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Literature Review of Coal Train Dust Management Practices

Prepared for

NSW Environment Protection Authority

December 2014

Final

Deliverable #:	D13066-6
Title:	Literature Review of Coal Train Dust Management Practices
Version:	1.1 (Final)
Client:	NSW Environment Protection Authority
Document reference:	D13066-6_Train Coal Dust Literature Review Final.docx
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Reviewed by:	Simon Welchman
Approved by:	Simon Welchman 1/12/2014

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Acknowledgements

Katestone Environmental acknowledges the following persons and organisations for their assistance in the preparation of this study:

- New South Wales Environment Protection Authority for constructive comments and suggestions following review of draft versions of this report.
- Applied Australia
- Vital Chemicals
- Halley and Mellows
- Ecotech Pty Limited

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List of technical terms and abbreviations

$\mu g/m^3$	micrograms per cubic metre
µm	microns
°C	degrees Celsius
km	kilometre
km/h	kilometre per hour
m	metre
m/s	metres per second
m^2	square metres
m^3	cubic metres
m^3/s	cubic metres per second
mg	milligram
t	tonnes
tpa	tonnes per annum
PM	Particulate matter (fine dust)
$PM_{2.5}$ and PM_{10}	Particulate matter less than 2.5 or 10 microns, respectively
TSP	Total suspended particles
EA	Environmental Authority
EPA	New South Wales Environment Protection Authority
AEMR	Annual Environmental Management Report
ML	Mine Lease
NEPM	National Environment Protection Measure
NPI	National Pollutant Inventory
US EPA	United States Environmental Protection Agency
Parasitic Coal	Coal that is deposited and carried on the external parts of a coal wagon, such as on: sills, shear plates and bogies. Parasitic coal is normally deposited during wagon loading and unloading
Ploughing	Occurs at unloading when coal wagons are driven through coal that has accumulated above the rail and unloading hopper. Ploughing is associated with coal wagons that unload via Kwik-Drop doors. Coal may accumulate above the rail when the rate of discharge from the wagon exceeds the capacity of the unloading hopper.
Residual Coal/Carry-back	Is coal that fails to discharge from the wagon whilst passing through the unloading station and are carried back to the mine. Coals that have poor discharge/flow properties and are significant contributors to residual coal in wagons are referred to as sticky coals.

EXECUTIVE SUMMARY

Katestone has been commissioned by NSW EPA to undertake a review of currently available literature relating to the control of fugitive coal dust emissions in the rail corridor. The purpose of this literature review is to provide a comprehensive knowledge and information register about management practices for fugitive coal dust emissions from trains, with a focus on measures that could be applied in the Hunter Valley rail corridor and other coal rail corridors in NSW.

The following scope of works has been addressed in this report:

- Source and review NSW, Australian and international literature, including government and industry reports and commercial product information relating to the control of fugitive dust emissions associated with the movement of coal by train defined as:
  - Coal loading (at coal processing plants and mines)
  - Transporting by train (rolling stock and track operations)
  - Coal unloading (at coal terminals and domestic users)
- Determine control effectiveness of identified management practices, where literature exists
- Determine indicative costs associated with application of management practices, including capital, operating and maintenance costs, where literature exists

A review of coal production found that:

- In 2013, approximately 90% of global coal production occurred in ten countries. China was the top coal producer with 3,680 Mt or 47% of the global total. Australia was ranked fourth, producing an estimated 478 Mt or 6% of the global total
- Coal production in New South Wales has increased steadily over the last five years, making up 47% of Australia's black coal production in 2012 – 13. The majority of NSW's black coal production (93%) is exported by rail through the Hunter Valley to coal terminals in Newcastle

The regulatory framework in relation to coal dust from trains was reviewed. The key findings were that:

- Regulatory frameworks for the management of the potential environmental effects of coal rail activities in NSW and Queensland are similar
- Environmental obligations are applied through premises based licensing and permitting, which means that the owner (or operator) of the tracks and other infrastructure holds the obligation for all activities that occur on the rail network
- A recent NSW EPA position paper identified an apparent lack of clear and direct environmental accountability between the relevant parties, in particular:

  "The lack of direct environmental accountability for rolling stock operators means that environmental issues and community concern are often difficult to resolve..... EPA considers that the impacts of the operational rail network on the environment and community cannot be adequately addressed under the existing regulatory framework, that is, by licensing only railway system operators under the POEO Act".

Coal dust emissions generated in the rail corridor occur as a result of three general mechanisms:

1. Coal handling emissions

2. Wind erosion of the exposed surface of coal in a wagon
3. Spillage of coal into the rail corridor and subsequent wind erosion or re-entrainment in the wakes of moving trains

The propensity for coal dust to be emitted in a rail corridor depends on the following factors and circumstances:

- Properties of coal being transported
- Air speed during transport (both ambient wind speed and the air speed induced by train movement)
- Rail corridor capacity and utilization
- Transport distance
- Precipitation at mine sites and along the transport route
- Coal dust management practices applied at loading and unloading facilities

The literature relating to monitoring of air quality in rail corridors carrying coal trains highlighted two recurring themes:

- Dust levels were generally found to increase during and immediately after the passing of a train, be it a loaded coal train, unloaded coal train, freight train or passenger train. Some studies suggest that highest dust levels are associated with loaded and unloaded coal trains; however, the magnitude of differences in dust levels between train types was not substantial
- No exceedances of air quality assessment criteria were found at monitoring stations in or near the rail corridor when measured in accordance with the relevant Australian Standards.

The most effective coal dust management practices identified in the literature, ignoring feasibility and practicality of implementation, for each of the three main coal dust generation mechanisms are summarised below. These practices would not necessarily be applied in parallel e.g. if profiling and surface treatment were sufficient to prevent wind erosion, other techniques may not be necessary to control wind erosion.

Preventing coal dust emissions from handling

- Ensure coal moisture content is above the dust extinction moisture level (DEM)
- Conduct loading or unloading within a shed or building with a fabric filter dust collection system

Preventing wind erosion of coal in the wagon

- Profiling the loaded coal wagon surface to reduce coal dust lift-off
- Apply chemical suppressant / veneer to the coal surface of a loaded wagon to reduce coal dust lift-off
- Fit lids to coal wagons to prevent coal dust lift-off – whilst theoretically effective, the literature identifies major potential disadvantages associated with the use of wagon lids
- Monitoring residual coal and cleaning/washing wagons after unloading to prevent residual coal carry-back to the mine

Preventing coal spillage

- The management practices described above will also reduce coal spillage and, as a consequence, coal dust generation by wind erosion
- Automated train loading systems with the following technologies are effective in preventing coal spillage:
    - Identification systems of unloaded wagon type and weight

- Precision wagon loading using telescopic chute
- System automation with feedback loops, warning alerts and minimal operator input

In relation to the effectiveness of coal dust management practices:

- The effectiveness of the majority of the coal dust management practices is not well documented in the literature, with the exception of the application of either water or chemical suppressant to the coal wagon surface
- Extensive testing of water and chemical suppressant application has found that, if applied correctly (and in the case of water, at the right frequency), water or suppressants can reduce coal dust emissions from a loaded wagon surface by 50% to 99%
- Correct application of water or chemical suppressant is dependent on good train loading practices and load profiling
- No documents were identified that demonstrated that lids have been applied to coal wagons to control dust emissions. Lids are used in the transportation of coal in North America to protect loads from snow and ice. Notwithstanding this, the potential effectiveness of wagon lids has been estimated in the literature, but the estimates do not appear to have been based on laboratory or field testing. The literature states the use of wagon lids will reduce dust emissions from the coal surface by 99%. The literature identifies a number of significant disadvantages with wagon lids:
    - Large operating cost (retrofitting only)
    - Modifications to all loading and unloading facilities
    - Ramifications of lid failure during loading, transit and unloading

The literature review obtained indicative costs for some coal dust management practices identified in the literature. Due to the established practice of chemical suppressant application to coal trains in Queensland, it was possible to source detailed costs for this management practice. For all other management practices identified in this literature review, a qualitative statement on the potential cost has been provided.

The detailed costs of the application of chemical suppressants and water are:

- Water application to all wagons in NSW was estimated to be $0.005 per tonne of coal
- Chemical suppressant application to all wagons in NSW ranged from $0.02 - $0.04 per tonne of coal.

1. INTRODUCTION

1.1 Study Background

New South Wales (NSW) has a rich resource of black coal. In 2011 NSW Trade and Investment estimated recoverable coal reserves in NSW exceeded 11 billion tonnes (NSW Trade and Investment, 2011). The majority of coal resources are located in shallow seams in the Gunnedah and Sydney basins where a mixture of underground and open cut mines can be found. Production of coal in NSW for the 2013 - 2014 financial year was 197 million tonnes (Mt), an increase of 50 Mt or 34% in the last 5 years (Coal Services, 2014a).

The most economical and efficient method of transporting large amounts of coal any significant distance is via train. A large proportion of coal produced in NSW is moved by train to either coal terminals for export to overseas markets or to domestic users such as power stations or steel works. A typical coal train in Australia consists of a number of locomotives pulling open topped wagons. Coal is loaded into the open topped wagons at a mine, transported along the rail network and received at the export terminal or end user. Coal may alternatively be transported by truck or conveyor from a mine site to a dedicated Coal Handling and Processing Plant (CHPP) or load-out facility before being loaded into wagons and transported by rail. These CHPP's and load-out facilities may be regulated under separate environmental licenses to the mine.

Over the past few years there has been an increase in the concern of communities near the rail corridor regarding both the health and amenity impacts associated with fugitive coal dust that may be generated during transportation of coal through the rail network.

The current literature relating to fugitive coal dust emissions associated with the movement of coal by train includes peer reviewed, grey, commercial and community literature. Numerous references cite established or prospective practices, commercial products and mandatory or voluntary codes relating to the management of fugitive coal dust and coal spillage.

1.2 Study Aims and Objectives

Katestone Environmental Pty Ltd (Katestone) has been commissioned by the NSW Environment Protection Authority (EPA) to undertake a literature review of the current management practices for fugitive coal dust associated with movement of coal trains in the rail corridor.

The purpose of this literature review is to provide a comprehensive knowledge and information register about management practices for fugitive coal dust emissions from trains, with a focus on measures that could be applied in the Hunter Valley rail corridor and other coal rail corridors in NSW.

The following scope of works has been addressed in this report:

- Source and review NSW, Australian and international literature, including government and industry reports and commercial product information relating to the control of fugitive dust emissions associated with the movement of coal by train defined as:
  - Coal loading (at coal processing plants)
  - Coal unloading (at coal terminals)
  - Transporting by train (rolling stock and track operations)
- Determine control effectiveness of identified management practices, where literature exists
- Determine indicative costs associated with application of management practices, including capital, operating and maintenance costs, where literature exists

1.3 Study Methodology and Document Outline

The key elements of this literature review and structure of the report are as follows:

- **Coal Production in NSW:** A summary of coal production in NSW was conducted to provide the local context and to identify the rail corridor infrastructure in NSW where coal dust may be generated (Section 2)
- **What is Coal Dust:** Definitions of coal dust and particulate matter are provided. A summary of the potential human health, amenity and the environmental impacts of dust is discussed (Section 3).
- **Legislative Framework for Rail Coal Dust:** Australian and international regulatory frameworks for the management of rail coal dust emissions have been researched and discussed (Section 4)
- **Considerations of Sources of Rail Coal Dust Emissions:** The literature and current knowledge on sources of coal dust generation in the rail corridor have been reviewed and summarised (Section 5)
- **Considerations, Factors and Circumstances That Contribute to Rail Coal Dust Emissions:** The literature and current knowledge on factors that contribute to coal dust generation in the rail corridor have been reviewed and summarised (Section 6)
- **Rail Corridor Air Quality Impacts:** Studies in Australia and overseas that have looked at the levels of dust in and around the rail corridor have been reviewed (Section 7)
- **Management Techniques for Controlling Rail Coal Dust Emissions:** Current Australian and International techniques for controlling rail coal dust emissions have been researched and identified (Section 8)
- **NSW Techniques for Controlling Rail Coal Dust Emissions:** Current techniques for controlling rail coal dust emissions in NSW have been researched (Section 9) by considering:
    - Documents published by the coal mines such as: Annual Environment Management Reports (AEMR), Environmental Management Plans (EMP), Particulate Reduction Program Reports (PRPs) and Environmental Management Systems (EMS).
    - Conditions of Approval and Environment Protection Licences (EPL).
    - Information sourced from other NSW Government Reports (Coal Mine Particulate Matter Benchmarking Report, NSW Trade and Investment Coal Industry Profile)
- **Estimated Costs of Reducing Rail Coal Dust Emissions in NSW:** An analysis has been conducted to determine the cost of reducing rail coal dust emissions in NSW using the various management techniques identified in Section 10. The benefits, in terms of the reduction in rail coal dust emissions, have been determined along with the cost (Section 10)

2. COAL PRODUCTION

2.1 Section Overview

This section provides a summary of coal production and transport with a focus on activities in NSW. The section starts with a brief summary of global coal production and then describes recent Australian coal production by state and territory. A detailed description of coal production and transport in NSW is then presented using data sourced from Coal Services Pty Limited (Coal Services).

Coal Services is an industry owned organisation that provides critical services and expertise to the NSW coal mining industry with statutory functions that are outlined within the *NSW Coal Industry Act 2001*. These functions include the collection of coal production and transport statistics from each member of the NSW coal chain (mines, ports and end users).

The section finishes with a summary of the NSW rail infrastructure including descriptions of the coal network rail systems, the number of loading points and the number of receival stations. The following data sources have been relied upon:

- ARTC (rail network owners) – website and publications
- Coal Services - coal production and export statistics for last 5 years
- NSW EPA – website, publications and environmental protection licenses (EPL)
- Individual mines - website and publications
- Export terminals and other receival stations - website and publications

2.2 Global Coal Production

The BP Statistical Review of World Energy (BP, 2014) reported that global coal production reached 7,896 Mt in 2013. Approximately 90% of global coal production occurred in ten countries, as detailed in Table 1. China was the top coal producer in 2013, producing 3,680 Mt or 47% of the global total. Australia was ranked fourth, producing an estimated 478 Mt or 6% of the global total (BP, 2014).

Table 1 Top ten global coal producing countries in 2013 (million tonnes)

Country	2013 Coal Production (Mt)	Proportion of total (%)	Cumulative proportion of total (%)
China	3,680	47%	47%
US	893	11%	58%
India	605	8%	66%
Australia	478	6%	72%
Indonesia	421	5%	77%
Russia	347	4%	81%
South Africa	257	3%	85%
Germany	190	2%	87%
Poland	143	2%	89%
Kazakhstan	115	1%	90%
Worldwide Production	**7,896**	-	

2.3 Production of raw black coal in Australia

A large proportion of coal production in Australia occurs from the Sydney and Gunnedah Basins in NSW and the Surat and Bowen Basins in Queensland. A map of Australia's coal resources is shown in Figure 1 (Australian Government, Geosciences Australia, 2014). The Australian Government's Bureau of Resources and Energy Economics (BREE) reported that in the 2012 - 2013 financial year, annual raw black coal production in Australia was 527 million tonnes (Mt) (BREE, 2013), with 51% produced in Queensland and 47% in NSW. Smaller quantities of coal were produced in Western Australia, South Australia and Tasmania.

Table 2 presents black coal production in Australia by state for five financial years from 2008-2009 to 2012-2013 (BREE, 2013). The data show that whilst Queensland has been the leading coal producing state, production has fluctuated between 240 Mt to 270 Mt. NSW production has steadily increased over the five years from 182 Mt to 246 Mt.

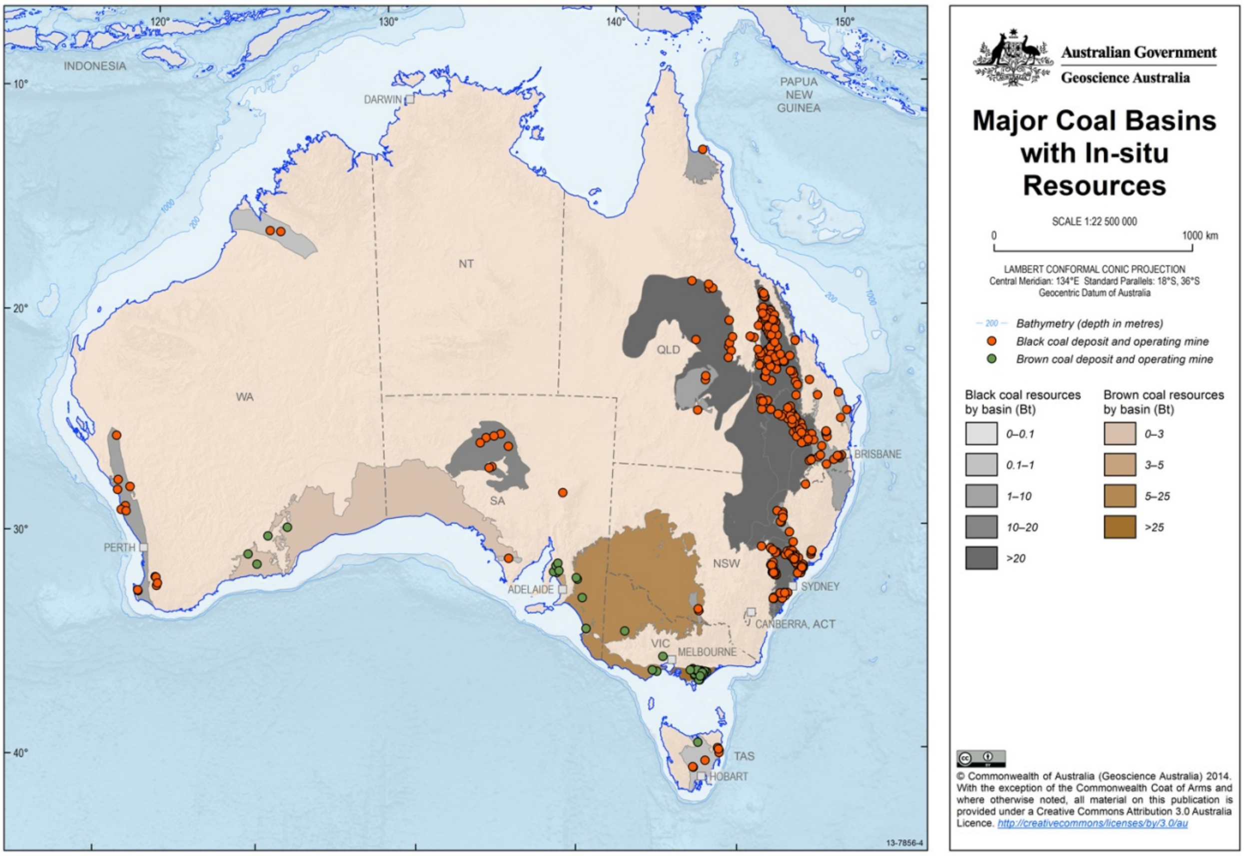

Figure 1 **Map of the major coal basins in Australia (Source: Australian Government, Geosciences Australia, 2014)**

Table 2 Australian raw black coal production by state (million tonnes)

State	2008 - 2009	2009 - 2010	2010 - 2011	2011 - 2012	2012 - 2013
Queensland	250	272	240	250	271
New South Wales	182	191	205	221	246
Victoria	68	69	66	n/a	n/a
Western Australia	9	8	5	5	5
South Australia	5	4	4	4	4
Tasmania	1	1	1	1	1
Table note: Statistics taken from BREE, 2013					

2.4 NSW Coal Industry

The NSW coal industry is the second largest in Australia. Recoverable coal reserves in NSW exceed 11 billion tonnes (NSW Trade and Investment, 2011). The majority of NSW's coal resources are located in relatively shallow seams of the Gunnedah and Sydney basins. A map of coal producing areas in NSW is shown in Figure 2. The basins are divided into six main coalfields, namely: Gunnedah, Hunter, Western, Central, Southern and Newcastle. Small quantities of coal are also produced in the Gloucester Basin north of Newcastle and the Oaklands Basin in southern NSW.

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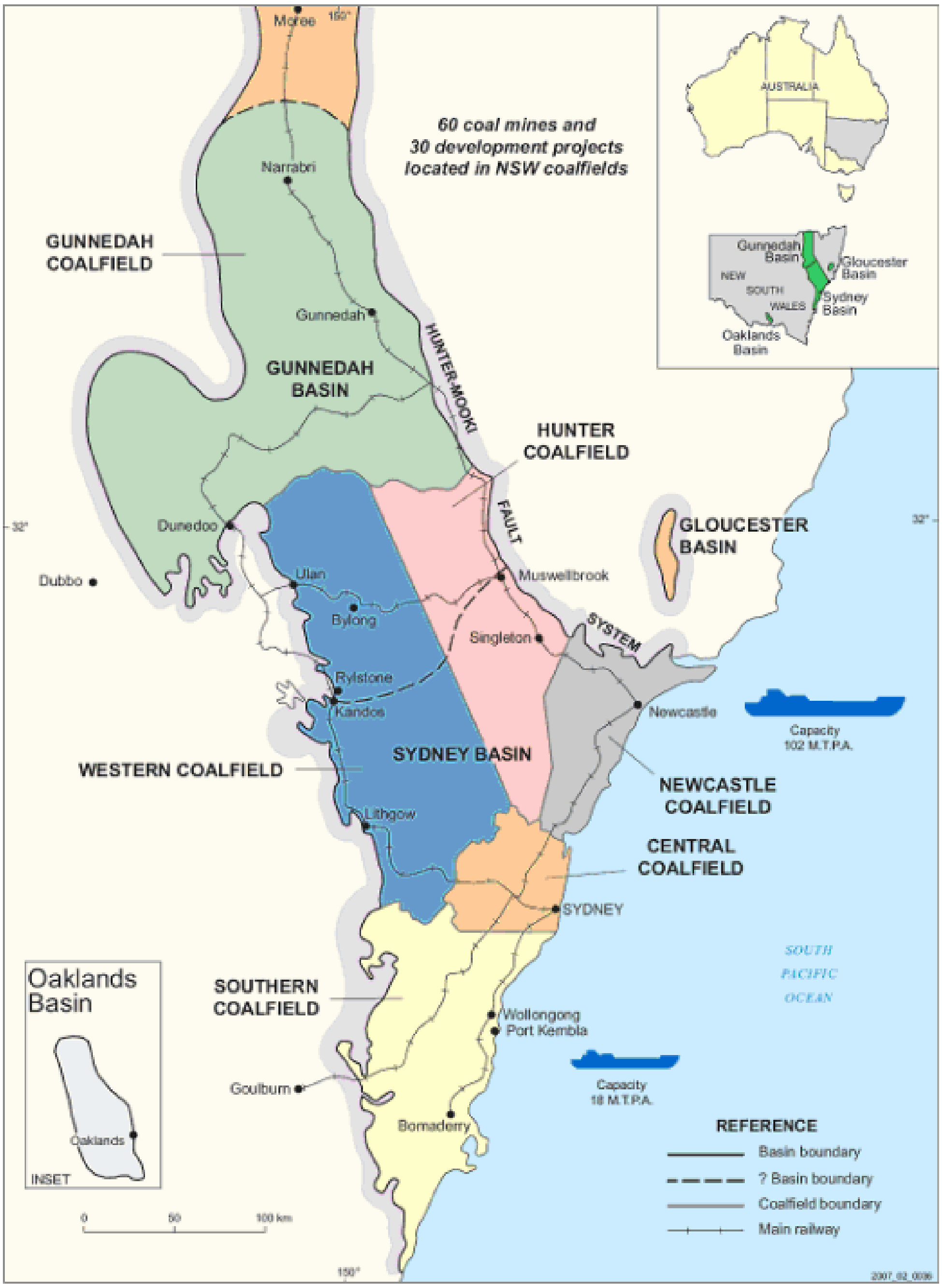


Figure 2 **Map of the NSW coalfields (Source: NSW Trade and Investment, 2011)**

2.4.1 Production of saleable black coal

There are approximately 61 operating mines in NSW, 29 underground operations and 32 open cut operations (Coal Services, 2014a). There are 7 combined facilities that have both open cut and underground operations. Therefore, a total of 54 mine facilities currently operate in NSW. There are also a number of potential mining projects in NSW waiting development, including the Maules Creek Mine, which is under development in the Gunnedah Basin. NSW coal is either used domestically for power generation and steel production or is sent for export from terminals at the Port of Newcastle or Port Kembla, south of Wollongong.

Production rates of saleable coal from NSW mines for the last 5 financial years are detailed in Table 3 and Figure 3 (Coal Services, 2014a). The data shows that production rates have increased year on year between 7% and

11%. The last five financial years has seen the production of saleable coal in NSW increase from 147 Mt to 197 Mt, an increase of 50 Mt or 34%.

Table 3 NSW saleable black coal production (Source: Coal Services, 2014a)

NSW Summary	NSW Coal Production (million tonnes)				
	2009 - 2010	2010 - 2011	2011 - 2012	2012 - 2013	2013 - 2014
Underground Mines	51	50	49	55	60
Open Cut Mines	96	107	118	130	137
All Mines	147	157	167	186	197

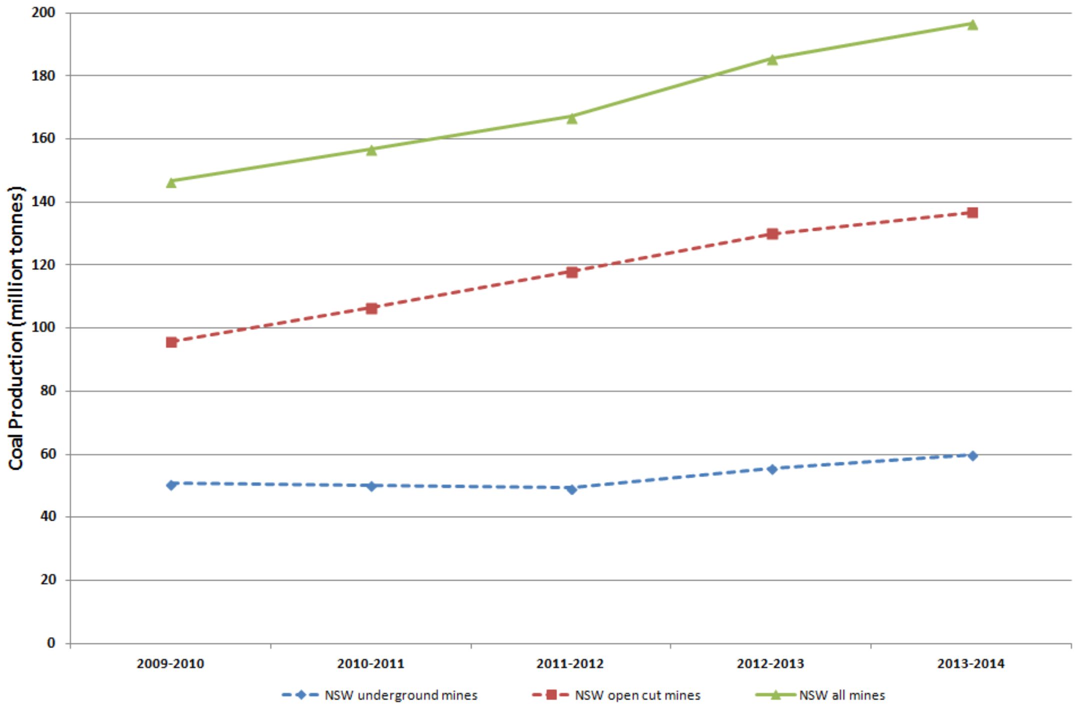


Figure 3 Saleable black coal production in NSW (Source: Coal Services, 2014)

Production rates of saleable coal from each mine for the last 5 financial years from the Gunnedah, Hunter, Newcastle, Western and Southern coalfields are detailed in Table 4 to Table 8, respectively. Table 9 and Figure 4 provide an overall summary of NSW coalfield production for the last five years. The data shows that the Hunter coalfield accounts for approximately 60% of total NSW production of saleable coal whilst production in the Gunnedah coalfield has increased by almost 200% in the past five years.

Table 4 **Gunnedah coalfield saleable black coal production (Source: Coal Services, 2014a)**

Gunnedah Coalfield	Coal Production (million tonnes)				
	2009 - 2010	2010 - 2011	2011 - 2012	2012 - 2013	2013 - 2014
Narrabri UG	0.0002	0.2	0.4	3.5	5.5
Boggabri OC	1.8	2.9	2.8	4.1	5.3
Rocglen OC	0.9	0.9	1.1	1.0	1.0
Sunnyside OC (closed)	0.2	0.3	0.5	0.3	0
Tarrawonga OC	1.4	1.6	1.7	1.9	2.0
Werris Creek OC	1.3	1.8	1.3	1.7	2.4
Whitehaven (Canyon) (closed)	0.01	0	0	0	0
Gunnedah Total	**5.7**	**7.6**	**7.7**	**12.4**	**16.2**
Table note: UG = underground OC = open cut					

Table 5 **Hunter coalfield saleable black coal production (Source: Coal Services, 2014a)**

Hunter Coalfield	Coal Production (million tonnes)				
	2009 - 2010	2010 - 2011	2011 - 2012	2012 - 2013	2013 - 2014
Ashton UG	1.5	1.2	0.9	1.1	1.6
Beltana/Blakefield South UG	3.7	2.9	0.6	4.5	5.3
Integra UG (Glennies Creek)	0.8	0.8	0.7	1.2	1.2
Ravensworth UG (Newpac)	2.3	1.9	1.6	1.7	1.9
United UG (closed)	1.2	0	0	0	0
Wambo UG	3.0	3.1	3.1	3.2	3.2
Ashton OC (closed)	1.2	0.5	0.1	0.0	0
Bengalla OC	5.7	5.3	6.0	7.6	8.6
Bulga OC	6.3	5.7	6.2	7.6	6.0
Cumnock South (closed)	0.1	0.4	0.0	0.0	0.0
Drayton OC	4.7	4.5	4.1	4.3	3.8
Hunter Valley Operations OC	11.0	11.6	12.0	13.3	13.4
Integra OC (Camberwell)	1.8	0.9	1.1	1.1	1.2
Liddell OC	4.2	4.2	4.5	4.4	4.6
Mangoola OC	0.0	3.3	8.5	8.6	8.8
Mt Arthur Coal OC	12.1	13.7	16.7	17.9	19.9
Mt Owen OC	7.8	9.1	9.7	8.8	8.7
Mt Thorley Warkworth OC	9.2	9.3	9.6	12.2	12.4
Muswellbrook OC	1.1	1.2	1.0	0.9	1.2
Ravensworth North OC	0.0	0.0	0.1	4.3	4.8
Ravensworth/Narama OC	5.0	4.5	3.2	2.2	1.7
Rix's Creek OC	1.5	1.4	1.5	1.5	1.6
United UG (closed)	1.2	0.0	0.0	0.0	0.0
Wambo OC	1.9	2.6	2.5	2.7	3.2
Hunter Total	**87.4**	**88.2**	**93.8**	**109.0**	**113.0**
Table note: UG = underground OC = open cut					

Table 6 Newcastle coalfields saleable black coal production (Source: Coal Services, 2014a)

Newcastle Coalfields*	Coal Production (million tonnes)				
	2009 - 2010	2010 - 2011	2011 - 2012	2012 - 2013	2013 - 2014
Abel UG	0.5	0.9	0.8	1.7	2.0
Austar UG	1.5	1.6	1.5	1.2	1.4
Awaba UG (closed)	0.7	0.8	0.5	0.0	0.0
Chain Valley UG	0.7	0.7	0.8	0.8	1.1
Mandalong UG	5.4	5.0	5.2	5.7	4.9
Mannering UG (closed)	0.7	0.6	0.6	0.1	0.0
Myuna UG	1.2	1.5	1.5	1.7	1.7
Newstan UG	0.0	0.0	0.2	0.3	0.5
Tasman UG	0.5	0.5	0.5	0.4	0.02
West Wallsend UG	2.5	2.7	2.8	3.0	3.1
Bloomfield OC	0.6	0.5	0.5	0.7	0.6
Donaldson OC	1.0	0.3	0.7	0.7	0.0
Duralie OC	1.1	1.1	1.6	1.5	1.4
Stratford OC	0.9	0.7	0.6	0.8	0.8
Unspecified Newcastle	0.0	0.0	0.0	0.0	0.007
Westside OC (closed)	0.7	0.9	0.5	0.0	0.0
Newcastle Total*	**18.1**	**17.8**	**18.3**	**18.6**	**17.7**

Table note:
* Includes mines in Central and Gloucester coalfields
UG = underground
OC = open cut

Table 7 Western coalfield saleable black coal production (Source: Coal Services, 2014a)

Western Coalfield	Coal Production (million tonnes)				
	2009 - 2010	2010 - 2011	2011 - 2012	2012 - 2013	2013 - 2014
Airly UG	0.1	0.3	0.7	0.4	0.1
Angus Place UG	3.4	3.9	3.7	3.4	3.3
Baal Bone UG (training facility)	1.3	1.8	0.3	0.0	0.0
Charbon UG	0.5	0.5	0.4	0.5	0.4
Clarence UG	1.9	1.8	1.8	1.9	2.2
Springvale UG	2.3	3.2	1.9	2.5	3.1
Ulan UG	4.7	3.0	5.8	3.3	4.4
Ulan West UG	0.0	0.0	0.0	0.6	1.1
Charbon OC	0.3	0.2	0.5	0.5	0.6
Cullen Valley OC	0.6	0.6	0.7	0.3	0.0
Invincible OC	0.8	1.0	0.8	0.7	0.0
Ivanhoe North OC (closed)	0.3	0.2	0.1	0.0	0.0
Lambert's Gully OC (closed)	0.1	0.0	0.0	0.0	0.0
Moolarben OC	0.3	5.7	5.0	5.7	6.5
Pine Dale OC	0.3	0.2	0.1	0.3	0.2
Ulan OC	0.0	0.0	0.4	1.7	1.5
Ulan West Box Cut OC (ceased)	0.0	0.0	1.3	0.1	0.0
Wilpinjong OC	8.2	9.5	10.8	10.8	14.6
Western Total	**25.2**	**31.8**	**34.4**	**32.7**	**38.1**

Table note:
UG = underground
OC = open cut

Table 8 Southern coalfield saleable black coal production (Source: Coal Services, 2014a)

Southern Coalfield	Coal Production (million tonnes)				
	2009 - 2010	2010 - 2011	2011 - 2012	2012 - 2013	2013 - 2014
Appin UG	2.3	1.9	2.8	2.2	2.4
Berrima UG	0.2	0.2	0.2	0.3	0.1
Dendrobium UG	2.4	2.8	3.4	3.7	3.1
Huntley UG clean-up (closed)	0.0	0.0	0.0	0.0	0.0
Metropolitan UG	1.4	1.8	1.6	1.5	1.7
NRE No1 UG	0.4	0.4	0.4	0.7	0.2
NRE Wongawilli UG	0.8	0.9	0.9	0.5	0.5
Tahmoor UG	1.0	1.0	2.0	1.8	1.7
West Cliff UG	1.6	2.4	1.6	2.1	1.9
Southern Total*	**10.2**	**11.5**	**12.9**	**12.8**	**11.7**

Table note:
UG = underground

Table 9 Summary of saleable black coal production in NSW by coalfield (Source: Coal Services, 2014a)

NSW Coalfield	Number of 2013 - 2014 active mines	Coal Production (million tonnes)				
		2009 - 2010	2010 - 2011	2011 - 2012	2012 - 2013	2013 - 2014
Gunnedah	5	5.7	7.6	7.7	12.4	16.2
Hunter	21	87.4	88.2	93.8	109.0	113.0
Newcastle*	13	18.1	17.8	18.3	18.6	17.7
Western	14	25.2	31.8	34.4	32.7	38.1
Southern	8	10.2	11.5	12.9	12.8	11.7
NSW Total	**61**	**147**	**157**	**167**	**186**	**197**

Table note:
* Includes mines from the Central and Gloucester coalfields

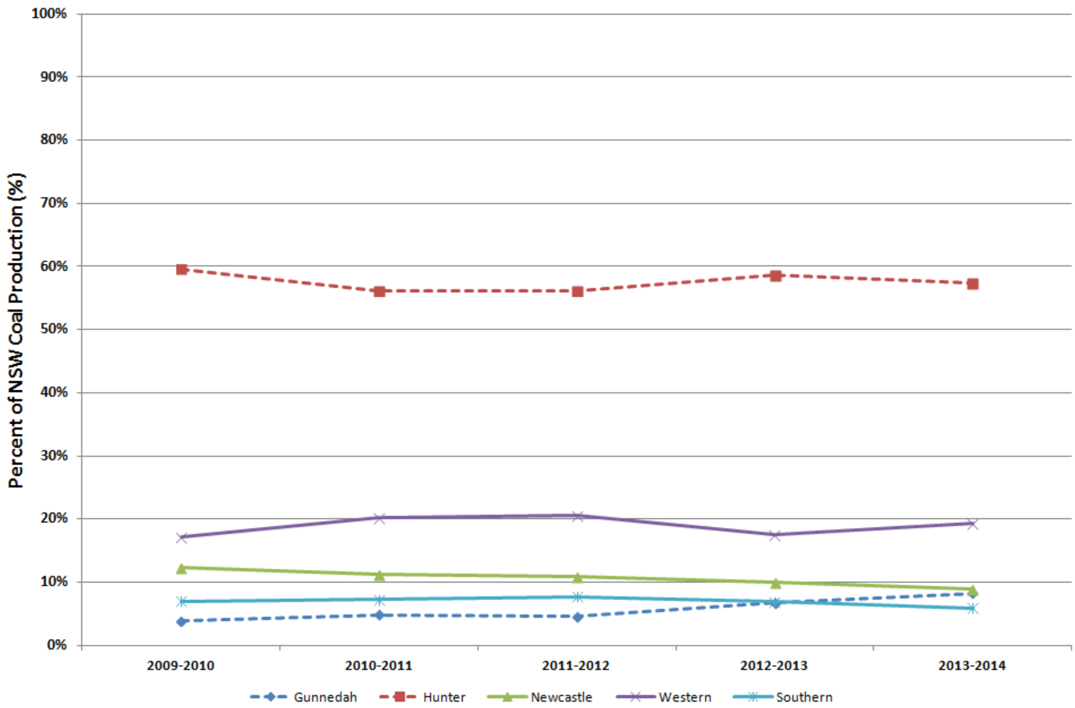


Figure 4 NSW coalfield saleable black coal production (Source: Coal Servicers Australia, 2014)

2.4.2 Export and Domestic Consumption

Exports of coal from NSW coal ports for the last four financial years are detailed in Table 10. The data shows that NSW coal exports have increased year on year for the past four years between 8% and 14%. The last four financial years have seen total coal exports increase from 122 Mt to 167 Mt, an increase of 45 Mt or 37%. This trend matches the increase seen in coal production over the same time period. Exports from Port Kembla have remained relatively consistent whilst Port of Newcastle exports have steadily increased year on year. This trend follows the increased production rates in the Hunter and Gunnedah coalfields, which utilise the Port of Newcastle.

Table 10 NSW black coal exports (Source: Coal Services, 2014b)

NSW Summary	NSW Coal Production (million tonnes)			
	2010 - 2011	2011 - 2012	2012 - 2013	2013 - 2014
Port of Newcastle	109	122	142	155
Port Kembla	13	14	13	12
Total Exports	122	136	155	167

Domestic consumption of NSW black coal for the past four financial years is detailed in Table 11 along with the total exports and total production. Domestic consumption figures were calculated as the difference between total NSW production of saleable black and coal and total exports. Small quantities of coal are sometimes stockpiled for an extended period at the mines so the total domestic consumption amounts presented here may over estimate actual domestic consumption. The data suggests that domestic consumption of coal in NSW has decreased over the last four years, which is consistent with the general falling trend in electricity demand in NSW over the same period (Pitt & Sherry, 2014).

Table 11 Domestic consumption of NSW coal

NSW Summary	NSW Coal Production (million tonnes)			
	2010 - 2011	2011 - 2012	2012 - 2013	2013 - 2014
Domestic Consumption*	35	31	30	29
Total Exports	122	136	155	167
Total Production	157	167	186	197

Table note:
* Calculated from the difference between export and production. In reality a small proportion of coal is stored in stockpiles

2.4.3 Infrastructure

2.4.3.1 Rail line

Coal mines in NSW are relatively close to ports and industrial end users in Newcastle, Sydney and Wollongong. The most distant coal mining area is the Gunnedah coalfield, which is approximately 320 km northwest of Newcastle.

Movement of coal in NSW is either by truck, train or conveyor, with train being the most effective means of long distance coal transport. To facilitate the movement of coal from the mines to export terminals and domestic users, approximately 1,000 km of rail network connects coal mine loadout points with receival stations at the export terminals and domestic users (power stations, steel plants and cement plants). Figure 5 and Figure 6 show schematics of the Northern and Southern rail networks that carry coal across NSW.

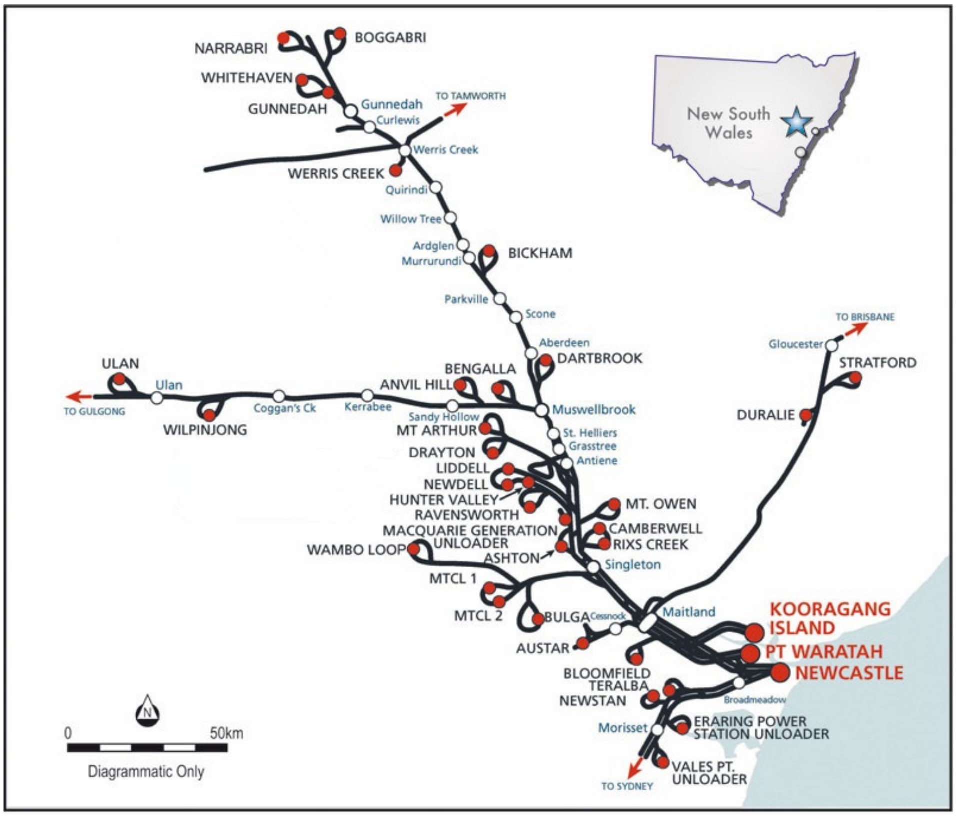


Figure 5 Schematic of the Northern NSW Coal Rail Network

Figure 6 Schematic of the Southern NSW Coal Rail Network

The Northern Rail System (also known as the Hunter Valley Coal Chain Network (HVCCN)) connects mines in the Gunnedah, Western, Hunter and Newcastle coalfields to the coal export terminals at the Port of Newcastle and domestic users in the Hunter Valley and Newcastle region.

The HVCCN is managed by the Australian Rail Track Corporation (ARTC), referred to as the "below rail" operator. ARTC maintains the rail network and arranges access agreements for shipping companies wishing to transport coal or other freight on the network, referred to as "above rail" operators. There are four "above rail" operators on the HVCCN, namely, Pacific National, Aurizon, Freightliner and Southern Short Haul Rail.

The HVCCN consists of a dedicated double track ‘coal line’ between Port of Newcastle and Maitland, a shared double track line (with some significant stretches of third track) from Maitland to Muswellbrook, and a shared single track with passing loops from that point north and west (ARTC, 2014).

A large proportion of the coal using the HVCCN originates from mine rail loading facilities dispersed along the Hunter Valley between Muswellbrook and Newcastle. Coal also feeds onto this line from Ulan and the Gunnedah basin, west and northwest of Muswellbrook, respectively, and also from Stratford, Pelton and the southern suburbs of Newcastle. A proportion of domestic coal is also transported over the HVCCN. All but a very small amount of the coal shipped through Newcastle is transported by rail (Coal Services, 2014a). ARTC estimated that on average approximately 61 loaded coal trains use the HVCCN each day (ARTC, 2014). Assuming that each coal train returns to its origin, a total of 120 coal trains per day travel on the HVCCN, which is equivalent to approximately 5 coal trains per hour.

The Southern Rail System connects mines in the Western and Southern coalfields to domestic users such as power stations and steel works and to the export terminal at Port Kembla. The volume of coal transported over the Southern Rail System is significantly lower the HVCCN with over 50% of the coal produced in the Western and Southern Coalfields transported via trucks or conveyors.

2.4.3.2 NSW Coal Loadout Points

The mines with coal production reported by Coal Services (Table 4 to Table 8) were investigated to determine how coal was transported offsite. The detailed information is provided in Section 8, but is summarised by coalfield in Table 12. The data shows there are approximately 35 individual rail loading points for coal and 19 truck loading points for coal in NSW.

Table 12 Summary of identified coal loading points by NSW coalfield

NSW Coalfield	Number of mines [A]			Number of train loading points	Number of truck loading points	Number of mines that use other train loading points	Number of mines using conveyors to transport coal offsite
	UG	OC	OC/UG				
Gunnedah	1	6[B]	0	5[B]	2	1	0
Hunter	0	11	5	14	2	1	0
Newcastle[C]	9	4	0	6	5	2	2
Western	4	5	2	7	5	0	0
Southern	8	0	0	3	5	0	0
NSW Total	**22**	**26**	**7**	**35**	**19**	**4**	**2**

Table note:
[A] Mines are counted as one if they are either open cut (OC), underground (UG) or an open cut and underground (OC/UG) complex (e.g. Ashton Coal Mine in the Hunter has both open cut and underground operations and is counted as OC/UG)
[B] Includes Mauls Creek Mine and Rail Loading Point that are currently under development
[c] Mines in the Gloucester basin (Duralie and Stratford) have been included in the Newcastle coalfield

A summary of the approximate travel distances from each identified rail loadout point to the destination export terminal is detailed in Table 13. Approximate travel distance for coal from each mine is provided in Table 14.

Table 13 Travel distance from coal rail loading point to export terminal by NSW coalfield

NSW Coalfield	Number of train loading points	Travel distance to port (km)		
		Average	Maximum	Minimum
Gunnedah	5[B]	329	375	275
Hunter	14	106	130	90
Newcastle[C]	6	59	156	25
Western	7	274	325	221
Southern	3	48	122	7
NSW Total	**34**	**151**	**375**	**7**

Table note:
[A] Mines are counted as one if they are either open cut (OC), underground (UG) or an open cut and underground (OC/UG) complex (e.g. Ashton Coal Mine in the Hunter has both open cut and underground operations and is counted as one mine)
[B] Includes Mauls Creek Mine and Rail Loading Point that are currently under development
[c] Mines in the Gloucester basin (Duralie and Stratford) have been included in the Newcastle coalfield

Table 14 Rail distance from coal loading point to export terminal by NSW mine

Rail Loadout Point	Coalfield	Distance by rail to port (km)
Boggabri OC	Gunnedah	364
Narrabri UG	Gunnedah	375
Rocglen OC	Gunnedah	316
Tarrawonga OC	Gunnedah	316
Werris Creek OC	Gunnedah	275
Ashton (UG+OC)	Hunter	95
Bengalla OC	Hunter	115
Bulga (=Beltana/Blakefield South UG)	Hunter	90
Drayton OC	Hunter	120
Hunter Valley Operations OC	Hunter	110
Integra UG (Glennies Creek) +Integra OC (Camberwell)	Hunter	90
Liddell OC	Hunter	107
Mangoola OC	Hunter	130
Mt Arthur Coal OC	Hunter	115
Mt Owen OC	Hunter	105
Mt Thorley Warkworth OC	Hunter	90
Muswellbrook OC	Hunter	125
Ravensworth (UG + North + Narama)	Hunter	110
Rix's Creek OC	Hunter	90
Wambo (UG+OC)	Hunter	95
Abel UG	Newcastle	36
Austar UG	Newcastle	65
Bloomfield OC	Newcastle	36
Mandalong UG	Newcastle	26
Newstan UG	Newcastle	26
Tasman UG	Newcastle	25
West Wallsend UG	Newcastle	25
Duralie OC	Gloucester	156
Stratford OC	Gloucester	136
Dendrobium UG	Southern	7
NRE Wongawilli UG	Southern	15
Tahmoor UG	Southern	122
Airly UG	Western	300
Charbon (UG+OC)	Western	325
Clarence UG	Western	221
Moolarben OC	Western	280
Springvale UG	Western	240
Ulan (UG+OC+West UG)	Western	280
Wilpinjong OC	Western	275

2.4.3.3 NSW Coal Receival Points

NSW coal receival points include the export terminals at Port of Newcastle and Port Kembla and the domestic users of coal such as power stations and coke works.

There are four coal export terminals located in NSW, three at the Port of Newcastle and the Port Kembla Coal Terminal at Port Kembla south of Wollongong. The Port of Newcastle is the largest coal handling port in NSW with three export terminals, namely:

- Port Waratah Carrington Coal Terminal
- Port Waratah Kooragang Coal Terminal
- Newcastle Coal Infrastructure Group (NCIG) Coal Terminal

A summary of the NSW export terminal rail receival infrastructure is provided in Table 15.

Table 15 Summary of export terminal coal receival points in NSW

NSW Port	Export Terminal	Number of Coal Rail Receival Stations	Number of Coal Road Receival Stations
Newcastle	Carrington	2	1
	Kooragang	4	0
	NCIG	2	0
Port Kembla	Port Kembla Coal Terminal	1	2
	Total	**9**	**3**

Approximately 85% of NSW domestic coal consumption occurs at coal fired power stations. Coal is also consumed in coke works and smaller amounts in cement plants. A summary of the NSW domestic coal consumer receival infrastructure is detailed in Table 16.

Table 16 Summary of domestic user coal receival points in NSW

Activity	Domestic User	Number of Coal Rail Receival Stations	Number of Coal Road Receival Stations	Coal Received by conveyor
Power Generation	Bayswater	2	0	Yes
	Eraring	1	1	Yes
	Liddell	2*	0	Yes
	Mount Piper	0	2	Yes
	Redbank	0	0	Yes
	Vales Point	1	1	Yes
	Wallerawang	1	1	Yes
Steel Production	Port Kembla Steelworks	1	1	No
Total		**6**	**6**	**-**

Table note:
* Shared with Bayswater

3. DEFINITIONS OF DUST

3.1 Overview

The purpose of this section is to provide the reader with a definition of particulate matter. Particulate matter is a term used to define solid or liquid particles that may be suspended in the atmosphere. Particulate matter is a generic term that is commonly used interchangeably with other terms such as smoke, soot, haze and dust (including coal dust). The potential effect of particulate matter on the environment, human health and amenity depends on the size of the particles, the concentration of particulate matter in the atmosphere, the composition of the particles (toxic or non-toxic) and the rate of deposition.

Concentration is the mass of particulate matter that is suspended per unit volume of air. Suspended particulate matter in ambient air is usually measured in micrograms per cubic metre ($\mu g/m^3$). Deposition is the mass of particulate matter that settles per unit surface area. Deposited particulate matter is usually measured as the mass in grams that accumulates per square metre (g/m^2) over a 1 month period.

Particulate matter with an aerodynamic diameter greater than 10 micrometres (µm) tends to be associated with amenity impacts, while particulate matter less than 10 µm is associated with health impacts. For this reason, particulate matter is sub-divided into a number of metrics based on particle size. These metrics are total suspended particulates (TSP), PM_{10}, $PM_{2.5}$ and dust deposition rate:

- TSP refers to the total of all particles suspended in the air. When TSP is measured using a high volume air sampler, the maximum particle size has been found to be approximately 30 µm (US EPA, 2010). TSP was first used as a human health metric, but research has found a poor correlation between the concentration of TSP and health effects. TSP is now used as a metric of the potential for particulate matter to affect amenity

- PM_{10} is a subset of TSP (US EPA, 2010) and refers to particles suspended in the air with an aerodynamic diameter less than 10 µm

- $PM_{2.5}$ is a subset of TSP and PM_{10} and refers to particles suspended in the air with an aerodynamic diameter less than 2.5 µm. $PM_{2.5}$ is also called fine particulate matter (US EPA, 2010)

- Dust deposition rate is the mass of particulate matter that collects on an area over a one month period. Dust deposition rate is used as a metric of the potential for particulate matter to affect amenity.

Ultrafine particulate matter (aerodynamic diameter less than 1 µm) is not likely to be associated with fugitive dust emissions from coal trains. Ultrafine particulates are generated mainly from combustion, gas to particle conversion, nucleation processes or photochemical processes (Morawska et al, 2004) and, therefore, are not relevant to this review of dust emissions from coal trains.

The atmospheric lifetime of particulate matter, that is how long the particle is airborne, depends on the size of the particle with the coarse (large) particulate matter tending to deposit quickly and in relatively close proximity to its point of emission, whilst fine particulate matter may remain suspended in the atmosphere for many days and travel many hundreds of kilometres. The atmospheric lifetimes of particles and potential travel distances based on the particle size are summarised in Table 17 (US EPA, 1996). It should be noted that, whilst smaller particles have longer atmospheric lifetimes, they also disperse as they travel. Dispersion will quickly reduce the overall concentration of particles.

The nuisance value of deposited dust may also depend on the colour of the dust. In this context, coal dust may be considered to have a greater nuisance potential than lighter coloured materials (SPCC, 1983). It should be noted; however, that particulate matter from many sources may be evident as a dark or black deposit on surfaces including: soot, moulds and tyre rubber.

Table 17 Atmospheric lifetime and potential travel distance for particles of various size categories

Particle size	Description	Atmospheric lifetime	Travel distance
TSP	Total of all particles suspended in the atmosphere	Minutes to hours	Typically deposits within the proximate area downwind of the point of emissions
PM_{10}	A subset of TSP, including all particles smaller than 10 µm in diameter.	Days	Up to 100 kilometres or more
$PM_{2.5}$	A subset of the PM_{10} and TSP categories, including all particles smaller than 2.5 µm in diameter.	Days to weeks	Hundreds to thousands of kilometres

Figure 7 shows the sizes of particulate matter as $PM_{2.5}$ and PM_{10} relative to the average width of a human hair, which is 70 µm (US EPA, 2010).

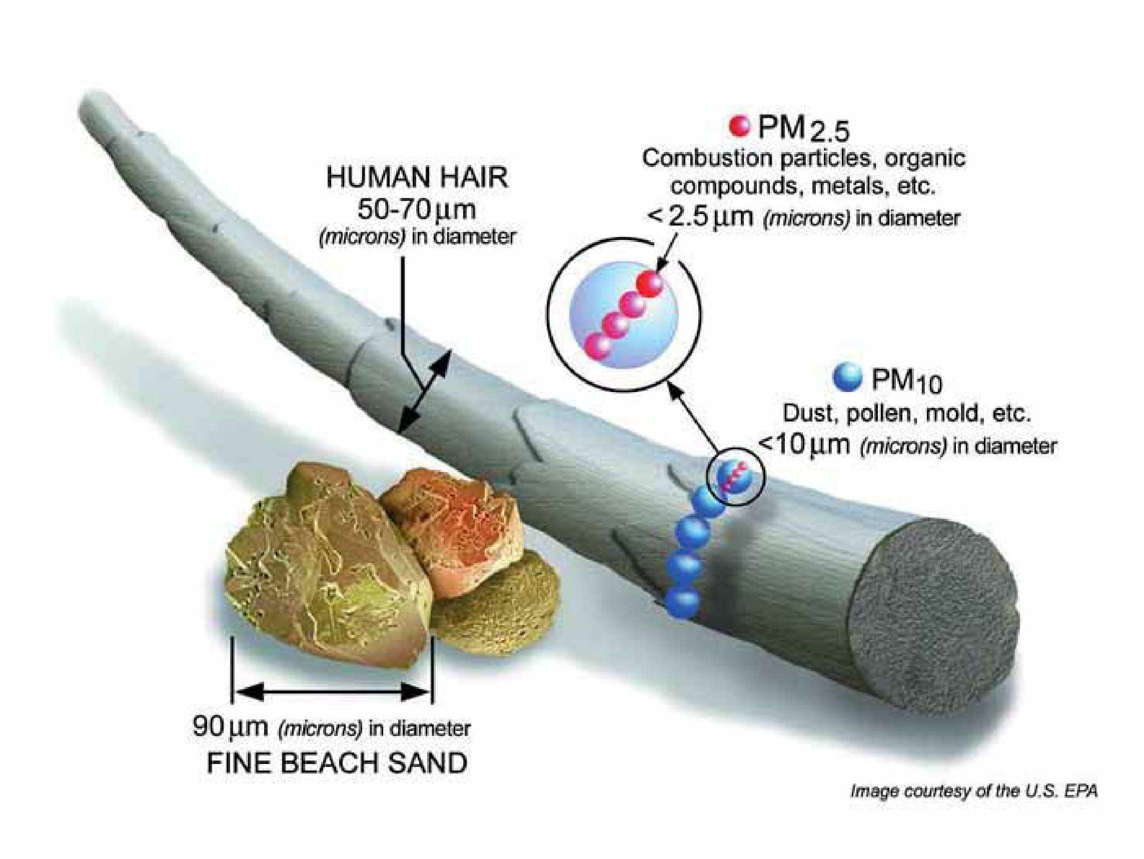


Figure 7 **Sizes of particulate matter smaller than $PM_{2.5}$ and PM_{10} relative to the average width of a human hair (US EPA, 2010)**

3.2 Effects of Dust

The recent report on the draft variation to the National Environment Protection (Ambient Air Quality) Measure (NEPM) (NEPC, 2014) reviews the available literature on the effects of airborne particulate matter (dust). It is widely accepted that airborne particulate matter in elevated concentrations can have adverse impacts on human health, amenity, ecosystems, visibility, cultural heritage and climate. The National Environment Protection Council (NEPC) report found that the main focus of public concern is currently on direct effects on human health, which account for the majority of the external costs associated with the impacts of air pollution (NEPC, 2014). The following sections provide a brief overview of effects of airborne particulate matter, focusing on health but also on amenity and ecosystems.

3.2.1 Health Effects

The health effects associated with exposure to ambient air pollution range from small transient changes in the respiratory tract and impaired lung function, to mortality, and can result in restricted activity/reduced performance, hospital emergency department visits and hospital admissions (UCRH, 2013).

In recent years, evidence has accumulated indicating that airborne particles have a range of adverse effects on health (NEPC, 2014). These effects - which are diverse in scope, severity and duration - include, but are not limited to, the following:

- Premature mortality
- Aggravation of cardiovascular diseases
- Aggravation of respiratory diseases
- Changes to lung tissue structure and formation
- Cancer
- Changes in nervous system function

Notwithstanding this, the human body has a number of defence mechanisms to protect against the harmful effects of particulate matter (NSW Health, 2007). Coarse particulate matter may be trapped in the mucus on the walls of the airways and can be removed by cilia, small hair-like structures that line the surface of the airways. The particulate matter is expelled from the body by coughing or is swallowed.

There is a demonstrated statistical association between health effects and the concentration of fine particulate matter. Studies by Ono (2005), Cowherd and Donaldson (2006) and USEPA (2006) indicate that in susceptible sub-populations, fine particulate matter from combustion related sources are markedly more detrimental to health than coarse particulate fractions ($PM_{10-2.5}$).

NSW Health (2007) considers that the following people may be more susceptible to the health effects of particles:

- Infants, children and adolescents.
- The elderly.
- People with respiratory conditions such as asthma, bronchitis and emphysema.
- People with heart disease.
- People with diabetes.

3.2.2 Amenity Impacts

Amenity impacts can occur when levels of particulate matter become elevated (NSW Health, 2007). The following impacts on amenity are commonly noted:

- Short-term reduction in visibility. For example, at a local scale particulate matter may pass across a road and temporarily affect a driver's ability to see oncoming traffic. At a regional scale, a visible plume of particulate matter may adversely affect the aesthetics of the environment such as scenic views.
- Build up of particulate matter on surfaces within homes resulting in the occupant needing to clean more frequently.
- Soiling of washing.
- Build up of particulate matter on the roofs of houses and, during rainfall, the flushing of the particulate matter into rainwater tanks potentially affecting quality of drinking water or tank capacity.

3.2.3 Ecosystems

Increased levels of particulate matter can have both direct and indirect effects on ecosystems (NEPC, 2014). Elevated levels of deposition on vegetation surfaces can influence both photosynthesis and the diffusion of gases to and from leaves. The effect of a given load of particulate matter depends on the particle size, especially in relation to the interception of light and the consequent effects on the rates of photosynthesis, plant health and growth (Doley, 2006).

The largest indirect effect to ecosystems is the acidification and eutrophication that occurs from sulfur and nitrogen deposition for which fine particulate matter plays a role during secondary aerosol formation (NEPC, 2014).

4. REGULATORY FRAMEWORK FOR RAIL COAL DUST

4.1 Section Overview

This section details the Australian and international regulatory frameworks for the management of rail coal dust emissions. The focus in Australia has been on information from NSW and Queensland because these are the largest coal markets (accounting for over 95% of coal export in Australia). The review of international regulatory frameworks has focused on the US, which has a large established coal rail network.

4.2 Australia

In Australia, air quality management is administered at the federal and state government levels. The National Environment Protection Council (NEPC) has set air quality standards for six criteria pollutants including particulate matter, promulgated under the *National Environment (Ambient Air Quality) Measure* (Ambient Air Quality NEPM) (NEPC, 1998). The Ambient Air Quality NEPM provides a nationally consistent framework for state governments to monitor and report ambient air quality. The Ambient Air Quality NEPM does not prescribe measures to control emissions of air pollutants, but the process of monitoring and reporting influences the development of policies that aim to achieve compliance with the air quality standards. There are no specific federal requirements for the management of coal dust from trains.

The state environmental regulatory bodies are responsible for setting ambient air quality objectives and assessment criteria to manage air quality issues associated with emissions from industry and other major sources.

4.2.1 New South Wales

In NSW, environmental protection from the effects of coal dust is primarily administered under the *Protection of the Environment (Operations) Act 1997* (POEO Act). The POEO Act provides a framework for the:

- Development of Protection of the Environment Policies
- Issuing Environment Protection Licenses (EPL) by EPA for activities that are defined under Schedule 1 of the POEO Act
- Development of regulations and guidelines that promulgate impact assessment criteria and emission standards for industry
- Definition of offences and penalties in relation to air pollution under Sections 124-129
- Provision of a mechanism for public participation in the environmental assessment of activities that may be licensed by EPA, in conjunction with the *Environmental Planning and Assessment Act 1979* (EP&A Act)

Schedule 1 of the POEO Act includes Clause 33 - “Railway systems activities”, which are defined under subclause (1) as:

> *(a) the installation, on site repair, on site maintenance or on site upgrading of track, including the construction or significant alternation of any ancillary works, or*
>
> *(b) the operation of rolling stock on track*

In relation to “Railway systems activities” Schedule 1 subclause (4) states:

The purposes of subclause (1)(b), rolling stock that is operated on track is taken to be operated by the occupier of the land on which the track is situated.

Consequently, in accordance with the POEO Act the environmental responsibility of all rail activities is held by the "below rail" operator.

There are no prescriptive regulatory requirements in NSW for the management of coal dust from rail activities. However, the POEO Act and its subordinate legislation clearly articulate the obligations of those that occupy premises (both licensed and unlicensed) to manage activities at the premises in a manner that prevents or minimises air pollution.

Under the POEO Act, the EPA has powers to require the holder of an EPL to develop Pollution Reduction Programs (PRPs), which are enforceable regulatory tools through which air emissions from industry can be investigated, managed and further controlled.

The recent position paper from the EPA titled "Review of regulation of railway systems activities under the *Protection of the Environment Operations Act* 1997" (NSW EPA, 2014) identified that under the current system of issuing EPLs for industrial activities, 'railway system activities' are defined and licensed to the occupier of the land on which the track is situated. This means that the 'below rail operators', such as ARTC and Sydney Trains (formerly RailCorp), are required to hold EPLs.

Consequently, under the current licensing framework, the 'below rail operators' are responsible for the environmental performance and impacts of the rail corridor including the rolling stock that are owned and operated by the 'above rail operators', regardless of the nature of the management controls they have on that rolling stock.

The 'below rail operators' should pass on their EPL obligations to the rolling stock operators through network access agreements granted to each operator. However, it is not always the case that the 'below rail operators' enforce their environmental obligations through the network access agreements.

The "Infrastructure Requirements for Unit Train Loading and Unloading Facilities for Coal and Minerals Products" (ARTC, 2011) is a Standard that sets out ARTC's infrastructure requirements for coal trains. The Standard includes information on the design of tracks, balloon loops, turnouts, overhead loading structures and unloading bins. The Standard also details that a batch weighting system is the preferred method of controlling the amount of product loaded into each rail vehicle to ensure that the rail vehicles are not over loaded in terms of axle load or spillage of materials onto the track. The Standard does allow alternative methods that must receive ARTC approval. The ARTC Standard does not detail specific rail coal dust management practices aside from the mass control at the loading facility.

However, there appears to be a lack of clear and direct environmental accountability between the relevant parties, the NSW EPA train position paper (NSW EPA, 2014) concluded that:

"The lack of direct environmental accountability for rolling stock operators means that environmental issues and community concern are often difficult to resolve..... EPA considers that the impacts of the operational rail network on the environment and community cannot be adequately addressed under the existing regulatory framework, that is, by licensing only railway system operators under the POEO Act".

The NSW EPA position paper considered the advantages and disadvantages of potential rail regulatory frameworks, including:

1. *Continue with the current framework of only licensing railway system operators under the POEO Act, that is, no change*
2. *Continue to only license railway system operators under the POEO Act and strengthen network access agreements*

3. *License only rolling stock operators under the POEO Act.*
4. *Develop a new regulation under the POEO Act to manage the rail industry*
5. *Continue to only license railway system operators under the POEO Act and actively regulate rolling stock operators under existing general powers in the POEO Act.*
6. *Improve the environmental performance of the rail industry using economic incentives*
7. *Introduce issues-based regulation of the rail industry, e.g. measures to deal with wheel squeal.*
8. *Self-regulation by the rail industry*
9. *Pass responsibility for regulating the rail industry to the Australian Government.*
10. *License both railway system operators and rolling stock operators under the POEO Act.*

The NSW EPA is currently seeking feedback on the proposed rail regulatory framework and will refine the proposed alternative framework where necessary in response to issues raised during stakeholder consultation. The NSW EPA proposed alternative rail regulatory framework would be:

> "the direct licensing of both railway system operators ('below rail operators') and rolling stock operators ('above rail operators') under Schedule 1 of the POEO Act"

The NSW EPA has published methods for sampling and analysis of air pollutants in NSW. The methods are to be applied when monitoring of air pollutants is required under a statutory instrument such as an EPL. The methods are contained in the Approved Methods for Sampling (DEC, 2007). Table 18 summarises sampling methods that are relevant to the measurement of coal dust. A number of methods have been superseded since the release of the Approved Methods for Sampling and these are noted where relevant.

Table 18 Approved Methods for Sampling (DEC, 2007) - ambient air quality sampling and analysis methods relevant to coal dust in NSW

Method no.	Parameter measured	Method
AM-1	Guide for the siting of sampling units	AS 2922–1987[1]
AM-3	Preparation of reference test atmospheres	AS 3580.2.1–1990[2] or AS 3580.2.2–1990[3] as appropriate
AM-15	Particulate matter – TSP – high volume sampler method	AS 2724.3-1984[4]
AM-17	Particulate matter – impinged matter – directional dust gauge method	AS 2724.5-1987
AM-18	Particulate matter – PM_{10} – high volume sampler with size-selective inlet	AS 3580.9.6-1990[5]
AM-19	Particulates – deposited matter – gravimetric method	AS 3580.10.1-1991[6]
AM-22	Particulate matter – PM_{10} – TEOM	AS 3580.9.8-2001[7]

Note:
[1] Superseded by 3580.1.1:2007
[2] Standard withdrawn
[3] Superseded by AS 3580.2.2:2009
[4] Superseded by AS 3580.9.3:2003
[5] Superseded by AS 3580.9.6:2003
[6] Superseded by AS 3580.10.1:2003
[7] Superseded by AS 3580.9.8-2008

4.2.2 Queensland

Queensland's primary legislation for environmental regulation is the *Environmental Protection Act 1994* (Queensland). The object of the Qld EP 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 Qld EP Act:

- Gives the Environment Minister the power to create Environmental Protection Policies such as the *Environment Protection (Air) Policy 2008* (Air EPP)
- Defines the framework for licensing Environmentally Relevant Activities (ERA). ERAs are defined in Schedule 1 of the *Environmental Protection Regulation 1998*
- Defines environmental harm, the offences of causing environmental harm and penalties
- In conjunction with the *Sustainable Planning Act 2009*, defines the framework for the approval of new ERAs
- Defines best practice environmental management
- Defines the general environmental duty

The Air EPP specifies air quality indicators and objectives for the air environment of Queensland. In addition to reporting in accordance with the requirements of the Ambient Air Quality NEPM, the Queensland Government has adopted the Ambient Air Quality NEPM standards for the six criteria air pollutants (including PM_{10}) and the advisory reporting standards for $PM_{2.5}$ as objectives in the Air EPP.

There are no specific Queensland regulatory requirements for the management of coal dust.

Like NSW, the 'below rail operator(s)' in Queensland hold environmental permits issued by the environmental regulator (Department of Environment and Heritage Protection) that make the 'below rail operator' responsible for the environmental performance and impacts of the rail corridor including the rolling stock.

4.2.2.1 Aurizon

Aurizon (formally QR National and QR Network) is both the 'below rail' and 'above rail' operator of the coal rail network in Queensland. In 2007 the Department of Environment and Heritage Protection (EHP) (formerly EPA) issued QR National with a notice under Section 323 and 324 of the Qld EP Act to undertake an Environmental Evaluation (EE) of fugitive emissions of coal dust from trains operating on its Central Queensland networks. The EE was prepared by Connell Hatch (2008).

One of the outcomes of the EE was that QR Network prepared a Coal Dust Management Plan (CDMP). The CDMP was developed in cooperation with coal supply chain participants through a Coal Chain Environmental Forum (CCEF) comprising:

- Coal producers
- Above rail operators
- Rail network managers
- Domestic coal terminals
- Export coal terminals

The CDMP provides a high level plan for the Central Queensland coal supply chain participant to manage coal dust from trains transporting coal (QR Network, 2010).

The CDMP provided a range of actions available across the Queensland coal supply chain to address fugitive dust. The following sections detail the Aurizon CDMP proposed actions for each coal supply chain participant.

Actions for coal producers (mines)

Timeframe	Action
Current (2010 - 2013)	Implementation of effective dust suppression (veneering) strategy across the central Queensland coal supply chain
	Sill brushes to remove parasitic load
	Profile design of chute loaders to improve load profiling
	Effective loading procedure to avoid overloading
	Community liaison
	Procedural review and operational training to avoid coal remaining in wagons and potential spillage associated with carry back
Short - Medium Term (< 3 years)	Development of Standards informed by monitoring processes and coal type testing
	Increase number of veneer spray stations at load-out facilities
	Wagon loading practices and wagon design to avoid overloading and improve load profiling
	Load-out facility infrastructure to avoid overloading and improve load profiling
	Coal moisture regulating system
	Internal communications
	Coal type testing for dustiness
Long Term (>3 years)	Load-out facility infrastructure to avoid overloading and improve load profiling
	Batch weighing load-out system to avoid overloading
	Load-out chute retrofitting to improve load profiling

Actions for 'above rail operators'

Timeframe	Action
Current (2010 - 2013)	Train speed indicators
	Operational procedures to avoid overloading and improve load profiling
	Operator procedural training to avoid overloading and improve load profiling
	Internal environmental awareness
	Community liaison and awareness
Short - Medium Term (< 5 years)	Wagon design to avoid overloading and improve load profiling
Long Term (>5 years)	Wagon replacement
	ECP brakes

Actions for rail network managers

Timeframe	Action
Current (2010 - 2013)	Coal dust removal (ballast cleaning)
	Complains management
	Community liaison
	Internal education and awareness
	Weighbridge to monitor loading
	Coal dust monitoring systems
	Commercial agreements
Short - Medium Term (< 3 years)	Ballast spoil management
	Corridor coal and spoil removal
	Corridor barriers and vegetation
	Commercial agreements
Long Term (>3 years)	Corridor barriers and vegetation
	Review monitoring system

Actions for coal export terminals

Timeframe	Action
Current (2010 - 2013)	Modify existing unloading facilities to avoid coal remaining in wagons and potential spillage associated with carry-back
	Operator procedural training to avoid spillage and hopper overloading
	Monitor empty wagons to avoid coal remaining in wagons and potential spillage associated with carry-back
	Community liaison and communication
	Increase internal environmental awareness
	Hopper level / train speed indicators
	Wheel washing (Dalrymple Bay Coal Terminal only)
Short - Medium Term (< 3 years)	Wagon vibrators to avoid coal remaining in wagons and potential spillage associated with carry-back
	Residual coal monitoring
	Wagon unloading practices
Long Term (>3 years)	Wagon unloading practices

Veneering strategy

In the Aurizon CDMP, the most favourable actions to manage coal dust was the development and implementation of a veneering strategy and implementing a "garden bed" profiling of loaded coal. Aurizon's veneering strategy has been implemented at train loading facilities located on Aurizon's network. Veneering obligations are included in each mine's loadout Transfer Facilities Licence (TFL). The TFL authorises the loading of coal trains onto the Aurizon network.

The current state of Aurizon's veneering strategy is that out of the 36 loadout facilities on the Central Queensland coal systems (Goonyella, Newlands, Blackwater and Moura systems), 34 (94 percent), have veneering stations installed.

Performance monitoring and reporting

Aurizon has developed an innovative monitoring system to identify dust levels on its rail systems (QR National, 2010). The monitoring stations measure the opacity of the air across the top of moving coal trains. The monitoring station sites concurrently record, wind speed and direction, relative humidity and rainfall to determine influences of weather on dust incidents. The monitoring system identifies when trains pass by the system and train movement information is used to determine the type of trains (coal (loaded or unloaded), freight or passenger).

There are currently four monitoring stations (one on each central Queensland coal rail system). The output from the monitoring stations is recorded and used to identify any dusty trains and to gauge the ongoing implementation and effectiveness of the CDMP. Data is reported to EHP on a monthly and annual basis. Specific data is not currently publicly available for this performance monitoring.

4.2.2.2 Queensland South West System Coal Dust Management Plan

The Queensland South West System (SWS) includes the Western and Metropolitan rail systems from the Moreton and Surat Basin Coal Mines to the Port of Brisbane. The SWS is approximately 650 km and runs through the major population centres of southeast Queensland including Toowoomba, Ipswich and Brisbane. The SWS is the smallest coal supply chain in Australia, hauling 8.9 Mtpa with plans for incremental growth. In 2013, the members of the SWS produced a Coal Dust Management Plan (SWS CDMP, 2013) to show evidence of their commitment to mitigate and manage coal dust in the SWS rail corridor. Members of the SWS include:

- Aurizon - rail transport operator
- New Hope Group - coal producer
- Peabody Energy - coal producer
- Queensland Bulk Handling - coal export terminal operator
- Queensland Rail - rail network manager
- Yancoal - coal producer

The SWS CDMP focuses on the transport of coal through the rural and urban communities along the SWS. It also includes the train loading and unloading processes at the mines, domestic users (power station) and the Port of Brisbane. The purpose of the CDMP is to present information regarding coal dust and coal dust management in a clear and transparent way.

The CDMP outlines the current coal dust management practices undertaken by SWS members and the proactive measures that are being taken to provide continuous improvement of coal dust mitigation. The SWS CDMP also provides information for community members, through information hotlines, email addresses, websites and notifications, to ensure that resources and information about SWS activities are readily available to all community members.

4.3 United States Railway Regulation

In the United States (US) the Department of Transportation regulates the railroads through two federal agencies:

- Surface Transportation Board (STB)
- Federal Railroad Administration (FRA)

The STB has exclusive jurisdiction over the construction, acquisition, operation, abandonment, and discontinuation of railroad operations or facilities in the US. The STB also has exclusive licensing authority for the construction and operation of rail lines.

Railroads are also subject to federal safety regulations promulgated by the FRA. The Federal Rail Safety Act (FRSA) authorizes the FRA to regulate “every area of railroad safety”. The authority extends to everything from hazardous materials to employee training.

Similar to the regulatory situation in NSW, there are no enforceable safety measures or mitigation measures in the US to prevent coal dust losses due to the conflict about who will bear the financial burden of mitigation measures (Trimming, 2013). Shippers (above rail operators) argue that it is the responsibility of the below rail operators to manage and maintain coal dust issues.

Trimming (2013) states in "*a review of mechanisms to regulate fugitive coal dust from rail transportation*" that the FRA should promulgate a safety rule regarding coal dust mitigation based on its statutory authority. A mandatory, enforceable mitigation rule would protect the environment from coal dust losses during transit and coal and fuel spills from derailments.

In 2013, BNSF, the below rail operators of the rail network in the western US, introduced a tariff for coal shippers to reduce their coal dust emissions by 85% through a variety of measures that need to be approved by BNSF. However, whilst the tariff was approved by the STB there are no enforcement requirements in the tariff. Further information on the BNSF tariff coal dust mitigation measures are described in Section 8.

5. CONSIDERATIONS FOR RAIL COAL DUST GENERATION

5.1 Literature Summary

The potential sources and mechanisms of coal dust generation in the rail corridor were well documented in the literature reviewed for this study. The reviewed literature included state, territory, national and international documents, working papers, guidelines, commercial material and grey material.

A recurring theme amongst the recent literature (last 5 years) on potential coal dust sources associated with rail transport is the Connell Hatch (2008) Environmental Evaluation of Fugitive Coal Dust Emissions from Coal Trains.

The Connell Hatch report was prepared for Queensland Rail (QR) Limited (which subsequently became QR Network, QR National and Aurizon) as requested by the Queensland EPA under the EP Act. One of the primary aims of the Connell Hatch report was to "identify all potential sources of coal dust emissions from QR trains in Central Queensland".

In preparing the EE report, the authors Connell Hatch, Katestone and Introspec, undertook a literature review that included studies and papers on coal dust emissions from the US, Canada and previous studies in Queensland. The QR report also detailed a number of investigations specifically undertaken for the Environmental Evaluation.

In the following sections, the considerations for rail coal dust generation are described and mainly referenced from the Connell Hatch report. Where the Connell Hatch report has used further studies, this has been noted and the reference documented. Other more recent literature that has been identified in this literature review has also been specifically referenced.

The literature review found very few studies conducted in NSW that describe the sources of rail coal dust generation. The final section of this chapter discusses any potential differences between the considerations for rail coal dust generation described in the Connell Hatch (2008) report, which focused specifically on central Queensland coal rail networks, and the applicability to the NSW coal rail network.

5.2 Overview

Coal dust emissions can be generated at any point in the rail network, from loading of trains at the mine, coal train transit up and down the network to receival at the dump stations of export terminals and domestic users. The specific mechanisms, factors and circumstances that can contribute to rail coal dust emissions are discussed in this section.

Coal dust emissions generated in the rail corridor are the result of three general mechanisms:

1. Coal handling
2. Wind erosion of the exposed surface of coal in a wagon
3. Spillage of coal into the rail corridor and subsequent wind erosion / re-entrainment

Coal dust emissions from coal handling can be generated from the following sources on a typical coal rail system:

- Loading coal into empty wagons (dropping action generates dust)
- Unloading of coal at the receival dump stations (dropping action generates dust)

Coal dust emissions from wind erosion of the exposed surface of coal in a wagon can be generated in the following situations on a typical coal rail system:

- During loading - Whilst loading of the train occurs, wagons that have been loaded will be subject to wind erosion as the train slowly moves along the rail loop at the mine
- During transit (loaded) - The exposed coal surface is subject to erosion by the wind and any air speeds induced by the train movement
- During unloading – Whilst unloading of the train occurs, wagons that have yet to be unloaded will be subject to wind erosion
- During return transit (unloaded) – Any residual coal within unloaded wagons may be subject to wind erosion as they travel back to the mine

Coal dust emissions from spillage of coal into the rail corridor and subsequent wind erosion / re-entrainment can be generated from the following sources on a typical coal rail system:

- Wagon overloading and subsequent coal spillage onto wagon surfaces (parasitic load)
- Spillage of coal from the top of a wagon and from parasitic loads into the rail corridor during transit
- Coal leakage from Kwik-Drop doors of loaded wagons into the rail corridor
- Generation of parasitic load on wagons during unloading (ploughing) and subsequent spillage
- Leakage of residual coal that may be present in unloaded wagons from wagon doors into the rail corridor

Anecdotal evidence in the literature suggests that the majority of spilt coal in the rail corridor occurs in close proximity to the mine loading point and the coal unloading point. Whilst this statement would appear to be logical, no relative quantification of spillage has been presented in the literature.

Emission of non coal dust particulate matter will also be generated in the rail corridor by the following sources:

- Locomotive exhaust emissions associated with diesel fuel combustion
- Entrainment of crushed sand from sandboxes used to provide traction during wet conditions and on steep grades
- Re-entrainment of non-coal dust within the ballast during the passage of a train
- Wind erosion of exposed ground in the rail corridor
- Wheel generated dust from service vehicles using unsealed access roads in the rail corridor
- Particulate matter generated during maintenance works in the rail corridor

The non coal sources of particulate matter in the rail corridor are outside the scope of this literature review and have not been considered further. The following sections describe in more detail the sources of coal dust generation in the rail corridor.

5.3 Coal handling

Coal dust can be generated during train (or truck) loading and unloading processes. The transfer of coal from any loading system into an empty wagon or from any wagon into an empty hopper will disturb fine particles within the material and inevitably result in some of these particles becoming airborne.

The amount of coal dust generated during loading and unloading depends on the relative velocities and accelerations involved in the transfer of the coal, generally resulting from the height at which the coal is released from and the transfer mechanism employed. Other variables such as coal properties (e.g. density, particle size distribution, moisture content relative to dust extinction moisture level (DEM)), wind exposure and material confinement will affect the quantity of disturbed particles, which may become airborne.

The National Pollution Inventory (NPI) Emissions Estimation Technique Manual for Mining (NPI, 2012) provides dust emission factors for the action of loading trains. Emission factors for TSP and PM_{10} emissions are 0.004 kg/tonne and 0.00017 kg/tonne, respectively. The NPI manual notes that coal handling contributes very little to the overall particle emissions from typical open-cut coal mines.

The Coal Mine Particulate Matter Benchmarking Study (OEH, 2011) ranked particulate matter emissions from 26 coal mining activities at open-cut and underground coal mines in the NSW. Train loading ranked 20th for TSP emissions, 22nd for PM_{10} emissions and 23rd for $PM_{2.5}$ emissions. The top 15 mining activities contributed 99.8% of the total TSP emissions.

Whilst train loading activities are shown to be relatively small sources of coal dust in both the NPI manual and the Coal Mine Particulate Matter Benchmarking Study, neither document quantifies the coal dust emissions that can occur after the physical action of train loading e.g. wind erosion of coal in transit or spillage of parasitic loads.

5.4 Wind erosion of the coal in wagons

Open topped coal wagons are used throughout NSW, Queensland, US and Canada for coal transport to facilitate quick and efficient loading and unloading of coal. There are a number of different open topped wagon designs to meet the requirements of each rail network. However, all open topped wagons have a substantial surface area of coal that may be subject to erosion by the wind. Figure 8 shows a typical open topped coal wagon used in Queensland.

Figure 8 Typical open topped coal wagon used in Queensland (Connell Hatch, 2008)

As previously mentioned wind erosion of coal in a wagon can occur when the train is loading and unloading (train is virtually stationary) and during transit (both loaded and unloaded). The key factors in generating coal dust lift off from open topped wagons are (Connell Hatch, 2008):

- The surface area of coal exposed to wind erosion
- The airflow induced by ambient wind conditions when the train is stationary
- The airflow induced by movement of the train combined with the ambient wind conditions

The exposed coal surface of a loaded coal wagon constitutes the largest area of coal exposed to air currents whilst the train is loaded, travels from mine to export terminal and whilst the train is unloaded. The magnitude of coal dust emissions from the surface of loaded and unloaded coal wagons will depend on a number of factors, but most important are the area of coal exposed, the speed of the air moving across the coal and the inherent dustiness of the coal. The total surface area of coal exposed to wind erosion is a function of the dimensions of each wagon, the amount of coal loaded into each wagon (or remaining in the wagon after unloading) and the load profile.

The total airflow across the train will be variable depending on the train speed, the physical environment of the rail corridor (embankments, cuttings and tunnels), the direction of travel relative to the ambient wind, and the magnitude of the ambient wind. The influence of the ambient wind on dust emissions will be relatively minor when the wind is perpendicular or behind the train (Connell Hatch, 2008).

Airflow across an open top wagon can move coal particles by three transport modes:

- Suspension
- Saltation

- Surface creep.

Particles that are less than 75 μm in size are small enough to become suspended in the airflow and readily follow the air currents. 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. Larger particles (from 500 to 1000 μm) move by surface creep propelled by the wind and the impact from 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 (Connell Hatch, 2008).

Figure 9 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.

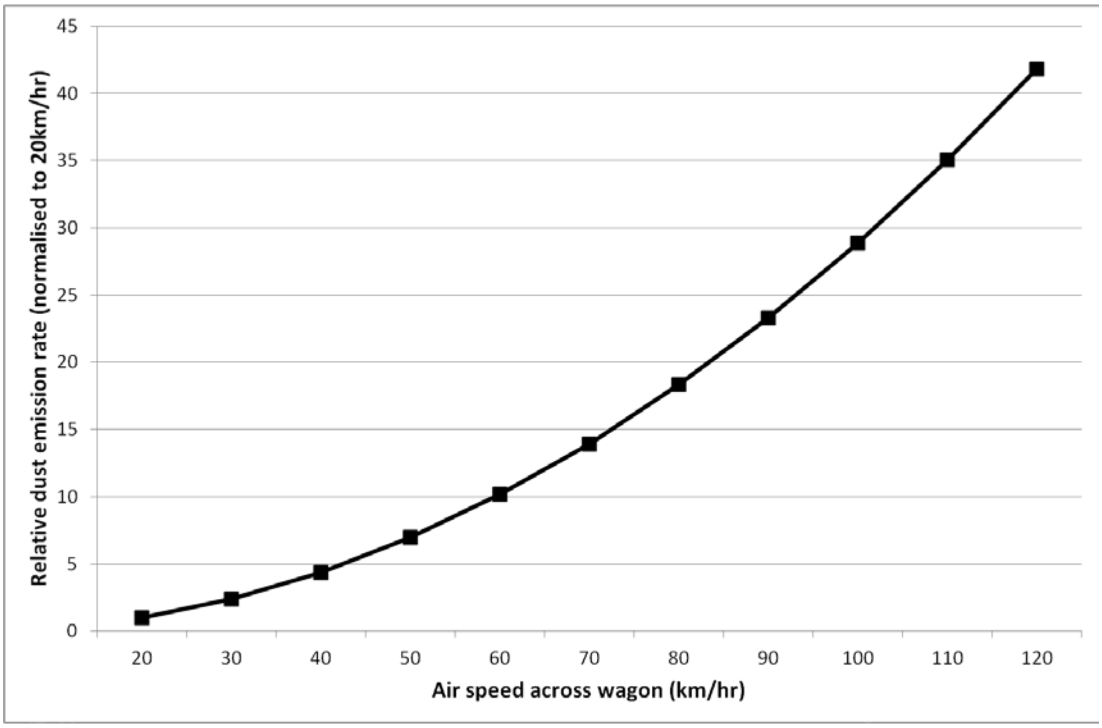


Figure 9 Dust lift off (Witt et al, 1999)

The design of a train can also influence the amount of coal dust generated by wind erosion. Wind modelling studies undertaken for QR Ltd indicated that the final few wagons of a coal train emit more dust than others due to the slipstream of the forward wagons and the first few wagons behind the locomotive tend to emit less (Connell Hatch, 2008).

5.5 Coal spillage into the rail corridor, wind erosion / re-entrainment

Activities on a typical coal rail system that result in coal spillage in the rail corridor are described in the following sections. Coal spillage in the corridor creates a potential for the coal dust emissions particularly as the coal dries. Spilled coal becomes a potential source of coal dust emissions from the corridor due to the action of wind erosion or re-entrainment of coal dust in the wakes of moving trains.

Spilled coal that falls into the track ballast is unlikely to be re-entrained into the ambient air because of the shielding effect of the large ballast particles. Little, if any, is likely to be carried far from the rail line (Connell Hatch, 2008). However, excess coal and other particles in the ballast causes ballast fouling, which damages the integrity of the tracks potentially leading to increased maintenance costs and the increased risk of derailment.

5.5.1 Overloading and spillage of coal onto external wagon surfaces

Poor coal loading practices can result in overloading of wagons, undulating coal profiles and the generation of parasitic coal on the external surfaces of coal wagons e.g. sills, sheer plates and bogies. Overloaded wagons and parasitic coal load may fall from moving trains into the rail corridor.

Coal spillage during loading can also occur when the loading mechanism is out of synchronisation with the passing wagons, when coal is loaded to the side of the wagon or when the flow of coal is not stopped between wagons.

5.5.2 Coal leakage from doors of loaded wagons

Coal is unloaded at the export terminal via 'Kwik-Drop' or 'Bomb-Bay' style doors built into the bottom of a coal wagon. Coal dust can leak from the doors during transit from the mine to the export terminal, especially if the doors are not fully closed prior to loading. The amount of coal dust falling from the doors will depend on the style of the door ('Kwik-Drop' or 'Bomb-Bay' - anecdotal evidence only), nature of the coal being transported (e.g. moisture level, particle sizes) and the vibrational forces acting on the wagons.

Some coals are free draining and, as a consequence, moisture contained in the coal when loaded into a wagon can drain out of the Kwik-Drop doors and carry with it fine particles of coal. In this instance the coal is likely to fall directly into the ballast.

A study conducted in Central Queensland found the following in relation to coal leakage from the Kwik-Drop doors used in Queensland (QR Network, 2010):

- The average coal loss from the Kwik-Drop doors was estimated to be 1,900 t and 1,800 t per annum for the Goonyella and Blackwater systems, respectively
- The average loss was equivalent to 300 kg of coal per train or 0.0027% of coal transported annual
- The upper bound estimate of the contribution to total coal dust emissions due to the entrainment of coal dust from the ballast due to spillage from Kwik-Drop doors was 6%

The study found that there appeared to be no correlation between:

- Coal lost through doors and door clearance (which is the gap between the door and the wagon) – majority of particles lost through doors were significantly smaller than the door clearances
- Coal lost through doors and travel distance
- Particle size distribution and door clearance

The study suggested that other factors could influence loss through doors including coal properties and other factors that may influence wagon vibration such as longitudinal forces and wagon stiffness.

5.5.3 Residual coal in unloaded wagons

Unloaded coal wagons returning to the mine may be a potential source of coal spillage if there is residual coal ("carry-back") in the wagons. Residual coal can dry and can become entrained in the air currents that develop in the empty wagons as the trains travel back to the mine. This mechanism is compounded by the increased speeds of trains with empty wagons.

Residual coal in the wagon above doors may also fall through the gap between the wagon's doors and become trapped within the ballast or entrained in the wake of the moving train. Ballast contamination is a recurring maintenance issue for rail operators. A study conducted in Queensland (Connell Hatch, 2008) estimated that unloaded trains contributed about 1% to total dust emissions associated with coal trains. According to a further study conducted in Queensland in 2007, an average coal wagon was determined to have "carry back" of approximately 0.36 tonnes of coal (CSIRO, 2008). An average coal wagon load would be able to carry between 75 - 100 tonnes of coal. Carry back would equate to less than 0.5% assuming the wagon capacity was 75 tonnes.

Certain loading practices have a greater propensity to lead to residual coal in wagons following unloading. An investigation conducted in Queensland (Connell Hatch, 2008) concluded that if the initial impact location of coal in the wagon was around the doors, the impact caused consolidation of the coal in the wagon that was more severe than the shunt and buff forces experienced during travel, ultimately resulting in arching in susceptible coals during unloading. Coal arching is the effect where compacted coal inside a wagon will form a self supporting 'arch' over an opening ultimately contributing to residual coal after unloading. Jackhammers are commonly used at the ports to vibrate the wagons to assist the flow of the coal.

In 2007, CSIRO conducted a study on behalf of ACARP to develop a coal handleability index (C14071). The relationships between coal properties and handleability were found to be complex and a simple handleability index was not able to be developed. A non linear data analysis technique was able to use the commonly determined coal properties of size distribution, moisture (total, free and bound) and ash abundance and ash constituents to cluster the coals in a way that replicated quite well their handleability performance. The CSIRO handleability test was found to be a good method of quantifying handleability, especially the unloading performance of bottom dump rail wagons.

ACARP is currently funding a study (C22034) to further investigate factors that cause flow problems during discharge from coal rail wagons as well as loading techniques and chemical additives that may improve unloading to avoid wagons containing significant quantities of residual coal.

5.5.4 Parasitic load associated with unloaded wagons

Parasitic load can occur on unloaded wagons due to coal ploughing during unloading of wagons. Coal ploughing occurs when the rate of wagon unloading is too fast for the discharge hoppers at the unloading facility which results in the build-up of coal above the discharge grates. As the wagons travel through the built up coal, coal collects on the wagon bogies. As described above, parasitic load can spill into the rail corridor as the unloaded wagons travel back to the mines.

5.6 Summary of rail coal dust sources in Queensland

A study of coal trains in Central Queensland (Connell Hatch, 2008) estimated the relative contribution of each source of coal dust described in the previous sections. Figure 10 illustrates the estimated source contribution of coal dust during rail transit form mine to export terminal. This study found that approximately 80% of coal dust emissions from coal trains were due to the surface of loaded coal wagons.

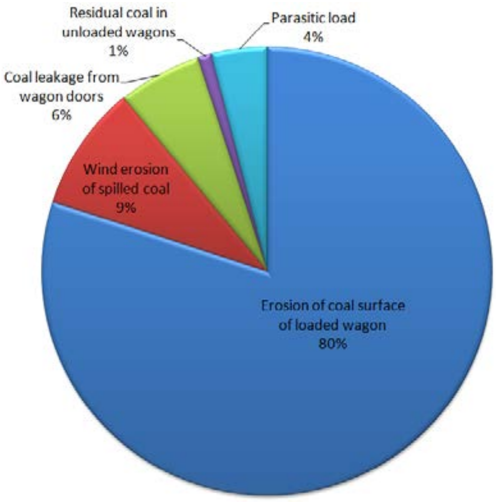


Figure 10 Source contributions to coal dust emissions from a coal trains

5.7 Differences between NSW and Queensland rail coal dust emission sources

In 2009, NSW DECCW issued a Pollution Reduction Program (PRP) to ARTC (NSW below rail operator) that required ARTC to investigate ways to reduce coal dust from the transportation of coal via rail. ARTC commissioned an environmental consulting company (PAE) to assist it with the PRP.

In particular, the purpose of the PRP was to:

- Determine the extent of the issue
- Identify, if possible, any potential environmental harm caused by fugitive dust from coal trains in the context of nuisance and health impacts
- Identify the potential reasonable and feasible measures that could reduce environmental harm

Stage 1 of the PRP was a gap analysis to identify where the existing data is lacking and highlight any additional work required in NSW. ARTC's response was provided in a report prepared by PAE (2010).

ARTC's response to the PRP evaluates the applicability of the work conducted in Queensland on behalf of QR Ltd (the Connell Hatch 2008 report) and to the NSW coal rail networks.

PAE (2010) concluded that the key drivers for coal dust emissions from rail transport in NSW would be the same as found in the Queensland study and that erosion from the top of open wagons is likely to be the major coal dust source. The mechanisms for generating coal dust emissions would also be the same. However, the PAE (2010) study also found that the specific coal dust emission rates would vary according to a number of factors that are different in NSW. The different factors are detailed in the following section.

6. FACTORS AND CIRCUMSTANCES THAT CONTRIBUTE TO RAIL COAL DUST EMISSIONS

6.1 Literature Summary

This section has reviewed literature on factors and circumstances that contribute to generation of coal dust in the rail corridor. The majority of information was sourced from Connell Hatch (2008). Where the Connell Hatch report has used further studies, this has been noted and the reference documented.

The literature review found very few studies conducted in NSW that specifically investigated the factors and circumstances that contribute to rail coal dust emissions. The final part of this chapter discusses potential differences between the factors and circumstances in Queensland and NSW coal rail networks that could contribute to significant differences in coal dust emissions.

6.2 Coal properties

As described in Section 5, coal properties can play an important role in the amount of coal dust generated in the rail corridor. Coal properties can vary significantly between coalfields and between mines within each coalfield.

6.2.1 Coal type

Coal types are generally defined by the end use of the coal, which depends on the specific properties of the coal. The properties of the coal depend on their age and the depth to which they have been buried under rock. Coal type is not necessarily a direct predictor of relative dustiness of coals. Coal types include:

- Coking and metallurgical coals
- Thermal or steaming coals
- Pulverised Coal Injection (PCI) coals, which can be used as thermal coals or low grade coking coals

Depending on the end use, coals may be washed or unwashed. Washing coal is the process of removing rock and other minerals to improve the overall quality of the coal. Washing involves immersing the crushed coal in a liquid of high specific gravity to separate the coal from the heavier impurities. Washed coals tend to retain some moisture from the washing process and consequently have higher moisture content then the coal in its unwashed state.

6.2.2 Coal dustiness/moisture

The dustiness of coal will vary from mine to mine and is a function of the density, chemical composition, hydrophobic/hydrophilic nature and particle size distribution of the specific coal type (Connell Hatch, 2008). In the context of coal handling (transfers and drop operations), there is a direct relation between dustiness and moisture content of a particular coal, which can be expressed in terms of a dust extinction moisture level (DEM).

DEM can be determined using a laboratory test procedure, as detailed in Australian Standard AS 4156.6-2000, Coal Preparation Part 6: Determination of dust/moisture relationship for coal. From this procedure it is possible to determine the DEM for each coal type. Keeping the moisture content of coal at or above the DEM will minimise dust emissions associated coal handling.

DEM is an inherent property of an individual coal. DEM of coals can vary over a wide range of moisture contents. For example, the DEM of 15 coal types shipped through the RG Tanna Coal Terminal in Gladstone were reported by Connell Hatch (2007). The DEM ranged from 5.7 % to 18.2%.

At some coal terminals in Australia (e.g. Hay Point in Queensland and NCIG in NSW), moisture management aims to ensure that the bulk moisture content of the coal received at the rail unloading facility is above the DEM of the individual coal type. This approach ensures that dust emissions are minimised during unloading and during transfer operations between conveyors and into the stockpiles. In the event that the coal arrives at the rail unloading facility with moisture content below DEM, moisture can be applied during unloading and at conveyor transfers to increase the bulk moisture content and to reduce coal dustiness. Other coal terminals may use more simplistic approaches to minimise dust emissions during unloading where water is applied routinely or in response to the observation of higher dust levels during coal unloading.

The concept of DEM has been developed specifically to manage dust emissions during the handling of coal. High moisture content relative to DEM will not guarantee minimal coal dust emissions during rail transit. Solar radiation and wind will tend to dry the surface of coal in a wagon making it susceptible to wind erosion.

However, moisture applied to the surface of coal wagons has been found to be effective in minimising dust emissions over short train journeys.

6.2.3 Dust lift-off wind speed

Wind tunnel testing has been used to investigate the relative dustiness of coals under simulated rail transport conditions. As described above, dust lift-off can be considered to develop in three stages: saltation, minor dust lift-off and major dust lift-off. Coals that produce dust lift-off at lower wind speeds will tend to produce greater quantities of dust in rail transport. The following lift-off thresholds were determined through wind tunnel testing of 15 coals shipped through the RG Tanna Coal Terminal in Gladstone:

- Saltation: 4.0 – 9.0 m/s
- Minor dust lift-off: 6.6 - 12.4 m/s
- Major dust lift-off: 9.5 – 13.7 m/s

Wind tunnel testing can also be used to investigate the relative benefits that can be achieved through the application of water or surface veneers under simulated rail transport conditions.

6.3 Train speed and ambient wind speed

As discussed in Section 5.4, the primary mechanism for coal dust lift-off from coal trains is the erosion of the transported coal by the movement of air, either from ambient wind conditions or a combination of ambient winds and induced air speeds from train movement. The air speed travelling across the coal surface during transport 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.

6.4 Train passing a loaded train

A rail transport system may have duplicated (or more) tracks, especially in urban areas, allowing trains to pass travelling in opposite directions. Depending on the location and conditions, coal trains (empty or full), freight trains and passenger trains, which can travel 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 can enhance the emission rate of dust from both trains. 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.

The increased wind speeds generated by trains passing will also increase any re-entrainment of coal dust spilt in the rail corridor.

6.5 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.

6.6 Train vibration

Evidence from coal fouling of ballast indicates that coal loss is more intense in areas where the vibration forces are greater. Vibration could also cause coal particles to break, producing finer material that will be lifted more readily from the coal surface. Train vibration can also enhance the spillage of coal from the surface of heavily loaded wagons and from wagon doors and spillage of parasitic coal from the exterior of wagons.

6.7 Profile of coal load

The profile of the coal load refers to the shape of the exposed surface area above the sill of a coal wagon. Works undertaken in Queensland (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 8). Poorly loaded wagons can also spill coal onto the ballast and within the corridor (Figure 11).

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 has shown that the three mound case (representing the irregularly shaped load) exhibits slightly higher velocities and turbulence intensities than the ‘garden bed’ configuration (Connell Hatch, 2008).

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

Figure 11 Photograph showing a poorly loaded wagon (extracted from Connell Hatch, 2008)

6.8 Transport distance

The longer the distance from mine to export terminal the higher the potential dust emissions. 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 can 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 potentially produce more coal dust. This is particularly the case where loading practice leads to irregularly shaped loads rather than the preferred "garden bed" profile.

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. A Queensland study found that, after two hours of travel time, the effectiveness of water applied to exposed surface of coal to reduce dust emissions was reduced (Connell Hatch, 2008). Reapplication of water would be required to continue to limit coal dust emissions.

6.9 Precipitation

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 gradually dry out and dust emissions may return to the levels prior to rainfall.

Precipitation can also impact on the amount of coal "carry back" occurring after the wagon is unloaded. A study conducted by CSIRO in 2007 found that during the survey period, torrential rains increased the coal "carry back" amount in an average wagon from 0.36 tonnes to 0.93 tonnes (CSIRO, 2007).

6.10 Factors that may affect coal dust emissions in NSW

PAE (2010) on behalf of ARTC examined the findings of work conducted in Queensland (Connell Hatch, 2008) and identified a number of factors that were considered to be different between Queensland and NSW that may result in different coal dust emission rates. The different factors highlighted included:

- Differences in coal properties
- Operational differences including, loading practices, wagon types, frequency of train movements, train speeds, tonnages of coal transported, haulage lengths
- Differences in climate and meteorology
- Differences in community perceptions and expectations

In summary, PAE (2010) identified issues that are relevant to the NSW coal train network and gaps in the NSW data and provided recommendations for further work, which included investigations into:

- DEM levels for NSW coal types
- Wind speeds for major dust lift off for NSW coal types
- Loading and unloading practises in NSW

The PAE (2010) also recommended the development of a code of practice to be written with rail network stakeholders, with the code providing clear guidance on:

- 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

7. RAIL CORRIDOR AIR QUALITY MONITORING STUDIES

The following section provides a review of the publically available air quality studies specifically pertaining to the measurement of coal dust in the rail corridor. Based on the methodologies and findings of each report, Katestone has rated each piece of literature as low, medium or high in terms of "relevance".

7.1 Literature

The following reports and monitoring data sets that are relevant to this literature review have been sourced from within Australia and overseas:

NSW

- ARTC - Particle Emissions from Coal Trains
  - PRP 4.1 Pilot Monitoring Program
  - PRP4.2 Monitoring Program
- UTS, Re-analysis of ARTC Data on Particle Emissions from Coal Trains
- Newcastle Community Group Air Quality Monitoring Campaigns
  - Coal Dust in Our Suburbs
  - Coal Train Pollution Signature Study
- Port Waratah Coal, Review of the Coal Dust in Our Suburbs Report

Queensland

- QR Environmental Evaluation monitoring study (2007 -2008)
- QR Environmental Evaluation review of historical rail monitoring programs, including:
  - 1993-94Gladstone study
  - 2004Goonyella study (Praguelands)
  - 2007Gladstone study (Callemondah)
- Department of Science, Information Technology, Innovation and the Arts (DSITIA) Monitoring Studies
  - Tennyson Study
  - Western Metropolitan Rail System Study

International

- Norfolk Southern Corporation Study
- BNSF Super Trial
- Seward Alaska Air Quality Monitoring Studies, including:
  - Government Studies
  - Community Studies
- Fugitive Coal Dust Emissions Study in Canada
- Fraser Surrey Dock Coal Transfer Facility Health Risk Assessment

7.2 Rating of Rail Corridor Air Quality Monitoring Studies

The following section presents a rating for each piece of literature reviewed on air quality monitoring in the rail corridor. A rating system of low, medium and high "relevance" was been determined based on satisfying the following criteria:

- Monitoring conducted in the rail corridor
- Monitoring conducted in accordance with relevant Australian Standards for dust
- Peer reviewed
- NSW specific

The rating of each piece of literature on rail corridor air quality monitoring is shown in Table 19.

Table 19 Rail corridor air quality monitoring literature rating

Literature		Monitoring within rail corridor	Dust monitoring conducted to relevant AS	Peer reviewed	NSW Specific	Rating
ARTC - Particle Emissions from Coal Trains	PRP 4.1 Pilot Monitoring Program	✓	×	×	✓	Medium
ARTC - Particle Emissions from Coal Trains	PRP4.2 Monitoring Program	✓	×	✓	✓	Medium
UTS, Re-analysis of ARTC Data on Particle Emissions from Coal Trains		×	n/a	✓	✓	Medium
Newcastle Community Group Air Quality Monitoring Campaigns	Coal Dust in Our Suburbs	✓	×	×	✓	Medium
Newcastle Community Group Air Quality Monitoring Campaigns	Coal Train Pollution Signature Study	✓	×	×	✓	Medium
Port Waratah Coal, Review of the Coal Dust in Our Suburbs Report		×	n/a	×	✓	Low
QR Environmental Evaluation monitoring study (2007 -2008)		✓	✓	✓	×	Medium
QR Environmental Evaluation review of historical rail monitoring programs	1993-94Gladstone study	✓	✓	×	×	Medium
QR Environmental Evaluation review of historical rail monitoring programs	2004Goonyella study (Praguelands)	✓	✓	×	×	Medium
QR Environmental Evaluation review of historical rail monitoring programs	2007Gladstone study (Callemondah)	✓	✓	×	×	Medium
DSITIA Monitoring Studies	Tennyson Study	✓	✓	×	×	Medium
DSITIA Monitoring Studies	Western Metropolitan Rail System Study	✓	✓	×	×	Medium
Norfolk Southern Corporation Study		✓	×	unknown	×	Low
BNSF Super Trial		✓	×	✓	×	Medium
Seward Alaska Air Quality Monitoring Studies	Government Studies	✓	✓	unknown	×	Medium
Seward Alaska Air Quality Monitoring Studies	Community Studies	✓	✓	unknown	×	Medium
Fugitive Coal Dust Emissions Study in Canada		×	n/a	unknown	×	Low
Fraser Surrey Dock Coal Transfer Facility Health Risk Assessment		×	n/a	unknown	×	Low

7.3 Summary of Findings of Rail Corridor Air Quality Monitoring Studies

The following section presents a summary of the findings of literature reviewed on air quality monitoring in the rail corridor. A detailed description of each piece of literature relating to rail corridor air quality monitoring studies is provided in Appendix A.

Two recurring themes seen in the air quality monitoring studies conducted in rail corridors are:

1. Particulate matter levels increase during and immediately after the passing of a train, be it a loaded coal train, unloaded coal train, freight train or passenger train. Some studies suggest that highest dust levels are associated with loaded and unloaded coal trains; however, the magnitude of differences in dust levels between train types is not substantial
2. No study found exceedances of air quality assessment criteria at monitoring stations in or near the rail corridor when measured in accordance with the relevant Australian Standards

8. MANAGEMENT PRACTICES TO CONTROL RAIL COAL DUST EMISSIONS

8.1 Literature summary

The following sections detail management practices to control rail coal dust emissions. The review of the literature found only a relatively small number of documents that attempted to directly quantify the effectiveness of rail coal dust management practices.

The effectiveness of rail coal dust management quantified in the literature has come from the following sources:

- QR Limited Environmental Evaluation (Connell Hatch, 2008)
- BNSF Super Trial
- Emission estimation technique manual for mining (NPI, 2012)

There is a relatively large amount of literature regarding the control of dust emissions that are not specific to rail coal dust. For example, the NPI (2012) manual details a range of dust management practices and their estimated control efficiency. Similarly, the Coal Mine Particulate Matter Benchmarking Study (OEH, 2011) collated a range of data relating to the effectiveness of emission controls relevant to coal mining activities.

8.2 Train Loading Practices

As discussed in Section 5, coal dust can be generated at any point along the rail network, from loading at mines, during transit and at the unloading point. Therefore, the loading practices at the mine will influence the amount of coal dust generated at the loading point and more importantly, as the train travels on the network. The technologies, methods and management practices that can be used to limit the amount of coal dust that is generated in the rail corridor from train loading are discussed below.

There are two types of coal train loading systems:

- Stationary loading
- Continuous loading

Stationary train loading systems are the simplest method of loading coal wagons. A stationary loading system typically uses front end loaders to transfer coal from storage piles to the empty wagons. The wagon is stationary during the physical loading. Underloading, overloading, spillage and inconsistent load profiles are common occurrences from stationary loading systems. Stationary loading systems are usually open systems that make controlling coal dust generation difficult.

The advancement in loading technology has seen the number of stationary loading systems decrease over the years. In the OEH (2011) study, the survey of loading practices of mines in the GMR indicated only one stationary train loading facility. Review of available mine information conducted by Katestone for this study (see Section 2.2) indicated three stationary train loading facilities across all mines in NSW.

Continuous train loading systems allow continual train movement throughout the loading process. Continuous systems have an overhead 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. Continuous loading systems can be manual, semi-automatic or fully automatic. Manual systems require a high level of human judgement as an operator uses line of sight control to start and stop the loading of each wagon. Semi-automatic system automatically trigger the flow of coal into a wagon, but an operator is required to communicate with the train driver to match the train speed with the loading speed. A fully-automated system requires very little human management as the loading of coal and the train speed is controlled automatically.

Coal dust generated from continuous loading systems can be controlled more effectively than stationary loading systems. Continuous train loading systems can be located in the open air, within sheds or enclosed buildings. The NPI (2012) emissions estimation manual details a 70% control efficiency for loading of trains in an enclosure and 99% control efficiency for loading trains in an enclosure with air extraction to a fabric filter.

The loading of trains within a building with a fabric filter will minimise any coal dust generated by the loading process being released into the local environment. Whilst the use of an enclosure will contain coal dust generation at the mine, the loading methods used by each mine will have an influence on the amount of coal dust generated as the train travels from mine to port and back.

For a continuous loading system, 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 bin into each wagon, namely:

- Volumetric loading or batch weighing
- Clamshell transfer or chute transfer

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 from the overhead bin. Volumetric loading is susceptible to overfilling if the operator leaves the overhead bin gate open for too long. Similarly, spillage can easily result from misjudgement or a lack of concentration from the operator.

Batch weighing systems load pre-weighed batches of coal into each wagon as they pass underneath the bin. Due to the higher level of control, the incidence of overfilling and spillage from batch weighing systems is lower than volumetric loading. It should be noted; however, that batch weighing systems that do not take into account the density of the coal could actually increase the risk of wagon overloading.

The reduction in coal dust generation between volumetric or batch weighing systems has not been directly quantified in the literature. Greater control on the amount of material entering each wagon will ultimately lead to fewer incidences of coal dust spillage or overloading, which will in turn reduce the potential for coal dust emissions from the rail corridor.

Loading stations with clamshell arrangements, attached to the underside of surge bins, consist of single or multiple sets of arms that meet in the middle when closed, and swing outwards allowing material flow when opened. Due to the operational nature of clamshell loading devices, minimal control is afforded over the final material profile in the wagon.

Loading stations with chute arrangements, attached to the underside of surge bins, consist of a square chute that can be lowered below the level of the wagon sill (telescopic chute). Material flow into the wagon is controlled by a valve which when opened, allows material to flow down the chute and into the wagon.

The reduction in coal dust generation between clamshell and chute loading systems has not been directly quantified in the literature. Chute systems provide more control over the material transfer process than clamshell systems. Load profiling of a wagon (discussed in the next section) can be successfully achieved through appropriate chute design leading to fewer incidences of coal dust spillage or overloading, which will in turn reduce the potential for coal dust emissions from the rail corridor. Load profiling can also occur with clamshell systems, but requires extra equipment to be installed to profile the wagon after it is loaded, which has a potential to result in spillage and generation of parasitic coal.

Coal mine operators monitor and track the amount of coal (tonnage) that is delivered to various markets (export terminal or local power station) through systems that measure the weight of coal trains before and/ or after loading. Export terminals and domestic users have similar systems to measure coal train weights after unloading.

These weigh systems allow the amount of coal to be tracked through the coal chain network. A potential additional use of the weigh systems would be to determine the amount of coal dust lost from trains by noting the difference between weight of a loaded train and unloaded train. This potential application is limited by the sensitivity of the weighing systems to small changes in weight from coal dust lift-off compared to the total weight of a fully loaded coal train. With more accurate weighing systems, it may be possible to estimate coal dust loss during transit.

In Queensland, it was concluded that the current industry best practice wagon loading system would consist of the following components (Connell Hatch 2008):

- 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

Such wagon loading systems minimise spillage, avoid overloading and potential spillage into the corridor and provide "garden bed" profiles that minimise velocities across the wagon load to prevent slip failure.

8.3 Control of Coal Dust Lift-off

Of all potential sources of coal dust emissions from coal trains (described in Section 5), wind erosion of the exposed coal surface in a wagon has been found to be most significant. The review of international literature relating to the control of coal dust emissions from coal wagons has found various approaches that have been postulated and/or adopted in Australia and in other jurisdictions to control wind erosion of the wagon load. These include:

- Reduction of incident air speeds on wagon loads by load profiling
- Reduction of incident air speeds on wagon loads by use of deflectors/container boards
- Protection of erodible surface by wagon lids
- Protection of erodible surface by surface treatments – including water and chemical suppressants (veneers)

Each of these approaches is described in more detail in the following sections.

8.3.1 Reduction of incident air speeds on wagon loads by load profiling

Load profiling is the process of creating a consistent coal surface (both cross section and height above the wagon sill) in a loaded coal wagon. Undulating profiles tend to be produced by coal loading facilities that use clamshell loaders or front end loaders to fill wagons with coal.

In the Powder River Basin of the United States, BNSF Railway Company (BNSF) has conducted research into emissions of coal particulate matter escaping from loaded wagons. BNSF's research has determined that coal particulate matter adversely affects the stability of the track structure and the operational integrity of the rail lines.

BNSF found that release of coal particulate matter can be partially reduced by loading wagons with a modified loading chute. Proper use of the modified loading chute will produce a rounded contour of the coal in wagons that eliminates the sharp angles and irregular surfaces that can promote the emission of coal particulate matter. (BNSF, 2014)

As a consequence of this research (not publically available), BNSF has implemented a coal loading rule that requires the profile of the load in coal wagons to be in compliance with BNSF's published Load Profile Template, as shown in Figure 12.

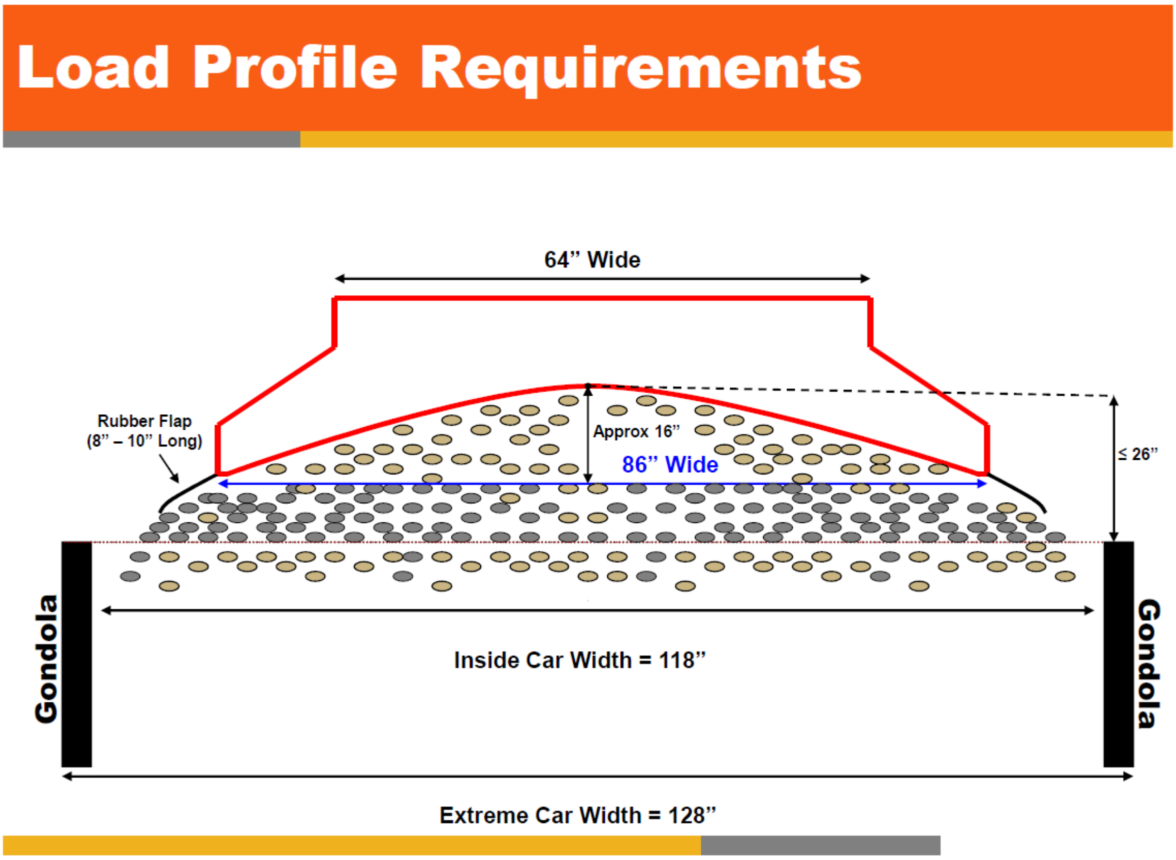


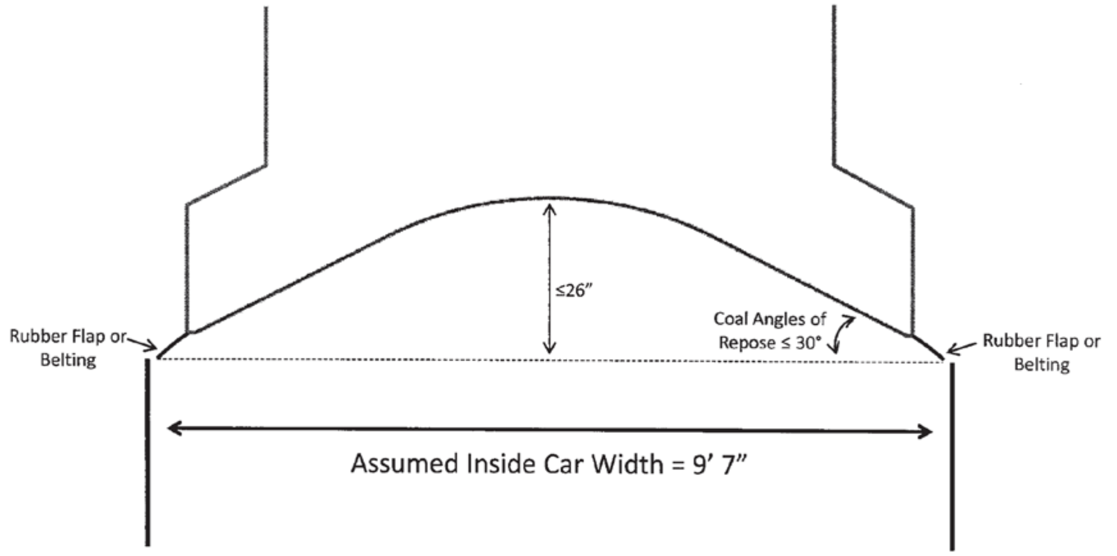
Figure 12 BNSF coal loading rule – load profile template

Similar to the BNSF coal loading rule, other rail companies in the US have adopted similar protocols. Union Pacific (UP, 2014) has directly adopted the BNSF coal loading rule for its recommended loading measures to mitigate coal dust for coal train originating in Wyoming.

CSX Transportation (CSXT) is North America's largest Class 1 Railroad east of the Mississippi River with over 21,000 miles of rail network. CSXT details loading conditions and coal dust mitigation for operators on the railroad in Publication 8200 "Terms and Conditions of Service and Prices for Accessorial Services and Common Carrier Line Haul of Coal, Coke and Iron Ore" (CSXT, 2013).

Section 4.2.2 details the CSXT coal load profile requirement which requires a "bread loaf" profile to reduce sharp edges and angle of repose of the coal profile. Figure 13 details the CSX load profile requirement.

Figure 1. CSXT Coal Load Profiling Requirement



Suggested Load Profiling Chute Specifications - Minor Adjustments May Need to Be Made for Individual Installations

Height Above Lowest Point on Chute (ft)	0.28	0.47	0.66	0.84	1.03	1.21	1.39	1.57	1.75	1.89	2.01	2.09	2.15	2.19	2.20	2.19	2.15	2.09	2.01	1.89	1.75	1.57	1.39	1.21	1.03	0.84	0.66	0.47	0.28
Distance from Center of Car (ft)	-4.41	-4.09	-3.76	-3.44	-3.12	-2.80	-2.49	-2.17	-1.86	-1.55	-1.24	-0.93	-0.62	-0.31	0.00	0.31	0.62	0.93	1.24	1.55	1.86	2.17	2.49	2.80	3.12	3.44	3.76	4.09	4.41

Designed by Simpson Weather Associates for CSXT

Figure 13 CSXT coal loading rule – load profile template

In Queensland, wind tunnel testing and Computational Fluid Dynamics (CFD) modelling has shown that coal wagons with an uneven coal surface are likely to be subject to higher turbulent intensity of airflow and, hence, higher levels of coal dust lift-off. Additionally, an uneven coal profile will have a larger surface area that would be subject to wind erosion than an even profile. This will also contribute to a greater degree of dust lift-off (Connell Hatch, 2008).

A consistent "garden bed" profile can be achieved by:

- Use of an adjustable load profiler
- Telescopic loading chute

The research work conducted in Queensland and in the United States demonstrates that a wagon that has a consistent coal surface will also improve the effectiveness of veneering treatments (discussed in Section 8.2.4) and will have reduced slip failure and therefore less chance of spillage.

In addition to the use of loading techniques to profile wagons, scrapers or compactors can also be used to profile a wagon after filling. An example of coal wagon compaction can be found at the Cerrejon Coal Mine in Colombia. The mine implements a number of measures to reduce its environmental impact from coal mining operations, including the reduction in dust emissions during rail coal haulage. The coal is loaded into wagons, levelled (profiled), sprayed with water before being compacted by a heavy roller.

The use of heavy roller to compact coal in a wagon reduces the height of the coal above the tops of the wagons and also avoids coal spillage into the rail corridor during travel. A picture of the Cerrejon Coal Mine compactor is shown in Figure 14. There is no detailed information on the effectiveness of compacting coal during loading. The compaction process may increase the spillage of coal in the immediate vicinity of the rail loading station, but is likely to reduce spillage in transit if an appropriate profile can be achieved.

Figure 14 Coal wagon compaction at Cerrejon Mine in Columbia (Source http://www.cerrejon.com)

8.3.2 Reduction of incident air speeds on wagon loads by use of deflectors/ container boards

Deflector or container boards (also known as hungry boards) have been suggested as a means of reducing incident air speeds on the coal surface and, consequently, particulate matter emissions. Wind tunnel and CFD testing (Connell Hatch, 2008) has shown that 300 mm container boards increase incident air speeds under certain circumstances. Container boards have also been associated with overloading of coal wagons. Consequently, container boards are not considered to be a viable mitigation measure.

8.3.3 Protection of erodible surface by wagon lids

Wagon lids are one method to control coal dust emissions from the top of a wagon. By fitting a wagon lid, wind erosion of the coal surface and spillage over the side of a wagon during transit are prevented. Wagon lids are used in the transport of some materials (grain and iron ore) in Australia and in the transport of coal in North America. However, the purpose of the lids in these instances is the prevention of load contamination rather than dust emission. For instance, in Canada very cold conditions, snow and ice can adversely affect coal in a wagon. Frozen coal can result in significant delays during the unloading process.

A recent application for a new coal export terminal in Western Australia (Western Australia Environmental Protection Authority, 2013) has proposed that all coal wagons entering the terminal will have lids. If approved, this would be a first in Australia for coal transport by rail.

Fibreglass, flexible and bi-directional wagon lids can be retrofitted to wagons as a means of preventing coal dust emissions into the rail corridor. An example of an old coal wagon (now used for grain transport) retrofitted with a lid is shown in Figure 15. The major advantage of wagon lids is that they prevent coal loss from the surface of coal wagons, the biggest source of coal dust generation. However, the disadvantages of wagon lids are a reduction in payload of each wagon, increased loading and unloading time of each train and that modifications will be required to all loading and unloading systems. Maintenance of lids when they fail may also cause reductions in the capacity of the network.

Figure 15 Retrofitted lid on an old coal wagon now used for grain transport

A review of coal wagon lids by Connell Hatch (2008) found that introducing lids would provide the following advantages:

- 99% reduction in coal dust emissions from the top of loaded and unloaded wagons
- Potential to completely seal the wagon doors
- Reduction in aerodynamic drag

The Connell Hatch (2008) review of wagon lids found the major disadvantages of introducing wagon lids included:

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

A recent article published in Coal Age (September 2013) in the US stated the following:

"a basic coal car cover has to meet several design requirements:

- *It must not slow down the progress of loading*
- *It must not twist or turn in the wind*
- *It must not freeze up or malfunction whenever there is snow, rain or ice*
- *It must not deform or fly off at maximum train speeds*
- *It must open and close in all kinds of weather without delaying the dumping process*
- *It must not cost so much that no-one would ever buy it"*

A number of companies provide coal wagon covers that fully enclose the coal and prevent coal dust from escaping the wagon. Table 20 provides details of a selection of railcar covers suppliers and the type of cover available.

Table 20 Selection of available railcar covers

Company	Cover description
Global One Transport (Coal Cap)	Retractable full-length doors
CleaRRails, LLC	Fully retractable solid cover in tracks
Strategic Rail Systems	Two semi-flexible doors hinged on each side
Structural Composites	Two-door wedge and funnel; one-door wedge and funnel
Ecofab Covers	Semi-rigid arched cover, hinged at one side
Table notes: Source – Gambrel (2013)	

Also noted in the Coal Age article are that wagon lids are a highly visible form of environmental protection and self regulation compared to veneering. It is simple to tell if a rail car is covered or not whereas veneering relies on spot checks and procedural controls to ensure that it has been applied.

Improved fuel efficiency is also a potential benefit associated with the use of railcar covers. A US Department of Energy funded study conducted by Lawrence Livermore National Laboratories in 2010 (Storms et al, 2010) concluded that aerodynamic drag on rail cars was reduced by 29% (full car) and by 41% (empty car) through the use of a wagon lid. It was estimated that the round trip fuel savings associated with the improved aerodynamics of the rail cars could be as much as 9% per trip.

8.3.4 Protection of erodible surface by surface treatments – including water and chemical suppressants (veneers)

Water and chemical suppressants have been traditionally used in the mining and extractive industries to control wheel generated particulate matter as well as wind erosion of erodible surfaces such as product stockpiles. There is substantial evidence in the literature, that chemical suppressants and, to a lesser extent, water are being applied to coal carrying rail wagons to control emissions of particulate matter.

In the US, BNSF's research has found that chemical suppressants applied to the surface of profiled coal wagons are effective in reducing emissions of coal particulate matter. Over the period from March to September 2010, BNSF and Union Pacific Railroad Company (UP) conducted a field evaluation of chemical suppressants in the Powder River Basin (BNSF Super Trial, 2010). The purpose of the Super Trial was to develop and provide to coal shippers information on suppression technologies that can be used to mitigate emissions of coal particulate matter.

The Super Trial investigated chemical suppressants that could be used as either "body treatments" or "topical treatments". Body treatments were applied to the coal before the coal was loaded into the wagon. The topical treatment was applied to the surface of the coal in the wagon after loading. The study found that the five topical treatments reduced emissions of particulate matter from the surface of the coal by between 75% and 93%. The study also found that there was no statistically significant reduction in coal dust emissions in trains that received the body treatment.

As a consequence, BNSF has implemented a coal loading rule that requires coal dust losses in transit be reduced by at least 85% compared to cars where no remedial measures have been taken. BNSF recommends the use of chemical suppressants ("topper agents") in conjunction with load profiling to achieve this reduction.

In Central Queensland, prior to 2008, South Walker, Callide, Boundary Hill and Ensham coal mines had trialled the use of chemical suppressants on the surface of coal wagons. Subsequently, an Environmental Evaluation conducted for QR National (now Aurizon) recommended the use of chemical suppressants (veneers) to control particulate matter emissions from coal wagons operating on the central Queensland rail systems: Moura, Blackwater and Goonyella rail systems (Connell Hatch, 2008).

The Environmental Evaluation included laboratory wind tunnel tests of 30 typical coal types that are transported in central Queensland. The laboratory wind tunnel tests found that significant coal particulate matter emissions occurred when coals were tested with wind tunnel air speeds of around 40 km/hr. Laboratory tests on seven typical coal types and five chemical suppressants (veneers) indicated that all surface veneer products, achieved a significant reduction in particulate matter emissions compared with nil treatment.

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 release of particulate matter from the untreated samples, the untreated samples were removed from the wind tunnel after exposure to the test conditions for only 1 minute. The Environmental Evaluation found that a reduction in particulate matter emissions of at least 85% is achievable.

In 2008 the Land and Environment Court of New South Wales approved the Duralie Extension Project with conditions. One condition required the mine's proponent to investigate particulate matter emissions from trains associated with the Project and identify any reasonable and feasible mitigation measures that could be implemented to reduce emissions from laden trains.

The proponent commissioned a study that found, in the context of the Duralie Coal Mine, the cost-effectiveness and practicality of the use of water to suppress particulate matter was better than that for chemical suppressants, considering the following:

- Water application was effective in reducing emissions from Duralie coal
- The as-mined moisture level in Duralie coal was high compared to the DEM
- The rail journey from the Duralie mine to the washplant was relatively short (approximately 20 km, taking approximately 30 minutes)
- The relatively low cost of water for the mine

Laboratory testing suggested that particulate matter emissions could be reduced by 98% by water application and, hence, was an appropriate solution in the circumstances.

The QR National EE (Connell Hatch, 2008) suggested that, for water application to be effective in central Queensland where journey times and travel distances are relatively long, water would need to be reapplied after every two hours of the journey.

The PAE (2010) report on a gap analysis of fugitive dust emissions from coal trains in NSW identified that the veneering coal dust mitigation measures proposed in Queensland would need to be investigated further to understand if similar measures could be applicable and relevant in NSW.

8.3.4.1 Effective design of the water/chemical suppressant station

The application of water or chemical suppressants should be conducted in a way that ensures water or chemical suppressant is applied to the surface of the wagon in an even and consistent manner. The number and type of nozzles that spray the tops of wagons with water or chemical suppressant can influence the effect of the surface treatment.

8.4 Prevention of Coal Leakage from the wagon doors

As discussed in Section 5, coal dust can leak from the coal wagon doors during transport from mine to port, which can foul the ballast. The wagon doors are designed with a clearance to ensure their correct, safe and reliable operation, especially keeping doors closed during transport and allowing doors to open reliably during unloading. The door mechanisms have therefore been designed with a nominal clearance

An obvious option to control leakage from wagon doors is to ensure that wagon doors are sealed, or the clearance is minimised, during transportation. This could be done by retrofitting rubber seals or resilient bushes around the wagon doors. However, trial studies conducted by Queensland Rail using non-metallic bushes proved unsustainable due to the relatively harsh environment and the poor lifespan of the bushes, which required regular maintenance.

A study by Aurecon Hatch (2009) suggested that improving future wagon design to reduce door loss is considered to be a more cost-effective activity than retrofitting seals to wagon doors. This was due to the low effectiveness of the seals and the high capital and operating cost. The study acknowledged that the Kwik-Drop mechanism is a necessary component of the door design; however, this was not found to preclude further research into door loss and wagon design improvements. Potential future Kwik-Drop door design options should consider the following:

- Potential force distribution in loaded wagons
- Wagon flexing during travel
- Longitudinal forces during travel
- Track irregularities

8.5 Controlling Emissions from Unloaded Trains

The cause of dust emissions from unloaded or empty coal trains is generally recognized as the presence of residual coal in wagons and parasitic load on wagons that results from difficulties in unloading coal at the unloading station and coal ploughing. Coal ploughing occurs when the rate of wagon unloading is too fast for the discharge pits at the unloading facility. This results in the build-up 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.

The key focus in recent years has been measures that aim to avoid coal being present in wagons on their return journey to the mines. These actions have been concentrated on unloading stations at the ports and have included:

- Unloading station design
- Receival station design improvements to avoid coal remaining in wagons

- Management of the unloading rate
- Lower the grate height
- Automatic wagon vibrators
- Increased automation

- Wagon washing/cleaning
- Other measures:
    - Operator procedural training to avoid spillage and hopper overloading
    - Monitoring of unloaded wagons to avoid coal remaining
    - Hopper level / train speed indicators
    - Residual coal monitoring

8.5.1 Unloading Station Design

There are two main methods for unloading coal from wagons, "bottom dump" or "rotary dump". The method of coal wagon unloading in Australia is the "bottom dump" method where coal is unloaded through doors in the bottom of each wagon into a hopper located below. The doors on the wagon are opened and closed by a trigger mechanism as the wagon passes through the rail unloading station. "Bottom dump" unloading can occur with the train constantly moving. Typical unloading rates are between 4,000 - 8,000 tonnes per hour. This speed in unloading and the fact that no "extra" infrastructure is required has seen "bottom dump" systems adopted throughout Australian coal export terminals.

A picture of a typical "bottom dump" unloading system is shown in Figure 16.

Figure 16 Bottom dump unloading

"Rotary dump" or "tippler" unloading systems involve unloading of coal by clamping the wagon to the track and rotating both parts so that coal empties from the open wagon top into an underground hopper (as shown in Figure 17).

Figure 17 Rotary dump unloading

Typical issues with "bottom dump" systems include failure of the coal to fall freely from the wagon into the hopper below or overfilling the hopper causing spillage and piles of coal around the unloading station and subsequent coal ploughing. There is some evidence to suggest "rotary dump" unloading may reduce the risk of residual coal in unloaded wagons. However, the literature is not definitive in this regard.

There are a number of practices and management techniques to reduce and limit coal dust emissions during the unloading process at the export terminals or receival stations at power stations and other users. Section 5 and Section 7 identified that residual coal in unloaded wagons and parasitic load from poor unloading practices can contribute to coal dust generation in the rail corridor from unloaded coal trains.

Coal train unloading management practices to limit coal dust generation are discussed in the following sections and have focused on the "bottom dump" unloading system that is found in Australia.

8.5.2 Receival station design improvements

The action of dropping coal from a height can generate a dust emissions point. Coal dust emissions from unloading coal will be localised around the unloading point and can be controlled by undertaking the unloading within a building or shed. Most of the coal receival stations at export terminals in Australia occur within a dedicated building or shed.

Fully enclosed coal receival stations require an air extraction system with appropriate filters to ensure that coal dust is removed from the air inside the building to protection the unloading station operators.

Rail receival station designs can also include water mist sprays / fogging sprays around the rail receival grates or hoppers to ensure optimum coal moisture level. Adding moisture to the coal upon arrival at the receival station ensures both limited dust generation during unloading and subsequent handling through the export terminal.

At the Port of Brisbane, the coal export terminal operators have just installed a visibility sensor in the rail receival building to identify any coal dust generation during unloading (pers. Comm. Ecotech - supplier). The purpose of this is to inform operators of dusty coal that may cause further problems during handling in the export terminal and also for health and safety concerns of the port operators.

8.5.3 Unloading rate

The unloading of coal by the "bottom dump" system occurs continuously, whilst the train is moving. The wagons pass through the receival station and unload the coal into hoppers below the tracks. The Kwik-Drop doors are opened by triggers as the wagon passes over the grates above the rail hopper. Feeders in the bottom of the hoppers transport received coal onto a conveyor and into the stockpile area.

There are a number of interrelated design variables that can affect the unloading rate of wagons and the subsequent generation of parasitic load and residual coal in the wagons. The unloading variables are a function of each rail unloading stations' design to accommodate the nominal unloading rate and include:

- Hopper dimensions
- Grate height
- Train speed indicators
- Door triggers

The properties of the coal can also affect the unloading rates with "sticky coals" resulting in poor unloading from the wagon doors requiring extra assistance through wagon vibrating. Management of the unloading rate to account for the variables specified above and the identification of sticky coals will reduce residual coal in wagons.

Connell Hatch (2008) indicated that the most effective mitigation strategies to reduce coal dust emissions during the unloading process were:

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

8.5.3.1 Lower the grate height

The grate height provides a visual cue to unloading operators on the level of coal in the hopper. Connell Hatch (2008) found that grates which were close to the rail line provide little time for the operators to react when hopper overfilling and spillage were occurring. Lowering the grate height below the rails allowed the operators improved vision of the hopper levels allowing more time to react to overfilling.

8.5.3.2 Automatic wagon vibrators

The problem of residual coal in the wagon can be partially improved by the installation of automatic wagon vibrators that apply a vibrating harmonic to wagons. Wagon vibration can be triggered by automatic detection systems or by visual cues. For unloading stations without automatic vibrators, problematic coal is removed by the use of jackhammers manually placed on the sides of wagons.

8.5.3.3 Increased automation

The level of automation usually depends on the age of the unloading facility. Increased autonomy inherently reduces variability in any process. Current technology is sufficiently advanced to apply automation to door trigger sequencing, train speed indicators, hopper level alarms and feeder rates. Automation can assist with early detection of potential overfilling and subsequent parasitic load. Automation can also assist with the detection of residual coal in wagons.

8.5.4 Wagon Washing

The extent of parasitic load and residual coal will vary with each unloading station and the management practices that are employed during unloading (described above). Measures to ensure that empty wagons leaving the unloading station are "clean" include:

- Wagon inspection
- Wagon cleaning

8.5.4.1 Inspection of empty wagons

Connell Hatch (2008) identified that main areas of parasitic load and residual coal to be the wagon interior, wagon sides and sills, wagon shear plates and bogies spring nets. Inspection of the outside of the wagons can be conducted manually to determine if further management is required. Operators can also inspect the wagon interiors if video systems are available. However, visual inspection may be somewhat subjective and may not be entirely effective in identifying residual coal.

The CSIRO has developed a system to detect residual coal in unloaded wagons. A twin laser based system scans each unloaded wagon and can identify large amounts of residual coal to inform operators that further action is required. The system has been developed at coal terminals in Queensland and has been found to be effective in identifying wagons containing relatively significant quantities of residual coal.

8.5.4.2 Cleaning of empty wagons

Unloaded wagons could be subject to wagon cleaning or washing to remove any parasitic load or residual coal. There are a number of methods for wagon cleaning or washing identified as being conceptually possible in the literature, including:

- Water sprays
- Compressed air spray
- Air and water combination
- Air / water / brush combination
- Tilting the wagon through 150 -180 degrees
- Shock loading the wagon

There is no evidence in the literature of the implementation of wagon cleaning or washing facilities in Australia or elsewhere. The NSW EPA understands that Port Kembla has a magnetic 'hammer type' wagon vibrator for cleaning wagons, but it is not routinely used.

Washing each wagon could remove coal from within the wagons and this coal could be recovered and sent to the port. Wagon washing could also eliminate the parasitic load from the wagon exterior and could be designed to be an automated process that occurs immediately after the unloading facility. Water could be recycled within the system minimising water usage. There may be adverse impacts on rolling stock due to washing that have not been addressed in an operational facility. Additionally, there are likely to be impacts on system capacity if washing or cleaning could not be conducted at the same rate as wagon unloading.

The capital investment is relatively large for a wagon washing facility. The Connell Hatch (2008) report estimated that a wagon washing facility would cost in the order or $5 million to $10 million per outloading stream. The cost per wagon is in the order of $0.50 - $0.60 per wagon per trip washing cost.

8.5.5 Other measures to reduce coal dust during unloading

A simple yet effective measure noted in the literature (Connell Hatch, 2008) to reduce residual coal in wagons is the provision of operator procedural training. Targeted training on identification and avoidance of spillage and hopper overloading was found to be beneficial in reducing the incidences of parasitic load and residual coal in wagons.

Good housekeeping at the receival station was identified in the literature as a coal dust management measure. It was also suggested that laying a concrete slab around the train unloading area allowed operators to easily keep the area relatively clean.

9. SUMMARY OF NSW PRACTICES FOR CONTROLLING RAIL COAL DUST EMISSIONS

Current techniques for controlling rail coal dust emissions in NSW have been researched by considering:

- Documents published by the coal mines such as: Annual Environment Management Reports (AEMR), Environmental Management Plans (EMP), Particulate Reduction Program Reports (PRPs) and Environmental Management Systems (EMS).
- Conditions of Approval and Environment Protection Licences (EPL).
- Information sourced from other NSW Government Reports (Coal Mine Particulate Matter Benchmarking Report, NSW Trade and Investment Coal Industry Profile)
- Information provided by NSW EPA

Katestone acknowledges that the information presented in this section is solely based on a desktop study of currently available information and may not accurately reflect all current management practices across NSW. A more refined representation of the current state of the NSW industry would potentially require detailed survey work and inspections of activities and facilities across NSW. This was beyond the scope of the current study.

9.1 Train Loading

Train loading practices in NSW have been researched from the sources detailed above and any other publically available information.

9.1.1 Coal mine survey results

The Coal Mine Particulate Matter Benchmarking Study (OEH, 2011) included the results of a survey of mines within the NSW Greater Metropolitan Area (GMR). One of the survey questions requested information on the methods used for loading coal to either trains or trucks. The results of this survey question were presented in Appendix E of the Coal Mine Particulate Matter Benchmarking Study. The 49 respondents provided 56 responses, which have been reproduced in Table 21. The identities of the respondents were confidential and therefore Katestone cannot identify which loading types were associated with which mine in the GMR. The survey of mines was completed in March 2011. It is possible that some of the loading facilities represented by the data in Table 21 may have since upgraded or shut down.

Table 21 **Responses to Survey Question 28: What methods are used for loading product coal to trains or trucks for off-site transport (Source: OEH, 2011)**

Responses to Coal Loading Method	Loading Type
Loader in the Open Air*	21
Loader within building	0
Batch weighing with loading by clamshell	4
Batch weighing with loading by chute	5
Volumetric loading by clamshell	7
Volumetric loading by chute	30
Not applicable	25
Excavator loading	1
Other (also includes excavator loading)	6

9.1.2 Train loading systems

During the review of NSW train loading practices it became apparent that two main types of systems are used at a number of mines to load coal trains. The two systems are described in the following sections.

9.1.2.1 Precision Loading System (PLS)

An industry supplier of material handling solutions has developed a precision loading system (PLS) for loading trains. The main features of the PLS includes:

- Triple batch process allows a wagon to be loaded in three precisely weighed batches
- Triple batch process increase accuracy and control of loading whilst allowing for possible decreasing weigh bin size
- Telescopic chute minimises dust
- Customisable final coal profile.
- Fully automated control requiring minimal operator intervention and intervention can be remote
- Loading rate of 5,500tph
- Low, medium and high density coal control to help prevent overfilling

Discussion with the supplier indicated that six PLS system have been installed at mines in NSW. The supplier also indicated that another 5 mines in NSW were in discussion about potential upgrades and / or installation of a PLS as their train loading solution. An example of a PLS at Narrabri mine train load out is shown in Figure 18.

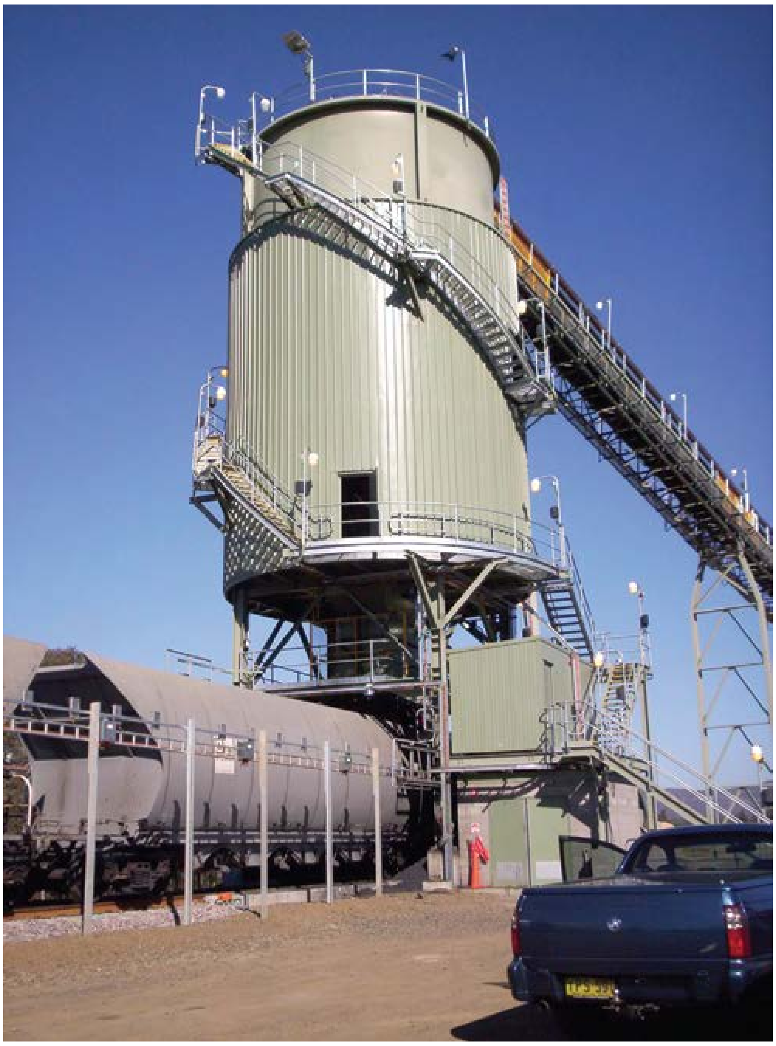


Figure 18 **Precision Loading System**

9.1.2.2 Train Loading Improvement (TLI) System

Upgrades to train loadout facilities can be a significant cost, particularly if upgrading from volumetric loading to a batch loading system. To minimise the cost of upgrades, an industry supplier has developed a Train Loading Improvement (TLI) system. The TLI system is able to mass load accurately but keeps costs down as the hardware uses a single load bin design (similar to volumetric loadouts). The TLI system uses a series of inbound and outbound weighbridges and accurate load cells in the weigh bin to determine the quantity of coal that is loaded into each wagon. A target load is known for each wagon type and as each wagon is identified the corresponding load is calculated from the TLI system software.

The TLI system is installed at approximately 14 mines in NSW (Bulk Material Handling Review, 2011) including Whitehaven's Gunnedah CHPP and Integra Coal Complex rail loadout (shown in Figure 19).

Figure 19 **Integra Coal TLI System**

9.1.3 Summary of train loading methods in NSW

Loading systems in NSW have been researched from publically available information for each mine rail loading point (as described in Section 2 - Table 12). A summary of the 35 rail load out points identified in this review are provided in Table 22 and Table 23.

Table 22 Identified rail loading facilities at NSW coal mines

Rail Loadout Point	Coalfield	Train loadout type	Manual, semi-automatic or automatic
Narrabri Coal Operations	Gunnedah	PLS	Automatic
Boggabri Coal Mine	Gunnedah	PLS	Automatic
Mauls Creek (under development)	Gunnedah	PLS	Automatic
Rocglen Coal Mine	Gunnedah	TLI	Automatic
Werris Creek Coal	Gunnedah	Overhead bin with water spray	Semi-Auto or Automatic
Bengalla Mine	Hunter	Overhead bin	Semi-Auto or Automatic
Drayton Coal Mine	Hunter	Overhead bin	Semi-Auto or Automatic
Hunter Valley Operations	Hunter	Overhead bins (x2)	One automatic, one semi automatic loader
Integra Coal Complex	Hunter	TLI	Automatic
Liddell Coal Operations	Hunter	Overhead bin with water spray	Automatic
Mangoola	Hunter	PLS	Automatic
Mt Thorley Operations	Hunter	Overhead bin	Semi-Auto or Automatic
Mt Arthur Coal	Hunter	Overhead bin with profiling	Automatic
Mt Owen Coal Mine	Hunter	Overhead bin	Automatic
Rix's Creek Colliery	Hunter	Unidentified	Unidentified
Ashton Coal Mine	Hunter	Unidentified	Unidentified
Bulga Coal Complex	Hunter	Overhead bin with retractable chute	Semi-Auto or Automatic
Ravensworth Mining Complex	Hunter	Unidentified	Unidentified
Wambo Coal Mine	Hunter	Overhead bin	Semi-Auto or Automatic
Austar Coal Mine	Newcastle	Unidentified	Unidentified
Newstan Colliery	Newcastle	Front End Loader with water cart	Manual
West Wallsend	Newcastle	Unidentified	Unidentified
Bloomfield Colliery	Newcastle	Overhead bin	Semi-Auto or Automatic
Duralie Coal Mine	Gloucester	Overhead bin with water spray	Semi-Auto or Automatic
Stratford Coal Mine	Gloucester	Overhead bin with water spray	Semi-Auto or Automatic
Dendrobium Mine	Southern	Overhead bin	Semi-Auto or Automatic
NRE Wongawilli Colliery	Southern	Front End Loader	Manual
Tahmoor Colliery	Southern	Overhead bin	Manual
Airly Mine	Western	PLS	Semi-Auto or Automatic
Clarence Colliery	Western	Overhead bin	Semi-Auto or Automatic
Springvale Colliery (Lidsdale siding)	Western	Front End Loader	Manual
Moolarben Coal Mine	Western	PLS	Semi-Auto or Automatic
Wilpinjong Coal Pty Ltd	Western	Overhead bin	Semi-Auto or Automatic
Carbon Coal	Western	Unidentified	Unidentified
Ulan Coal Mines	Western	Unidentified	Unidentified

Table 23 Summary of the types of rail loading facilities at NSW coal mines

Rail Loadout Type	Number identified
PLS	6
TLI	2
Automated with water spray	4
Automated from overhead bin	10
Automated with profiling	1
Unidentified	8
Automated with retractable chute	1
Front End Loader	3

9.2 Wagon Lids

No coal wagon rail operators in NSW were identified as using lids or covers to reduce coal dust emissions.

9.3 Water or Chemical Suppression

The review of available information on the use of dedicated water and chemical suppressant spray stations at rail loadouts in NSW found the following:

- No rail loadouts use chemical suppressants treatments to control the fugitive release of coal dust from the wagons
- Four rail loadouts, out of 35, use a water spraying station to control fugitive coal dust

9.4 Unloading Practices in NSW

This section details the available information on the current unloading management practices at the coal export terminals in NSW. Whilst domestic users will also have train unloading facilities, these have not been investigated in this section of the literature review.

Section 2.4 detailed the number of export terminal coal receival points in NSW. There are a total of nine coal rail receival stations currently in operation in NSW.

The identified coal dust management practices at each export terminal rail receival station are detailed in Table 24.

Table 24 Summary of export terminal coal receival points in NSW

NSW Port	Export Terminal	Number of Coal Receival Stations	Contained within a building or shed	Use of water to suppress dust during unloading	Wagon vibration	Wagon washing
Newcastle	Carrington	2	Yes	Unknown	Unknown	No
	Kooragang	4	Yes	Yes	Unknown	No
	NCIG	2	Yes	No	Unknown	No
Port Kembla	PKCT	1	Yes	Unknown	Yes (magnetic wagon vibrator)	No

9.5 Ranking coal travel distances in NSW

To provide a comparative analysis of the coal rail travel distances in NSW, each facility has been ranked by the coal tonne kilometre travelled per year. Data has been taken from the travel distance from loadout to port (Table 14) and the 2013-2014 coal production moved by rail to the export terminals and is expressed as million tonne kilometers travelled (MTKT).

The distance rankings are shown in Table 25 (by mine) and Table 26 (by coalfield).

Table 25 Summary of MTKT ranking by NSW mine

Mine Rail Loadout Point	Coalfield	Travel Ranking (MTKT)
Wilpinjong OC	Western	4021
Mt Arthur Coal OC	Hunter	2286
Narrabri UG	Gunnedah	2068
Ulan (UG+OC+West UG)	Western	1975
Boggabri OC	Gunnedah	1928
Moolarben OC	Western	1824
Hunter Valley Operations OC	Hunter	1470
Mangoola OC	Hunter	1144
Mt Thorley Warkworth OC	Hunter	1117
Bulga (=Beltana/Blakefield South UG)	Hunter	1022
Bengalla OC	Hunter	991
Ravensworth (UG + North + Narama)	Hunter	925
Mt Owen OC	Hunter	916
Springvale UG	Western	744
Werris Creek OC	Gunnedah	655
Tarrawonga OC	Gunnedah	627
Wambo (UG+OC)	Hunter	606
Liddell OC	Hunter	489
Clarence UG	Western	488
Drayton OC	Hunter	454
Charbon (UG+OC)	Western	342
Rocglen OC	Gunnedah	318
Duralie OC	Gloucester	219
Integra UG (Glennies Creek) +Integra OC (Camberwell)	Hunter	214
Tahmoor UG	Southern	208
Ashton (UG+OC)	Hunter	149
Muswellbrook OC	Hunter	147
Rix's Creek OC	Hunter	141
Mandalong UG	Newcastle	128
Stratford OC	Gloucester	111
Austar UG	Newcastle	92
West Wallsend UG	Newcastle	77
Abel UG	Newcastle	72
Airly UG	Western	41
Bloomfield OC	Newcastle	23
Dendrobium UG	Southern	22
Newstan UG	Newcastle	14
NRE Wongawilli UG	Southern	7
Tasman UG	Newcastle	0.5

Table 26 Summary of MTKT ranking by NSW coalfield

NSW Coalfield	Maximum	Minimum	Average	Weighted Average (by production)
Western	4,021	41	1,348	2,547
Gunnedah	2,068	318	1,119	1,529
Hunter	2,286	141	805	1,185
Newcastle	219	0.5	82	105
Southern	208	7	79	80

10. SUMMARY OF RAIL COAL DUST MANAGEMENT PRACTICES

This section provides a summary of the coal dust management practices that may be applied to reduce dust emissions from in the rail corridor. A comparison has been undertaken between the identified management practices and their effectiveness in the literature and whether or not they are currently used on the NSW coal rail network.

10.1 Management practices for coal dust emissions from coal handling

Section 5.3 details the sources of coal dust emissions from coal handling activities in the rail corridor, namely:

- Loading - transfer from overhead bin into an empty wagon
- Unloading - transfer from wagon into below rail hopper

The management practices to reduce rail coal dust from coal handling activities identified in the available literature compared with the management practices identified in NSW are summarised in the Table 27.

Table 27 Summary of rail coal dust management practices for coal handling activities

Rail Coal Dust Source	Coal Dust Management Practice	Coal Dust Reduction Effectiveness	Identified in NSW
Coal Handling	Ensuring coal moisture content is above DEM	High (80%)	Yes
	Loading/unloading within shed or building	Medium (70%)	Yes
	Loading/unloading within shed or building with a fabric filter dust collection system	High (99%)	Yes

10.2 Management practices for coal dust emissions from wind erosion of coal in wagons

Section 5.4 details the sources of coal dust emissions from wind erosion of coal in the wagons, namely:

- Wind erosion of coal in wagons during loading at the mine
- Wind erosion of coal in loaded wagons during transit from mine to end user
- Wind erosion of coal in wagons during unloading at the end user
- Wind erosion of residual coal in unloaded wagons during transit back to the mine

The management practices to reduce wind erosion of coal in the wagons identified in the available literature compared with the management practices identified in NSW are summarised in the Table 28.

Table 28 **Summary of rail coal dust management practices for reducing wind erosion of coal in wagons**

Rail Coal Dust Source	Coal Dust Management Practice	Coal Dust Reduction Effectiveness	Identified in NSW
Wind erosion of coal in wagons	Profiling the loaded coal wagon surface to reduce coal dust lift-off	Low / Medium	Yes
	Compacting the coal in a loaded wagon to reduce coal dust lift-off	Low / Medium	No
	Application of water to the coal surface of a loaded wagon to reduce coal dust lift-off – short trips less than 2 hours	Medium	Yes
	Application of water to the coal surface of a loaded wagon to reduce coal dust lift-off – trips greater than 2 hours	Low	Yes
	Application of chemical suppressant / veneer to the coal surface of a loaded wagon to reduce coal dust lift-off	Medium / High	No
	Fitting lids to coal wagons to prevent coal dust lift-off	High	No
	Re-application of veneer to the surface of a loaded wagon between the mine and end user	Medium / High	No
	Fitting deflectors / container boards on wagons to reduce coal dust lift-off	Low	No
	Using wagon vibrators after unloading to prevent residual coal carry-back to the mine	Medium	Yes (one export terminal)
	Monitoring residual coal in wagons after unloading to prevent carry-back to the mine	Low	Unknown
	Monitoring residual coal and cleaning/washing wagons after unloading to prevent residual coal carry-back to the mine	High	Unknown

10.3 Management practices for coal dust emissions from spillage of coal in the rail corridor

Section 5.5 details the sources of coal dust emissions from spillage of coal in the rail corridor and subsequent wind erosion / re-entrainment, namely:

- Wagon overloading and subsequent coal spillage onto wagon surfaces (parasitic load) and the ground
- Spillage of coal from the top of a wagon into the rail corridor during transit
- Coal leakage from bottom dump doors of loaded wagons into the rail corridor
- Generation of parasitic load on wagons during unloading (ploughing) and subsequent spillage
- Leakage of residual coal from wagon doors into the rail corridor

The management practices to reduce spillage of coal in the rail corridor identified in the available literature compared with the management practices identified in NSW are summarised in the Table 29.

Table 29 Summary of rail coal dust management practices for coal spillage in the rail corridor

Rail Coal Dust Source	Coal Dust Management Practice	Coal Dust Reduction Effectiveness	Identified in NSW
Spillage, overloading and parasitic load generation during loading	Ensure the correct amount of coal is loaded into each wagon through automatic batch weighing systems	Medium	Yes
	Use of a telescopic loading chute to load coal from below wagon sills	Medium	Yes
	Profile / compact the surface of coal in a wagon	Low / Medium	Yes / No
	Design / upgrade loading stations to be fully automated systems to minimise spillage	Medium	Yes
	Undertake loading operator training programs	Medium	No
Spillage of coal from the tops of wagons during transit	Same management practices as for prevention of wind erosion (Table 27)		
Coal leakage from bottom dump doors in loaded wagons	Seal the gap between bottom dump wagon doors	Low / Medium	Unknown
	Minimise clearance between bottom dump doors	Low / Medium	Yes

Rail Coal Dust Source	Coal Dust Management Practice	Coal Dust Reduction Effectiveness	Identified in NSW
Spillage, ploughing and parasitic load generation during unloading	Automate unloading rate with train speed to allow wagons to be completely unloaded over the hopper	Medium	Yes
	Monitor receival hopper levels to ensure no overfilling	Low / Medium	Yes
	Operator training to avoid spillage and hopper overloading	Low / Medium	Unknown
	Wagon washing or cleaning to remove parasitic load after unloading	High	No
	Ensure bottom dump doors are fully closed after unloading	Low / Medium	Yes
Residual coal leakage from bottom dump doors in unloaded wagons	Seal the gap between bottom dump wagon doors	Low / Medium	Unknown
	Minimise clearance between bottom dump doors	Low / Medium	Unknown
	Monitoring of unloaded wagons to avoid and detect residual coal	Low / Medium	Unknown
	Monitoring residual coal and wagon washing or cleaning to remove residual coal	High	No

11. ESTIMATED COST OF REDUCING RAIL COAL DUST EMISSIONS IN NSW

11.1 Overview

This section estimates the costs of the dust management practices presented in Section 10 using the following rating system:

- Low cost = < $10,000
- Medium cost = $10,000 - 100,000
- High cost = > $100,000

Specific costs for the treatment of the coal surface by chemical suppressants were made available by industry suppliers. Using this supplied information, the cost of using either water or chemical suppressants on all coal wagons on the NSW network has been estimated in Section 11.5.

11.2 Estimated costs of dust management practices

11.2.1 Coal handling

The estimated costs of the coal handling dust management practices are detailed in Table 30.

Table 30 Estimated cost of coal handling dust management practices

Coal Dust Management Practice	Estimated Cost	Rationale
Ensuring coal moisture content is above DEM	Low / Medium	Relatively low cost to ensure moisture content above DEM for washed coal. Measurement and moisture addition may be required for unwashed coals
Loading/unloading within shed or building	Medium / High	One off cost for infrastructure design and construction
Loading/unloading within shed or building with a fabric filter dust collection system	Medium / High	One off cost for infrastructure design and construction

11.3 Wind erosion of coal in wagons

The estimated costs of management practices to reduce wind erosion of coal in the wagons are shown in Table 31.

Table 31 Estimated costs of coal dust management practices for reducing wind erosion of coal in wagons

Coal Dust Management Practice	Estimated Cost	Rationale
Profiling the loaded coal wagon surface to reduce coal dust lift-off	Low / Medium	Depends on the loading system. Retrofit may be required to achieve appropriate profile. New continuous batch weighing systems will naturally produce optimal profile
Compacting the coal in a loaded wagon to reduce coal dust lift-off	Medium	Medium infrastructure design and construction costs
Application of water to the coal surface of a loaded wagon to reduce coal dust lift-off	Low / Medium	Detailed description provided in Section 11.5
Application of chemical suppressant / veneer to the coal surface of a loaded wagon to reduce coal dust lift-off	Low / Medium	Detailed description provided in Section 11.5
Fitting lids to coal wagons to prevent coal dust lift-off	High	Potentially significant design and installation costs for all wagons and retrofitting all loading and unloading stations with appropriate infrastructure. May affect network capacity
Re-application of water / veneer to the surface of a loaded wagon between the mine and end user	Medium	Requires design, installation and operation
Fitting deflectors / container boards on wagons to reduce coal dust lift-off	Low / Medium	Requires wagon retrofitting and material purchasing
Using wagon vibrators after unloading to prevent residual coal carry-back to the mine	Low / Medium	Installation and operation cost, would vary depending on the type of equipment installed
Monitoring residual coal in wagons after unloading to prevent carry-back to the mine	Medium	Monitoring equipment novel and likely to be relatively expensive, operational costs low
Cleaning/washing wagons after unloading to prevent residual coal carry-back to the mine	High / Medium	Monitoring equipment novel and likely to be relatively expensive, operational costs of monitors likely to be low. Cleaning infrastructure requires further development. Relatively high capital costs of cleaning equipment likely

11.4 Spillage of coal in the rail corridor

The estimated costs for management practices to reduce spillage of coal in the rail corridor are summarised in Table 32.

Table 32 Summary of rail coal dust management practices for coal spillage in the rail corridor

Coal Dust Management Practice	Estimated Cost	Rationale
Ensure the correct amount of coal is loaded into each wagon through automatic batch weighing systems	Medium / High	Upgrade of loading stations to be automatic can be costly and requires design and construction components
Use of a telescopic loading chute to load coal from below wagon sills	Medium/ High	Upgrade of chute can be costly and requires design and construction components
Profile / compact the surface of coal in a wagon	Low / Medium	Low operating cost but requires initial design and construction
Design / upgrade loading stations to be fully automated systems to minimise spillage	Medium/ High	See rationale for item 1
Undertake loading operator training programs	Low	
Seal the gap between bottom dump wagon doors and the wagon chaise	Medium	Design and implementation costs are high, material costs are relatively low
Minimise clearance between bottom dump doors and wagon chaise	Medium	Material costs are relatively low but have been shown to require regular replacement
Automate unloading rate with train speed to allow wagons to be completely unloaded over the hopper	Low / Medium	Requires train speed indicators
Monitor receival hopper levels to ensure no overfilling	Low / Medium	
Operator training to avoid spillage and hopper overloading	Low	
Wagon washing or cleaning to remove parasitic load after unloading	High / Medium	Cleaning infrastructure requires further development. Relatively high capital costs of cleaning equipment likely
Ensure bottom dump doors are fully closed after unloading	Low	Currently in place

Coal Dust Management Practice	Estimated Cost	Rationale
Monitoring of unloaded wagons to avoid and detect residual coal	Medium	See table above
Wagon washing or cleaning to remove residual coal	High / Medium	See table above

11.5 Detailed cost estimates for treatment of the coal surface in wagons

The costs associated with reducing emissions of coal dust from rail activities have been estimated for the treatment of the coal surface in wagons and aggregated for each NSW coalfield. The cost calculations have been made based on the amount of coal hauled by rail in the 2013 - 2014 financial year.

The total cost of each surface treatment was determined assuming that no surface treatment control measures are in place. In a small number of cases, the control measure may already be undertaken at a particular mine. Therefore, the total cost may be conservative.

The total amount of coal transported by rail was calculated from the information on coal production rates provided by Coal Services (discussed in Section 2). For each mine identified as having a rail loadout or shared rail loadout, it was assumed that all the coal produced by the mine was transported by rail. This may be a conservative assumption as some mines may transport coal via rail and also by truck and conveyor.

The number of trains and number of wagons were calculated for each mine for the 2013 -2014 financial year based on the assumption that average capacity of a wagon was 80 tonnes and the average number of wagons per trains was 100. A summary of the calculated coal amount moved by rail, number of trains and number of wagons for the 2013 -2014 financial year is shown in Table 33.

Table 33 Summary of calculated coal rail movements in NSW in 2013 -2014

Coal field	Coal Moved via Rail (Mtpa)	Loaded train trips per annum	Number of wagons per day
Gunnedah	16.2	2,023	554
Hunter	113	14,124	3,870
Newcastle	15	1,852	508
West	35	4,336	1,188
South	5	662	181
Total	**184**	**22,997**	**6,300**

11.5.1 Water and chemical suppressant application costs per mine

As part of this literature review, Katestone contacted a number of suppliers and manufactures of water and veneering stations for the rail industry. Based on discussions with the suppliers, costs associated with the capital investment, installation, operation and maintenance of water and suppressant application stations were provided.

The cost of water only application to the surface of wagons is presented in Table 34. The cost of water application has been based on the following assumptions:

- Application rate of 2L/m^2
- Wagon surface area of 30m^2
- The cost for water has been estimated to $2.19 per kL (Hunter Water, 2014)

Capital, installation and maintenance costs at the lower end of the range of those presented in Table 35 for chemical suppressants.

Table 34 Cost of water application

Cost Item	Total Cost	Total cost per wagon
Capital cost and installation	$58K	$0.21
Operating cost	-	$0.13
Maintenance cost	$4K	$0.03
Total cost		$0.37

The range of costs for chemical suppressant application stations, as advised by a range of Australian suppliers, is listed in Table 35. The costs are based on standard installations at coal mines in Queensland and the following assumptions:

- 80-100 tonne wagons
- 100,000 wagons/annum
- Minimum contract period of 3 years

Table 35 Cost of chemical suppressants as advised by Australian suppliers

Cost Item	Total Cost	Total cost per wagon
Capital cost and installation	$58K – $190K	$0.21-$0.70
Operating cost	-	$1.20-$2.30
Maintenance cost	$4K - $15K per annum	$0.03-$0.11
Total cost		$1.44-$3.11

11.5.2 Industry wide application cost - surface treatment - water

The cost for the application of water as a surface treatment to all coal transported by rail in NSW is detailed in Table 36 based on the cost information provided in the previous section. The calculation shows that the total cost of water application to all coal moved by rail would be 0.005 cents per tonne of coal.

Table 36 Cost of water application as a surface treatment

Coal field	Application cost of water treatment per wagon (cents)	Incurred cost of water treatment per annum ($)	Incurred cost of water treatment per tonne of coal ($)
Gunnedah	0.37	74,848	0.005
Hunter		522,580	
Newcastle		68,539	
West		160,424	
South		24,490	
NSW Total		**850,881**	

11.5.3 Industry wide application cost - surface treatment - chemical suppressant

The cost for the application of a chemical suppressant as a surface treatment to all coal transported by rail in NSW is detailed in Table 37 based on the cost information provided in Section 11.5.3. The calculation shows that the total cost of chemical suppressant application to all coal moved by rail ranges from 0.02 - 0.04 cents per tonne of coal.

Table 37 Cost of chemical suppressant application as a surface treatment

Coal field	Application cost of chemical suppressant per wagon ($)		Incurred cost of chemical suppressant treatment per annum ($)		Incurred cost of chemical suppressant treatment per tonne of coal ($)	
	Low cost	High cost	Low cost	High cost	Low cost	High cost
Gunnedah	1.44	3.11	291,301	629,129	0.02	0.04
Hunter			2,033,824	4,392,494		
Newcastle			266,745	576,095		
West			624,354	1,348,432		
South			95,313	205,850		
NSW Total			**3,311,537**	**7,152,000**		

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APPENDIX A RAIL CORRIDOR AIR QUALITY MONITORING STUDIES

A1 NSW STUDIES

A1.1 ARTC - PRP 4.1 - Particulate Emissions from Coal Trains - Pilot Monitoring Program

In 2011/2012, the Australian Rail Track Corporation (ARTC) implemented a pilot monitoring air quality program to determine whether coal trains and rail transport generally contribute to ambient particulate levels along the Hunter Valley rail network. The air quality monitoring program was required under Pollution Reduction Program (PRP) 4.1 within ARTC's Environmental Protection Licence (EPL 3142).

Environ Australia Pty Ltd (Environ) undertook the monitoring program on behalf of ARTC (Environ, 2012). The pilot program consisted of two air quality monitoring stations located on the Hunter Valley rail network. The air quality monitoring stations were deployed for one month and comprised an Osiris instrument (light scattering laser photometer) for continuous measurement of TSP, PM_{10} and $PM_{2.5}$.

The Osiris instrument was selected for its fast response time, ability to capture the passing of trains and relatively small size suitable for deployment in the rail corridor. It should be noted that the Osiris instrument does not conform to the requirements of the Australian Approved Methods for Sampling of particulate matter as is know to overestimate particulate matter concentrations. However, the purpose of the pilot monitoring program was to understand if coal trains and rail transport generally contribute to ambient particulate levels so the Osiris instrument was the most suitable

The conclusions of the ARTC pilot monitoring program were (Environ, 2012):

1. Determine whether coal trains operating on the Hunter Valley rail network are a source of particulate matter emission

- At the Mayfield site, the analysis showed that in the rail corridor all train types are a source of TSP and PM_{10} and only freight and passenger trains were a source of $PM_{2.5}$
- At the Metford site, the analysis showed that in the rail corridor all train types are a source of TSP, PM_{10} and $PM_{2.5}$. The $PM_{2.5}$ analysis was confounded by the longer atmospheric residence time of fine particles
- At both sites it was found that the loaded coal trains data set when compared to the no train dataset increased levels TSP, PM_{10} and $PM_{2.5}$ in the rail corridor

2. Determine whether loaded coal trains operating on the Hunter Valley rail network are a larger cause or source of particulate matter emissions than unloaded coal trains or other trains on the network

- At the Mayfield site, the analysis showed loaded coal trains were not a statistically different source of particulate matter in the rail corridor when compared to other train types
- At the Metford site, the analysis showed loaded and unloaded coal trains to have statistically different, but only marginally higher PM_{10} concentrations compared to passenger trains
- The analysis showed freight, loaded coal and unloaded coal trains to have statistically different, but only marginally higher $PM_{2.5}$ concentrations compared to passenger trains
- TSP analysis at Metford showed concentrations associated with coal trains were marginally higher compared to passenger trains, but the difference was not statistically significant

- TSP, PM_{10} and $PM_{2.5}$ concentrations coinciding with loaded and unloaded trains at Metford were not statistically different
- The Mayfield site results were found to be unreliable due to the following:
    - Relatively few (44%) pass-bys were single trains. This meant that 66% of trains passing the Mayfield monitor during the pilot monitoring program were excluded from the analysis
    - Train speeds were relatively slow indicating that the monitoring site was not representative of the operating conditions elsewhere in the network
    - Significant difficulties in relating train pass-bys to monitoring data. This was because the system of recording train pass-bys (known as 4TRAK) could not record pass-bys to the nearest second. The pass-by time had to be assumed and resulted in poor accuracy in relating train type to particulate concentrations at the Mayfield monitoring location.

The ARTC pilot program did not investigate compliance monitoring or health impact assessment as this was not within the scope of work. However, the Environ (2012) report did provide the average concentrations of PM_{10} and $PM_{2.5}$ measured during the monitoring period compared against the equivalent NSW OEH monitoring station data in Newcastle (3 sites). The measured particulate matter concentrations across all sites (NSW OEH and ARTC) were similar, albeit slightly higher at the ARTC sites.

A1.2 ARTC - PRP 4.2 - Particulate Emissions from Coal Trains - Monitoring Program

Following the pilot monitoring program required under PRP 4.1, ARTC was required to undertake a detailed monitoring program to provide further evidence of whether coal trains and rail transport generally are contributing to ambient particulate levels along the Hunter Valley rail network. The detailed monitoring program was required under Pollution PRP 4.2 within ARTC's Environmental Protection Licence. Katestone undertook the monitoring program on behalf of ARTC (Katestone, 2013).

The objective of PRP 4.2 was to determine whether:

- Trains operating on the Hunter Valley rail network are associated with elevated particulate matter concentrations; and
- Loaded coal trains operating on the Hunter Valley rail network have a stronger association with elevated particulate matter concentrations than unloaded coal trains or other trains on the network (and by inference contributing to ambient rail corridor particulate levels).

To achieve the objective of PRP 4.2, a continuous particulate monitoring station was installed at one location to measure particulate levels in the rail corridor adjacent to tracks carrying various types of trains. The findings of the PRP 4.2 monitoring program were as follows:

- Passenger trains were not associated with a statistically significant difference in TSP, PM_{10} and $PM_{2.5}$ concentrations when compared with the concentrations recorded when no train was passing the monitoring station
- Freight trains were not associated with a statistically significant difference in TSP, PM_{10} and $PM_{2.5}$ concentrations when compared with the concentrations recorded when no train was passing the monitoring station.
- Loaded coal trains were not associated with a statistically significant difference in PM_{10} and $PM_{2.5}$ concentrations when compared with the concentrations recorded when no train was passing the monitoring station. However, loaded coal trains were associated with a statistically significant difference

in TSP concentrations when compared with concentrations when no train was passing the monitoring station.

- Unloaded coal trains were associated with a statistically significant difference in TSP, PM_{10} and $PM_{2.5}$ concentrations when compared with the concentrations recorded when no train was passing the monitoring station.

- Average concentrations of TSP associated with loaded coal trains, unloaded coal trains and freight trains were higher by 3.2 µg/m^3, 6.1 µg/m^3 and 4.5 µg/m^3, respectively compared to when no train passes the monitoring station.

- Average concentrations of PM_{10} associated with loaded coal trains, unloaded coal trains and freight trains were higher by 2.3 µg/m^3, 4.5 µg/m^3 and 3.0 µg/m^3, respectively compared to when no train passes the monitoring station.

- Average concentrations of $PM_{2.5}$ associated with loaded coal trains, unloaded coal trains and freight trains were higher by 0.6 µg/m^3, 1.2 µg/m^3 and 0.7 µg/m^3, respectively compared to when no train passes the monitoring station.

- Loaded coal trains operating on the Hunter Valley rail network, when measured at Metford, did not have a statistically stronger association with elevated TSP, PM_{10} and $PM_{2.5}$ concentrations than other trains.

- There was a statistically significant difference in concentrations of TSP, PM_{10} and $PM_{2.5}$ between unloaded coal trains and passenger trains. However, there was no statistically significant difference in concentrations of TSP, PM_{10} and $PM_{2.5}$ between the other train types.

- There was no increasing or decreasing trend in average concentrations with respect to train speed.

- When the wind direction was between 150 degrees and 300 degrees (blowing from the rail tracks towards the monitoring station) there was a statistically significant difference in the average concentrations of TSP, PM_{10} and $PM_{2.5}$ associated with loaded coal trains and unloaded coal trains compared with concentrations recorded when no trains were passing the monitoring station.

- There was a statistically significant difference in average concentrations of TSP, PM_{10} and $PM_{2.5}$ between unloaded coal trains and passenger trains when the wind direction was between 150 degrees and 300 degrees (blowing from the rail tracks towards the monitoring station).

- There was no statistically significant difference in average concentrations of TSP, PM_{10} and $PM_{2.5}$ between freight trains and passenger when the wind direction was between 150 degrees and 300 degrees (blowing from the rail tracks towards the monitoring station).

- There was a statistically significant difference in average concentrations of TSP between loaded coal trains and passenger trains; however, there was no statistically significant difference in average concentrations of PM_{10} and $PM_{2.5}$ between loaded coal trains and passenger trains when the wind direction was between 150 degrees and 300 degrees (blowing from the rail tracks towards the monitoring station).

- Average concentrations of TSP, PM_{10} and $PM_{2.5}$ associated with unloaded coal trains were higher than concentrations when no train was passing the monitor by 10.1 µg/m^3, 7.6 µg/m^3 and 2.1 µg/m^3, respectively, when wind direction was from the rail tracks towards the monitoring station. This corresponds to an increase in average concentrations when no train passes the monitoring station of 23%, 24% and 21% for TSP, PM_{10} and $PM_{2.5}$, respectively.

- Average concentrations of TSP, PM_{10} and $PM_{2.5}$ associated with loaded coal trains were higher than concentrations when no train was passing the monitor by 6.0 µg/m^3, 4.3 µg/m^3 and 1.1 µg/m^3, respectively, when wind direction was blowing from the rail tracks towards the monitoring station. This corresponds to an increase in average concentrations when no train passes the monitoring station of 14%, 14% and 11% for TSP, PM_{10} and $PM_{2.5}$, respectively.

- There was no increasing or decreasing trend in average concentrations with respect to ambient wind speed.

A1.3 University of Technology Sydney - Re-analysis of Data in ARTC's Particulate Emissions from Coal Trains Study

In 2013 the NSW EPA engaged Professor Louise Ryan, Distinguished Professor of Statistics at University of Technology Sydney, on the recommendation of the NSW Chief Scientist and Engineer, Professor Mary O 'Kane, to undertake a thorough independent review of the statistical analysis used in the ARTC PRP 4.2 Monitoring Program Report prepared by Katestone (2013).

Professor Ryan found that there were some serious limitations with the statistical analyses used in the Katestone report and recommended a re-analysis of the data (AccessUTS, 2013). The NSW EPA subsequently engaged Professor Ryan to undertake re-analysis of the data in the ARTC report (Katestone, 2013).

Professor Ryan and Professor Matthew Wand from the University of Technology in Sydney issued the report "re-analysis of ARTC Data on Particulate Emissions from Coal Trains" in February 2014" (AccessUTS, 2014). The report detailed the re-analysis of ARTC’s data on particle emissions from coal and other trains in the Hunter rail corridor. The study was based on regression modelling which was recommended by Professor Ryan in her initial review report (AccessUTS, 2013) and by Professor Luke Knibbs, engaged by the NSW EPA to provide an initial report on the statistical methods used in the ARTC report.

The ARTC PRP 4.2 monitoring data was analysed using, a variant of linear regression, with outcome variables corresponding to one of the four particulate measures (PM_1, $PM_{2.5}$, PM_{10} or TSP).

The regression analysis took into consideration the likelihood of serial correlation due to the time-series nature of the data. The advantage of regression analysis over the analyses undertaken in the Katestone (2013) report, is that it allows for simultaneous adjustment with respect to various confounding factors that may otherwise bias or distort the analysis.

The regression analysis conducted by Professor Ryan showed;

- clear evidence that particulate levels were elevated when all train types passed by the monitoring station for all four particle types (TSP, PM_{10}, $PM_{2.5}$ and PM_1)
- particulate levels were elevated in the few minutes before and the few minutes after a train had passed
- elevated levels were strongest and of a similar magnitude (approximately 10% increase above background levels) and highly statistically significant for freight and coal trains, both loaded and empty
- no evidence that loaded coal trains had a stronger association compared with unloaded coal trains or freight trains
- elevated level from passenger train was a smaller magnitude, though still mostly statistically significant. This may be caused by the air turbulence associated with their passing. The effect for passenger trains became non-significant when the analysis excluded times when multiple trains were passing simultaneously.

The study discussed the idea that other contaminants such as diesel may be of more concern than coal dust. Passenger train effects were non-significant for PM_1 and only marginally significant for $PM_{2.5}$. Coal dust is likely to be of a larger particle size so the data suggests that other sources may be contributing. The size of the effect on all particle sizes for all train types (freight, loaded and unloaded coal trains) was shown to be similar and all coal trains are pulled by diesel locomotives.

A1.4 Newcastle Community Group Air Quality Monitoring Programs

A1.4.1 Coal Dust in our suburbs: A community-led study of particle pollution in Newcastle and the Lower Hunter coal train corridor

In 2012 - 2013 a study was carried out by the Coal Terminal Action Group (*Coal Dust in our suburbs: A community-led study of particle pollution in Newcastle and the Lower Hunter coal train corridor*, CTAG, 2013a) to draw attention to the growing concern in Newcastle and other 'coal corridor communities' about exposure to elevated levels of PM_{10} emissions.

A Dust and Health Community Steering Group was formed in 2012 and resolved to undertake an independent 'snapshot' of air quality in residential areas close to the Port of Newcastle and associated rail corridors.

The objectives of the air quality monitoring study were to inform the community of:

- The level of particle pollution
- The relationship between particle pollution levels and proximity to coal infrastructure
- The extent to which elevated levels of particle pollution persist at various distances from the coal corridor and coal infrastructure

The monitoring study methodology used three Osiris portable air quality monitors deployed across 12 sites in the lower Hunter Valley. The Osiris monitor records simultaneous concentrations of PM_{10}, $PM_{2.5}$ and PM_1 at either 1 minute or 10 minute intervals. Osiris monitors were located at each monitoring site for a period of days (varying between 2 and 7) over December 2012 and January 2013.

Wind speed and wind direction instruments were co-located with each Osiris monitors and recorded every 15-minutes.

The CTAG study report only focused on 5 monitoring sites out of a total of 11 (one site was completely excluded due to poor data collection). Appendix A of the CTAG study presents the 24-hour average PM_{10} and $PM_{2.5}$ concentrations recorded at each site. Corresponding concentrations measured by the NSW EPA in the lower Hunter were also presented for comparison purposes.

The results of the CTAG report can be summarised as follows:

- Seven of the 11 CTAG sites recorded a 24-hour average PM_{10} concentration above the Ambient Air Quality NEPM standard of 50 µg/m³
- Four CTAG sites did not record 24-hour average PM_{10} concentrations above the Ambient Air Quality NEPM standard
- The NSW EPA sites did not record 24-hour average PM_{10} concentrations above the Ambient Air Quality NEPM standard during the CTAG monitoring period
- One of the 11 CTAG sites recorded a 24-hour average $PM_{2.5}$ concentration above the Ambient Air Quality NEPM advisory reporting standard of 25 µg/m³
- Ten of the 11 CTAG sites recorded 24-hour average $PM_{2.5}$ concentrations below the Ambient Air Quality NEPM advisory reporting standard
- The NSW EPA sites did not record 24-hour average $PM_{2.5}$ concentrations above the Ambient Air Quality NEPM advisory reporting standard during the CTAG monitoring period

The review of the CTAG study found the following based on the evidence provided in the report:

- The Osiris monitor uses light scattering and calibration factors to determine indicative particulate mass concentrations. A limitation of using this type of monitor is that the indicative concentrations cannot be compared with mass based air quality objectives to determine compliance or non-compliance
- The analysis of the monitoring data conducted during the CTAG study has not considered the likely contributions of different sources, both natural and anthropogenic, other than the port and coal rail as possible contributors to particulate levels in the lower Hunter Valley region. Evidence provided in the PWCS review indicates that salt spray may contribute to high levels of particulates at coastal locations

A1.4.2 Coal Train Pollution Signature Study

In 2013 a second study was undertaken by the CTAG (*Coal Train Pollution Signature Study,* 2013b) to further investigate particle pollution from passing coal trains. Particle pollution levels in residential areas of Beresfield, Hexham and Mayfield adjacent to rail corridors were measured between 15 July and 17 July 2013.

The Osiris instrument was utilised for the study which allowed for the concurrent monitoring of various particle sizes: PM_1, $PM_{2.5}$ and PM_{10}.

The coal train signature study aimed to answer two questions:

1. What is the particulate profile (signature) of loaded and unloaded coal trains?
2. What is the increase in particulate matter associated with the passage of loaded and unloaded coal trains, measured by comparing to pre-train particle concentrations? Is the proportion of increase the same across all particulate fractions (PM_{10}, $PM_{2.5}$ and PM_1)?

A total of 73 coal trains were observed during the three days of monitoring. The corresponding pollution data was analysed to generate ‘signatures’ which depict particle concentrations before, and during the trains’ pass by. The method compares a two-minute average pollution level before each train to a two-minute average while the trains were passing by the monitoring equipment. Eight signatures are examined in this study. These signatures were selected to demonstrate an indicative range of signatures under various conditions (wind direction, wind speed, train speed, train type etc).

All coal train signatures were associated with a increase in PM_{10} particle pollution levels. In the case of Signatures 1 and 5, this represents increases of 94% and 427% respectively for loaded coal trains. Signature 6 increased PM_{10} concentrations significantly, up to 1210%. In sum, coal trains increase PM_{10} levels by between 94% and 1210%. While coal trains pass, particle pollution concentrations increase up to 13 times pre-coal train levels.

While the study was not intended to compare different types of trains, a number of freight and passenger trains were captured in our signature measurements. The study noted city link trains did not produce a definable signature, while freight trains and the XPT did show signatures in some cases, but they were much smaller in comparison to those observed for coal trains, and of shorter duration.

A2 QUEENSLAND STUDIES

A2.1 Queensland Rail Environmental Evaluation

To quantify the ambient concentrations of coal dust in the rail corridor associated with coal trains in Central Queensland (Connell Hatch, 2008) the results of three previous rail corridor air quality monitoring programs were considered, namely:

- Gladstone study, 1993-94 (Katestone Scientific, 1994)
- Goonyella study (Praguelands), 2004 (Simtars, 2004)
- Gladstone study (Callemondah, 2007 (Simtars, 2008)

Additionally, a monitoring program was conducted between November 2007 and February 2008. The program comprised the following monitoring equipment:

- Partisol - measuring ambient TSP (24-hour average), located at 8 residential locations
- TEOM - performing continuous monitoring of TSP, located at 5 locations within the rail corridor
- Osiris - performing continuous monitoring of TSP, located at 3 locations within the rail corridor (2 co-located with TEOM)

The results of each of the monitoring studies were assessed against air quality goals for human health. The following observations can be made about the results of this assessment:

- Although the Air EPP PM_{10} goal was 150 µg/m³ at the time of the study, comparisons were also made against the Ambient Air Quality NEPM standard of 50 µg/m³ (24-hour average), equivalent to the current Air EPP objective
- Exceedances of the Ambient Air Quality NEPM standard at the monitoring locations were very rare and not likely to be caused by coal trains
- In cases where an exceedance was recorded, the contribution of coal dust was found to be minor
- The studies did not find the potential for health impacts inside or outside of the rail corridor as assessed against current air quality objectives due to coal dust emissions from trains. The 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 results of each of the studies were also assessed against air quality guideline for amenity and the following conclusions were drawn:

- At 3 metres or 5 metres from the tracks, deposition rates were likely to be above the nuisance threshold of 120 mg/m²/day however at 10 metres from the tracks the deposition rate dropped well below the threshold

The coal content of deposited dust samples was determined by laboratory analysis as part of the 2007 Callemondah study by Simtars (Simtars, 2004). At 10 metres from the track, coal was shown to make up between 35 and 75 percent of deposited dust.

The monitoring program conducted as part of the Environmental Evaluation identified the rail corridor as being approximately less than 10 metres from the rail line and indicated that outside of the rail corridor the likelihood of coal dust from coal trains impacting on the environment was low.

However, although atypical, observations and photographs taken during the QR Environmental Evaluation showed that visible dust was emitted by some coal trains operating in Queensland and that dust was observed to travel beyond the rail corridor.

A2.2 DSITIA Tennyson Study

In response to community concerns over dust from coal trains, the Queensland Department of Science, Information Technology, Innovation and the Arts (DSITIA) conducted a one-month study of dust in the Brisbane suburb of Tennyson (DSITIA, 2012); the Tennyson Study. In 2012, the period coinciding with the study, the Brisbane Metropolitan Rail (BMR) System was used to transport approximately 9 million tonnes of coal to the port of Brisbane from mines in the Clarence-Moreton and Surat coal measures (Western System). The coal train corridor associated with the BMR System passes through the suburb of Tennyson.

In summary, coal dust from trains was found to be a measurable source of dust in the Tennyson area; however, it was not the major source of dust. Conservative air quality objectives were not exceeded during the month long study. The methodology and results of the study are summarised in this section.

The Tennyson Study involved track-side and residential dust monitoring using three types of monitoring equipment: 1. Low-volume samplers – Partisol 2025; 2. Aerosol monitors – Dusttrak 8533; and 3. Dust deposition gauges. The monitoring sites and associated equipment are, summarised in Table A1.

Table A1 Sites and equipment used in the Tennyson dust monitoring investigation

Site	Location	Equipment	Description
Tennyson Station	6 metres from the northern track	Low-volume sampler (Partisol 2025)	24-hour average measurements of PM_{10}, for comparison to Air EPP
		Dust deposition gauge	1-month average dust deposition rate, proportion of coal in deposited dust
		Aerosol monitor (Dusttrak 8533)	5-minute average particle measurements, not for comparison to Air EPP
Myla Terrace	Residential street, 20 metres from the northern track	Dust deposition gauge	1-month average dust deposition rate, proportion of coal in deposited dust
Vivian Street	Residential street, 300 meters from the rail line	Dust deposition gauge	1-month average dust deposition rate, proportion of coal in deposited dust

The following limitations of the monitoring campaign were recognised by the study:

- The monitoring program lasted a single month, which coincides with the averaging period for the dust deposition monitoring. Therefore only a single data point was available for the assessment of dust deposition rates at each site
- While the exact distribution of trains on either track was not reported, full coal trains predominantly used the northern track while empty coal trains predominantly used the southern track. This is unlikely to have an effect on results at Myla Terrace or Vivian Street monitoring sites; however, the Tennyson Station monitoring equipment was located approximately 6 metres from the nearest (northern) track, and

approximately 9 metres from the farther (southern) track. This placement may have an influence on the results.

Air quality objectives for the project were selected to give an indication of the relative impact of the measured parameters. No exceedance of the criteria applied was identified at any of the sites based on results from the monitoring program. The air quality objectives applied to monitoring results were:

- Measured 24-hour average PM_{10} concentrations to the Air EPP objective of 50 µg/m³
- Measured dust deposition rates to the New Zealand Ministry for the Environment's (in the absence of legislated criteria in Queensland) recommended trigger level for dust nuisance of 130 mg/m²/day over a 30 day period.

Dusttrak measurements taken before and after the passing of trains indicated that loaded coal trains showed a higher average and median concentration compared to empty coal trains. Empty coal trains were shown to produce the lowest average change in dust concentration after passing; lower than passenger or freight trains. With reference to the study limitations the differences observed could to some extent be attributable to the monitor being further away from the empty than the full coal trains or the fact that only average and not peak contributions were presented. Analysis of the results indicated that the re-entrainment of surface dust by air movements associated with the passing train appeared to be more important than the loss of coal dust from the surface of the wagons.

Compositional analysis of the samples indicated that:

- 40 to 50 percent of the dust at each site was mineral dust (e.g. soil, rock, fly ash, cement, glass.
- 10 to 20 percent could be classified as dust of coal origin
- 10 percent of dust at all sites was identified as rubber dust. Rubber dust has a similar black colour to coal dust and is generated from tyre action of motor vehicles.

The proportions of coal dust found in the insoluble dust samples in the Tennyson investigation (at between 10 and 20 percent) were higher than those determined from previous sampling carried out between July 1998 and August 1999 by Simtars (Coal Dust Monitoring: West Ipswich to Fishermans Island). The Simtars study found coal dust to be between 1 and 3 percent of the insoluble dust sample. The recent study notes that different methods were used to determine the fraction of coal dust in the sample and caution should be used when comparing the results like for like. However, the increase in coal dust fraction roughly relates to the threefold increase in coal haulage along the system since the Simtars study.

A2.3 DSITIA Western Metropolitan Rail System Study

In October 2013, the Queensland Government Department of Science, Information Technology, Innovation and the Arts (DSITIA) published the findings of the Western – Metropolitan Rail Systems Coal Dust Monitoring Program (Final Report). This program involved monitoring over a four month period between early March and early July 2013. Monitoring was conducted at six locations along the Western and Metropolitan rail system, used to transport coal to the Port of Brisbane, at Oakey, Willowburn (Toowoomba), Dinmore, Tennyson, Fairfield and Coorparoo. One background monitoring station was located on a section of the Metropolitan rail system not used by coal trains (Chelmer). The timing of the monitoring program was necessary to coincide with the commencement of a coal wagon veneering trial at New Acland mine north of Oakey in May 2013. It was noted that frequent rainfall occurred during the investigation period, most notably during the months prior to and during the pre-veneering monitoring period. The rainfall may have reduced measured particle levels.

Consistent with the Tennyson Study, the 24-hour average air quality objectives of 50 µg/m^3 for PM_{10} based on the Queensland Environmental Protection (Air) Policy 2008 (EPP Air) and the New Zealand Ministry for the Environment's (in the absence of legislated criteria in Queensland) recommended trigger level for dust nuisance of 130 mg/m²/day over a 30 day period were adopted. In addition to this the EPP Air $PM_{2.5}$ objectives of 25 µg/m^3 and 8 µg/m^3 associated with 24-hour average and annual average values respectively were applied.

The monitoring results showed that ambient particle concentrations complied with ambient air quality objectives at all rail corridor monitoring sites during both the pre- and post-veneering monitoring periods. An observation made by the study is that close correspondence between monitoring results from the study with PM_{10} and $PM_{2.5}$ levels measured at DSITIA ambient monitoring sites elsewhere in Brisbane for the same periods would suggest that urban particulate emission sources rather than rail transport emissions have greater influence on ambient PM_{10} and $PM_{2.5}$ concentrations.

Microscopic analysis of the dust samples collected showed that:

- 50 to 90 percent of larger particles was mineral dust (soil or rock dust)
- On average 10 percent of the total surface area of dust collected was coal particles – with some individual samples containing up to 20 percent
- Rubber dust, another black-coloured particle made up 10 percent of the samples on average

At the Tennyson, Fairfield and Coorparoo monitoring sites the passage of trains was found to be associated with little change in 10-minute average PM_{10} and $PM_{2.5}$ levels; during both the pre- and post-veneering monitoring periods. Additionally the variation in particle levels associated with different train types was not statistically significant.

The results from the study also showed that, based on statistical analyses, the impact from veneering was less than the day-to-day variability in PM_{10} and $PM_{2.5}$ concentrations. A general trend of decreased dust deposition rates and lower levels of coal dust in the deposited dust samples was observed at most monitoring sites following the implementation of rail wagon veneering. While this suggests that veneering reduced the loss of coal particles during transit, monitoring over a period longer than one to two months is needed to demonstrate that this improvement is ongoing.

A further interpretation of the results from the Queensland Government stated that *'The Queensland Department of Health has concluded that, for people living along the rail corridor, the dust concentrations, resulting from all particle sources, measured during the investigation are unlikely to result in any additional adverse health effects.'*

A3 OVERSEAS STUDIES

A3.1 Norfolk Southern Corporation (NS)

Norfolk Southern Rail Company (NS) is a large Virginia (USA) based rail company servicing the coal producing regions of the eastern USA, its fleet of coal cars numbers approximately 45,000 with each car in a typical 180-car train carrying approximately 100 tonnes when fully loaded (Commonwealth of Virginia, 1997). NS rail corridors were the subject of a study published in 1996 (Calvin and Emmitt). NS rail corridors were chosen due to the variety of terrain, the relatively high volume of coal traffic and the number of complaints received. The main objectives of the study were to quantify the amount of coal dust generated during rail transport of coal and to determine the effects of several dust suppression techniques including load shaping, water spraying and surfactant spraying. The major findings of the study were:

- Based on scale weight changes average material losses from untreated cars was estimated at 0.36 tonnes and 0.20 tonnes for unshaped and shaped wagons respectively
- Based on passive sampling
    - Load shaping combined with chemical treatment reduced fugitive dust emissions by up to 95%
    - water spray at the mine was only effective for the first two to three hours of each trip.

- Increased fugitive emissions were associated with:
    - Trains accelerating from 15-30miles/h and when passing oncoming trains
    - Tunnels, trestles and topographic interfaces

In 1991 NS representatives told the General Assembly that the cost of covering each car would be 700 USD and the cost of loading and unloading a covered car would add additional 200 USD. (Commonwealth of Virginia, 1997)

A3.2 Burlington Northern Santa Fe Railway (BNSF)

Burlington Northern Santa Fe Railway (BNSF) operates a vast rail network across the USA with its greatest coverage mid-north and mid-south and to a lesser extent in the west. In 2013 BNSF transported 2.2 million shipments of coal, with more than 90% originating in the Power River Basin in Wyoming and Montana.

Coal dust was initially raised as a track maintenance issue back in 2005 where coal dust on BNSF lines in and near the Powder River Basin resulted in significant maintenance expenditure. Coal dust is also perceived as a community issue in the Northwest of the USA. In 2009, a testimony from a BNSF railway representative indicated that that it was possible that up to 645 pounds of coal dust could escape from each rail car over a 400 mile trip .(Ahern, 2013).

From March to September 2010 the well-known 'Super Trial' (BNSF and UP, 2010) was conducted. The purpose of this study was to develop and provide information on coal dust suppression technologies and measures that coal shippers could implement for coal dust control. The 'Super Trial' involved treatment of 1,633 trains with either a 'body treatment' where the chemical is applied to the coal prior to loading, or a topical treatment', where the chemical is applied to coal after loading. Dust identification was predominantly by trackside monitoring with 115 being tested with passive dust collectors and weather stations.

The Super Trial showed that 'topical treatment' of loaded coal substantially reduces coal dust emissions with trains that were 'body treated' only showing only a limited reduction. A recommendation of the Super Trial was that effective coal dust reduction requires careful attention to proper application of the 'topical treatment' combined with appropriate load shaping. During the trial it was observed there was potential for inconsistency in both load shaping and application of the dust suppression treatment that could reduce the effectiveness of the treatment. Since October 2011, following on from the 'Super Trial' BNSF have required coal shippers to load coal in a low profile, a bread loaf shape, and to apply one of 5 approved topping agents that are non-toxic and non-hazardous. However this has not eliminated public concern over the issue with community groups still calling for coal train cars to be covered.

Around the same time the Northwest states of Wyoming, Montana, Washington and Oregon required that coal companies to apply a surfactant or topper to all coal trains prior to departure from the load out facility.(Ahern, 2013) BNSF research has shown that the surface treatment of coal with a surfactant can decrease coal dust emissions by up to 93%. (BNSF & UP, 2010).

In the case of coal mines delivering to the Westshore Terminal in Delta, British Columbia once coal is loaded into rail cars at the mine it is leveled and sprayed with a latex-water spray. In addition to this Canadian National (CN) Rail, using BNSF tracks, operates a mid-journey spray station (Kerr, 2013). Westshore Terminal has also spent close to 7 million USD on rain guns and high mast sprays to prevent coal dusting during storage and transfer through the terminal; water costs as of 2013 account for 1.5 million USD of annual operating costs (Ahern, 2013). An additional measure taken by Westshore to control road dust is through regular use of water trucks and spraying with magnesium chloride a couple of times a year.

A3.3 Air Quality Monitoring in Seward, Alaska, USA

The Seward Coal Loading Facility (SCLF) is the southern terminus of the Alaska Railroad, located in the small coastal town of Seward. Coal is transport to the SCLF and loaded onto ships bound for markets in Asia. The SCLF has been operating for 25 years and currently receives approximately 5-8 trains per week. The SCLF coal stockpile has a nominal capacity of 95,000 tonnes.

Over the past 10 years Seward city officials and Alaska Department of Environmental Conservation (ADEC) have received numerous complaints regarding wind-blown dust generated by the activities at the SCLF. There have been two air quality monitoring studies conducted in Seward to determine particulate matter concentrations. One study was conducted by ADEC and the other by a Seward community group. A summary of the two studies is provided in the following sections.

A3.3.1 Alaska Government Air Quality Monitoring

The ADEC Air Quality Division set up a monitoring network in Seward to assess airborne dust measured as PM_{10} (ADEC, 2013). The monitoring program began in January 2011 and collected data from 20 February 2011 through to 27 May 2012.

The objective of the monitoring program was to collect samples that were representative of the overall air quality in terms of PM_{10} for the City of Seward. Samples were collected in accordance with US EPA Reference Methods. Air quality samples were collected from three locations across Seward according to the US EPA 1 in 6 day sampling schedule.

The US EPA National Ambient Air Quality Standard (NAAQS) for PM_{10} is 150 µg/m^3 for a 24-hour period. There were no exceedances of the PM_{10} NAAQS recorded at any of the sites during this monitoring program. The highest 24-hour PM_{10} concentration recorded during the sampling program was 54 µg/m^3. According to the US EPA air quality index (AQI) the highest PM_{10} concentration recorded during the monitoring period would be categorized as "good air quality."

A3.3.2 Community Air Quality Monitoring

Air quality monitoring was undertaken by citizen volunteers in Seward, Alaska to determine possible health impacts from the local coal export facility (Zimmer et al, 2014). A year-long air quality monitoring project was undertaken with assistance and training from Global Community Monitor (GCM), Alaska Community Action on Toxics (ACAT) and Resurrection Bay Conservation Alliance (RBCA).

Two portable particulate monitors (MiniVols) were placed at selected locations around Seward.

The compositional data indicated that coal made up the majority of the dust captured in the air monitors, however, the PM_{10}. 24 hour average concentrations ranged from 13.2 µg/m^3 to 27.3 µg/m^3 and the $PM_{2.5}$ 24-hour average ranged from 3.6 µg/m^3 to 8.5 µg/m^3, below the US EPA's NAAQS.

A3.4 Fugitive Coal Dust Emissions in Canada

In 2001 D. Cope Enterprises, 2001 completed a report titled "*A Study of Fugitive Coal Dust Emissions in Canada*" for the Canadian Council of Ministers of the Environment (CCME). The study found that the emission factors to quantify coal dust emissions from coal trains travelling from mine to port were developed during the late 1970s and early 1980s (D Cope Enterprises, 2001). These emission factors were based on three research studies that suggested 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) was 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 was recommended for use. Emission rates of PM_{10}

can be 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 NSW is difficult to ascertain.

A3.5 Fraser Surrey Dock Coal Transfer Facility

Fraser Surrey Docks LP (FSD) retained the services of SNC-Lavalin Inc. (SNC-Lavalin) to conduct a human health risk assessment (HHRA) of the Direct Transfer Coal Facility proposed for the existing Fraser Surrey Docks (FSD) terminal site located on the Fraser River in Surrey, British Columbia (BC).

The HHRA is based largely on the results of an Air Quality Assessment (AQA) conducted by Levelton Consultants Ltd. (Levelton, 2014). As part of the AQA, Levelton, in consultation with Port Metro Vancouver and Metro Vancouver, developed a detailed air dispersion model to predict potential emissions from proposed direct transfer coal facility. The AQA considered proposed emission sources related to operations, in addition to the current emission sources from FSD's current agricultural operations. The results of the Levelton (2014) AQA were used to estimate exposures to the receptors of concern identified in the HHRA.

The Levelton (2014) AQA concluded, that with the exception of the maximum predicted annual NO_2, the maximum concentrations of Criteria Air Contaminants (CACs) plus background were below the most stringent of the municipal, provincial, national and international air quality objectives and guidelines. The higher annual NO_2 concentrations were predicted adjacent the FSD fenceline in the area of the berth, in a region concentrated over the waters of the Fraser River.

In addition to the results of the Levelton (2014) AQA, the HHRA considered the results of the analysis of the coal that is proposed to be transported as part of the Project, as well as the results of a background soil assessment that was conducted in the Study Area. The HHRA also considered the material safety data sheets for the binding and suppressing agents that will be used to control dust as part of the Project.

The HHRA was conducted using methods and guidance recommended by Health Canada, and using a series of conservative assumptions that will tend to overpredict exposures, and therefore risks, to receptors in the Study Area. Despite the conservative approach, no unacceptable risks have been predicted for the receptors in the Study Area (residents, commercial workers, urban park users, agricultural receptors, people involved in fishing activities), including those that have the potential to be exposed to the maximum Project emissions.

In summary, no unacceptable health risks are predicted for exposures to the Project emissions in the Study Area.