar to apply suppressant to the coal profile
- Control system facilitating autonomous operation
- A shield to enclose the system to prevent infrastructure fouling

Site specific features which could alter the design and costs associated with installing, commissioning and operating the system include water availability, geometric constraints, topography, meteorological conditions, coal type and properties etc.

The estimated capital investment required for the installation and commissioning of an autonomous veneering system is $50,000 – $65,000 per wagon lading facility, with an operating cost range of $1.55 – $3.06 per wagon trip. Veneering rates very highly with respect to the weighted rating system, presenting the most practical and cost-effective short-term mitigation strategy to reduce coal dust emissions from the top of coal wagons.

Appendix A

Veneering Fact Sheet

Veneering

Veneering is the process of applying a suppressant to the coal surface of a loaded coal wagon, prior to transportation, in order to reduce coal dust emissions.

"Although atypical, … visible dust is emitted by some trains … Such occurrences need to be mitigated." (QR EE Interim Report, Jan 2008)

Capital Investment
$50,000 - $65,000*

Operational Cost
$1.55 - $3.06#

Major Benefit
75% reduction in coal dust from the top of wagons

Additional Information
Chemical
$1.40 - $2.80

Water
35 – 70 L
$0.11 - $0.21

Maintenance (5%)
$0.04 - $0.05

Relative wind speed and direction during travel lift particles from the coal surface emitting coal dust on public amenities and in the rail corridor. Applying a suppressant significantly reduces coal loss by creating a web over the coal surface.

Currently, suppressant trials are being conducted by Anglo Coal at Boundary Hill and Callide mines using a DuPont product. Ensham and South Walker mines have also trialled suppressants with Applied Chemicals.

A number of veneering products have been trialled by the consultants for the Environmental Evaluation. The results have shown that the effectiveness of veneering according to coal type, suppressant to solution strength.


1


2

Advantages

- Simple, cost-effective system
- Effective in the Central Queensland coal industry conditions
- Compatible with continuous, low speed loading operations
- Area of technical development
- System downtime does not impact the supply chain

Disadvantages

- Reliance on chemical and water availability
- Suppressant affects on rolling-stock
- Suppressant affects on infrastructure at wagon loading facilities (including overhead insulators)

1. Suppressant trial
2. Suppressant trial

* per wagon loading facility
\# per wagon trip

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Appendix B

Mitigation Strategies Assessment

Client: Queensland Rail Limited
Job Number: H327578-N00-EE00
Project: Environmental Evaluation
Description: Coal Dust Emissions Mitigation Strategies Rating Guide

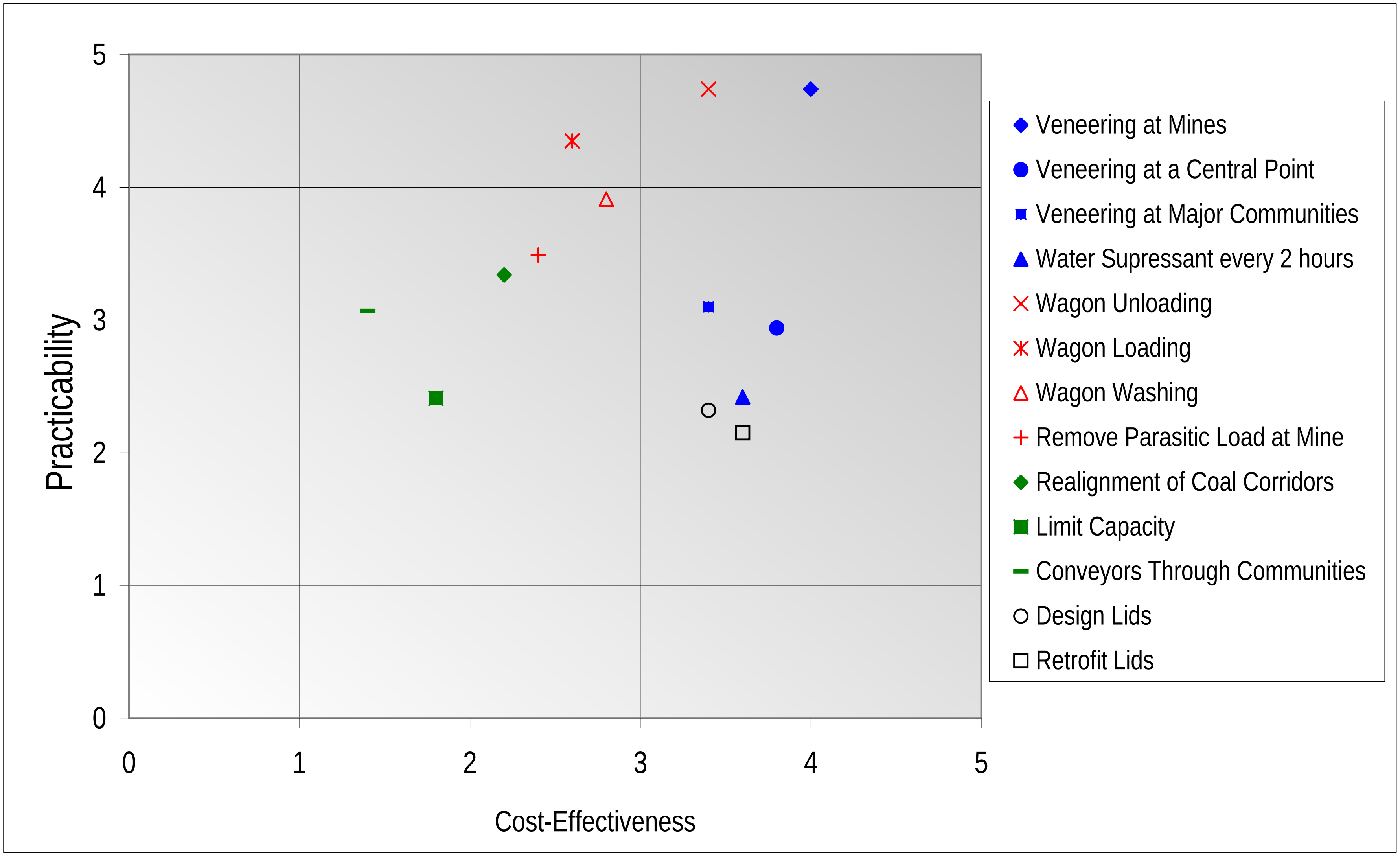
Date: 31.03.2008
Revision: 0

Mitigation Strategies Rating Guide

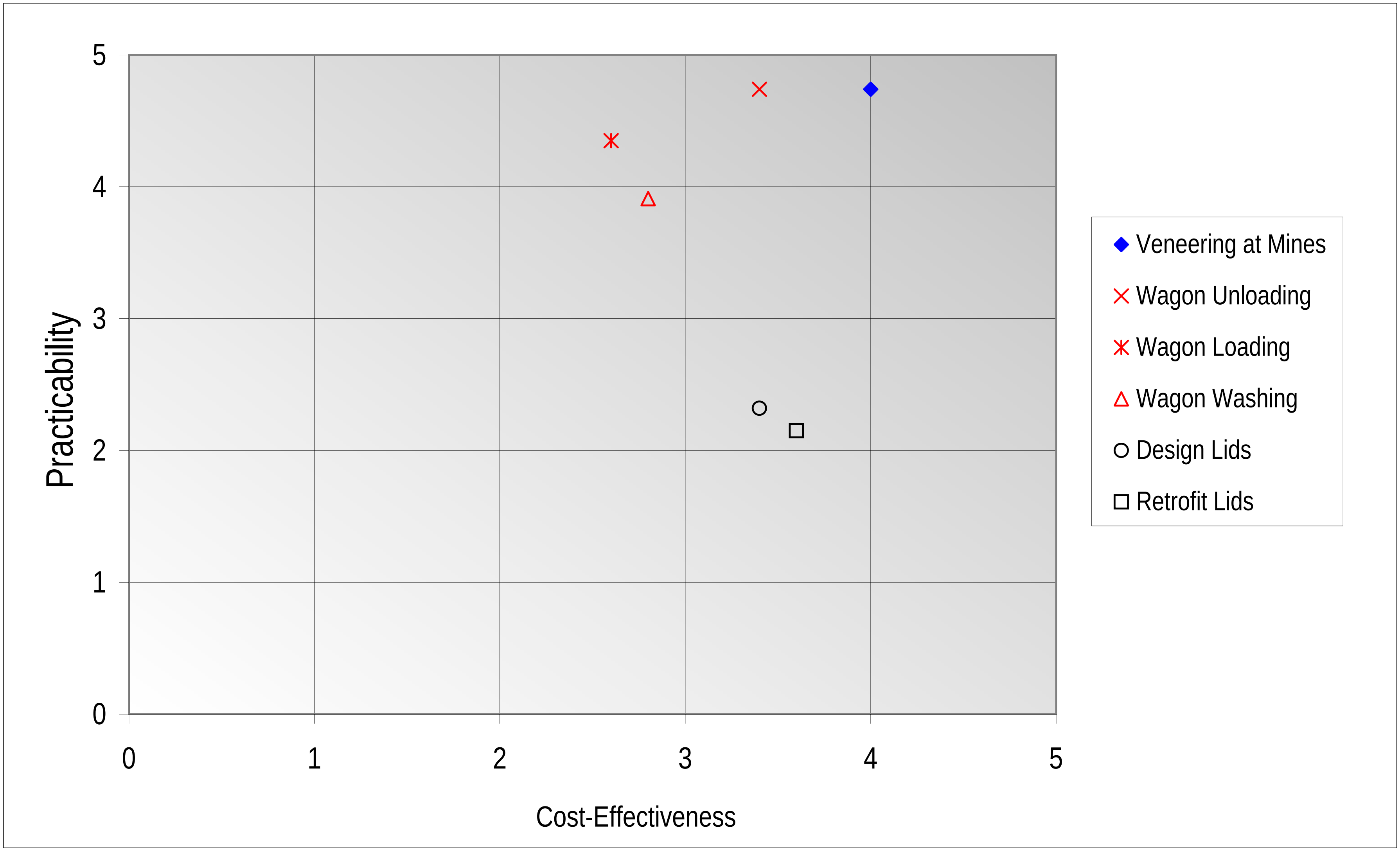
		Rating Code						
		A	B	C	D	E	F	G
Rating	5	<$1M	<$1	>80%	Very Easy	<1 month	No Impact	Very Low
	4	$1M – $10M	$1 – $5	>60 – 80%	Easy	1-12 months	Low Impact	Low
	3	>$10M - $25M	>$5 – $10	>40 – 60%	Achievable	>1-2 years	Some Impact	Medium
	2	>$25M - $50M	>$10 –$15	20 – 40%	Difficult	>2-5 years	High Impact	High
	1	>$50M	>$15	<20%	Extremely Difficult	>5 years	Untried	Very High

Rating Units

A	industry cost
B	per wagon trip
C	reduction of overall emissions
D	overall assessment
E	implementation timeframe
F	overall assessment
G	overall assessment



Practicability
Cost-Effectiveness
0
1
2
3
4
5
Veneering at Mines
Veneering at a Central Point
Veneering at Major Communities
Water Supressant every 2 hours
Wagon Unloading
Wagon Loading
Wagon Washing
Remove Parasitic Load at Mine
Realignment of Coal Corridors
Limit Capacity
Conveyors Through Communities
Design Lids
Retrofit Lids



Practicability
Cost-Effectiveness
0
1
2
3
4
5
Veneering at Mines
Wagon Unloading
Wagon Loading
Wagon Washing
Design Lids
Retrofit Lids

Cost-Effectiveness Assessment

	Rating Code	Weighting	Veneering at Mines	Wagon Loading	Wagon Washing	Wagon Unloading	Retrofit Lids	Design Lids	Conveyors Through Communities	Realignment of Coal Corridors	Limit Capacity	Remove Parasitic Load at Mine	Water Supressant every 2 hours	Apply Deflectors to Wagons	Veneering at a Central Point	Veneering at Major Communities
Capital Investment	A	20%	4	1	2	3	4	3	1	1	5	2	4	3	5	5
Operational Cost	B	40%	4	5	4	5	2	2	2	4	1	4	5	5	4	4
Effectiveness	C	40%	4	1	2	2	5	5	1	1	1	1	2	0	3	2
Total:		100%	4	2.6	2.8	3.4	3.6	3.4	1.4	2.2	1.8	2.4	3.6	2.6	3.8	3.4

Practicability Assessment

	Rating Code	Weighting	Veneering at Mines	Wagon Loading	Wagon Washing	Wagon Unloading	Retrofit Lids	Design Lids	Conveyors Through Communities	Realignment of Coal Corridors	Limit Capacity	Remove Parasitic Load at Mine	Water Supressant every 2 hours	Apply Deflectors to Wagons	Veneering at a Central Point	Veneering at Major Communities
Implementation																
Ease	D	8%	5	2	2	4	3	5	1	1	2	3	2	2	3	4
Time	E	8%	4	2	2	4	2	1	1	1	2	3	3	1	4	4
Resources	D	8%	4	5	3	5	5	5	4	2	5	2	1	5	3	4
Capacity Impact	G	35%	5	5	5	5	2	2	3	4	1	4	1	5	1	1
Maintainability	D	2%	5	4	4	5	3	5	4	5	5	4	4	4	4	4
Reliability	F	15%	5	4	4	5	1	1	3	5	4	3	3	5	5	5
Implementation Risk	G	14%	5	5	3	5	1	1	4	3	1	3	4	1	4	4
Safety	F	5%	5	5	5	4	2	2	5	4	5	5	5	5	5	5
Environment	F	5%	3	5	5	4	4	5	4	3	5	5	5	5	3	3
Total:		100%	4.74	4.35	3.91	4.74	2.15	2.32	3.07	3.34	2.41	3.49	2.42	3.86	2.94	3.1

Appendix G

Wagon Loading Practices Analysis

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Wagon Loading Practices Analysis
Environmental Evaluation
Queensland Rail Limited

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Infrastructure for Industry

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Rev No	Date	Revision Details	Typist	Author	Verifier	Approver
0	14 February 2008	Draft Report	BB	DJP	SMC	RJH
1	31 March 2008	Final Report	BB	DJP	SMC	RJH

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Contents

Executive summary

This supplementary report presents the particulars of a review of wagon loading practices employed throughout the Central Queensland Coal Industry that was undertaken with respect to the Environmental Evaluation commissioned by Queensland Rail Limited. Improving wagon loading practices has been identified as a mitigation strategy to reduce coal dust emissions from the top of load wagons during transport, residual coal in unloaded wagons and parasitic load on the wagon exterior. Accordingly, the completion of this report aims to:

- Identify wagon loading practices employed throughout the Central Queensland Coal Industry
- Identify factors and circumstances that attributable to wagon loading practices that contribute to coal dust emissions
- Develop a set of weighted Key Performance Indicators for wagon loading practices
- Rate the identified wagon loading practices with respect to the nominated indicators
- Propose an industry best practice for wagon loading systems
- Estimate the capital investment associated with upgrading wagon loading practices to reflect current best practice
- Assess the practicability and cost-effectiveness associated with upgrading wagon loading practices to reflect current best practice

The outcomes achieved with respect to the aims of the report include:

- The majority of wagon loading systems throughout the Central Queensland Coal Industry are volumetric loading systems relying on an operator to control loading on visual cues
- Volumetric systems are a root cause of a large proportion of coal dust emissions attributable to wagon loading practices
- The proposed best industry practice with respect to reducing coal dust emissions includes:
  - Inbound wagon identification system to determine the class of wagon about to be loaded
  - Inbound weighbridge to measure the tare weight of each incoming wagon
  - Batch weighing system to load the correct amount of coal into each wagon
  - Telescopic loading chute to profile the load in each wagon and control dust generated in the loading activity
  - Outbound weighbridge to measure the gross weight of each outgoing wagon
  - Volumetric scanning to measure the profile of each outgoing wagon
- The estimated capital investment required to upgrade existing volumetric wagon loading systems to reflect industry best practice is the range of $2 – 4 million
- The assessment of this best practice proposal indicates that the practicability of the system is rated highly, whereas the cost effectiveness is an average result, due mainly to the high capital investment combined with a low dust reduction score.

Glossary of terms

CQCI
Central Queensland Coal Industry – entire coal supply chain

CQCN
Central Queensland Coal Network – entire rail infrastructure network

EE
Environmental Evaluation

KPI
Key Performance Indicator

QR
Queensland Rail Limited

QRNA
Queensland Rail Network Access – below rail operator

QRN
Queensland Rail National – above rail operator

1. Introduction

Queensland Rail Limited (QR) has appointed Connell Hatch, John Planner of Introspec Consulting and Katestone Environmental to prepare an Environmental Evaluation (EE) of coal dust emissions engendered from rollingstock in the Central Queensland Coal Industry (CQCI) in response to a Notice issued by the Queensland Environmental Protection Agency (EPA). The deliverables of the report have been stipulated by the Terms of Reference for the project which encompass:

a) *Identify all potential sources of coal dust emissions from QR trains in Central Queensland on land described as rail lines connecting coal mines in the Bowen and Callide Basins with ports at Dalrymple Bay, Hay Point and Gladstone*

b) *Quantify the potential risk of environmental harm posed by each dust source*

c) *Identify the factors and circumstances that contribute to dust emissions and/or impacts from each source. Consideration should be given to (but not limited to) issues such as coal type, coal properties and meteorological conditions.*

d) *Based on the findings from the above, identify locations within QR's Central Queensland operations where proximity of railway lines to communities may give rise to higher risk of environmental harm due to fugitive coal dust*

e) *Identify ways to reduce the risk being caused by coal dust emissions and assess each for practicability, effectiveness and cost, in relation to the mitigation of environmental impacts of fugitive coal dust emissions*

The sources of coal dust emissions that have been identified in the CCQI include emissions from:

- The coal surface of loaded wagons
- Coal leakage from the doors of loaded wagons
- Wind erosion of spilled coal in the rail corridor
- Residual coal in unloaded wagons and leakage of residual coal from the doors
- Parasitic load on sills, shear plates and bogies of wagons

This report presents the particulars of a review into wagon loading practices that was undertaken by Connell Hatch with respect to the EE commissioned by QR. Wagon loading practices have been identified as a contributing factor to coal dust emitted from the top of loaded wagons, residual coal in unloaded wagons as well as parasitic load on the wagon exterior. Accordingly, the review will identify the various wagon loading practices employed throughout the CQCI and determine the coal dust emissions factors and circumstances that contribute to coal dust emissions.

Wagon loading survey data collected by QR will provide the basis for analysing the various wagon loading practices employed across the CQCI. Coal dust emission mechanisms attributable to wagon loading practices will be identified through this analysis and assessed for relative contribution, giving rise to a weighted set of Key Performance Indicators (KPI) for wagon loading systems. These KPI will provide a comparison base to evaluate the respective systems across the CQCI and upon completion of the report, establish the industry best practice for wagon loading systems. The cost of upgrading the various systems currently operational across the CQCI to reflect current industry best practice will be estimated.

This supplementary report to the overall Environmental Evaluation report does not quantitatively estimate the reduced coal dust emission and associated benefits that would result from implementing best practice across the CQCI.

2. Wagon loading practices

2.1 Background

A coal wagon loading system can be defined as a system that facilitates coal transfer from storage into wagons which constitute a rollingstock consist. Throughout the CQCI, wagon loading systems are found at every mine that utilises rollingstock to transport coal from mine to customer, generally through another facility such as a port. Data relating to wagon loading practices has been collected through a survey of all the mines in the CQCI conducted by QR, providing the basis for the information presented below. Wagon loading systems can be classified as either continuous or stationary systems.

2.2 Stationary loading

Stationary loading systems are the most primitive method of loading coal wagons utilised in the CQCI. A typical stationary loading system essentially refers to loading coal wagons using front end loaders to transfer coal from storage to the wagons (see Figure 1). By this means, the train indexes past the loading area as the wagons are loaded, however the train is stationary during the physical loading process, giving rise to the name of stationary loading. Due to significant advancements in technology, only two mines residing in the CQCI rely on a stationary loading system to transport coal (see Table 1).

Figure 1 – Stationary Wagon Loading System

2.3 Continuous loading

The remaining, and therefore majority of the loading systems residing in the CQCI are continuous loading systems, which are systems that supports continual train movement throughout the loading process. Such systems have significant levels of automation and technology built-in to reduce operator input and therefore variation in the process. The continuity in loading is achieved by incorporating a surge bin, which is filled at a rate that allows it to periodically empty into the wagons passing beneath the bin at a relatively constant speed. There are two distinct methods of determining when to empty the surge bin into each wagon, as well as two distinct methods of achieving the coal transfer from the surge bin into each wagon. These variants are discussed in the following subsections.

2.3.1 Load Control Systems

Batch weighing systems

Batch weighing systems (see Figure 2) utilise load cells built into the support structure to weigh the contents of the weigh bin. The batch weighing process is achieved by the following sub-processes:

- A surge bin above the weigh bin is filled with coal from a conveyer, acting as an input buffer
- The surge bin fills the weigh bin (mounted on load cells) to a predetermined weight
- The weigh bin is emptied into the wagon, closes, and begins to fill again from the surge bin

More advanced batch weighing systems load each wagon with multiple batches to increase accuracy. By this means, the quantity of coal emptied into each wagon can be accurately controlled, resulting in optimised payloads in the sense that they are as close as possible to, but do not exceed, the tolerances stipulated by QR.

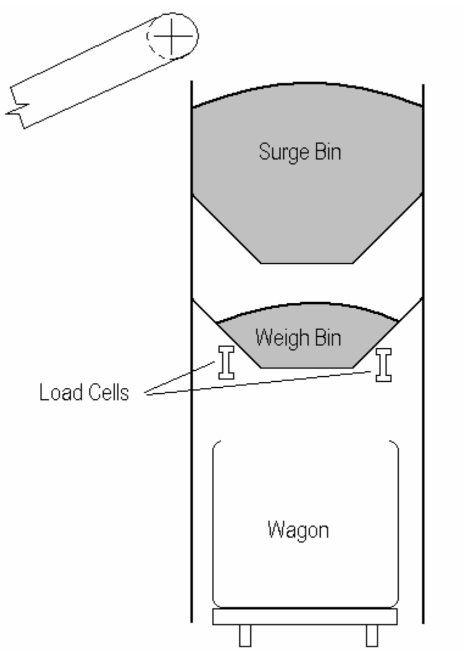

Figure 2 – Batch Weighing System

Volumetric loading systems

Volumetric loading systems are systems that rely on a surge bin and an operator controlled valve that controls coal flow from the surge bin into each wagon passing beneath. To this effect, such a system relies heavily on operator skill to avoid overfilling and spillage, with flow to each wagon being controlled at the operator's discretion based upon his visual observation of the loading process. Volumetric systems can be accompanied by an outbound weighbridge to provide feedback for the operator to adjust the filling levels based on previous wagons.

The accuracy of the load placed inside each wagon is highly variable, and is dependant upon operator skill. The result is underloading of wagons or overfilling which results in upset conditions (risk) and inevitably consist lost time to rectify.

2.3.2 Product Transfer Systems

Clamshell transfer systems

Clamshell arrangements (see Figure 3) are attached to the underside of surge bins and consist of single or multiple sets of arms which meet in the middle when closed, and swing outwards allowing material flow when opened. Due to the operational nature of such devices, minimal control over the final material profile in the wagon is gained.

Chute transfer systems

Chute arrangements (see Figure 4) are attached to the underside of surge bins and often are telescopic in nature. Material flow into the wagon is controlled by a valve which when opened, allows material to flow down the chute and into the wagon. Chute systems provide more level of control over the material transfer process than clamshell systems. Load profiling can be successfully achieved through appropriate chute design (see Figure 5).

Figure 3 – Clamshell Transfer System

Figure 4 – Chute Transfer System

Figure 5 – Consistent Coal Profile

2.4 Summary

A summary of the wagon loading practices employed in the CQCI are tabulated in Table 1.

Table 1 – CQCI Wagon Loading Practices by System

System	Stationary	Continuous				Total
		Batch Weighing		Volumetric Loading		
		Clamshell	Chute	Clamshell	Chute	
Goonyella	0	0	3	7	9	19
Blackwater	1	0	1	0	9	11
Newlands	0	0	0	0	3	3
Moura	1	0	1	0	2	4
Total	2	0	5	7	23	37

QR Data Collection

2.5 Attachments

Some wagon loading facilities have infrastructure in place to correct overloaded wagons. Such infrastructure nominally removes coal from identified wagons, however they will not be considered further for the purposes of this report as they:

- Vary in existence, design, application and utilisation throughout the CQCI
- Provide corrective action for wagon overfilling, but do not address the root cause of overfilling
- Cause unstable profiles, promoting spillage and potentially compromise veneering applications

3. Coal dust emission contributing factors

Analysis of the various wagon loading practices with respect to coal dust lost throughout the CQCI determines that there are many factors associated with wagon loading systems which constitute the root cause of coal dust emissions associated with the rollingstock coal transport. These coal dust emission contributing factors are detailed in the following subsections.

3.1 Material transfer

The transfer of material from any wagon loading system into a wagon will disturb fine particles within the material and inevitably result in some of these particles becoming airborne. The amount of disturbance experienced depends on the relative velocities and accelerations involved in the transfer of material, generally resulting from the height at which the material is released from and the transfer mechanism employed. Variables such as coal properties (density, particle size distribution, moisture content etc), wind exposure and material confinement will affect the quantity of disturbed particles which become and remain airborne respectively.

3.2 Initial impact location

An investigation conducted by QR concluded that the initial impact location during loading, when coinciding with a location that was around the doors, caused consolidation in the wagon that was more severe than the shunt and buff forces experienced during travel, ultimately resulting in arching[1] in susceptible coals during unloading. Coal arching during unloading requires the application of vibration techniques to stimulate mass flow, negatively impacting upon the unloading process. Poor unloading performance can directly result in residual coal in unloaded wagons and parasitic load on the wagon exterior, contributing to coal dust emissions associated with rollingstock transport.

3.3 Overfilling

Overfilling is considered to occur when the quantity of coal discharged into a wagon exceeds the volumetric capacity of the wagon, resulting in the coal flowing over the sides and ends of the wagon. The issue of wagon overfilling during loading results in numerous associated coal dust emissions, namely:

- Direct loss of coal
- Parasitic load that is lost from the wagon exterior during transport
- Increased wind exposure to the coal profile and subsequent dust release during transport

3.4 Spillage

Spillage of coal during loading is considered to be all coal that leaves the loading mechanism but does not remain inside a coal wagon, excluding overfilling. Therefore, spilling results when the loading mechanism is out of synchronisation with the passing wagons, loads coal to the side of the wagons or the flow of coal is not stopped between wagons. Spillage that occurs during wagon loading tends to form parasitic load on the wagon exterior, which is inevitably lost during transport.

3.5 Coal profile

Information presented in the reports titled Coal Dust Emissions Literature Review and Coal Erosion Wind Tunnel Testing have concluded that a consistent coal profile (cross-section and height above the sill) reduces turbulent air flow and wind speed across the top of the coal profile during transport, subsequently reducing the severity of coal dust emissions. Accordingly, it is acknowledged that inconsistent coal profiles resulting from wagon loading practices have a greater contribution to coal dust emissions than those systems which produce a consistent profile.

[1] Arching – The effect where compacted coal inside a wagon will form a self supporting “Arch” over an opening such as a door. This results in unloading issues.

3.6 Wagon loading agreements

Acknowledging that coal profile and wagon overfilling are coal dust emission mechanisms associated with wagon loading practices implies that wagon loading agreements also contribute to coal dust emissions. Agreements for rollingstock transport stipulate that there is a maximum gross axle loading criteria that must be met which is in place to protect the design life of the rail infrastructure.

The only volumetric constraint in place is a height restriction of 3950 mm from the top of rail designed to protect the overhead infrastructure. Consequently, it is understandable that coals with lower densities, when filled to the allowable payload, will produce a profile that promotes increased coal dust emissions through a greater contact surface area and are more likely to result in profile instability.

4. Key performance indicators

The establishment of industry best practice with respect to coal wagon loading practices is critical to assess the practicability and cost-effectiveness of upgrading wagon loading systems to reflect current best practice. To this effect, a set of weighted KPI for wagon loading systems (see Table 2) has been developed in order to provide a comparison base to evaluate the various wagon loading practices. The indicators nominated relate specifically to coal dust emission contributing factors, without considering capital investment, operational procedures and methodologies.

Table 2 – Key Performance Indicators

Key Performance Indicator	Weighting
Quantity Control	25%
Overfilling Control	25%
Spillage Control	15%
Profile Control	30%
Emissions Control	5%

4.1 Quantity control

Quantity control is a significant factor in the quality of a wagon loading system. The current system estimates expected payloads based upon the make-up of a consist. Accurate quantity control is therefore relatively important because it aids in achieving planned tonnages without exceeding maximum axle loadings.

4.2 Overfilling control

Avoiding wagon overfilling is relatively significant in terms of reducing coal dust emissions associated with wagon loading practices. By definition, overfilling infers that too much coal has been loaded into a wagon, promoting coal dust emissions through increased wind affects, profile slumping and parasitic load on the wagon exterior.

4.3 Spillage control

Spilling that occurs during loading is not as common as overfilling due to the nature of many of the continuous loading systems in operation in the CQCI. However, similarly, it results in parasitic load on the wagon exterior. Spillage is not necessarily related to an unstable or larger coal profile, and therefore it is considered to have a smaller contribution to coal dust emissions than overfilling.

4.4 Profile control

As acknowledged through wind tunnel testing, achieving a consistent coal profile in loaded coal wagons is critical to aid in reducing coal dust lift off during transport. Good profile control minimised the surface area available for wind interaction and reduces the air speed over the coal surface. Further, good profile control would ensure that the integrity of any veneering application considered is maintained. Accordingly, profile control has received the highest rating of any KPI.

4.5 Emissions control

Emissions that occur at the point of loading are localised dust emissions which are generally confined within the boundaries of the mine, however a proportion of these emissions will become parasitic load which is carried from the loading facility into the wider environment. Consequently, these emissions are considered to be minimal and emissions control has received a minimal weighting with respect to the other KPI.

5. Wagon loading practices comparison

The following subsections present discussions which pre-empt the ratings given for each wagon loading practice against the weighted KPI.

5.1 Stationary loading systems

Stationary loading systems rely primarily on operators for quantity control, leaving them at a distinct disadvantage over continuous loading systems. Human control inherently introduces an increased level of variation into a process. Accordingly, these systems rate poorly with respect to quantity control and overfilling, both of which are difficult to control when emptying a large quantity of a coal from a front end loader bucket.

Due to the nature of loading wagons in this way, the incidence of spillage is also significantly elevated over continuous loading systems. Front end loaders impart little control over the profile of the coal loaded into each wagon, with the coal forming a slope which is centred around the loading point, which varies in every wagon. Consequently, these systems rate extremely poorly with respect to profile control. Front end loaders provide no protection from wind and tend to load coal from a considerable height (relative to other systems) with a distinct lack of control, thus rating poorly with respect to emissions.

5.2 Continuous Loading Systems

Volumetric loading systems

Volumetric loading systems rely heavily on operator control to determine the quantity of coal loaded into each wagon. The operators rely on visual cues to determine the amount of coal loaded into each wagon. Where outbound weigh bridges have been installed, they can use these measurements to adjust the loading of subsequent wagons. The human involvement in the process renders volumetric loading susceptible to overfilling if the gate is open for too long. Similarly, spillage can easily result from misjudgement or a lack of concentration.

Batch weighing systems

Batch weighing systems, due to their inherent design, provide accurate quantity control. Loading pre-weighed batches of coal into each wagon introduces a high level of accuracy which is limited only by the accuracy and tolerance of the equipment. This high level of control can be adapted readily to help rapidly reduce the incidence of overfilling, based on an approximate average or measured coal density for a given product. Due to the autonomous operation of these systems, they have good control over spillage.

5.3 Product Transfer Systems

Clamshell loading

Clamshell loaders distribute the quantity of coal loaded into each wagon relatively consistently, however the surface of the coal is not profiled to a desired shape. Clamshell loaders are inherently more likely to spill coal over the sides of wagons than chute designs, due to the lack of control over the material flow during transfer. Clamshell loading devices provide reasonable wind protection during loading, resulting in lower emissions compared to stationary loading systems however significant particle disturbance will still occur due to the drop involved in material transfer from clamshell to wagon.

Chute loading

Chute loading presents a distinct advantage over the other loading methods by imparting control over the flow of coal. Consequently, spillage is significantly lower than other systems. Chute loading also significantly reduces disturbance and wind exposure during loading. Telescopic chutes perform particularly well as the control of the product extends to the sill of each wagon, at which time the coal is also profiled by the trailing edge of the chute, constantly producing a consistent profile.

5.4 Summary

Table 3 – Wagon Loading Practices Comparison

Key Performance Indicator	Weighting	Stationary	Continuous			
			Batch Weighing		Volumetric Loading	
			Clamshell	Chute	Clamshell	Chute
Quantity Control	25%	2	9	9	6	6
Overfilling Control	25%	2	8	8	6	6
Spillage Control	15%	3	6	10	6	7
Profile Control	30%	2	3	8	3	8
Emissions Control	5%	1	5	8	5	8
Weighted Average		21.00%	63.00%	85.50%	50.50%	68.50%

5.5 Discussion

Based on the analysis of the wagon loading practices currently operational in the CQCI, batch weighing systems with a telescopic chute present as the current industry best practice coal wagon loading system. Volumetric loading systems with chutes rate as the next best system, followed by volumetric clamshell arrangements (considering that there are no batch weighing clamshell systems in the CQCI). Stationary loading systems rate very poorly with respect to the nominated KPI, an outcome that is reflective of the historical trend to move towards continuous loading systems.

6. Current best practice proposal

The analysis of wagon loading systems has enabled the identification of the features of loading systems that are preferable. The results of analysis have concluded that the current industry best practice wagon loading system would consist of the following components:

- Inbound wagon identification system to determine class of wagon about to be loaded
- Inbound weighbridge to measure the tare weight of each incoming wagon
- Batch weighing system to load the correct amount of coal into each wagon
- Telescopic loading chute to profile the load in each wagon
- Outbound weighbridge to measure the gross weight of each outgoing wagon
- Volumetric scanning to measure the profile of each outgoing wagon

Integration of these components with control logic will provide a robust, accurate and autonomous wagon loading system which represents current industry best practice with respect to wagon loading systems. A flowchart depicting the proposed control logic (see Figure 6) has been detailed to represent the benefits in terms of accurate loading (both mass and volume) and data collection purposes.

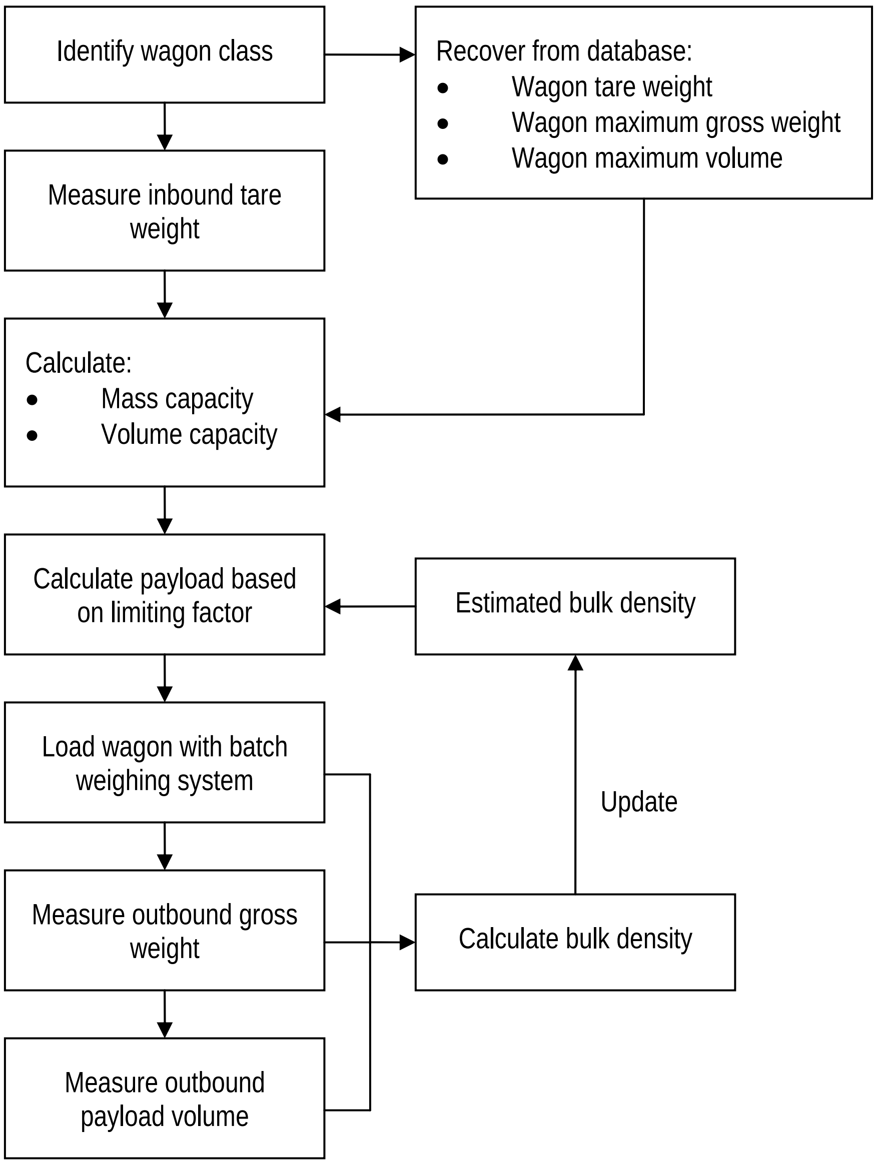

Figure 6 – Proposed control logic

6.1 Description

a) Identify each incoming wagon and retrieve the following information from a database:
   – Nominal wagon tare weight
   – Nominal wagon maximum gross weight
   – Nominal wagon maximum payload volume

b) Compare the measured inbound tare weight of each wagon with the nominal tare weight of each wagon to identify conditions such as:
   – Parasitic load
   – Residual coal in wagons
   – Lighter wagons (such as those with worn wheels)

   Alarms could be established to alert QR central control of variations between expected and measured tare weights of wagons (outside of a certain tolerance), differentiating between increased tare weights which would represent parasitic load and/or residual coal and decreased tare weights which would indicate factors such as worn wheels or wagon damage

c) Determine condition one:
   – Retrieve the maximum volume that can be loaded from the database
   – Convert this volume into a mass using the estimated bulk density

d) Determine condition two:
   – Calculate the maximum mass that can be loaded by subtracting the measured inbound tare weight from the maximum gross weight (database entry)

e) Feed the lesser of the two resultant masses to the batch weigher as an input for loading

f) Load the wagon with the chosen mass of coal (determined by Mass or Volumetric capacity)

g) Weigh and scan the outbound wagon

h) Average the weigh bin load cell measurements with the difference between the inbound and outbound weighbridge measurements

i) Divide the average mass by the scanned volume of coal to estimate the bulk density of the load

j) Update the estimated coal density based on a rolling average of past measurements

6.2 Benefits

The implementation of the aforementioned control system, in conjunction with current industry best practice proposal, will provide the following benefits:

- Accurate mass and volumetric based loading of each wagon
- Optimisation of payloads of each wagon
- Load profiling of each wagon
- Identification of parasitic load and residual coal in unloaded wagons
- Significantly reduced risk of overfilling, and consequently
   – Reduced incidence of parasitic load
   – Reduced incidence of load profiling after loading
   – Reduced risk of pantograph damage due to setback manoeuvres
   – Reduced loading times

7. Industry perspective

Connell Hatch engaged the support of an industry supplier to provide some industry based perspective to coal wagon loading systems.

7.1 New installations

This supplier has developed a precision loading system (PLS) which uses an automatic triple batch weighing system with a telescopic chute which produces acceptable coal profiles as required. The main features of a PLS include:

- Three batches per wagon to increase accuracy and control whilst allowing for possible decreasing weigh bin size
- Fully automated control requiring minimal operator intervention, intervention can be remote
- Loading rate of 5,500tph which is increasable with minimal capital expenditure
- Customisable final coal profile.
- Telescopic chute minimises dust emissions present with some other systems
- Low, medium and high density coal control to help prevent overfilling

7.2 Retrofitting existing systems

Discussion with the industry supplier representatives lead to the identification of two possible scenarios for upgrading the non batch weighing systems that are extensively employed throughout the CQCI. Issues such as lost throughput during upgrading have been discounted in this analysis.

7.2.1 Volumetric Systems

With respect to volumetric loading systems, which present as the most prominent system across the network, it is possible to upgrade the existing infrastructure to implement a batch weighing system. The retrofitting proposal is to re-use the existing infrastructure up to loading the hopper.

The bottom of the hopper itself would be cut-off and replaced with a retrofitted batch weighing system at a cost significantly less than building a new system. By this means, it is relatively cost-effective to upgrade volumetric loading systems, the prominent system throughout the CQCI, with an automated triple batch weighing system.

7.2.2 Stationary Systems

Based on the results of the wagon loading system analysis, the use of stationary loading systems is not recommended within the context of the EE. It is acknowledged that significant infrastructure investments would be required in order to upgrade such a facility to a completely automated batch weighing system. Accordingly, such capital investments may not be financially viable for smaller operators. In order to address this potential barrier, an alternative system has been proposed for these systems.

The system would implement a smaller hopper and travelling conveyer which could move longitudinally and parallel to the train to load each wagon, rather than loading directly from front end loaders. Load cells could then be placed underneath the hopper or weighing idlers could be implemented on the conveyor to quantify the mass of coal being loaded into each wagon. In this way, more accurate loading of wagons at stationary loading systems could be achieved, and when combined with an adjustable load profiler, this would result in a much better system than currently in operation, without the high capital investment of an automated batch weighing system.

Further work is required to develop this system should the industry require this stop gap measure.

8. Capital investment

Connell Hatch engaged the services of an industry based supplier of batch weighing systems in order to gain an accurate understanding of the processes and costs involved in upgrading an existing loading system to reflect industry best practice, as well as the installation of a brand new system.

8.1 New installation

A new installation refers exclusively to the loading system in terms of the structure to support the surge and weigh bins, telescopic chute and valves, weighbridges, volumetric scanning system and control system required for autonomous operation.

Other items including the rail infrastructure, civil works, handling equipment to feed the surge bin, surrounding buildings and services etc are considered to be excluded from this cost estimate.

The estimated capital investment associated with the installation and commissioning of a new industry best practice wagon loading system is estimated to be in the range $6 – $9 million.

8.2 Retrofitting existing systems

8.2.1 Volumetric system upgrade

The upgrade of an existing volumetric loading system presents a lower estimated capital investment as it is proposed that the major structure of these systems is in a fit state to be reused. The estimated price is based wholly on the assumption that the surge bin arrangement can remain, such that the lower half of the structure is replaced a weigh bin on load cells and a telescopic chute.

Allowing for weighbridges, a volumetric scanning system and the upgrade of the existing control system, the capital investment required for such an upgrade is estimated to be in the range of $2 – $4 million.

8.2.2 Stationary system upgrade

The upgrade of a stationary loading system is highly dependant upon the requirements of the site, and due to the absence of an existing conveyer, silo type loading arrangement could result in an enormous capital investment to reflect industry best practice.

A more reasonable approach for these systems could be to consider an alternative approach which produces a significantly improved loading system at a cost which is somewhat comparable with that of upgrading a continuous loading site.

Due to the limited number of these facilities in the CQCN, these systems will be discounted in the ongoing analysis

9. Assessment

9.1 Prelude

The practicability and cost-effectiveness of the proposed wagon loading system is determined by giving a weighted score to predetermined rating factors. The rating system has been developed in order to facilitate a weighted score for each mitigation strategy arising from the EE which has a generic comparable base. This was achieved by developing:

- A set of weighted rating factors which are relevant to the practicability and cost-effectiveness of a mitigation strategy, and
- A rating guide (see Appendix A) pertaining to various aspects of the rating factors which will highlight the differences between the different mitigation strategies

9.2 Wagon loading

Table 4 shows that wagon loading scores only at an acceptable level with respect to the rating factors for cost-effectiveness, scoring 2.6 out of 5, with a score of 5 being the highest. This is mostly due to the fact that the capital investment is very large for an individual installation with a low dust reduction score (effectiveness) in the order of sub 20% of the total coal dust emitted.

Table 4 – Wagon Loading Cost-Effectiveness Assessment

Factor	Rating Code	Weighting	Rating
Capital Investment	A	20%	1
Operational Cost	B	40%	5
Effectiveness	C	40%	1
Total		100%	2.6

Table 5 indicates that wagon loading scores very highly with respect to the weighted rating factors for practicability, scoring 4.35 out of 5. This is due to the low impact upon the system from an operational point of view together with excellent safety and environmental factors.

Table 5 – Wagon Loading Practices Practicability Assessment

Factor	Rating Code	Weighting	Rating
Implementation			
Ease	D	8%	2
Time	E	8%	2
Resources	D	8%	5
Capacity Impact	G	35%	5
Maintainability	D	2%	4
Reliability	F	15%	4
Implementation Risk	G	14%	5
Safety	F	5%	5
Environmental	F	5%	5
Total		100%	4.35

The combination of these high and medium scores determines that wagon loading practice is a practical and cost-effective mitigation strategy to reduce coal dust emissions from the top of loaded coal wagons during transport in the CQCI.

9.3 Comparison

Appendix B contains a complete assessment including both practicability and cost-effectiveness for all of the identified mitigation strategies.

Figure 7 shows that improving the loading methodology into wagons rates highly with respect to practicability and average with respect to cost-effectiveness.

Wagon loading practices is considered to be a medium to long-term mitigation strategy that could be implemented in 2-10 years. Accordingly, it is not feasible to consider it as a solution for reducing coal dust emissions from the top of wagons in isolation. The most benefit accrues to the system when wagon loading improvements are combined with veneering.

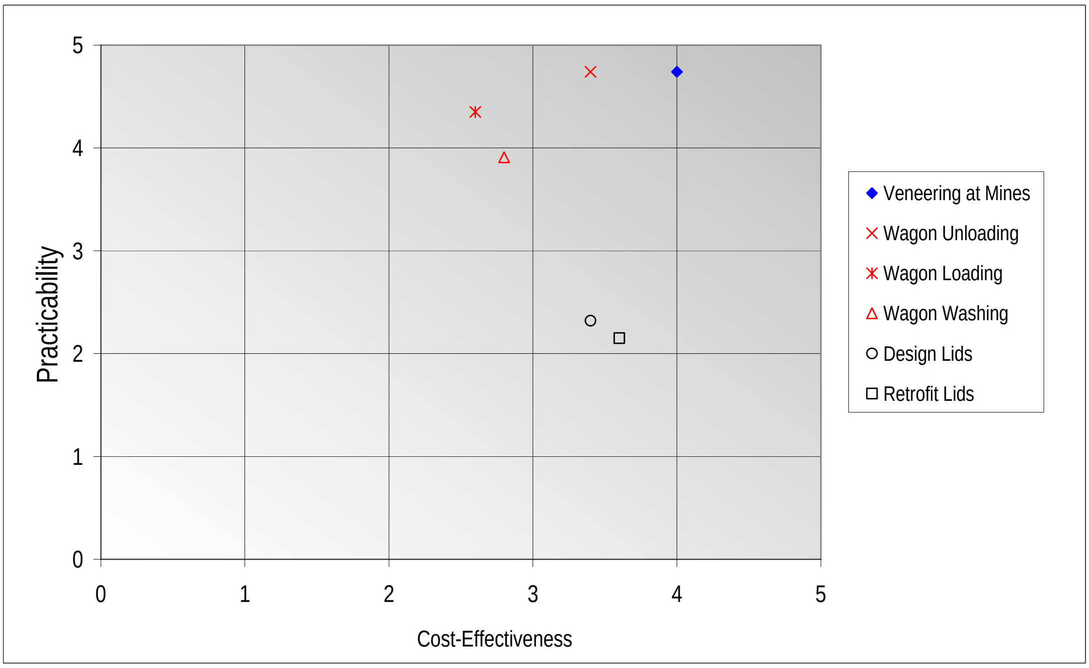

Figure 7 – Mitigation Strategies Assessment Summary

10. Conclusion

The investigation into coal dust emissions that are related back to wagon loading practices identified numerous attributes that contribute to the incidence of coal emissions associated with rollingstock transport. The majority of wagon loading systems throughout the CQCI are volumetric systems relying on operator control based on visual cues, which have many features which contribute in varying degrees to coal emissions from the top of loaded wagons, residual coal in unloaded wagons and parasitic load on the wagon exterior. Current best industry practice with respect to reducing coal emissions includes:

- Inbound wagon identification system to determine class of wagon about to be loaded
- Inbound weighbridge to measure the tare weight of each incoming wagon
- Batch weighing system to load the correct amount of coal into each wagon
- Telescopic loading chute to profile the load in each wagon
- Outbound weighbridge to measure the gross weight of each outgoing wagon
- Volumetric scanning to measure the profile of each outgoing wagon

The estimated capital investment required to upgrade existing volumetric wagon loading systems to reflect industry best practice is the range of $2 – 4 million.

The system noted in this analysis rated medium (2.6 out of 5) on the cost-effectiveness rating guide noted in Section 9 of this report. This is compared with a high practicability score of 4.35 out of 5, indicating that this system could be easily implemented and have minimal effect upon operations across the coal chain.

Appendix A

Wagon Loading Fact Sheet

Loading

Wagon loading refers to the process of continuously and accurately loading coal wagons with a batch weighing system, to a maximum weight and volume, producing a coal profile with a consistent cross section and height above the sill.

"For the coal samples tested…major lift-off occurred in the range of 27 km/hr to 53 km/hr for samples at 37 degrees." (QR EE Interim Report, Jan 2008)

Capital Investment
$2-4 million*

Operational Cost
Nil

Major Benefit
Significantly reduces coal dust due to overfilling and spillage

Overfilling and spilling during loading are the root cause of a significant proportion of parasitic load on the wagon exterior, therefore improved loading practices will help reduce the rate of coal loss and improve capacity.

It has been identified that the first point of impact during loading should occur on the internal end slope sheets to avoid consolidation in the wagon and hang-up during the unloading process.

Wind Tunnel Testing and CFD modelling have concluded that a ‘garden-bed’ profile reduces the wind speed over the coal surface during transport and therefore complements veneering applications.


1

Advantages

- Improve effectiveness of veneering application
- Eliminate overfilling, spillage and associated coal dust
- Improves effectiveness of unloading operations

Disadvantages

- Large capital investment
- Training required


2

1. Consistent 'garden-bed' profile
2. Best practice batch weighing system

* upgrade of existing volumetric loading system, site specific

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Infrastructure for Industry

Appendix B

Mitigation Strategies Assessment

Client: Queensland Rail Limited
Job Number: H327578-N00-EE00
Project: Environmental Evaluation
Description: Coal Dust Emissions Mitigation Strategies Rating Guide

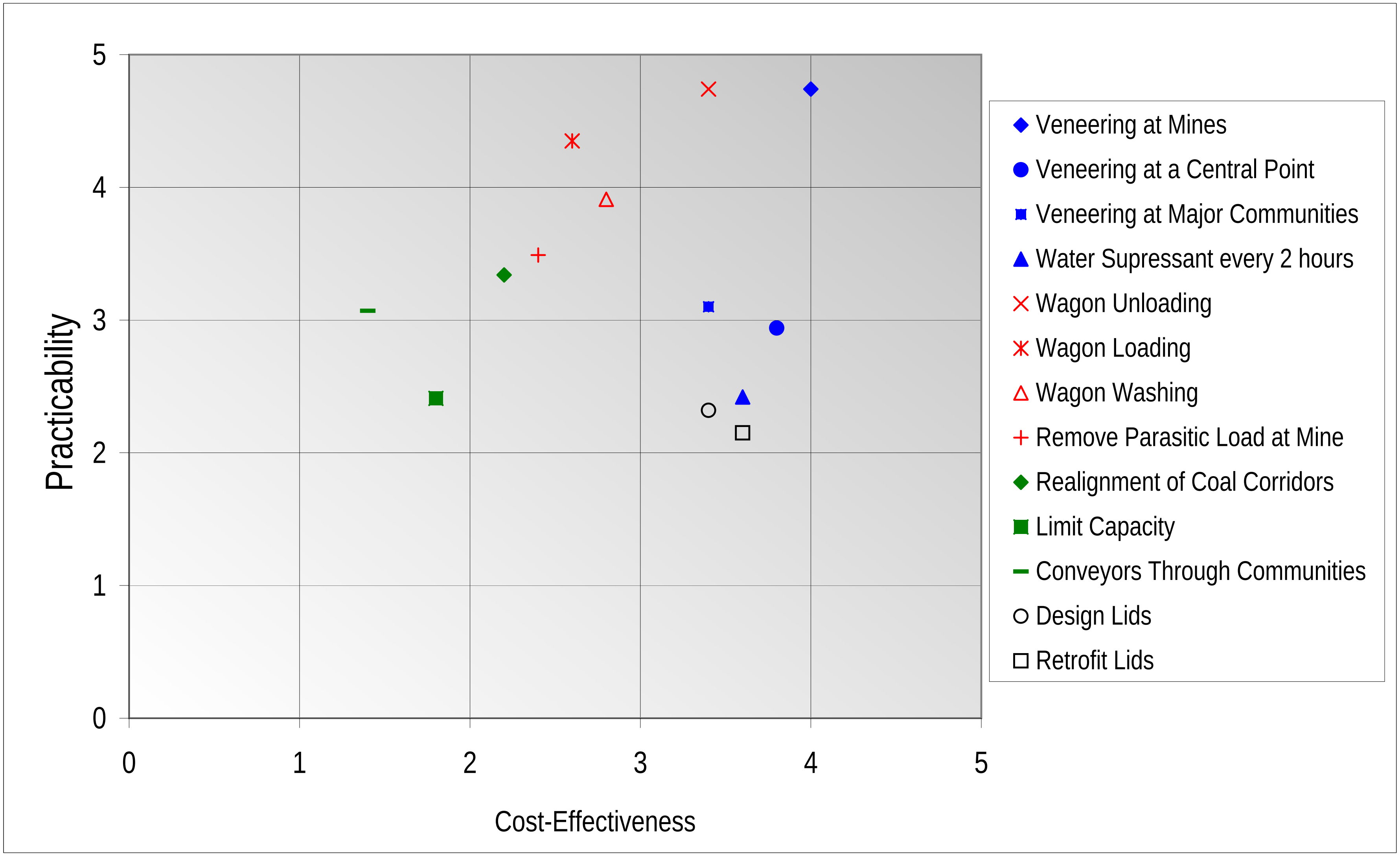
Date: 31.03.2008
Revision: 0

Mitigation Strategies Rating Guide

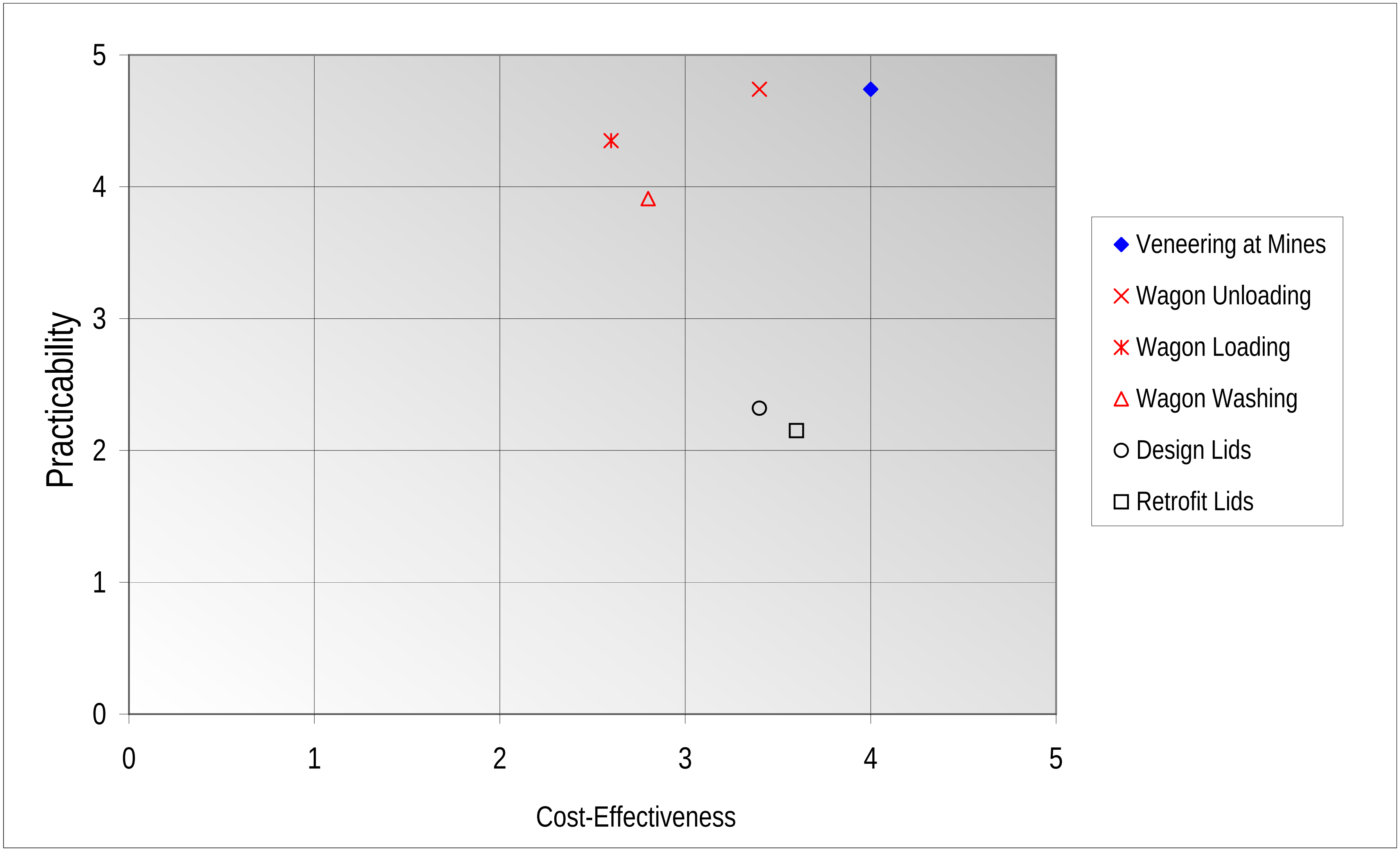
		Rating Code						
		A	B	C	D	E	F	G
Rating	5	<$1M	<$1	>80%	Very Easy	<1 month	No Impact	Very Low
	4	$1M – $10M	$1 – $5	>60 – 80%	Easy	1-12 months	Low Impact	Low
	3	>$10M - $25M	>$5 – $10	>40 – 60%	Achievable	>1-2 years	Some Impact	Medium
	2	>$25M - $50M	>$10 –$15	20 – 40%	Difficult	>2-5 years	High Impact	High
	1	>$50M	>$15	<20%	Extremely Difficult	>5 years	Untried	Very High

Rating Units

A	industry cost
B	per wagon trip
C	reduction of overall emissions
D	overall assessment
E	implementation timeframe
F	overall assessment
G	overall assessment



Practicability
Cost-Effectiveness
0
1
2
3
4
5
Veneering at Mines
Veneering at a Central Point
Veneering at Major Communities
Water Supressant every 2 hours
Wagon Unloading
Wagon Loading
Wagon Washing
Remove Parasitic Load at Mine
Realignment of Coal Corridors
Limit Capacity
Conveyors Through Communities
Design Lids
Retrofit Lids



Practicability
Cost-Effectiveness
0
1
2
3
4
5
Veneering at Mines
Wagon Unloading
Wagon Loading
Wagon Washing
Design Lids
Retrofit Lids

Client: Queensland Rail Limited
Job Number: H327578-N00-EE00
Project: Environmental Evaluation
Description: Coal Dust Emissions Mitigation Strategies Assessment

Connell HATCH
Infrastructure for Industry

Date: 31.03.2008
Revision: 0

Cost-Effectiveness Assessment

	Rating Code	Weighting	Veneering at Mines	Wagon Loading	Wagon Washing	Wagon Unloading	Retrofit Lids	Design Lids	Conveyors Through Communities	Realignment of Coal Corridors	Limit Capacity	Remove Parasitic Load at Mine	Water Supressant every 2 hours	Apply Deflectors to Wagons	Veneering at a Central Point	Veneering at Major Communities
Capital Investment	A	20%	4	1	2	3	4	3	1	1	5	2	4	3	5	5
Operational Cost	B	40%	4	5	4	5	2	2	2	4	1	4	5	5	4	4
Effectiveness	C	40%	4	1	2	2	5	5	1	1	1	1	2	0	3	2
Total:		100%	4	2.6	2.8	3.4	3.6	3.4	1.4	2.2	1.8	2.4	3.6	2.6	3.8	3.4

Practicability Assessment

	Rating Code	Weighting	Veneering at Mines	Wagon Loading	Wagon Washing	Wagon Unloading	Retrofit Lids	Design Lids	Conveyors Through Communities	Realignment of Coal Corridors	Limit Capacity	Remove Parasitic Load at Mine	Water Supressant every 2 hours	Apply Deflectors to Wagons	Veneering at a Central Point	Veneering at Major Communities
Implementation																
Ease	D	8%	5	2	2	4	3	5	1	1	2	3	2	2	3	4
Time	E	8%	4	2	2	4	2	1	1	1	2	3	3	1	4	4
Resources	D	8%	4	5	3	5	5	5	4	2	5	2	1	5	3	4
Capacity Impact	G	35%	5	5	5	5	2	2	3	4	1	4	1	5	1	1
Maintainability	D	2%	5	4	4	5	3	5	4	5	5	4	4	4	4	4
Reliability	F	15%	5	4	4	5	1	1	3	5	4	3	3	5	5	5
Implementation Risk	G	14%	5	5	3	5	1	1	4	3	1	3	4	1	4	4
Safety	F	5%	5	5	5	4	2	2	5	4	5	5	5	5	5	5
Environment	F	5%	3	5	5	4	4	5	4	3	5	5	5	5	3	3
Total:		100%	4.74	4.35	3.91	4.74	2.15	2.32	3.07	3.34	2.41	3.49	2.42	3.86	2.94	3.1

Appendix H

Wagon Washing

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Wagon Washing System Proposal
Environmental Evaluation
Queensland Rail Limited

31 March 2008
Reference H327578-N00-EE00.05
Revision 1

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Rev No	Date	Revision Details	Typist	Author	Verifier	Approver
0	12 March 2008	Draft Report	BB	DJF	SMC	RJH
1	31 March 2008	Final Report	BB	DJF	SMC	RJH

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Contents

Executive summary

This supplementary report presents the particulars of a design proposal for a wagon wash facility to be implemented throughout the Central Queensland Coal Industry that was undertaken by Connell Hatch with respect to the Environmental Evaluation commissioned by Queensland Rail Limited. Improving wagon cleanliness has been nominated as a mitigation strategy to be used to reduce coal dust emissions from residual coal remaining unloaded wagons and parasitic load on the wagon exterior. Accordingly, the completion of this report aims to:

- Identify practical wagon washing systems that are applicable for use in the CQCI
- Develop a weighted set of Key Performance Indicators for wagon washing systems
- Rate the applicable wagon washing systems with respect to the Key Performance Indicators
- Determine the preferred wagon washing system based upon the outcomes
- Estimate the capital investment and operational costs associated with the preferred option
- Assess the practicability and cost-effectiveness associated with the wagon washing proposal

The outcomes achieved with respect to the aims of the report include:

- The preferable method of washing wagons in the Central Queensland Coal Industry is a system that uses a combination of air and water
- The estimated capital investment for a single installation is in the range of $5 - $10 million, which is highly variable due to the differences between each terminal and the compromises required to minimise the installation time due to track interference
- The estimated operational cost is in the range of $0.50 to $0.60 per wagon trip
- The assessment of the prefer option determines that wagon washing is a very practical but not very cost-effective mitigation strategy, which is reflective of the fact that it is not addressing the primary coal dust emission source

Glossary of terms

AS
Australian Standards

CQCI
Central Queensland Coal Industry – entire coal supply chain

CQCN
Central Queensland Coal Network – entire rail infrastructure network

EE
Environmental Evaluation

ktpa
Kilo tonnes per annum

KDD
Kwik-Drop Doors – wagon doors and operating mechanisms

KPI
Key Performance Indicators

QR
Queensland Rail Limited

QRNA
Queensland Rail Network Access – below rail operator

QRN
Queensland Rail National – above rail operator

PSI
Pounds per Square Inch

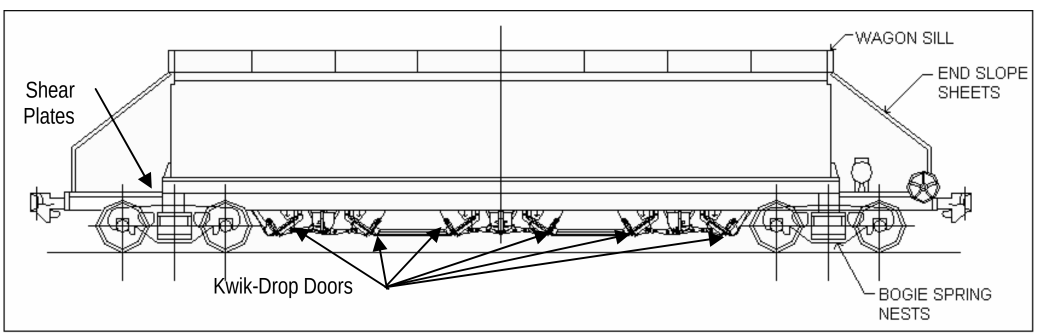


Figure 1 - Wagon Naming Conventions

1. Introduction

Queensland Rail Limited (QR) has appointed Connell Hatch, John Planner of Introspec Consulting and Katestone Environmental to prepare an Environmental Evaluation (EE) of coal dust emissions engendered from rollingstock in the Central Queensland Coal Industry (CQCI) in response to a Notice issued by the Queensland Environmental Protection Agency (EPA). The deliverables of the report have been stipulated by the Terms of Reference for the project which encompass:

a) *Identify all potential sources of coal dust emissions from QR trains in Central Queensland on land described as rail lines connecting coal mines in the Bowen and Callide Basins with ports at Dalrymple Bay, Hay Point and Gladstone*

b) *Quantify the potential risk of environmental harm posed by each dust source*

c) *Identify the factors and circumstances that contribute to dust emissions and/or impacts from each source. Consideration should be given to (but not limited to) issues such as coal type, coal properties and meteorological conditions.*

d) *Based on the findings from the above, identify locations within QR's Central Queensland operations where proximity of railway lines to communities may give rise to higher risk of environmental harm due to fugitive coal dust*

e) *Identify ways to reduce the risk being caused by coal dust emissions and assess each for practicability, effectiveness and cost, in relation to the mitigation of environmental impacts of fugitive coal dust emissions*

The sources of coal dust emissions that have been identified in the CCQI include emissions from:

- The coal surface of loaded wagons
- Coal leakage from the doors of loaded wagons
- Wind erosion of spilled coal in the rail corridor
- Residual coal in unloaded wagons and leakage of residual coal from the doors
- Parasitic load on sills, shear plates and bogies of wagons

This supplementary report presents the particulars of a design proposal for a generic wagon washing facility that was undertaken by Connell Hatch with respect to the EE commissioned by QR. Wagon washing has been nominated as a mitigation strategy to reduce coal dust emissions resulting from residual coal remaining in unloaded wagons and parasitic load on the wagon exterior. Accordingly, this report aims to develop a conceptual design for a generic wagon washing facility to be installed at a typical export facility. More specifically, the facility must:

- Negate coal recirculation currently experienced due to coal remaining in unloaded wagons
- Clean coal dust and solids left on the exterior of the wagons, particularly on the tops, sides, doors and shear plates
- Reclaim the majority of the coal removed from the wagons
- Be an automatic system requiring minimal maintenance
- Present as a generic system to be installed at a typical port facility
- Consider the geographic, geometric and environmental constraints at a typical port facility
- Present no additional environmental concerns
- Comply with all AS (Australian Standards) as well as QR design and safety standards
- Recycle and reuse water for washing

This report is based upon a typical high volume throughput installation as would be expected at a major unloading facility at an export facility. Several facilities within the CQCI handle smaller throughputs, which would require a smaller and cheaper system, but because they represent only a small percentage of the overall supply chain, will be excluded from this analysis.

Each installation will need specific design variations to the generic design proposed hereafter, hence this document is to be used as a tool for discussion within the industry.

2. Wagon washing

2.1 Introduction

Parasitic load on the wagon exterior and residual coal on the interior wagons following unloading are commonplace in the CQCI, with the extent of each varying significantly. These coal deposits may vibrate loose or be emitted from the wagon during the return trip to the mines. Some coal deposits may become airborne coal particles during travel and have significant impacts on the environment and surrounding communities.

It has been estimated that carry-back from the one coal terminal is in the order of 70 ktpa. This equates on average, to be approximately 0.10 t of coal carry-back per wagon per trip. Not all of this coal is emitted to the environment, however the coal that is emitted to the environment represents economic losses and environmental nuisance.

Hence the onus is upon the industry to provide a wagon that is relatively clean when it leaves the unloading facility to reduce the losses on the return trip to the mines. By cleaning these wagons, the industry reduces the coal dust emitted on the return travel journey.

From observations it was seen that the main areas where coal deposits was retained on wagons included:

- End slope sheets
- Wagon sills, doors and door mechanisms
- Shear plates, interior under end plates and sloping hopper
- Bogie bearings, frames, wheels and brake gear, and
- Spring nests

From similar observations it was found that the coal retained in and on wagons after wagon unloading generally occurred from the following:

- Coal ploughing
- Loading and unloading practices
- Coal properties, and
- The absence of autonomous wagon vibration systems.

Other aligned reports being generated as part of the Environmental Evaluation discuss the impact of wagon loading practices upon transport operation, which is aimed to produce a reduction in the quantity of coal retained on some areas of the wagon. One of the areas that could see reduced amounts of retained coal will be the wagon shear plates. A percentage of the coal retained on these wagon shear plates would occur from wind borne coal particles during travel and changes to loading practices would not fully prevent this build-up.

This requires the washing system to concentrate on removing remaining coal from the following areas:

- Wagon interior (Figure 2)
- Wagon sides and sills (Figure 3)
- Wagon shear plates (Figure 4)
- Bogie spring nests (Figure 5)

Figure 2 – Residual Coal Deposits

Figure 3 – Parasitic Load on Wagon Sills

Figure 4 – Parasitic Load on Shear Plates

Figure 5 - Parasitic Load in Spring Nests

2.2 Washing requirements

The following sections describe the requirements of washing the wagons in some detail.

2.2.1 Wagon interior washing

The wagon washing facility must remove the majority of residual coal from inside the wagon. Anecdotal evidence suggests that the majority of coal is resides around the Kwik-Drop Doors (KDD) (refer Figure 2), however this would need to be further investigation prior to a detailed design at each facility. This is believed to be due to coal lodging in the corners of the wagon during the unloading process.

The areas that should be targeted to remove coal from the wagon interior include:

- Around the KDD
- On top of the vertices between each door opening
- On and around sills and
- Hopper valley angles (end to side)

The wagon wash facility requires the doors to be open during washing to successfully remove coal from the interior of the wagon. To prevent coal falling out between the unloading pit and the wash facility, the doors will be closed after unloading and then reopened prior to washing.

2.2.2 Wagon exterior washing

Along with coal residing on the interior of the wagon there will also be coal that attaches to the outside of the wagon. This coal (parasitic load) arises from spillage during loading and from travel effects. Anecdotal evidence suggests that the locations where the majority of parasitic load resides include:

- End slope sheets
- Wagon sills
- Bogie bearings, frames, wheels and brake gear, and
- Spring nests
- Wagon shear plates

The system must avoid spraying water near the live overhead traction wiring for safety reasons. Given the difficulty involved in achieving this isolation with the large quantities of water that are required and the potential for moisture in the surrounding environment, there must be no high voltage overhead wires running through the wagon washing facility.

2.2.3 Coal reclaim

The wagon washing facility will require a system to collect major coal deposits removed from the train during washing. Collecting this coal will increase the efficiency of the coal delivery process while preventing it from contaminating the environment or ballast. This system will be required to return the collected coal to the unloading pit.

The coal reclaim system must be both simple and reliable in design to enable the washing facility to operate efficiently. The reclaim system must be linked to both the unloading pit (to return removed coal) and the water processing system (to recycle the used water).

Design of the reclaim system will be focussed upon the return of coal from the current shipment to be returned to that shipment, to avoid any cross contamination of coals into the pit. Where such a risk of contamination exists, the system will place reclaimed coal in a storage facility for disposal elsewhere.

2.2.4 Water reclaim and processing

The washing process will use large quantities of water which will need to be reclaimed and recycled for reuse. The system will require channels underneath the wagon to collect and transport the fluidised coal slurry to a location where the coal is able to be separated from the water.

This system will be required to clarify the used water and store it in large tanks or settlement ponds ready for reuse in the washing process. The water must be clarified to a quality standard suitable for use through nozzles and other system equipment without adverse effects.

The reclaim system must be reliable and capable of treating a large quantity of water to ensure that the system meets its functional requirements.

2.2.5 Control systems

The wagon wash facility must have the following controls to ensure safe and automatic operation:

- Identification of full wagons
- Wagon or locomotive identification
- Wagon type and height detection
- Locomotive speed and direction detection
- Wagon location tracking system
- Reclaim coal tracking system to prevent cross contamination
- Pressure/ volume regulation for water power optimisation
- Sensors for water flow, levels, clarity, pH and
- Alarms for system, process and equipment protection
- Switching and direction control of water cannons
- Switching of air and water nozzles

The system must be able to identify whether a locomotive or wagon is entering the wash facility. This will prevent locomotives from being washed and damaged. The control system will ensure that only empty wagons will be washed which will reduce water usage in the facility.

The system will be required to detect the height of wagons as they vary between wagon types and within types. Determining the height for each wagon will identify the height that the system must operate at. This height detection will also be used in conjunction with wheel sensors in differentiating between locomotives, wagons, and wagon types.

Another control system that will be required in the wash facility are location and speed sensors that can detect the travelling speed of the consist. This is needed to avoid any collisions between rollingstock and the infrastructure in the washing facility. Should the consist stop, the system will stop the washing process and await the commencement of unloading prior to resuming the washing process. The locomotive speed will vary depending on unloading rate, coal type or incidents in the unloading process. This will also require the system to detect if a locomotive is reversing through the facility, in this case the system will once again go into standby mode to prevent damage.

2.2.6 Safety

The wagon wash facility is required to meet the following safety standards:

- QR's design safety standards
- Relevant Australian standards
- Environmental regulations, and
- Workplace Health and Safety guidelines

The QR safety standards require the system, when non-operational to be clear of all rollingstock. The design must be based around QR's typical coal rail gauge dimensions.

3. Washing method analysis

3.1 Introduction

An analysis was performed to consider and compare various methods for cleaning parasitic load and residual coal from the wagons following unloading. The comparison was used to determine the optimum method for removing this coal. The different methods considered in this comparison were:

1. Water spray
2. Compressed air spray
3. Air and water combination
4. Air / Water / Brush combination
5. Wagon vibration (already used at some ports during wagon unloading)
6. Tilting the wagon through 150-180 deg, and
7. Shock loading the wagon

A full description of these methods is available in Appendix C to this report.

3.2 Analysis of options

In the comparison each method was given a rating out of 10 for each of the nine nomianted Key Performance Indicators (KPI). A rating of 1 indicates poor performance and a rating 10 indicates a good performance. The KPI chosen are important criteria which will influence the methods ability to meet the functional requirements for the wagon wash facility. They present a clear and concise way of separating methods that are similar in terms of meeting all the functional requirements.

The following criterion were chosen for this analysis:

- Remove coal from wagon interior
- Remove coal from wagon exterior
- Reclaim coal removed from wagons
- Automated system with minimal maintenance
- Present as a generic system
- Present no environmental concerns
- Nil interruption to the unloading process
- Cost effective design
- Nil effect upon rollingstock

Each of the KPI criteria, were given a weighting (see Table 1) to indicate their relative importance. This weighting would separate the optimal methods from the others.

Table 1 – Key Performance Indicator Weightings

Key Performance Indicator	Weighting
Effect of interruptions on unloading	16%
Effect upon rollingstock	16%
Remove coal from wagon interior	13%
Remove coal from wagon exterior	13%
Automated system with minimal maintenance	13%
Present no environmental concerns	13%
Is the system a cost effective design	10%
Reclaim coal removed from wagons	4%
Present as a generic system	2%
Total	100%

The most important KPI is that the washing system does not have any adverse affects on wagon unloading rates or QR rollingstock. The least important KPI is that the systems need to be generic and that the coal needs to be reclaimed from the system for reuse. The system must not create additional environmental concerns as its purpose is to reduce current environmental concerns.

3.3 Method comparison

The table below is a comparison of each Key Performance Indicators (KPI) for the different methods.

Table 2 - KPI Scoring Matrix

KPI	Weight	Water	Air Blast	Air/ Water	Air/ Water/ Brush	Vibration	Tilting	Shock
Effect upon unloading	16%	8	8	8	8	6	1	1
Effect upon Rollingstock	16%	6	7	7	7	1	2	1
Interior Clean	13%	8	7	8	8	6	7	5
Exterior Clean	13%	8	7	8	9	4	4	4
System Automation	13%	8	8	7	4	6	2	3
Environmental Concerns	13%	6	4	6	6	7	6	7
Cost Effectiveness	10%	7	7	6	5	6	1	6
Reclaim Coal removed	4%	9	4	9	9	7	8	6
Generic System	2%	7	7	7	7	6	6	5
Total	100%	73.4%	67.8%	72.7%	69.1%	51.1%	34.9%	37.3%

Table 2 indicates that two options are worthy of further consideration, the full water wash and a combination of air and water washing.

The water washing system has significant advantages over other solutions in the simplicity of the design, however the major drawback is the effect upon the rollingstock as the water around the wheel and axle combination on a regular basis would cause additional maintenance effort as well as possibly reducing the fatigue life of the wheelset components.

To minimise this effect the Air / Water combination strategy was developed. It has been rated as the best solution to meet the functional requirements of the cleaning station. This option incorporates the advantages from the air and water methods and eliminates some of their individual disadvantages. The main downfall with this method was the cost of additional equipment, requiring air compressors to operate.

The other option that rates quite well is the Air / Water / Brush combination. This option rates consistently well in most criteria. The method has disadvantages that were eliminated by combining or removing parts of each method. Experience (through consultation with industry suppliers of such systems) has shown that it is inadvisable to use a brush for cleaning as the regular replacement of the brushes would increase maintenance costs and affect the reliability of the system.

3.4 Recommendations

This comparison indicates that the Air / Water combination appears to be the optimal method for cleaning wagons. This method will remove the majority of coal remaining on wagons after wagon unloading.

It will not interrupt the coal wagon unloading or damage rollingstock. The proposed system is more reliable than the air / water / brush method because there is no need to replace and repair brushes frequently. The method performs well in all KPI.

4. Capital Investment

The wagon wash facility based on the method noted in this report would cost in the range of $5 million to $10 million per unloading system to design, supply and install. The large variation reflects the difficulty experienced in defining the scope of the project, particularly the civil component where retrofitting to an existing installation is concerned. Economical design elements may need to be put aside in favour of expediency when considering the installation period for this equipment as the installation period will involve some shutdown time of the rail corridor.

The items considered in this cost can be separated into costs which are generic and those that are site specific. For some sites this generic wagon wash facility could be installed and commission for less than this value as it would require less civil and building works. At other sites the additional costs may become large when considering these site specific items.

In the price above the following items have been considered:

Generic items:

- Washing Facility

Site Specific items:

- Buildings
- Civil Works
- Supply of power
- Supply of water (for makeup)
- Statutory approvals or fees
- Specific Standards required by QR
- Pump header tank (200m^3)

Exclusions:

- Consequential losses

5. Operating Costs

The operating costs of this facility will include cost estimation of the following items

- Water use
- Water treatment
- Maintenance
- Electrical Load
- Cleaning

5.1 Water use

The water use of this system will be minimised as much as possible to reduce the footprint of this facility on the site.

All steps will be installed to minimise the water lost through the wagons as well as the water into the atmosphere, however water quality will dictate the make up volumes required to replace the blow down from the system. This blow down will be used to control the pH level of the water as it recirculates as the water may become polluted with impurities from the coal causing an acidic environment.

It is estimated that a blowdown of at least 5 kL per day would be required to maintain operations.

In addition the losses to the environment will amount to a volume of 25 kL per day on wagons and as water vapour.

Per annum, this water cost would amount to $15k per unloading stream.

5.2 Water Treatment

The water recirculating around the system will be similar to that found in a cooling tower, and may require biological treatment to prevent pathogen build-up.

The estimated cost of this would be in the order of $5k per annum

5.3 Maintenance cost.

The maintenance cost of such a facility is relatively minor, pump screen and nozzle maintenance being the major elements of maintenance.

An allowance of 0.5% of the capital installed cost is expected to cover the installation requirements due to the large civil component of the installation.

This equates to a range of maintenance cost of between $25k to $50k for a single outloading station per annum.

5.4 Electrical load

The Electrical loading for this installation is low in relation to other areas of the site. A relatively large compressor would be required for the air wash of the bogies as well as a number of pumps.

Costs expected to operate the electrical load would be in the order of $10k per annum.

5.5 Cleaning costs

The cleaning costs for the system are minimal, with a cleanout proposed only on shut down days if required for maintenance. Therefore this cost is discounted amongst the other systems on the site.

5.6 Operating cost summary

Total expected operating costs are noted in Table 3 below.

Table 3 – Operating Cost Summary

Item	Estimated cost per unloading stream per annum
Water used	$25,000
Water treatment	$15,000
Maintenance costs	$25,000 to $50,000
Electrical costs	$15,000
Cleaning cost	$5,000
Contingency (20%)	$17,000 to $22,000
Total:	$102,000 to $132,000

Adjusting this to a per wagon trip cost, an anticipated 200,000 wagons unloaded per annum per stream would provide a cost per wagon trip to be in the order of $0.50 to $0.60 per wagon trip.

6. Assessment

6.1 Prelude

The practicability and cost-effectiveness of the proposed wagon washing system is determined by giving a weighted score to predetermined rating factors. The rating system has been developed in order to facilitate a weighted score for each mitigation strategy arising from the EE which has a generic comparable base. This was achieved by developing:

- A set of weighted rating factors which are relevant to the practicability and cost-effectiveness of a mitigation strategy, and
- A rating guide (see Appendix B) pertaining to various aspects of the rating factors which will highlight the differences between the different mitigation strategies

6.2 Wagon washing

Table 4 shows that wagon washing scores only just at an acceptable level with respect to the rating factors for cost-effectiveness, scoring 2.8 out of 5.0, with a score of 5 being the highest. This is mostly due to the fact that the capital investment is very large for an individual installation with a low dust reduction score (effectiveness) in the order of sub 20% of the total coal dust emitted.

Table 4 – Wagon Washing Cost-Effectiveness Assessment

Factor	Rating Code	Weighting	Rating
Capital Investment	A	20%	2
Operational Cost	B	40%	4
Effectiveness	C	40%	2
Total		100%	2.8

Table 5 indicates that wagon washing scores very highly with respect to the weighted rating factors for practicability, scoring 3.91 out of 5. This is due to the low impact upon the system from an operational point of view together with excellent safety and environmental factors.

This installation will cause installation issues for a portion of the project as the exit track from the unloading station will be required to be replaced as a portion of this work.

Table 5 – Wagon Washing Practices Practicability Assessment

Factor	Rating Code	Weighting	Rating
Implementation			
Ease	D	8%	2
Time	E	8%	2
Resources	D	8%	3
Capacity Impact	G	35%	5
Maintainability	D	2%	4

Factor	Rating Code	Weighting	Rating
Reliability	F	15%	4
Implementation Risk	G	14%	3
Safety	F	5%	5
Environmental	F	5%	5
Total		100%	3.91

The combination of these medium scores determines that wagon loading practice is a practical and somewhat cost effective mitigation strategy to reduce coal dust emissions from the top of loaded coal wagons during transport in the CQCI.

6.3 Comparison

Appendix B contains a complete assessment including both practicability and cost-effectiveness for all of the identified mitigation strategies.

Figure 6 shows that improving the loading methodology into wagons rates highly with respect to both practicability and cost-effectiveness.

Wagon washing facilities are considered to be a medium term mitigation strategy that could be implemented in 2-5 years. Accordingly, it is not feasible to consider it as a solution for reducing coal dust emission from the wagons upon the return trip in isolation.

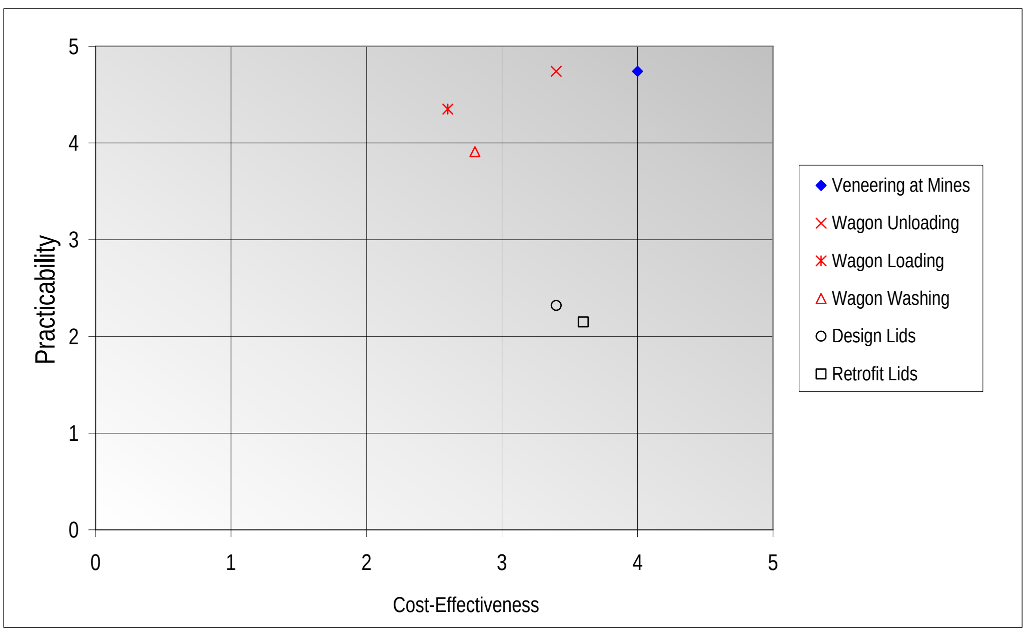


Figure 6 – Mitigation Strategies Assessment Summary

7. Conclusion

The investigation into coal emissions that are related back to wagon hygiene factors have identified numerous attributes that contribute to the incidence of coal emission associate with rollingstock transport.

Studies have shown that in the QR fleet, an estimated 0.1 tonne of coal per wagon is recirculating at any one time around the system. This represents an opportunity for improvement if this material is left at the port each unloading process.

The cost to install a wagon washing facility is estimated to be in the order of $5 M to $10 M per outloading stream and it is expected to cost in the order of $0.50 to $0.60 per wagon per trip washing cost.

The system noted in this analysis rated low on the cost effectiveness rating guide noted in Section 6 of this report with a score of 2.8 out of a possible 5.0. The practicality of this installation was assessed in the standard manner and this rating was a more acceptable 3.9 out of the possible 5.

Appendix A

Wagon Washing Fact Sheet

Wagon Washing

Wagon washing is the process of washing the interior and exterior of coal wagons immediately following unloading, using a combination of water and air.

"Empty coal wagons travelling from the port back to the coal mines are a source of coal dust emissions due to the residual coal in the wagons." (QR EE Interim Report, Jan 2008)

Capital Investment
< $1 million – low volume*
$5-10 million – high volume*

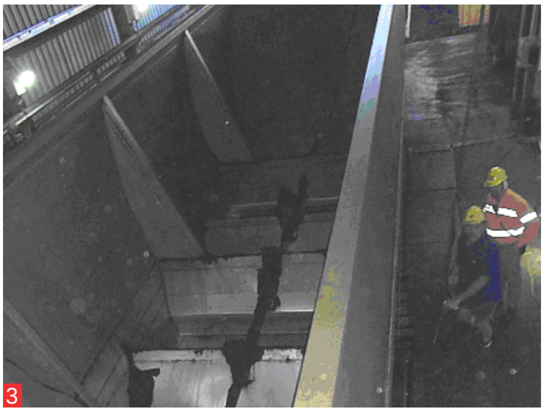
Operational Cost
TBD

Major Benefit
Significantly reduces residual coal and parasitic load

There have been a number of community complaints specifically targeted at dust emissions from residual coal in unloaded wagons.

It has been measured, through studies, that an average of 0.13 t of coal remains inside each wagon after unloading. Washing each wagon will reclaim the residual coal, eliminating parasitic load on the wagon interior and exterior, and address community concern.


1


3


2

Advantages

- Effective reduction residual coal
- Effective reduction parasitic load
- Addresses community concern
- Ability to recycle water

Disadvantages

- Water availability and usage
- Large capital investment
- Affects on rollingstock

1. Parasitic load under shear plates
2. Parasitic load in spring nests
3. Residual coal in unloaded wagon

* site specific

DRAFT

Connell HATCH
Infrastructure for Industry

Appendix B

Mitigation Strategies Assessment

Client: Queensland Rail Limited
Job Number: H327578-N00-EE00
Project: Environmental Evaluation
Description: Coal Dust Emissions Mitigation Strategies Rating Guide

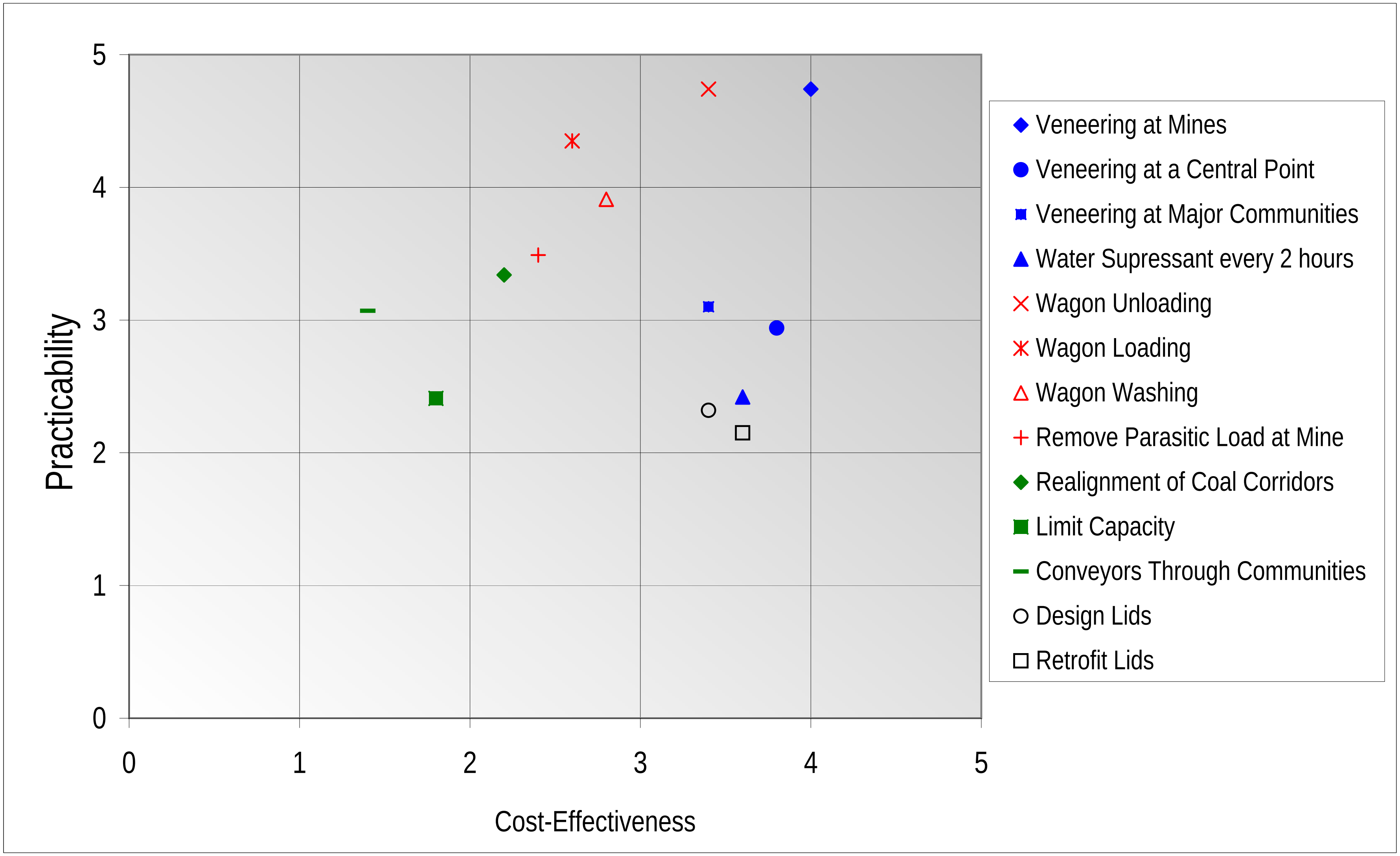
Date: 31.03.2008
Revision: 0

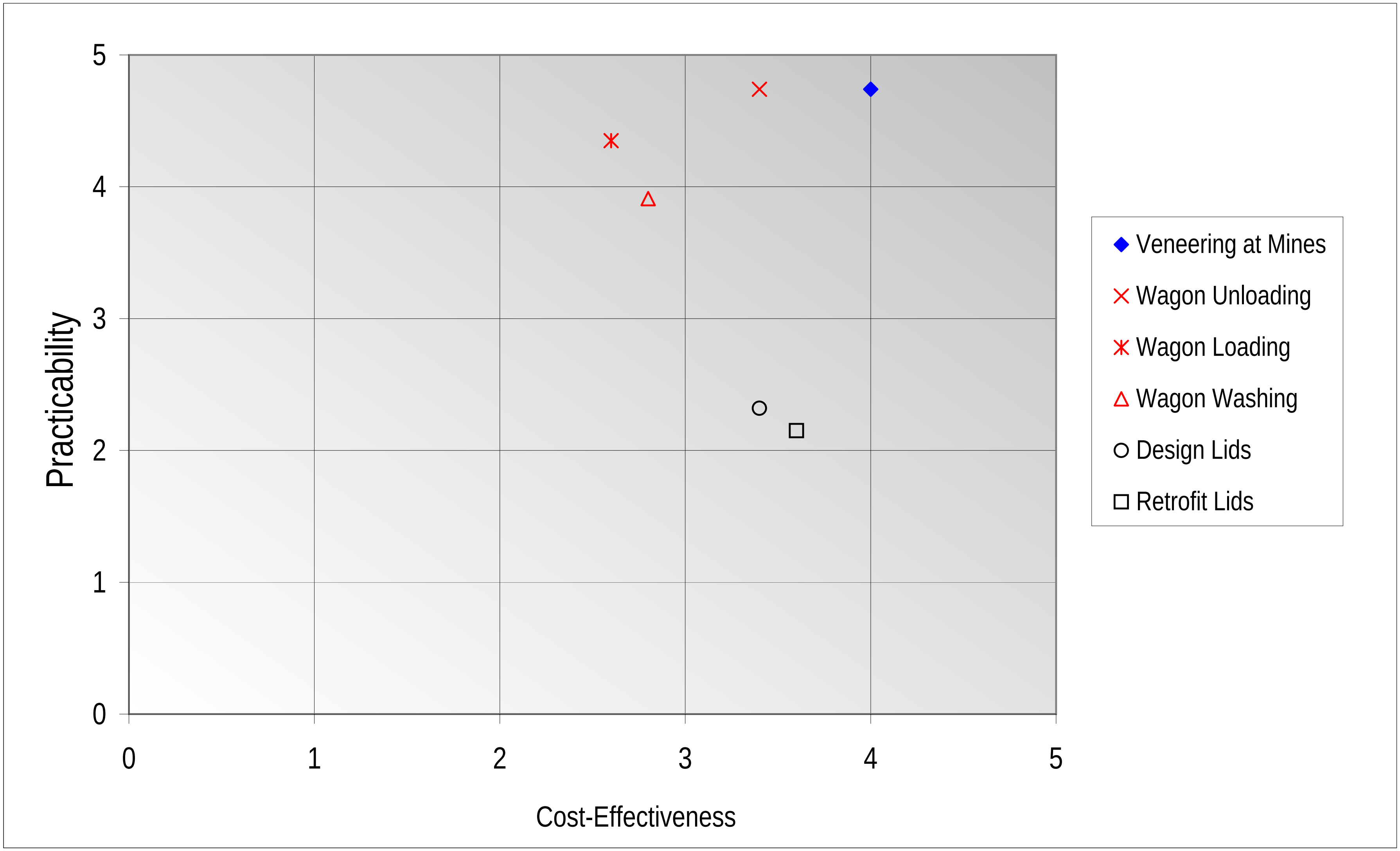
Mitigation Strategies Rating Guide

		Rating Code						
		A	B	C	D	E	F	G
Rating	5	<$1M	<$1	>80%	Very Easy	<1 month	No Impact	Very Low
	4	$1M – $10M	$1 – $5	>60 – 80%	Easy	1-12 months	Low Impact	Low
	3	>$10M - $25M	>$5 – $10	>40 – 60%	Achievable	>1-2 years	Some Impact	Medium
	2	>$25M - $50M	>$10 –$15	20 – 40%	Difficult	>2-5 years	High Impact	High
	1	>$50M	>$15	<20%	Extremely Difficult	>5 years	Untried	Very High

Rating Units

A	industry cost
B	per wagon trip
C	reduction of overall emissions
D	overall assessment
E	implementation timeframe
F	overall assessment
G	overall assessment


Practicability
Cost-Effectiveness
0
1
2
3
4
5
Veneering at Mines
Veneering at a Central Point
Veneering at Major Communities
Water Supressant every 2 hours
Wagon Unloading
Wagon Loading
Wagon Washing
Remove Parasitic Load at Mine
Realignment of Coal Corridors
Limit Capacity
Conveyors Through Communities
Design Lids
Retrofit Lids


5
4
3
2
1
0
Practicability
0
1
2
3
4
5
Cost-Effectiveness
Veneering at Mines
Wagon Unloading
Wagon Loading
Wagon Washing
Design Lids
Retrofit Lids

Client: Queensland Rail Limited
Job Number: H327578-N00-EE00
Project: Environmental Evaluation
Description: Coal Dust Emissions Mitigation Strategies Assessment

Date: 31.03.2008
Revision: 0

Cost-Effectiveness Assessment

	Rating Code	Weighting	Veneering at Mines	Wagon Loading	Wagon Washing	Wagon Unloading	Retrofit Lids	Design Lids	Conveyors Through Communities	Realignment of Coal Corridors	Limit Capacity	Remove Parasitic Load at Mine	Water Supressant every 2 hours	Apply Deflectors to Wagons	Veneering at a Central Point	Veneering at Major Communities
Capital Investment	A	20%	4	1	2	3	4	3	1	1	5	2	4	3	5	5
Operational Cost	B	40%	4	5	4	5	2	2	2	4	1	4	5	5	4	4
Effectiveness	C	40%	4	1	2	2	5	5	1	1	1	1	2	0	3	2
Total:		100%	4	2.6	2.8	3.4	3.6	3.4	1.4	2.2	1.8	2.4	3.6	2.6	3.8	3.4

Practicability Assessment

	Rating Code	Weighting	Veneering at Mines	Wagon Loading	Wagon Washing	Wagon Unloading	Retrofit Lids	Design Lids	Conveyors Through Communities	Realignment of Coal Corridors	Limit Capacity	Remove Parasitic Load at Mine	Water Supressant every 2 hours	Apply Deflectors to Wagons	Veneering at a Central Point	Veneering at Major Communities
Implementation																
Ease	D	8%	5	2	2	4	3	5	1	1	2	3	2	2	3	4
Time	E	8%	4	2	2	4	2	1	1	1	2	3	3	1	4	4
Resources	D	8%	4	5	3	5	5	5	4	2	5	2	1	5	3	4
Capacity Impact	G	35%	5	5	5	5	2	2	3	4	1	4	1	5	1	1
Maintainability	D	2%	5	4	4	5	3	5	4	5	5	4	4	4	4	4
Reliability	F	15%	5	4	4	5	1	1	3	5	4	3	3	5	5	5
Implementation Risk	G	14%	5	5	3	5	1	1	4	3	1	3	4	1	4	4
Safety	F	5%	5	5	5	4	2	2	5	4	5	5	5	5	5	5
Environment	F	5%	3	5	5	4	4	5	4	3	5	5	5	5	3	3
Total:		100%	4.74	4.35	3.91	4.74	2.15	2.32	3.07	3.34	2.41	3.49	2.42	3.86	2.94	3.1

Appendix C

Wagon Washing Analysis

Appendix C

Wagon washing analysis

Water method (Option 1)

The method of cleaning the wagon discussed in option 1 is cleaning by water. Water is sprayed through nozzles which are aimed to remove all coal deposits from the interior and exterior of the wagon after wagon unloading. The process would be fully automated with controls to recognise the following:

- Wagon or locomotive identification, using height detection
- Wagon speed detection and wagon location tracking
- Pressure/ volume regulation for water and power optimisation
- Wagon class identification to optimise cleaning

This system would use a high volume of water to remove coal deposits. It would require large settlement ponds for the recycling of the wash down water. The figures below show the direction of the nozzles for the interior and exterior of the wagon in this method.

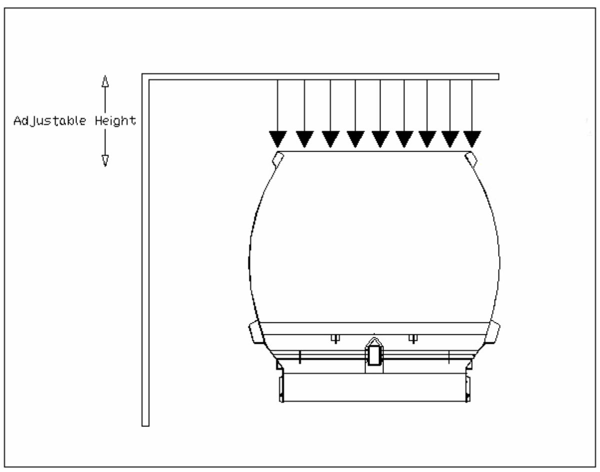


Figure 7 –Internal nozzles – water method

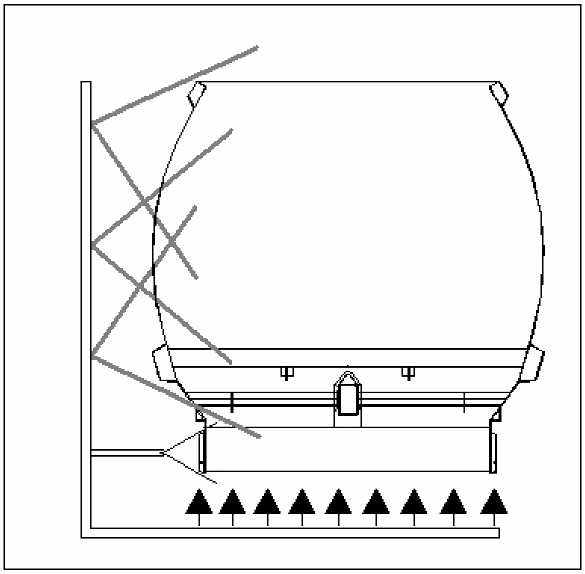


Figure 8 –External nozzles – water method

Advantages

The following is a list of advantages for using water to clean the wagons:

- Provide effective cleaning
- The majority of water can be recycled
- Fast method of removal of coal
- Low health risk to operators
- Easy collection of coal and water
- Washing is continuous and is compatible with current unloading systems

Disadvantages

The following is a list of disadvantages for using water to clean the wagons:

- Will potentially use large quantities of water
- Losses of water in the process
- Large settlement ponds for recycling process
- Possible corrosion problems for the brake cylinder shafts and wagon wheel bearings
- Equipment needed for recycling the water

Key performance indicators (KPI)

Key Performance Indicators	(1:Poor – 10:Good) Performance Rating (1-10)
1. Remove coal from wagon interior	8
2. Remove coal from wagon exterior	8
3. Reclaim coal removed from wagons	9
4. Automated system with minimal maintenance	8
5. Present as a generic system	7
6. Present no environmental concerns	6
7. Effect of interruptions on unloading	8
8. Is the system a cost effective design	7
9. Effect upon Rollingstock	6
TOTAL	67

Air blast method (Option 2)

The method of cleaning the wagon discussed in option 2 is cleaning by compressed air. This process is similar to water but uses air instead to remove coal deposits from the interior and exterior of the wagon. This system would also be fully automated and use the same controls as mentioned previously. The air would be directed similar to that shown in Figures 5 & 6 for the water method.

The system would require large air compressors to produce the required air flow to loosen and remove coal. Using this method would create coal dust that would need to be extracted or it could cause safety concerns.

Advantages

The following is a list of advantages for using air to clean the wagons:

- No need for recycling of air
- Readily available
- Simple and reliable design

Disadvantages

The following is a list of disadvantages for this cleaning method:

- Cost to compress large volumes of air
- Creates dust and a need for dust extraction
- Health risks to operators from coal dust particles in air
- Possible explosion from static build up in an explosive environment
- Possibility of not working with excessive amounts of coal
- Limited possibility of reclaiming coal (would need a separate reclaim system)

Key performance indicators

Key Performance Indicators	(1:Poor – 10:Good) Performance Rating (1-10)
1. Remove coal from wagon interior	7
2. Remove coal from wagon exterior	7
3. Reclaim coal removed from wagons	4
4. Automated system with minimal maintenance	8
5. Present as a generic system	7
6. Present no environmental concerns	4
7. Effect of interruptions on unloading	8
8. Is the system a cost effective design	7
9. Effect upon Rollingstock	6
TOTAL	58

Air / water combination method (Option 3)

The method of cleaning the wagon discussed in option 3 is cleaning by a combination of water and air. The process would have the same concepts as both the water and air methods (Options 1 & 2). The difference being that this method reduces air and water usage. This combination also eliminates some of the disadvantages from options 1 & 2. The water spray could be used to control dust created from the air blast. This would reduce harm to operators and eliminate any potential risks of explosions.

In this method air would be applied to the brake cylinder shafts and wagon wheel bearings while water would be applied everywhere else on the wagon. A water mist would be generated around the air blast zone to control airborne dust particles generated by the cleaning process. The figure below shows the direction of the nozzles for the exterior of the wagon (where the air is shown on the RHS and the water on the LHS).

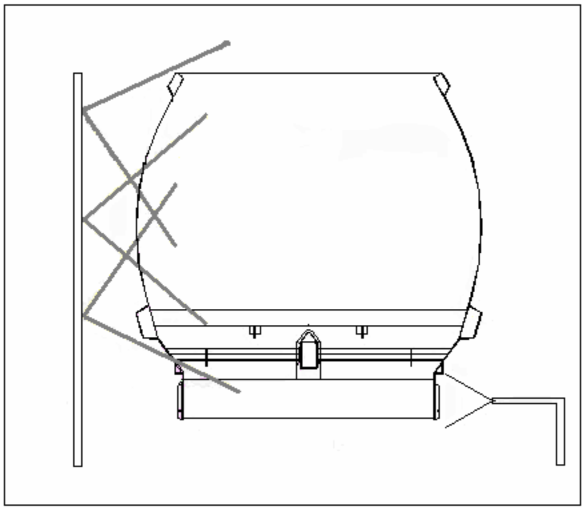


Figure 9 –External nozzles – Air / Water Method

Advantages

The following is a list of advantages for this cleaning method:

- Will remove most coal deposits
- Less water required than Option 1
- Less air required than Option 2
- Fast method of removal of coal
- Low health risks to operators
- Coal can still be reclaimed using this method

Disadvantages

The following is a list of disadvantages for this cleaning method:

- Expense to incorporate two methods
- Will still use large quantities of water
- Will still require settlement ponds
- Will still need to compress large volumes of air

Key performance indicators (KPI)

Key Performance Indicators	(1:Poor – 10:Good) Performance Rating (1-10)
1. Remove coal from wagon interior	8
2. Remove coal from wagon exterior	8
3. Reclaim coal removed from wagons	9
4. Automated system with minimal maintenance	8
5. Present as a generic system	7
6. Present no environmental concerns	6
7. Effect of interruptions on unloading	8
8. Is the system a cost effective design	6
9. Effect upon Rollingstock	9
TOTAL	69

Air / water / brush combination method (Option 4)

The method of cleaning the wagon discussed in option 4 is cleaning the wagon by air, water and brushes. The system will use wet brushes to remove the coal residue left on the sides of the wagon. The interior of the wagon would be cleaned using water and the bogies would be cleaned using air. The underside of wagon (i.e. doors) would be cleaned using water nozzles which spray upwards from underneath the wagon. This system would be improving on method 3 by reducing water consumption by using brushes to clean the sides of the wagon instead of water.

This system improves on Option 3 with the only possible concern being maintenance/ replacement of brushes. The brushes would remove more coal residue from the sides of the wagon than by purely using water.

The figure below shows the direction of the nozzles and brushes for cleaning the interior (water) and exterior (brushes & air) of the wagon.

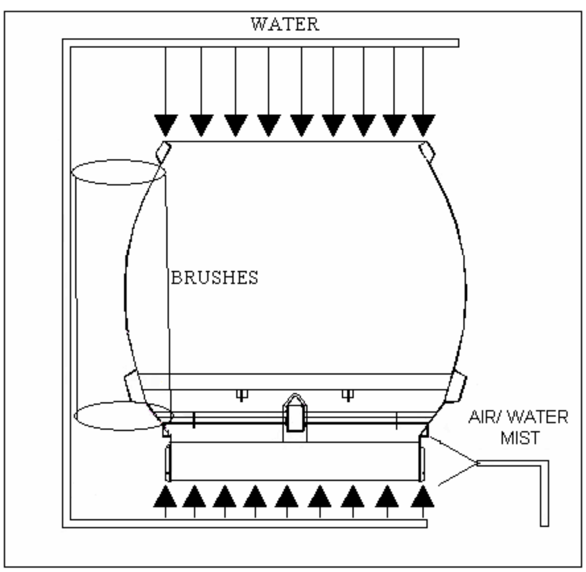


Figure 10 – Air / Water / Brush Combination Method

Advantages

The following is a list of advantages for this cleaning method:

- Will remove most coal deposits
- Less water required than Option 1 & 3
- Less air required than Option 2
- Fast method of removal of coal
- Low health risks to operators
- Coal can still be reclaimed using this method

Disadvantages

The following is a list of disadvantages for this cleaning method:

- Expense to incorporate three methods
- Brushes will need cleaning and replacement
- Will require settlement ponds
- Will need to compress large volumes of air

Key performance indicators (KPI)

Key Performance Indicators	(1:Poor – 10:Good) Performance Rating (1-10)
1. Remove coal from wagon interior	8
2. Remove coal from wagon exterior	9
3. Reclaim coal removed from wagons	9
4. Automated system with minimal maintenance	4
5. Present as a generic system	7
6. Present no environmental concerns	7
7. Effect of interruptions on unloading	8
8. Is the system a cost effective design	6
9. Effect on Rollingstock	9
TOTAL	67

Vibration method (Option 5)

The method of cleaning the wagon discussed in option 5 is by vibration. There are similar vibration methods presently being used at some coal terminals for unloading wagons. This process would require a vibration device to shake the wagon in order to loosen coal deposits. The vibration device would be connected to the wagon and would create vibrations at a magnitude great enough to remove coal without causing damage to the wagon.

This method would require structures that would isolate and absorb vibrations. These structures would be large in mass or significant in foundations, hence maybe expensive. The design would also impose health risks on operators exposed to the vibrations and noise produce by these vibrations.

Advantages

The following is a list of advantages for this cleaning method:

- Quick removal of coal deposits
- Low water/ energy use

Disadvantages

The following is a list of disadvantages for this cleaning method:

- Detrimental to wagon structurally and mechanically
- Expensive civil works to isolate vibrations to adjoining structures
- Difficulty directing the vibration to the appropriate areas
- May not remove all coal hung-up in wagon
- Workplace health and safety issues with vibration, noise and dust generated

Key performance indicators (KPI)

Key Performance Indicators	(1:Poor – 10:Good) Performance Rating (1-10)
1. Remove coal from wagon interior	6
2. Remove coal from wagon exterior	4
3. Reclaim coal removed from wagons	7
4. Automated system with minimal maintenance	6
5. Present as a generic system	6
6. Present no environmental concerns	7
7. Effect of interruptions on unloading	6
8. Is the system a cost effective design	6
9. Effect upon Rollingstock	1
TOTAL	49

Tilted wagon method (Option 6)

The method of cleaning the wagon discussed in option 6 is cleaning by tilting the wagon. This method would require wagons to be disconnected from the consist, and then tilted to remove all remaining coal deposits. This method would cause the wagon to come to a halt as it is disconnected and then reconnected to the consist. The wagon would need to be rotated at least 150 deg to 180 deg to remove all coal and then returned to the tracks. This rotational motion would loosen coal particles which would then be emptied from the top of the wagon as it is tilted.

This design would be quite complicated, but it is believed would be quite effective at removing remaining coal deposits. With appropriate guarding and control systems this design would be quite safe for operators. The figure below shows the basic principles behind this tilting method.

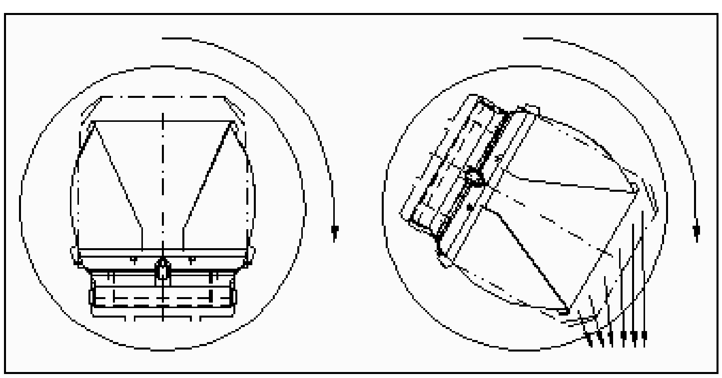


Figure 11 – Tilted wagon method

Advantages

The following is a list of advantages for this cleaning method:

- Inside of wagon would be emptied
- No use of water/air or need for recycling

Disadvantages

The following is a list of disadvantages for this cleaning method:

- Slow and disruptive when unloading wagons
- Expensive rotating equipment
- Having to disconnect wagon from consist
- Some coal may be hung-up inside and under end slope sheets
- May not remove coal in bogies and spring nests
- Would create coal dust
- Reduces unloading throughput

Key performance indicators (KPI)

Key Performance Indicators	(1:Poor – 10:Good) Performance Rating (1-10)
1. Remove coal from wagon interior	7
2. Remove coal from wagon exterior	4
3. Reclaim coal removed from wagons	8
4. Automated system with minimal maintenance	2
5. Present as a generic system	6
6. Present no environmental concerns	6
7. Effect of interruptions on unloading	1
8. Is the system a cost effective design	1
9. Effect upon Rollingstock	2
TOTAL	37

Shock loading method (Option 7)

The method of cleaning the wagon discussed in option 7 is cleaning by shock loading the wagon. This method is similar to using vibrations. It involves using potential energy stored in the bogie spring to create vibrations which would loosen coal deposits. The wagon would be pushed vertically down by a mass and then released. Upon releasing the energy will be released and would try to jump the wagon vertically up. This motion would cause coal particles to become loose.

The main issue with this method would be the fatigue created in the bogie springs from frequently being compressed and then released. Another issue would be keeping the consist from derailing after the springs are released. The figure below shows the basic concept behind this method.

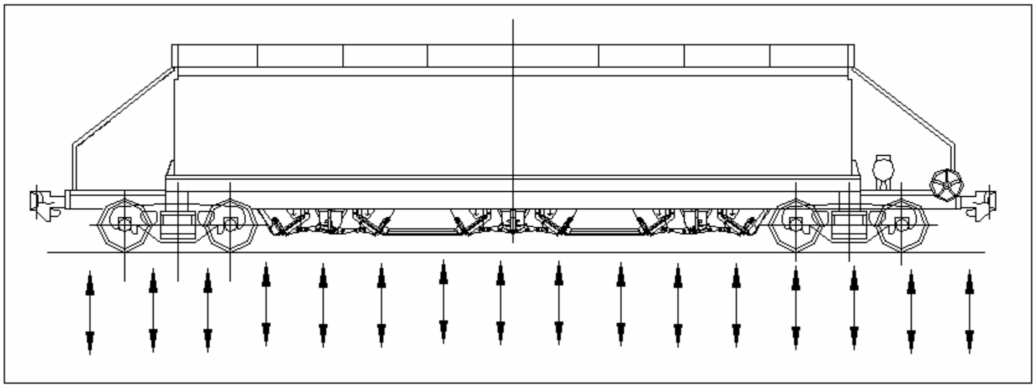


Figure 12 – Shock loading method

Advantages

The following is a list of advantages for this cleaning method:

- Will shake most interior coal loose

Disadvantages

The following is a list of disadvantages for this cleaning method:

- High forces on wagon could cause fatigue wear
- Uncontrolled travel of wagon after energy release
- A need for strong guarding
- Expensive equipment needed
- May require stopping wagons
- Would probably not remove coal from end slope sheets and bogies

Key performance indicators (KPI)

Key Performance Indicators	(1:Poor – 10:Good) Performance Rating (1-10)
1. Remove coal from wagon interior	5
2. Remove coal from wagon exterior	4
3. Reclaim coal removed from wagons	6
4. Automated system with minimal maintenance	3
5. Present as a generic system	5
6. Present no environmental concerns	7
7. Effect of interruptions on unloading	1
8. Is the system a cost effective design	6
9. Effect upon Rollingstock	1
TOTAL	38

Appendix I

Wagon Unloading Practices Analysis

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Environmental Evaluation
Queensland Rail Limited

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0	14 February 2008	Draft Report	BB	DJP	SMC	RJH
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Contents

Executive summary

This supplementary report presents the particulars of a review of wagon unloading practices employed throughout the Central Queensland Coal Industry that was undertaken by Connell Hatch with respect to the Environmental Evaluation commissioned by Queensland Rail Limited. Improving wagon unloading practices has been identified as a mitigation strategy to reduce coal dust emissions resulting from residual coal in unloaded wagons and parasitic load on the wagon exterior. Accordingly, the completion of this report aims to:

- Identify factors and circumstances attributable to wagon unloading practices that contribute to coal dust emissions
- Detail mitigation strategies pertaining to the coal dust emission sources
- Assess the practicability and cost-effectiveness of the mitigation strategies

The outcomes achieved with respect to the aims of the report include:

- The most influential factors and circumstances attributable to wagon unloading practices that contribute to coal dust emissions include:
  - Coal ploughing
  - Carry-back
  - Grate height
  - Wagon vibrators
  - Automation

- Preventive solutions to reduce coal losses associated with wagon unloading practices include:
  - Lowering the grate height
  - Installing automatic wagon vibrators
  - Increasing the level of automation

- Improving wagon unloading practices rates as a very practical, but not very cost-effective mitigation strategy, because it is not addressing the primary coal dust emission source

Glossary of terms

ACARP
Australian Coal Association Research Program

APCT
Abbot Point Coal Terminal, Abbot Point, North Queensland

BPCT
Barney Point Coal Terminal, Gladstone

CQCI
Central Queensland Coal Industry – entire coal supply chain

CQCN
Central Queensland Coal Network – entire rail infrastructure network

CSIRO
Commonwealth Scientific and Industrial Research Organisation

DBCT
Dalrymple Bay Coal Terminal, Mackay

EE
Environmental Evaluation

EPA
Environmental Protection Agency

HPCT
Hay Point Coal Terminal, Mackay

KDD
Kwik-Drop Doors – wagon doors and operating mechanisms

QR
Queensland Rail Limited

QRNA
Queensland Rail Network Access – below rail operator

QRN
Queensland Rail National – above rail operator

RGTCT
RG Tanna Coal Terminal, Gladstone

TSI
Train Speed Indicator

1. Introduction

Queensland Rail Limited (QR) has appointed Connell Hatch, John Planner of Introspec Consulting and Katestone Environmental to prepare an Environmental Evaluation (EE) of coal dust emissions engendered from rollingstock in the Central Queensland Coal Industry (CQCI) in response to a Notice issued by the Queensland Environmental Protection Agency (EPA). The deliverables of the report have been stipulated by the Terms of Reference for the project which encompass:

a) *Identify all potential sources of coal dust emissions from QR trains in Central Queensland on land described as rail lines connecting coal mines in the Bowen and Callide Basins with ports at Dalrymple Bay, Hay Point and Gladstone*

b) *Quantify the potential risk of environmental harm posed by each dust source*

c) *Identify the factors and circumstances that contribute to dust emissions and/or impacts from each source. Consideration should be given to (but not limited to) issues such as coal type, coal properties and meteorological conditions.*

d) *Based on the findings from the above, identify locations within QR's Central Queensland operations where proximity of railway lines to communities may give rise to higher risk of environmental harm due to fugitive coal dust*

e) *Identify ways to reduce the risk being caused by coal dust emissions and assess each for practicability, effectiveness and cost, in relation to the mitigation of environmental impacts of fugitive coal dust emissions*

The sources of coal dust emissions that have been identified in the CCQI include emissions from:

- The coal surface of loaded wagons
- Coal leakage from the doors of loaded wagons
- Wind erosion of spilled coal in the rail corridor
- Residual coal in unloaded wagons and leakage of residual coal from the doors
- Parasitic load on sills, shear plates and bogies of wagons

This supplementary report presents the particulars of a review of wagon unloading practices that was undertaken by Connell Hatch with respect to the EE commissioned by QR. Wagon unloading practices have been identified as a factor that contributes to residual coal remaining in unloaded wagons and parasitic load on the wagon exterior. Accordingly, this review will identify the factors and circumstances associated with wagon unloading practices that contribute to coal dust emissions throughout the CQCI. Mitigation strategies pertaining to these coal dust emission sources can then be outlined and analysed for practicability and cost-effectiveness.

2. Wagon unloading stations

The unloading facilities and stations that receive the majority of the coal produced in the CQCI are detailed in Table 1, comprising of five export facilities (coal terminals) and two domestic coal users.

Table 1 – CQCI Unloading Facilities and Stations

Facility	Acronym	Mtpa[1]	%	Stations
Abbot Point Coal Terminal	APCT	11.15	6.23	1
Dalrymple Bay Coal Terminal	DBCT	49.85	27.86	2 (3)*
Hay Point Coal Terminal	HPCT	36.38	20.33	2
RG Tanna Coal Terminal	RGTCT	45.20	25.26	2 (3)*
Barney Point Coal Terminal	BPCT	6.30	3.52	1
Gladstone Power Station	NRG	30.03	16.78	1
Queensland Alumina Limited	QAL			1

[1] http://www.dme.qld.gov.au/mines/coal_statistics.cfm
Central Queensland Ports Authority Annual Report 2006-07 Page 9
Ports Corporation of Queensland Ports and Projects Report 2006-07 Pages 2, 5
** Commissioned during or after 2006-07*

3. Wagon unloading practices

3.1 Background

A coal wagon unloading system is as a system that facilitates coal transfer from rollingstock into a hopper and from the hopper to its intended destination. Unloading throughout the CQCI is achieved with bottom dump Kwik-Drop Doors (KDD) which empty wagons as they travel atop the hopper by means of opening and closing triggers. Feeders in the base of the pit remove coal from the hopper onto a conveyer belt which transports the coal to its destination, typically an intermediate transfer point.

Unloading stations have evolved from initial rotary dump systems to the current bottom dump systems. Rotary dump systems unload two wagons at a time, rotating them 180 degrees to allow the coal to flow out of the top of the wagons into the hopper before returning them to the rails. This process is much slower and more tedious due to the continual starting and stopping of the train.

3.2 Wagon unloading variables

Many interrelated variables determine wagon unloading system performance, the most influential of which are detailed in the following subsections. Many of the variables are a function of the design which have been determined to ensure that the system can achieve nominal unloading rates.

3.2.1 Hopper dimensions

The length, width, volume and geometry of each hopper are different. The hopper acts as a buffer between the wagon unloading rate experienced from the KDD and the hopper unloading feeder system. The differential between these two rates determines how quickly the buffer is filled and therefore how effectively the buffer works to prevent overfilling whilst maintaining nominal hopper unloading rates (see Figure 1). The average wagon unloading rate seen by the hopper varies linearly with the speed of the train. The hopper unloading rate can be altered by changing the feeder output rates. Feeder type, arrangement, the control system and geometric constraints also factor in the geometry of each hopper.

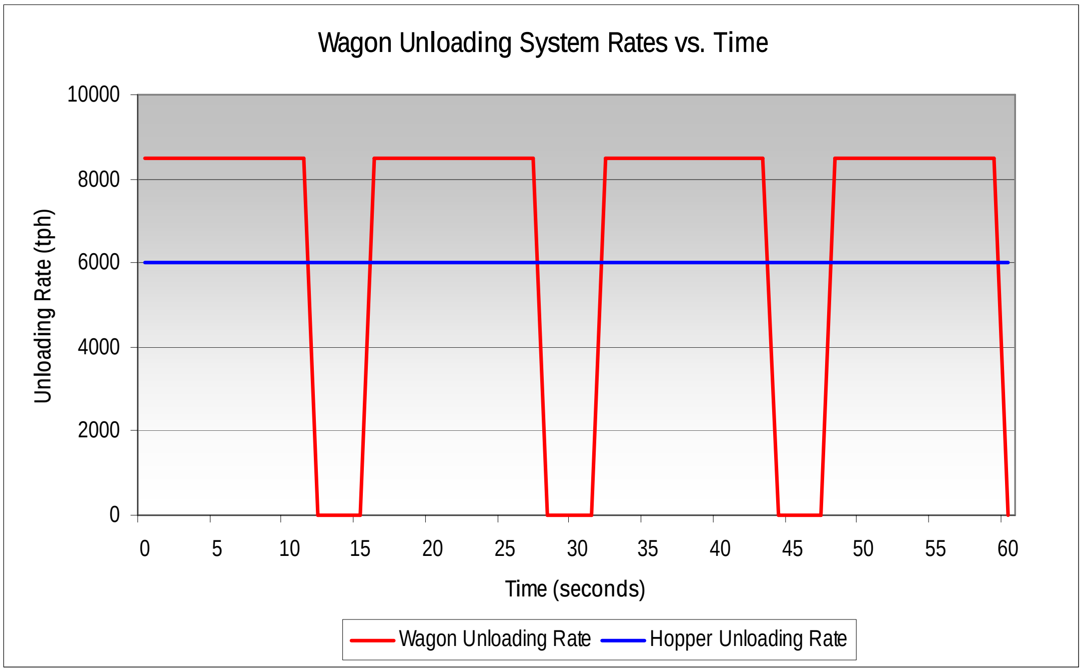


Figure 1 – Indicative Wagon Unloading System Rates vs. Time

3.2.2 Grate height

All hoppers have a metal grate lying across the top to prevent large foreign objects from entering the hopper as well as to provide a safe working environment for personnel working in the unloading station. Older unloading station designs have the top of the grate lying approximately 100-150 mm underneath the top of rail height (see Figure 2). More recent hopper designs have seen this distance increase to approximately 500-600 mm (see Figure 3).

Figure 2 – Old Style Grate

Figure 3 – Current Best Practice Grate

3.2.3 Train speed indicators

Train Speed Indicators (TSI) are installed at some unloading stations to help monitor and control train speeds during unloading. Two-way radio communications are sued in their absence to relay requests from unloading operators to train drivers, reportedly causing confusion between trains at unloading facilities with multiple unloading stations. TSI match an unloading station with a train with communication occuring as follows:

- The unloading operator sends a signal through the TSI to the train driver requesting a speed change
- An alarm goes off in the train drivers cabin to notify them of the request
- The train driver adjusts the train speed accordingly and sends a response through the TSI to the unloading operator to communicate that the change has been acknowledged and made

This technology provides unloading operators with greater and more efficient communication methods to vary train speed to match hopper performance.

3.2.4 Wheel washers

Some unloading stations have a train wheel washing system (see Figure 4) installed immediately following unloading. Coal attaches to the train wheels during the unloading process as the wheels crush coal lying atop the tracks. The washing systems are in place to remove this coal to help reduce parasitic load, maintain wheel concentricity and inturn minimise wear on the train wheels. Any coal that leaves the facility attached to the wheels is considered to be parasitic load.

Figure 4 – Wheel Washers

3.2.5 KDD triggers

The quantity and location of the KDD triggers (see Figure 5) vary according to the design of each unloading station. Typically, three to four opening triggers (see Figure 7) are installed at varying distances from the beginning of the hopper on the opening side (right hand side in the direction of travel) of the wagons, with one closing trigger at the end of the hopper on the closing side (left hand side in the direction of travel) of the wagons. Multiple opening triggers are used to spread the coal across the length of the hopper, rather than concentrating it at one point.

The location of the triggers is a function of the nominal train speed during unloading to ensure that sufficient time is allowed for the coal to discharge from the wagon before reaching the end of the hopper. Coals with poor characteristics encourage unloaders to favour the use of the early triggers in order to provide time to react if the coal does not flow freely from the wagon.

Figure 5 – KDD Trigger

Figure 6 – Opening Side KDD Triggers

3.2.6 Wagon vibrators

Generally, small quantities of coal remain in every wagon following unloading. The Commonwealth Scientific and Industrial Research Organisation (CSIRO) in conjunction with QR are currently working on a project titled “Reduction of Carry-Back and Coal Spillage in Rail Transport” funded by the Australian Coal Association Research Program (ACARP). In October 2007 a draft report (P2007/893) “Analysis of Carry-Back at the RG Tanna Coal Terminal” was released with preliminary results from a carry-back quantification experiment. The study used two laser scanners to reconstruct a three dimensional model of the interior of each wagon. The study has estimated that for the particular unloading station concerned, an average of 100 kg of coal remains unloaded in every wagon.

Newer unloading stations have automatic wagon vibrators installed, which automatically apply a vibrating harmonic to wagons identified by sensors to not be unloading sufficiently. Older unloading stations have manual wagon vibrators such as jackhammers or vibration pads (see Figure 8) to deal with sticky coal, that is coal that hangs up significantly in the wagon during unloading. Visual cues are utilised to determine when to a train should be stopped and manual vibration applied. These systems are inherently less efficient than automatic wagons vibrators because they are not autonomous and are not compatible with continuous unloading operations.

Figure 7 – Automatic Wagon Vibrator

Figure 8 – Manual Wagon Vibrator

3.2.7 Automation

The level of automation and technology varies at each unloading station. Newer systems benefit from improvements in technology with more information and more autonomous features to reduce operator control. Increased autonomy inherently reduces variability in any process. Technology is sufficiently advanced that trigger sequencing, feeder rates and TSI could operate autonomously.

4. Coal dust emission contributing factors

4.1 Coal ploughing

Coal ploughing (see Figure 9) is defined as the overfilling of the hopper at a wagon unloading station to the extent that the coal is ploughed by the wagon framework and bogies as they travel across the top of the hopper. Coal ploughing results in parasitic load on the wagon exterior and can contribute to residual coal in some instances.

Figure 9 – Coal Ploughing Leading to a Derailment

Hopper overfilling occurs as a result of a differential (transfer differential) between wagon unloading rates and hopper unloading rates. This differential produces a net gain of coal in the hopper, and if this gain is maintained over time, the hopper will overfill. Consequently, overfilling can be controlled by either reducing wagon unloading rates (by reducing train speed) or increasing hopper unloading rates (if possible). There are many factors that potentially contribute to overfilling which are discussed in the following subsections:

4.1.1 Hopper unloading faults

Any fault with the hopper unloading system that lowers the nominal hopper unloading rate will increase the transfer differential. Generally, a fault with the feeder system would occur due to failure or a blocked feeder. If train speed remains at nominal rates, this transfer differential may result in the hopper overfilling.

4.1.2 Excessive train speed

Excessive train speed (above nominal rates) can result in an increase in the transfer differential. Reducing train speed is the most effective method of preventing overfilling and coal ploughing. Therefore, it would be prudent to have technology which effectively provides information to both unloading operators and train drivers as to when and by how much to change speed.

4.1.3 KDD trigger locations

Although multiple opening triggers are installed at unloading stations, the tendency to only use the earlier triggers (due to poor handling coals) can result in uneven loading of the hopper. This imbalance can result in decreased hopper unloading rates, subsequently increasing the transfer differential.

4.1.4 Grate height

During normal unloading operations, the coal discharges from each wagon into the hopper through the grate atop the hopper. Once the coal passes through the grate, the operator has no visual indication of the level of material in the hopper. Some hoppers have instruments installed to provide this information, however to date this information has reportedly been shown to be unreliable at times based on a number of factors. Consequently, unloading operators rely mainly on visual signals to determine hopper levels.

With the older unloading stations where the grating is very close to the rails, the operator has very little time to detect and react to hopper overfilling based on visual cues. Accordingly, the time taken for this process is insufficient to prevent coal ploughing. Newer unloading stations have the grate recessed between the rails, or the rails lying higher that the entire grate. This improved design feature provides more time for unloading operators to react to hopper overfilling based on visual cues.

4.1.5 Track foundations

The crevices in the track rails facilitate the build-up of coal above the hopper. This build-up can potentially contribute to coal ploughing and parasitic load. One facility trialled the use of sloped foundations to overcome this problem, however there were some implications that required the foundations to be removed.

Figure 10 – Common Foundation

Figure 11 – New Sloped Foundation

4.1.6 Automation

The control logic implemented at each unloading station may also contribute to coal ploughing. Trigger sequencing, as discussed above, may not be utilising all the opening triggers for various reasons, potentially contributing to hopper overfilling. The control of the feeders which empty the hopper can alter, and may not account for localised overfilling due to wagon unloading sequences. Insufficient reaction to variations within the hopper can result in overfilling. Other logic relating to train speed, the utilisation of sensory inputs etc can also contribute to coal ploughing if the logic does not reflect realistic system performance or is not robust enough to deal with variations in the unloading process.

Manual control has an advantage over automated systems due to human intelligence that will outweigh automated logic in decision making, particularly when the control system has limited available information. However, automatic systems do not suffer from fatigue and concentration and other human related attributes, and therefore is still preferable provided sufficient information is available and reliable for the system to function correctly.

4.2 Carry-back

Carry-back is defined as coal which remains in a wagon following the unloading process (residual coal). Such coal dust emission sources are susceptible to turbulent air flows during travel back to the mines, as well as falling through the gap between the doors during travel back to the mines. Consequently, carry-back is considered to be a fugitive coal loss mechanism associated with wagon unloading practices. A study currently being exercised at RG Tanna Coal Terminal has shown that on average 0.10 t of coal is carried back per wagon (P2007/893 "Analysis of Carry-Back at the RG Tanna Coal Terminal" October 2007). Factors which contribute to carry-back events are detailed in the following subsections.

4.2.1 Sticky coal

Sticky coals have high internal friction angles and therefore they do not flow as well as other coals do. These coals are susceptible to not flowing freely from wagons during the wagon unloading process, particularly in the valley angles in the corners of the wagons. Consequently, sticky coals potentially contribute more to carry-back then normal coals. Because detection of sticky coals events is based on visual observations, generally only severe cases are noticed and consequently sticky coals can contribute significantly to an increase in carry-back without appearing to be visually significant. In extreme cases of sticky coal, the coal will form a crust of major build-up inside the wagon requiring manual removal from the wagon interior.

4.2.2 Wagon vibrators

The absence of automatic wagon vibrators at some unloading stations, due their superior autonomy and operation during continuous train unloading, will remove more coal on average then manual vibrators because:

- They are more effective a commencing mass flow
- They apply a thoroughly spread harmonic to reach the majority of the wagon
- The decision to apply them is not based on disruptions to the supply chain

4.2.3 Coal ploughing

When hopper overfilling and consequently coal ploughing occurs, the flow of coal discharging from each wagon is inhibited. Depending upon the location and extent of overfilling, it is possible for the resulting flow disturbance to prevent the complete discharge of coal from the wagons prior to the wagon reaching the KDD closing trigger. In such instances, any coal that remains in a wagon is trapped within the wagon after the doors have closed and can be considered to be carry-back.

5. Mitigation strategies

5.1 Description

Based on the review of wagon unloading practices, the mitigation strategies that present as the most practical and effective (in terms of reducing the incidence of coal ploughing) include:

- Lowering the grate height
- Installing automatic wagon vibrators
- Increasing the level of automation

5.2 Capital Investment

The cost involved in the mitigation strategies is all based around capital investment, with operational costs considered to be negligible. The indicative capital investment required for the installation of an automatic wagon vibrator was sourced from an industry supplier of the machinery. The remaining costs (see Table 2) are estimates based on the work involved. The cost to increase the level of automation is highly site specific, therefore this cost has a large range to provide a realistic representation of the industry.

Table 2 – Capital Expenditure Estimate

Item	Quote	Estimate	Total
Lowering the grate height		✓	$50,000 – $100,000
Installing automatic wagon vibrators	✓	✓	$2,000,000
Increasing the level of automation		✓	$100,000-$300,000
Total			$2,150,000 – $2,400,000

6. Assessment

6.1 Prelude

The practicability and cost-effectiveness of the proposed wagon unloading system upgrades system is determined by giving a weighted score to predetermined rating factors. The rating system has been developed in order to facilitate a weighted score for each mitigation strategy arising from the EE which has a generic comparable base. This was achieved by developing:

- A set of weighted rating factors which are relevant to the practicability and cost-effectiveness of a mitigation strategy, and
- A rating guide (see Appendix A) pertaining to various aspects of the rating factors which will highlight the differences between the different mitigation strategies

6.2 Wagon unloading

Table 3 shows that wagon unloading scores poorly with respect to the rating factors for cost-effectiveness, scoring 3.4 out of 5, with being the highest. Table 4 shows that wagon unloading scores very highly with respect to the weighted rating factors for practicability, scoring 4.74 out of 5. The combination of these scores determines that improving wagon unloading practices is a practical but not a cost-effective mitigation strategy to reduce coal dust emissions. The lower score received for cost-effectiveness is primarily due to the fact that improving wagon unloading practices is not targeting the major coal dust emission dust source.

Table 3 – Wagon Unloading Cost-Effectiveness Assessment

Factor	Rating Code	Weighting	Rating
Capital Investment	A	20%	3
Operational Cost	B	40%	5
Effectiveness	C	40%	2
Total		100%	3.4

Table 4 – Wagon Unloading Practicability Assessment

Factor	Rating Code	Weighting	Rating
Implementation			
Ease	D	8%	4
Time	E	8%	4
Resources	D	8%	5
Capacity Impact	G	35%	5
Maintainability	D	2%	5
Reliability	F	15%	5
Implementation Risk	G	14%	5
Safety	F	5%	4
Environmental	F	5%	4
Total		100%	4.74

6.3 Comparison

Appendix B contains a complete assessment including both practicability and cost-effectiveness for all of the identified mitigation strategies. Figure 12 shows that wagon unloading is one of the most practical mitigation strategies, but does not match the cost-effectiveness of the other strategies because it is not addressing the primary source of coal dust.

Wagon unloading and wagon washing address the same coal dust emission sources. Accordingly, a comparison between the two shows that wagon unloading is a more practical and cost-effective mitigation strategy than wagon washing. This is primarily due to the significantly higher capital investment and operating costs associated with washing. Furthermore, while washing could produce a more effective reduction of coal dust from the identified sources, the sources do not constitute the primary coal dust emission source.

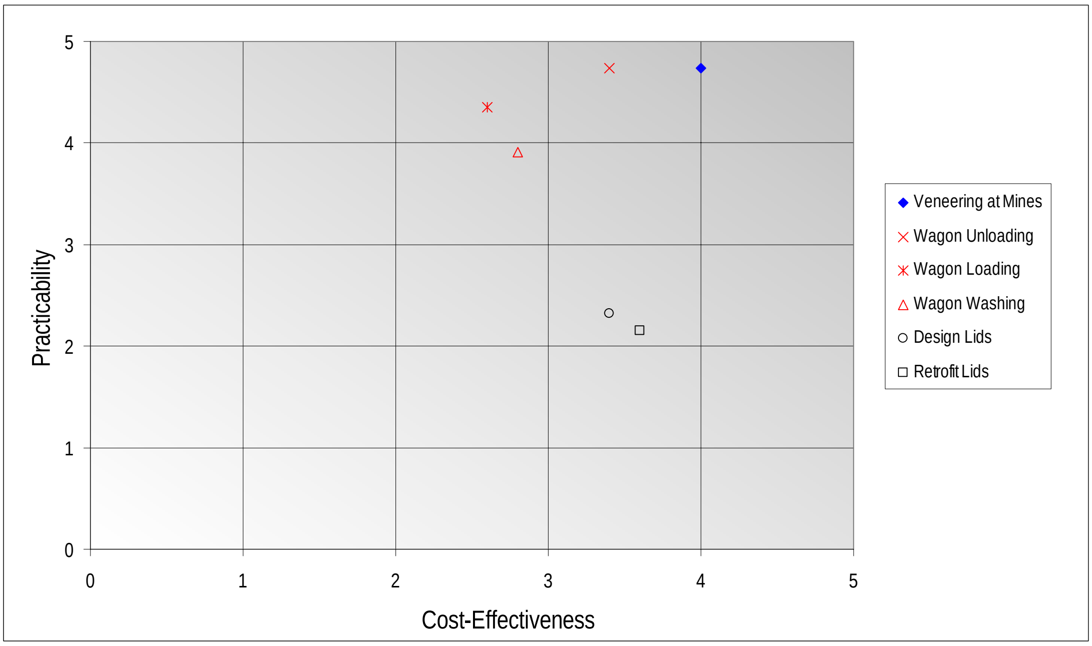


Figure 12 – Mitigation Strategies Assessment Summary

7. Conclusion

Analysis of the wagon unloading practices identified many factors and circumstances that contribute to coal dust emissions form the sources of residual coal in unloaded wagons and parasitic load on the wagon exterior. Some factors were identified to be the most influential factors with respect to contributing to coal dust emissions, viz:

- Coal ploughing
- Carry-back
- Grate height
- Wagon vibrators
- Automation

The mitigation strategies proposed to reduce the coal dust emissions from these sources include

- Lowering the grate height
- Installing automatic wagon vibrators
- Increasing the level of automation

It is estimated that the capital investment required to implement these changes is approximately $2-$2.5 million. Based on the weighted rating system, improving wagon unloading practices presents as a very practical but not very cost-effective solution of reducing coal dust emissions. This poor cost-effectiveness is attributable to the fact that the mitigation strategy is not addressing the primary coal dust emission source.

Appendix A

Mitigation Strategies Assessment

Client: Queensland Rail Limited
Job Number: H327578-N00-EE00
Project: Environmental Evaluation
Description: Coal Dust Emissions Mitigation Strategies Rating Guide

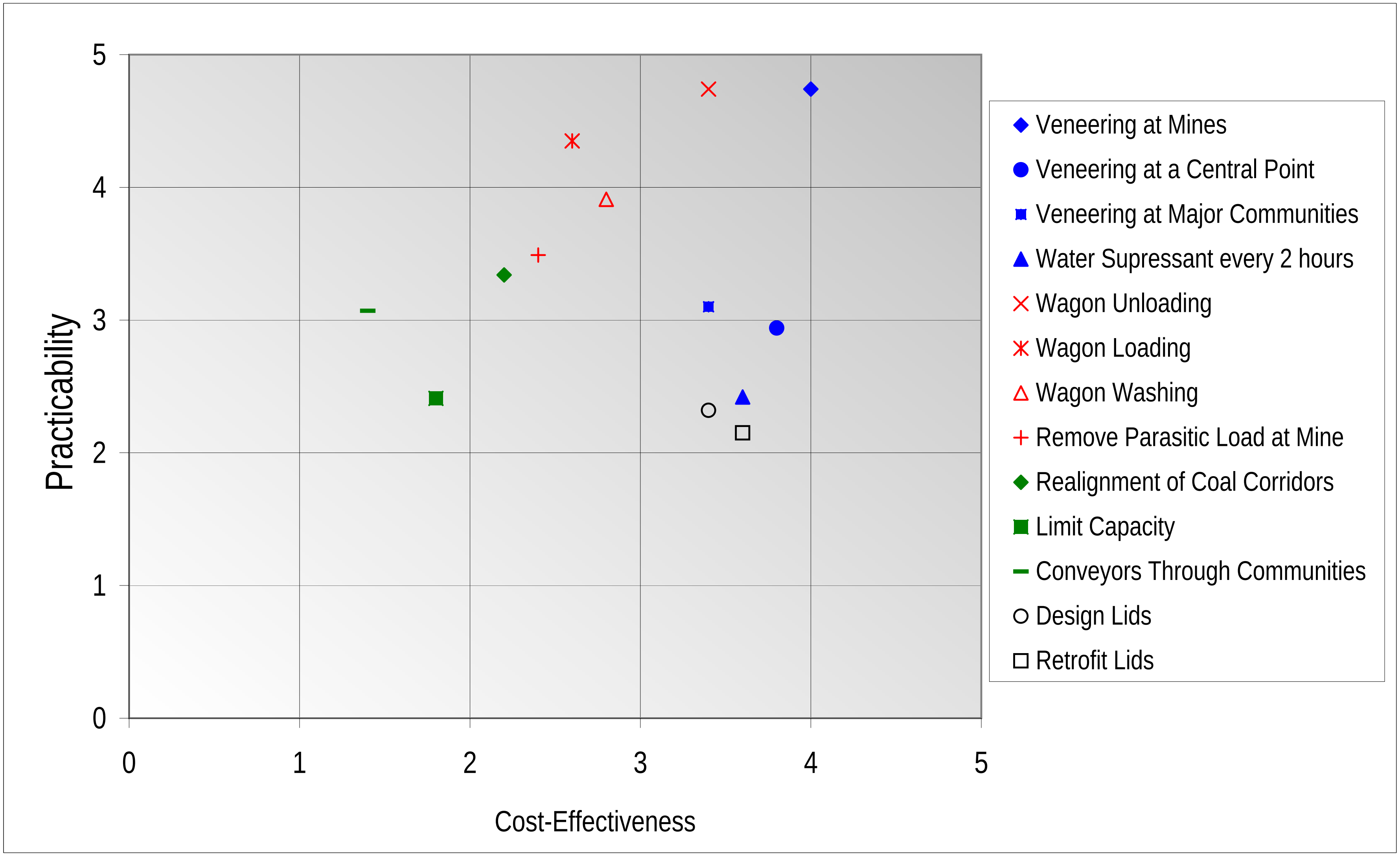
Date: 31.03.2008
Revision: 0

Mitigation Strategies Rating Guide

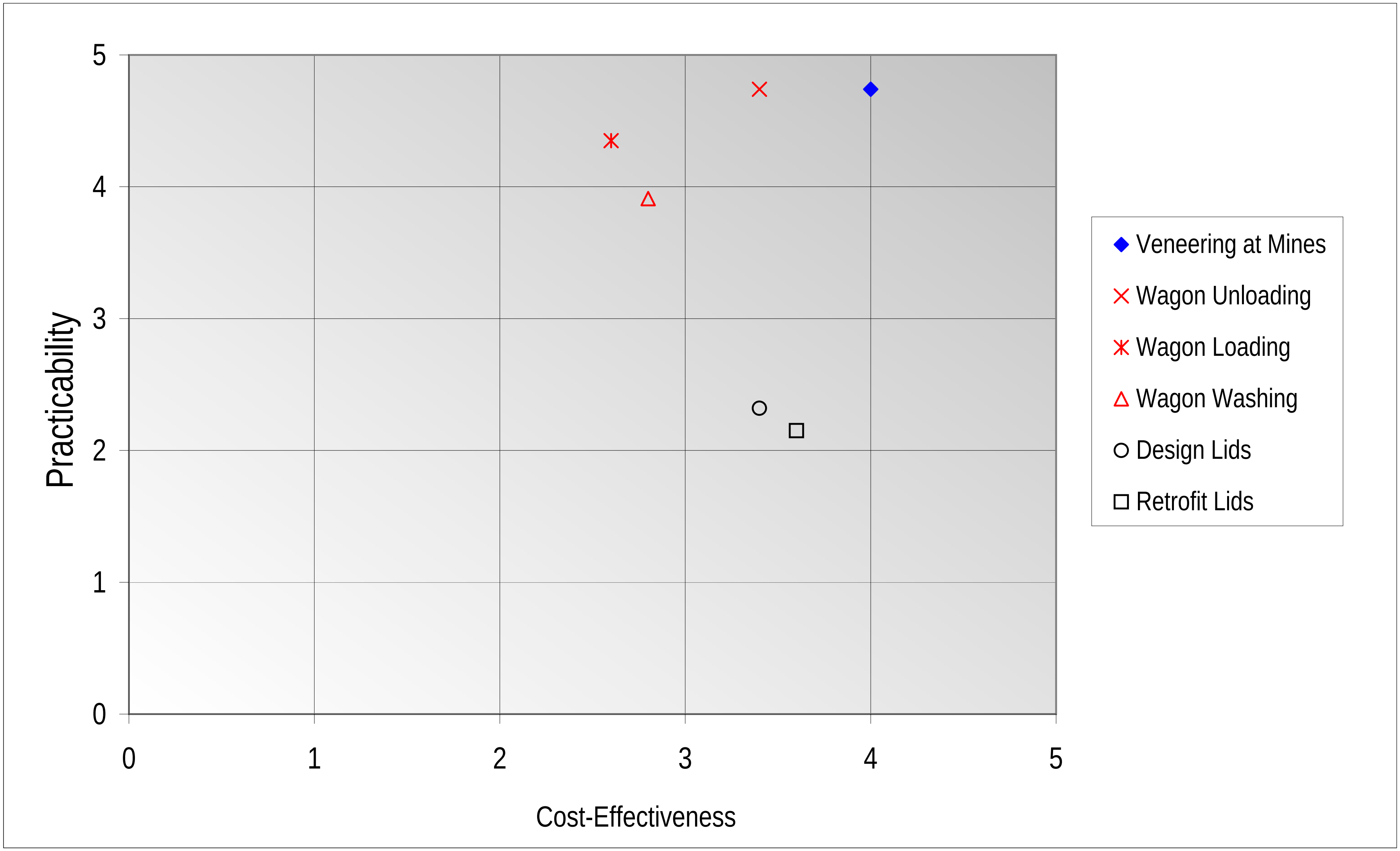
		Rating Code						
		A	B	C	D	E	F	G
Rating	5	<$1M	<$1	>80%	Very Easy	<1 month	No Impact	Very Low
	4	$1M – $10M	$1 – $5	>60 – 80%	Easy	1-12 months	Low Impact	Low
	3	>$10M - $25M	>$5 – $10	>40 – 60%	Achievable	>1-2 years	Some Impact	Medium
	2	>$25M - $50M	>$10 –$15	20 – 40%	Difficult	>2-5 years	High Impact	High
	1	>$50M	>$15	<20%	Extremely Difficult	>5 years	Untried	Very High

Rating Units

A	industry cost
B	per wagon trip
C	reduction of overall emissions
D	overall assessment
E	implementation timeframe
F	overall assessment
G	overall assessment



Practicability
Cost-Effectiveness
0
1
2
3
4
5
0
1
2
3
4
5
Veneering at Mines
Veneering at a Central Point
Veneering at Major Communities
Water Supressant every 2 hours
Wagon Unloading
Wagon Loading
Wagon Washing
Remove Parasitic Load at Mine
Realignment of Coal Corridors
Limit Capacity
Conveyors Through Communities
Design Lids
Retrofit Lids



Practicability
0
1
2
3
4
5
Cost-Effectiveness
Veneering at Mines
Wagon Unloading
Wagon Loading
Wagon Washing
Design Lids
Retrofit Lids

Client: Queensland Rail Limited
Job Number: H327578-N00-EE00
Project: Environmental Evaluation
Description: Coal Dust Emissions Mitigation Strategies Assessment

Date: 31.03.2008
Revision: 0

Cost-Effectiveness Assessment

	Rating Code	Weighting	Veneering at Mines	Wagon Loading	Wagon Washing	Wagon Unloading	Retrofit Lids	Design Lids	Conveyors Through Communities	Realignment of Coal Corridors	Limit Capacity	Remove Parasitic Load at Mine	Water Supressant every 2 hours	Apply Deflectors to Wagons	Veneering at a Central Point	Veneering at Major Communities
Capital Investment	A	20%	4	1	2	3	4	3	1	1	5	2	4	3	5	5
Operational Cost	B	40%	4	5	4	5	2	2	2	4	1	4	5	5	4	4
Effectiveness	C	40%	4	1	2	2	5	5	1	1	1	1	2	0	3	2
Total:		100%	4	2.6	2.8	3.4	3.6	3.4	1.4	2.2	1.8	2.4	3.6	2.6	3.8	3.4

Practicability Assessment

	Rating Code	Weighting	Veneering at Mines	Wagon Loading	Wagon Washing	Wagon Unloading	Retrofit Lids	Design Lids	Conveyors Through Communities	Realignment of Coal Corridors	Limit Capacity	Remove Parasitic Load at Mine	Water Supressant every 2 hours	Apply Deflectors to Wagons	Veneering at a Central Point	Veneering at Major Communities
Implementation																
Ease	D	8%	5	2	2	4	3	5	1	1	2	3	2	2	3	4
Time	E	8%	4	2	2	4	2	1	1	1	2	3	3	1	4	4
Resources	D	8%	4	5	3	5	5	5	4	2	5	2	1	5	3	4
Capacity Impact	G	35%	5	5	5	5	2	2	3	4	1	4	1	5	1	1
Maintainability	D	2%	5	4	4	5	3	5	4	5	5	4	4	4	4	4
Reliability	F	15%	5	4	4	5	1	1	3	5	4	3	3	5	5	5
Implementation Risk	G	14%	5	5	3	5	1	1	4	3	1	3	4	1	4	4
Safety	F	5%	5	5	5	4	2	2	5	4	5	5	5	5	5	5
Environment	F	5%	3	5	5	4	4	5	4	3	5	5	5	5	3	3
Total:		100%	4.74	4.35	3.91	4.74	2.15	2.32	3.07	3.34	2.41	3.49	2.42	3.86	2.94	3.1

Appendix J

Wagon Lid Proposal

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Wagon Lids Analysis
Environmental Evaluation
Queensland Rail Limited

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Reference H327578-N00-EE00.07
Revision 1

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Rev No	Date	Revision Details	Typist	Author	Verifier	Approver
0	12 March 2008	Draft Report	BB	DJP	SMC	RJH
1	31 March 2008	Final Report	BB	DJP	SMC	RJH

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Contents

Executive summary

The supplementary report presents the particulars of an analysis of wagon lids that was undertaken by Connell Hatch with respect to the Environmental Evaluation commissioned by Queensland Rail Limited. Covering coal wagons with lids has been identified as a mitigation strategy to reduce coal dust emissions from the top of both loaded and unloaded wagons. This report must address two potential variations to the proposed mitigation strategy, retrofitting lids to existing wagons and designing lids into future wagons. Accordingly, for each of the aforementioned, the aim of this report is to:

- Determine the advantages and disadvantages associated with implementing wagon lids
- Consider the impact of lid failures to the industry
- Estimate the capital investment and operational cost associated with wagon lids
- Assess the mitigation strategy for practicability and cost-effectiveness

The outcomes achieved with respect to the aims of this report include:

- The major advantages associated with implementing wagons lids include:
  - 99% reduction in coal dust emissions from the top of wagons, the major coal dust emission source
  - Potential to completely seal the wagons doors
  - Reduction in aerodynamic drag
  - Environmentally friendly solution
- The major disadvantages associated with implementing wagons lids include:
  - Large operating cost (retrofitting only)
  - Modifications to all loading and unloading sites
  - Ramifications of lid failure
- The estimated costs associated with implementing both options are highly dependant upon factors which require a detailed investigation, prior to making an informed judgement. Accordingly, it is considered to be prudent to accept the outcomes of the practicability and cost-effectiveness assessment, which currently show relatively good results, in the absences of such an analysis
- The major concerns with the introduction of any form of lids is the untried nature of these in the coal industry, a harsh environment. The lids proposed as a retrofit are of an experimental nature, hence are not able to be tried with any certainty as to whether they are reliable, safe or effective. The lids which would be incorporated in any design are by definition untried, however QR experience with this style of lids in other industries has proven that these are maintenance intensive, hence cannot be recommended without significant development work being undertaken.
- The final finding of this report is that the implementation of lids to wagons is not to be undertaken at the current time, with further development being warranted prior to any implementation proposal.

Glossary of terms

CQCI
Central Queensland Coal Industry – entire coal supply chain

CQCN
Central Queensland Coal Network – entire rail infrastructure network

EE
Environmental Evaluation

QR
Queensland Rail Limited

QRNA
Queensland Rail Network Access – below rail operator

QRN
Queensland Rail National – above rail operator

1. Introduction

Queensland Rail Limited (QR) has appointed Connell Hatch, John Planner of Introspec Consulting and Katestone Environmental to prepare an Environmental Evaluation (EE) of coal dust emissions engendered from rollingstock in the Central Queensland Coal Industry (CQCI) in response to a Notice issued by the Queensland Environmental Protection Agency (EPA). The deliverables of the report have been stipulated by the Terms of Reference for the project which encompass:

a) *Identify all potential sources of coal dust emissions from QR trains in Central Queensland on land described as rail lines connecting coal mines in the Bowen and Callide Basins with ports at Dalrymple Bay, Hay Point and Gladstone*

b) *Quantify the potential risk of environmental harm posed by each dust source*

c) *Identify the factors and circumstances that contribute to dust emissions and/or impacts from each source. Consideration should be given to (but not limited to) issues such as coal type, coal properties and meteorological conditions.*

d) *Based on the findings from the above, identify locations within QR's Central Queensland operations where proximity of railway lines to communities may give rise to higher risk of environmental harm due to fugitive coal dust*

e) *Identify ways to reduce the risk being caused by coal dust emissions and assess each for practicability, effectiveness and cost, in relation to the mitigation of environmental impacts of fugitive coal dust emissions*

The sources of coal dust emissions that have been identified in the CCQI include emissions from:

- The coal surface of loaded wagons
- Coal leakage from the doors of loaded wagons
- Wind erosion of spilled coal in the rail corridor
- Residual coal in unloaded wagons and leakage of residual coal from the doors
- Parasitic load on sills, shear plates and bogies of wagons

This supplementary report presents the particulars of an analysis of wagon lids that was undertaken with respect to the EE commissioned by QR. Wagon lids have been identified as mitigation strategy for reducing coal dust emissions from the top of loaded and unloaded wagons. There are two potential approaches that could be adopted regarding wagon lids: retrofitting lids to existing wagons or designing lids into wagons. The former is a shorter-term strategy whereas the latter is considered to be a longer-term option, therefore it is imperative that both options are considered exclusively.

In order to assess the practicability and cost-effectiveness, the capital investment and operational costs associated with each option will be determined and then each option will be rated against a set of weighted rating factors.

2. Advantages

There are numerous advantages that would result from the implementation of wagon lids, the most influential of which include:

- 99% reduction in coal dust emissions from the top of loaded and unloaded wagons
- Potential to completely seal the wagons doors
- Reduction in aerodynamic drag
- Environmentally friendly solution

The reduction in aerodynamic drag had been reported to be in the order of 20% based on trials conducted in the US (diesel haul). Due to varying conditions between the US trials and what would be experienced in the CQCI, this figure cannot be applied to the CQCI. Considering that the majority of the network is electrified, the only feasible method of estimating the reduction in aerodynamic drag would be to conduct trials in the CQCI and measure the change in, and cost of, the energy savings.

3. Disadvantages

There are numerous disadvantages that would result from the implementation of wagon lids, the most influential of which include:

- Additional capital expenditure to purchase and install
- Lid failure (discussed in detail in the Section 3.1 Failure)
- Decreased payload due to the weight of the lids
- Modifications required to all loading and unloading stations
- Provisions must be provided for lid maintenance and replacement operations
- Cost of maintenance to lids on wagons

3.1 Failure

3.1.1 Definition

Lid failure is defined as any situation when the wagon lid does not function as it is designed. This definition therefore includes all instances where lids do not open or close as designed, seizes up, collides with other equipment, inhibits the supply chain in any way due to malfunction etc.

3.1.2 Consequences

In a continuous loading situation, the failure of a lid could result in a chute or loading system component colliding with the lid causing damage to both the lid and loading system. Alternatively, the loading system could attempt to load the wagon, damaging the lid, spilling coal and significantly increasing the potential to derail the train. Increased automatic sensing equipment in the control system is required to be implemented in order to avoid either of the aforementioned incidents. Regardless of the potential for damage, if a lid was to fail under any circumstances, the potential resulting scenarios include:

- Stop the train and attempt to fix the lid
  - Delays train
  - Requires trained personnel
  - If the lid cannot be fixed then the wagon will travel around empty until it can be shunted out of the wagon set or replaced
- Leave the wagon unloaded
  - The wagon will travel around empty until it can be shunted out of the wagon set or replaced

A potential problem with leaving damaged lids in service is that if loading and unloading operators are unaware of the failure or particular operations are autonomous, there is the potential for further damage to the lid and surrounding infrastructure, downtime etc if an already failed lid is activated.

Another consideration which would need to be made is how to deal with a failure. Presuming that a failed lid needs replacing, it can either be done immediately, resulting in significant downtime for a particular train and wagon set. Or, the wagon would have to remain in service unloaded until it receives its next three-weekly reliability evaluation. There are many factors which could influence which course of action to take, such as if there were multiple failures in a wagon set, or how close the wagons were to their next reliability evaluation.

4. Costing

4.1 Retrofit

In order to estimate the costs involved with retrofitting lids to the existing fleet, an industry supplier of wagon lids was engaged.

The proposal put forward is a leasing arrangement, which will provide the lids for an operating cost on a time basis. The following indicative cost estimate was provided:

- Capital investment : Nil
- Operational cost : $5.00 - $8.00 per wagon trip

The operating cost presented covers the installation, commissioning of the lids as well as modifications to loading and unloading facilities, ongoing service and maintenance and any staff training. However, there are also many costs and benefits that are not included in the price that could have a marked impact on the estimated operational cost, viz:

- Potential energy savings associated with reduced aerodynamic drag. The only feasible method to estimate this cost would be to perform trials in the CQCI with wagon lids installed on trains to measure the energy savings
- Provisions for additional non-electrified sections of track at central points, with appropriate facilities, access and safety features to perform maintenance operations
- Lost payload due to the weight of each wagon lid. The impact of this would depend highly on the weight of each lid in relation to the accuracy of the weighbridge equipment, reportedly 500 kg. If this was the case, for example, it could be argued that a lid of 250 kg would push the average measurement to the next level
- Costs associated with lid failure
  - Train delays
  - Lost payload
  - Removing trains from service and shunting
  - Damage to infrastructure

All of the aforementioned costs are highly variable and dependant on a range of variables, therefore it considered to be prudent not to attempt to quantify these costs without an in-depth analysis of the full costs and benefits associated with wagon lids, taking into account potential scenarios and operational decisions which would alter the outcomes significantly.

4.2 Design

The capital investment required to design lids into wagons is estimated to be $10000 per wagon. This cost reflects the cost difference between a wagon with a lid and one without. Considering the need for a highly reliable and therefore simplistic design with a minimum of moving parts, this cost difference is considered to be relatively minimal. Extrapolating this cost to a fleet of 7,000 wagons, the estimated capital investment required is in the order of $70 million.

There would be no specific operating cost associated with this type of wagon lid as assessed. Further assessment of the option is required to determine the final cost of the lid in totality.

However, all of the costs which are applicable to the retrofitting option which cannot be accurately estimated are not taken into account. Arguably, a highly reliable wagon lid could be designed as part of the wagon, which might reduce the probability of lid failure, which could reduce some of these costs.

5. Assessment

5.1 Prelude

The practicability and cost-effectiveness of introducing wagon lids is determined by giving a weighted score to predetermined rating factors. The rating system has been developed in order to facilitate a weighted score for each mitigation strategy arising from the EE which has a generic comparable base. This was achieved by developing:

- A set of weighted rating factors which are relevant to the practicability and cost-effectiveness of a mitigation strategy, and
- A rating guide (see Appendix B) pertaining to various aspects of the rating factors which will highlight the differences between the different mitigation strategies

5.2 Retrofit

Table 1 shows that retrofitting lids scores well with respect to the rating factors for cost-effectiveness, scoring 3.6 out of 5, with 5 being the highest. This outcome is achieved because of the estimated 99% reduction in coal dust emissions from the top of the wagons, the primary identified coal dust emissions source as well as the fact that full operating cost of the lids cannot be estimated accurately. Table 2 shows that retrofitting lids scores relatively poorly with respect to the weighted rating factors for practicability, scoring 2.15 out of 5.

This score when compared to other alternatives is not in the acceptable range.

Table 1 – Retrofit Lids Cost-Effectiveness Assessment

Factor	Rating Code	Weighting	Rating
Capital Investment	A	20%	4
Operational Cost	B	40%	2*
Effectiveness	C	40%	5
Total		100%	3.6

** Does not account for many factors*

Table 2 – Retrofit Lids Practicability Assessment

Factor	Rating Code	Weighting	Rating
Implementation			
Ease	D	8%	3
Time	E	8%	2
Resources	D	8%	5
Capacity Impact	G	35%	2
Maintainability	D	2%	3
Reliability	F	15%	1
Implementation Risk	G	14%	1
Safety	F	5%	2
Environmental	F	5%	4
Total		100%	2.15

5.3 Design

Table 3 shows that design lids scores acceptably with respect to the rating factors for cost-effectiveness, scoring 3.4 out of 5, with 5 being the highest. This can be associated with the fact that like retrofit lids, this outcome is achieved because of the estimated 99% reduction in coal dust emissions from the top of the wagons, the primary identified coal dust emissions source. Table 4 shows that design lids scores poorly with respect to the weighted rating factors for practicability, scoring 2.32 out of 5.

QR's experience with this style of lid has indicated that the cost of maintenance could be >$10.00 per day per wagon based upon their experience in other industries. This is a significant cost impost when compared to the current maintenance costs.

The combination of these mediocre scores determines that lids are not practical and are not a cost effective mitigation strategy to reduce coal losses from the top of loaded coal wagons during transport in the CQCI.

Table 3 – Design Lids Cost-Effectiveness Assessment

Factor	Rating Code	Weighting	Rating
Capital Investment	A	20%	3
Operational Cost	B	40%	2
Effectiveness	C	40%	5
Total		100%	3.4

** Does not account for many factors*

Table 4 – Design Lids Practicability Assessment

Factor	Rating Code	Weighting	Rating
Implementation			
Ease	D	8%	5
Time	E	17%	1
Resources	D	8%	5
Capacity Impact	D	40%	2
Maintainability	D	2%	5
Reliability	F	15%	1
Implementation Risk	G	14%	1
Safety	F	5%	2
Environmental	F	5%	5
Total		100%	2.32

5.4 Comparison

Appendix B contains a complete assessment including both practicability and cost-effectiveness for all of the identified mitigation strategies. Figure 1 highlights the distinct difference between the two lid options as mitigation strategies. There are a few factors which contribute to the differences, mainly:

- Cost (both capital investment and operating cost)
- Operational impact

Designing lids is a cheaper operating cost option because if lids are retrofitted and sourced from another company, they will inherently cost more. There is also therefore less control over the design of the lids, the reliability of the lids, the facilities required to operate and maintain the lids etc.

Potentially the most important difference to consider upfront is the difference in timeframes between the options. Retrofitting lids is estimated to be achieved in 1-5 years, whereas given the design life and cost of building wagons, designing lids into wagons would only be reflected in the industry in the 20-30 year period. Accordingly, retrofitting lids is really a shorter-term solution that could be considered in the interim, with designing in wagon lids to be considered as a long-term migration strategy.

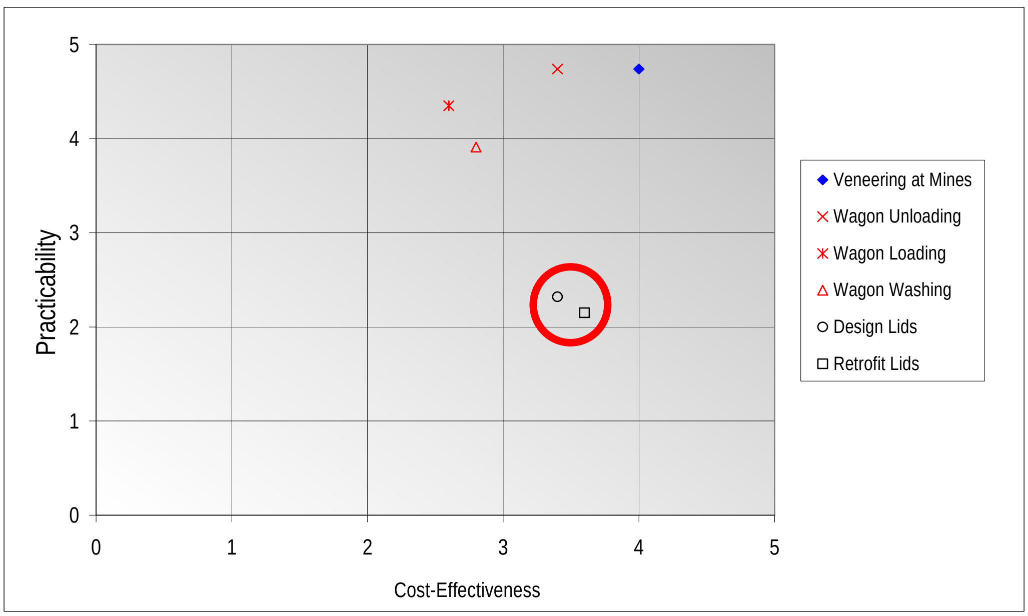


Figure 1 – Mitigation Strategies Assessment Summary

6. Conclusion

An analysis of introducing wagon lids to cover coal wagons in the CQCI has concluded that the major advantages associated with implementing this mitigation strategy would include:

- 99% reduction in coal dust emissions from the top of wagons, the major coal dust emission source
- Potential to completely seal the wagons doors
- Reduction in aerodynamic drag
- Environmentally friendly solution

The major disadvantages associated with implementing wagons lids include:

- Large operating cost (retrofitting only)
- Modifications to all loading and unloading sites
- Ramifications of lid failure

It was acknowledged that there are many potential operational impacts and costs associated with implementing wagon lids that cannot be estimated without a thorough detailed investigation which would need to consider the operational decisions, reliability of lids, facilities at very intricate level of detail. It is therefore considered prudent not to consider wagon lids as a potential mitigation strategy without undertaking the aforementioned course of action.

This initial assessment of wagon lids has indicated that both options are not cost effective, given that both would almost eliminate coal dust emissions from the primary dust source, however without a full comprehension of the costs associated with wagon lids, this result cannot be taken at face value. Both retrofitting and designing lids showed mediocre good scores with respect to practicability, but these scores are highly dependant upon the operational impact and reliability of the lids, wither of which can be accurately estimated without a thorough investigation.

Appendix A

Wagon Lids Fact Sheet

Wagon Lids

Lightweight, automatic fibreglass wagon lids can be installed on train wagons to prevent coal loss during transportation.

"The key factor that contributes to the emission rate of coal dust from wagons is the speed of the air passing over the coal surface." (QR EE Interim Report, Jan 2008)

Capital Investment
Nil

Operational Cost
$5.00 - $8.00*

Major Benefit
Stops coal dust and spillage from the top of rail wagons

Operating devices at either side of loading stations will also be required to open and close the lids prior to and following loading.

Installing lids will provide a highly effective and visible solution to managing coal loss, which will address community, environmental and industry concern.

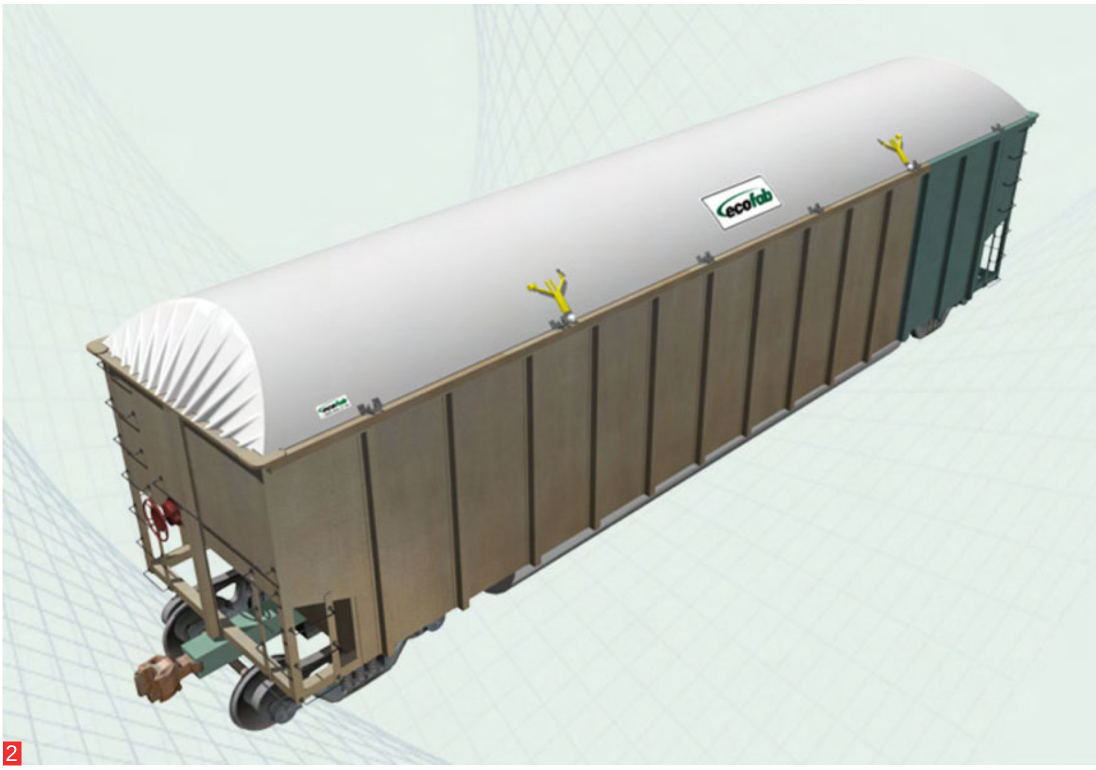
1

Advantages

- Eliminate dust from the top of loaded and empty wagons
- Fuel savings due to reduced aerodynamic drag
- Reduce environmental and community concern

Disadvantages

- Modifications required to all loading systems
- Capacity impacts due to lid failure



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1. Artist impression © Ecofab 2008
2. Artist impression © Ecofab 2008

* per wagon trip - does not account for lid failure or fuel savings

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Appendix B

Mitigation Strategies Assessment

Client:	Queensland Rail Limited
Job Number:	H327578-N00-EE00
Project:	Environmental Evaluation
Description:	Coal Dust Emissions Mitigation Strategies Rating Guide

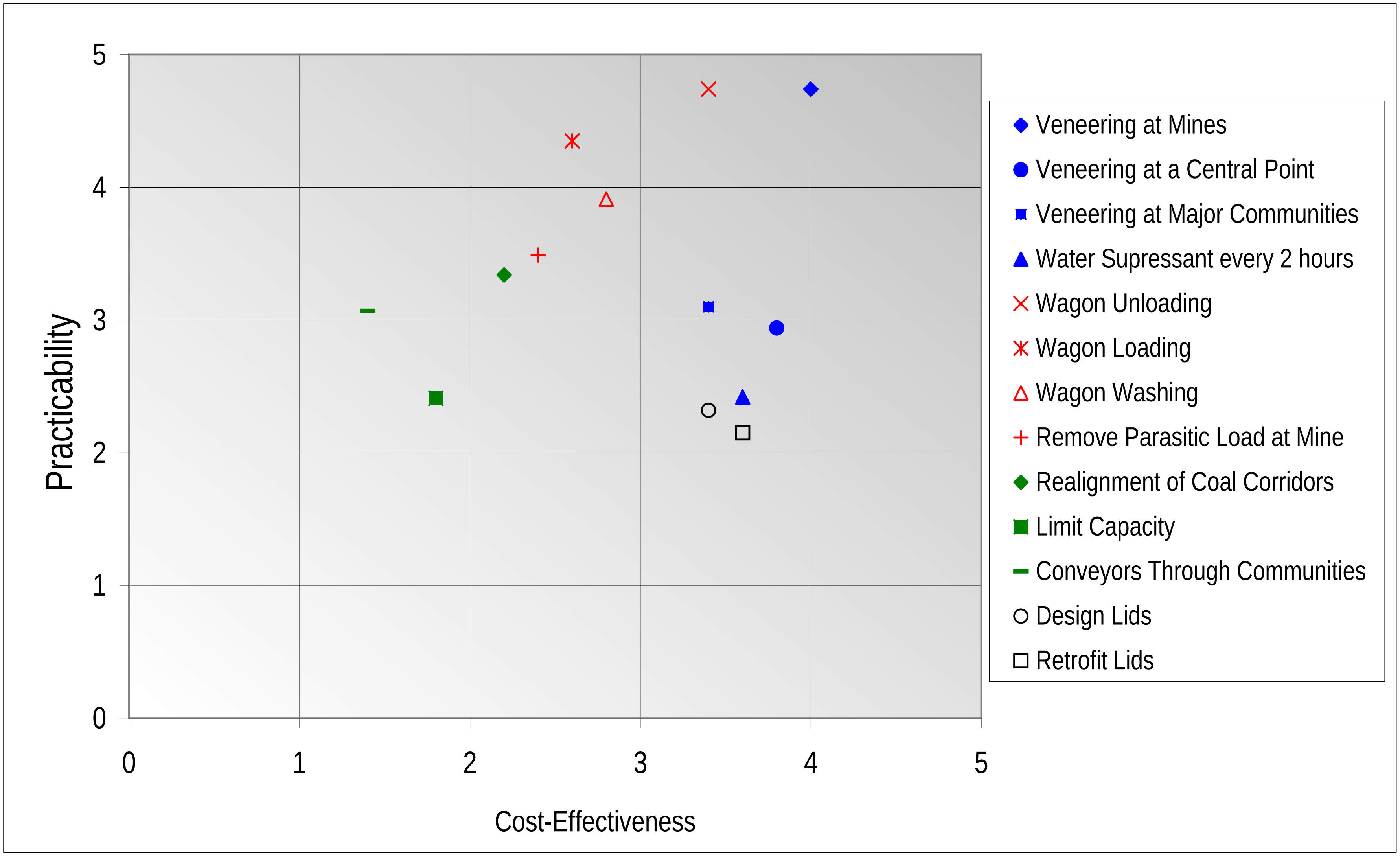
Date: 31.03.2008
Revision: 0

Mitigation Strategies Rating Guide

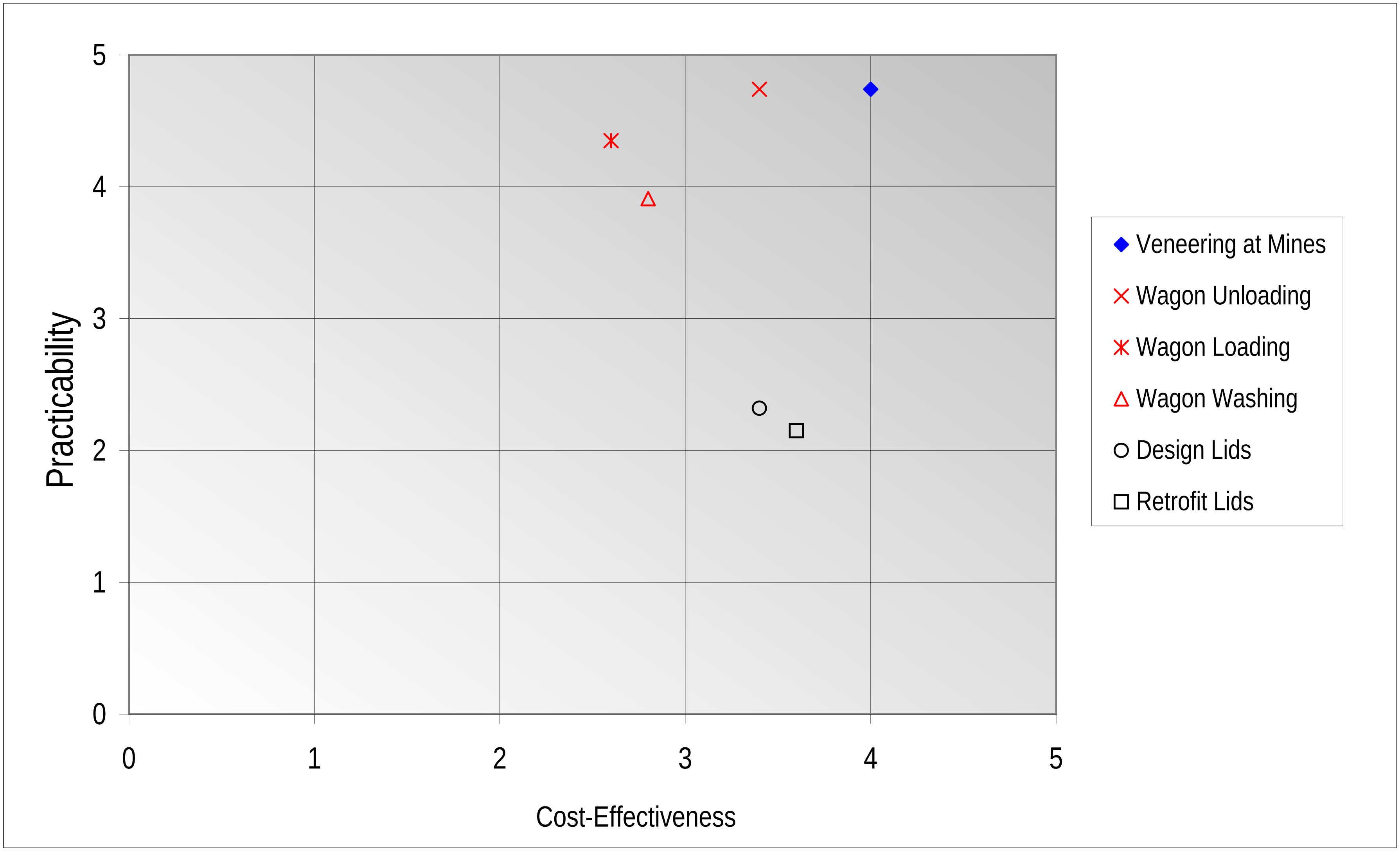
		Rating Code						
		A	B	C	D	E	F	G
Rating	5	<$1M	<$1	>80%	Very Easy	<1 month	No Impact	Very Low
	4	$1M – $10M	$1 – $5	>60 – 80%	Easy	1-12 months	Low Impact	Low
	3	>$10M - $25M	>$5 – $10	>40 – 60%	Achievable	>1-2 years	Some Impact	Medium
	2	>$25M - $50M	>$10 –$15	20 – 40%	Difficult	>2-5 years	High Impact	High
	1	>$50M	>$15	<20%	Extremely Difficult	>5 years	Untried	Very High

Rating Units

A	industry cost
B	per wagon trip
C	reduction of overall emissions
D	overall assessment
E	implementation timeframe
F	overall assessment
G	overall assessment



Practicability
Cost-Effectiveness
0
1
2
3
4
5
Veneering at Mines
Veneering at a Central Point
Veneering at Major Communities
Water Supressant every 2 hours
Wagon Unloading
Wagon Loading
Wagon Washing
Remove Parasitic Load at Mine
Realignment of Coal Corridors
Limit Capacity
Conveyors Through Communities
Design Lids
Retrofit Lids



Practicability
Cost-Effectiveness
0
1
2
3
4
5
Veneering at Mines
Wagon Unloading
Wagon Loading
Wagon Washing
Design Lids
Retrofit Lids

Client: Queensland Rail Limited
Job Number: H327578-N00-EE00
Project: Environmental Evaluation
Description: Coal Dust Emissions Mitigation Strategies Assessment

Connell HATCH Infrastructure for Industry

Date: 31.03.2008
Revision: 0

Cost-Effectiveness Assessment

	Rating Code	Weighting	Veneering at Mines	Wagon Loading	Wagon Washing	Wagon Unloading	Retrofit Lids	Design Lids	Conveyors Through Communities	Realignment of Coal Corridors	Limit Capacity	Remove Parasitic Load at Mine	Water Supressant every 2 hours	Apply Deflectors to Wagons	Veneering at a Central Point	Veneering at Major Communities
Capital Investment	A	20%	4	1	2	3	4	3	1	1	5	2	4	3	5	5
Operational Cost	B	40%	4	5	4	5	2	2	2	4	1	4	5	5	4	4
Effectiveness	C	40%	4	1	2	2	5	5	1	1	1	1	2	0	3	2
Total:		100%	4	2.6	2.8	3.4	3.6	3.4	1.4	2.2	1.8	2.4	3.6	2.6	3.8	3.4

Practicability Assessment

	Rating Code	Weighting	Veneering at Mines	Wagon Loading	Wagon Washing	Wagon Unloading	Retrofit Lids	Design Lids	Conveyors Through Communities	Realignment of Coal Corridors	Limit Capacity	Remove Parasitic Load at Mine	Water Supressant every 2 hours	Apply Deflectors to Wagons	Veneering at a Central Point	Veneering at Major Communities
Implementation																
Ease	D	8%	5	2	2	4	3	5	1	1	2	3	2	2	3	4
Time	E	8%	4	2	2	4	2	1	1	1	2	3	3	1	4	4
Resources	D	8%	4	5	3	5	5	5	4	2	5	2	1	5	3	4
Capacity Impact	G	35%	5	5	5	5	2	2	3	4	1	4	1	5	1	1
Maintainability	D	2%	5	4	4	5	3	5	4	5	5	4	4	4	4	4
Reliability	F	15%	5	4	4	5	1	1	3	5	4	3	3	5	5	5
Implementation Risk	G	14%	5	5	3	5	1	1	4	3	1	3	4	1	4	4
Safety	F	5%	5	5	5	4	2	2	5	4	5	5	5	5	5	5
Environment	F	5%	3	5	5	4	4	5	4	3	5	5	5	5	3	3
Total:		100%	4.74	4.35	3.91	4.74	2.15	2.32	3.07	3.34	2.41	3.49	2.42	3.86	2.94	3.1