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Assessment of Options Report

Adelaide Brighton Cement Limited
Licence number: 1126
Premises Address: Victoria & Elder Roads, Peterhead (Birkenhead Site)

August 2018

Contents

Glossary

Term	Definition
$\mu g/m^3$	micrograms per cubic metre
μm	micrometre
°C	degrees Celsius
km	kilometre
m	metre
m/s	metres per second
m^2	square metres
m^3	cubic metres
m^3/s	cubic metres per second
Nomenclature	**Definition**
TSP	Total suspended particulates
PM_{10}	particulate matter with a diameter less than 10 micrometres
$PM_{2.5}$	particulate matter with a diameter less than 2.5 micrometres
Abbreviations	**Definition**
Air EPP	Environment Protection (Air Quality) Policy 2016
CKD	Clinker Kiln Dust
CM 1	Cement mill 1
CM 6	Cement mill 6
EET	Emission Estimation Technique
EP Act	Environment Protection Act 1993
EF	Emission factor
EPA	Environment Protection Authority
MM	Fringe Materials Management System
NPI	National Pollutant Inventory database
SA EPA	South Australian Environment Protection Authority

Assessment of Options

1.0 Purpose:

An Assessment of Options report (assessment report) has been prepared to fulfil the requirements of South Australian Environment Protection Authority (SA EPA) licence 1126, dated 1 November 2017, condition, Assessment of Options (U-730). This condition requires a 'detailed assessment of options to prevent or minimise particulate emissions' from the Birkenhead cement plant.

2.0 Scope:

The scope of the Assessment of Options report is as detailed in the licence condition:

4.1 ASSESSMENT OF OPTIONS (U - 730)

The Licensee must:

4.1.1 ensure a suitably qualified expert:

a undertakes a detailed assessment of options to prevent or minimise particulate emissions from the following sources at the Premises:

i exposed and unsealed areas;

ii external material stockpiles;

iii vehicle movements;

iv material conveyor and transfer systems; and

v dust collector units associated with processing and storage facilities.

4.1.2 submit to the EPA for its approval, by the date listed below, an 'Options Assessment Report', ensuring the report contains but is not limited to:

a the details of the options assessed under sub paragraph 1 of this condition;

b a feasibility assessment of each option;

c the expected environmental outcomes of the options identified;

d the methodology used and considerations made in selecting the preferred measure(s) or action(s); and

e recommendation(s) of proposed options to be taken to prevent or minimise particulate emissions.

3.0 Introduction:

ABC engaged Katestone Environmental Pty ltd (Katestone) a leading provider of air quality services in Australia with extensive experience in designing, implementing and reviewing air quality monitoring and management systems, as suitably qualified experts, to undertake a detailed assessment of options in accordance with condition U-730, 4.1.1 of EPA Licence 1126.

Katestone has produced a report titled *"Birkenhead Cement Plant – Options Assessment Report" dated June 2018* (Katestone options report), which is attached in appendix A.

The scope of work for the Katestone options report is as follows:

- Conduct a Best Management Practice Study to identify the most practicable means to reduce particulate emissions at the Facility.
- Prepare a report of the study that includes the following:
  - Identification, quantification and justification of existing measures that are being used to minimise particulate emissions at the Facility
  - Identification, quantification and justification of best practice measures that could be used to minimise particulate emissions at the Facility
  - Evaluation of the expected environmental (air quality) outcomes of implementing these best practice measures at the Facility.

The Katestone options report references previous work undertaken by Katestone to assess and model emissions for particulate matter from the Birkenhead site, the details of which are contained in the Katestone Environmental, 2017, "Air Quality Assessment of the Birkenhead Cement Plant" report previously supplied to SA EPA. This reference report provides the baseline for evaluation of the environmental outcomes that are predicted to be achieved by the various options identified in the Katestone options report in terms of the predicted change in concentration of PM_{10}, and nuisance dust expressed as a dust deposition rate, at both the Community Park and Gunn Street ambient dust monitoring locations.

4.0 Identified Options

In the Katestone options report, Adelaide Brighton Cement (ABC) current practices have been bench marked against best practice measures to minimise particulate emissions from fugitive dust sources. The report identifies options that are not already in place at the Birkenhead site that might be able to be utilised to further reduce fugitive dust and provides for each option:

- Specific details
- Potential reduction in offsite impacts calculated as the reduction in 24-hr average PM_{10} concentration predicted by dispersion modelling at the Community Park, as an average over the 25 highest days (detailed in Section 5 of the Katestone options report).
- The predicted reduction in peak concentrations at the Community Park and Gunn Street for each of the identified options (detailed in Table 10 of the Katestone options report).

The potential off site impact associated with each option has been considered independently (without consideration of other options). Therefore implementing more than one option on a single source will reduce the assessed benefit associated with each subsequent option. Further, some of the options are alternatives to one another, so that if one alternative is implemented, the other alternative/s will no longer be available for implementation.

5.0 Assessment of Options

To be able to rank each option, an assessment of the potential off-site dust reduction is required. The Katestone options report provides various predicted off-site dust concentrations for each option at both off site community monitors as follows:

- PM10 (μg/m3) 1-hour average at percentile values of 100 (max), 99, 95 and 90 (Table 10)
- PM10 (μg/m3) 24-hour average at percentile values of 100 (max), 99, 95 and 90 (Table 10)
- Maximum dust deposition (mg/m2/day) monthly average (Table 10)

Analysis of this data shows that the relationship between the predicted off-site concentrations for different averaging periods and percentiles remains the same, for both the PM_{10} and deposited dust criteria, at both the Community Park and Gunn Street locations. The analysis also shows that for each option the predicted off-site reduction is greatest at the Community Park location. This means that in rating options based on off-site dust reduction, it is preferable to choose a predicted criterion at the Community Park location. The reduction in 24-hour average PM_{10} concentration, predicted by dispersion modelling at the Community Park, as an average over the 25 highest days/year was chosen as the appropriate criterion for the following reasons:

- Offsite reduction for each option can be compared against the Air EPP criterion of 50 (μg/m3) PM10 (24-hour average)
- The average of the 25 highest days of PM_{10} concentration (24-hour average), represents the 96.5 percentile
- There is no Air EPP PM_{10} (1-hour average) criterion to compare the off-site dust reduction against
- There is no deposited dust criterion in the Air EPP by which to compare the offsite reduction
- Fugitive dust options aim to improve air quality to achieve compliance with Air EPP criterion of 50 (μg/m3) PM_{10} (24-hour average)

ABC has assessed the options identified and detailed in the Katestone options report, taking into consideration the following attributes of the options:

- Reasonable and practical
- Predicted improvement in air quality outcomes
- Ability to maintain efficiency of the control measures
- Other consequential environmental impacts (noise, water consumption, ground water run off)
- Capital investment

- Operational and maintenance costs
- Ability to apply within existing site constraints

A scoring methodology has been used to select the preferred options for further investigation. Details of the scoring factors are documented in Table 1: Scoring Matrix.

Table 1: Scoring Matrix

Category	Score		
	1	5	10
Feasibility to Implement	External Factors outside ABC's control Regulatory approvals Land owner approvals High water table and legacy hydrocarbon plumes impacts on civil/structural works	Major project, including design, civil and electrical works and outage time and/or significant planning requirements Regulatory approvals	Works to existing plant and equipment - with minor shutdown Regulatory approvals
Predicted reduction in off-site dust PM_{10} $\mu g/m^3$ *	< 2	2 - 4	> 4
Capital Investment $ Million	> 2	1 - 2	< 1
Annual maintenance/ operating costs $ Million	> 0.3	0.1 - 0.3	< 0.1

* Where off site dust reduction has not been quantified, PM_{10} reduction is estimated to be < 2 $\mu g/m^3$ for scoring purposes

A summary and assessment of all identified options in the Katestone options report are provided in Table 2: Assessment of Identified Options.

Where alternative options for some of the dust control measures that can be applied to a fugitive dust source have been identified, they have been grouped together in the table to facilitate their comparison.

All of the identified options in the Katestone options report are scored. To reflect the importance of the off-site PM_{10} reduction, the relevant weighting is doubled. The higher the ranking score, the more favourable the option is for further investigation and these options are highlighted with green cells in Table 2: Assessment of Identified Options.

Table 2 : Assessment of Identified Options

Fugitive Dust Source	Dust Control Measure	Option	Description	Factors to consider	Feasibility to Implement (a)	Capital Required (b)	Annual Mainten-ance + operating cost (c)	Predicted PM_{10} reduction µg/m³ & Score (d)	Ranking Score = (a+b+c)+2*d
Stockpiles	Wind break applied to external limestone storage on Shell block	Curtain **OR**	Install 15 m high windbreak curtain to Western perimeter of external Limestone Stockpile - (Shell block)	Engineering design required Windbreak curtain supported on poles typically 18m apart over 350 metres Minor foundation work required to support poles (guys, bracing, can be used to minimise civil/foundation requirements) Flexibility of lay out – ability to reconfigure Low visual impacts Development approval needed Approval required from landowner Minimal site remediation costs on termination of property lease Financing approval	10	10	10	5 (2.3 µg/m³)	40
		Bunker Walls **OR**	Install 15 m high bunkers for external Limestone Stockpile – (Shell block).	Engineering design required 700m x 15m concrete bunker walls Major foundation work required to support walls (peer & beam construction - Piling for peers typically every 6m) May not be structurally feasible • partly filled/reclaimed sandy substrate • high water table 2 m below ground level • legacy free phase hydrocarbon plume High visual impact Development approval needed Approval from landowner Financing approval High site remediation costs on termination of property lease Permanent structure – no flexibility to change	1	1	1	10 (7 µg/m³)	23
		Vegetation	Establish tree wind break along western perimeter external of Limestone Stockpile - (Shell block)	Long lead time for trees to mature Long lead time for dust control measure to be effective Potential environmental impacts on growth • High water table 2 m below ground level / Impact of drought etc. • Legacy free phase hydrocarbon plume • Acid sulphate substrate Reduction in available space for stockpiling Financing approval	10	10	10	5 (2.3 µg/m³)	40

Table 2 : Assessment of Identified Options

Fugitive Dust Source	Dust Control Measure	Option	Description	Factors to consider	Feasibility to Implement (a)	Capital Required (b)	Annual Mainten-ance + operating cost (c)	Predicted PM_{10} reduction µg/m³ & Score (d)	Ranking Score = (a+b+c)+2*d
Stockpiles	Surface stabilisation of inactive stock piles on shell block	Geo-fabric **OR**	Geo- fabric cover to be applied to 11,500 m² on inactive areas of limestone stockpiles on shell block	Limestone stockpile on shell block is progressively built over 5 years - emergency stock pile for ship dry dock maintenance period Low cost surface stabilisation Flexibility – Can be progressively applied and removed as stockpile is built/reclaimed Can be used in conjunction with wind breaks and chemical suppressants which mitigate dust from worked areas of stockpiles Fixing arrangement for geo- fabric textiles Development approval may be needed Financing approval	10	10	10	1 (0.9 µg/m³)	32
		Re-vegetation	Layer of top soil seeded with low ground cover vegetation applied to 2000 m² area of inactive limestone stockpile	Watering and time to establish growth Applied only after stockpile is built Removal of top soil when stock pile is reclaimed Can be used in conjunction with wind breaks which mitigate dust from worked areas of stockpiles	10	10	10	1 (0.2 µg/m³)	32
Stockpiles	Reduced vehicle movements relocate stockpile closer to process entry point and apply wind shielding	Relocate Bauxite stockpile	Relocate Bauxite stockpile closer to MM Pit area and store in a bunker **OR**	Reduced vehicle movement stockpile closer to system Engineering design required Development approval needed Foundation work required to support walls Significant cost to build bunkers Permanent structure Significant cost and potential to increase dust levels to move Bauxite stockpile – better to relocate stockpile when a new shipment of Bauxite received.	5	5	5	1 (0.2 µg/m³)	17
			Relocate bauxite stockpile close to MM Pit area and cover inactive area with Geo-fabric	Reduced vehicle movement stockpile closer to MM pit Low cost surface stabilisation Flexibility – Can be progressively applied & removed as stockpile is built/reclaimed Can be used in conjunction with wind breaks and chemical suppressants which mitigate dust from worked areas of stockpiles Cost effective to relocate stockpile when new shipment of Bauxite received	10	10	10	1 (0.2 µg/m³)	32

Table 2 : Assessment of Identified Options

Fugitive Dust Source	Dust Control Measure	Option	Description	Factors to consider	Feasibility to Implement (a)	Capital Required (b)	Annual Mainten-ance + operating cost (c)	Predicted PM_{10} reduction µg/m³ & Score (d)	Ranking Score = (a+b+c)+2*d
Stockpiles	Improved Water delivery to Limestone stockpile - Shell block	Automated sprinkler system **OR**	Automated sprinkler system with 26 large sprinklers to continually apply water to surface areas of limestone stockpile.	Water continually applied to match evaporation rate. Large use of mains water 135 ML/year. Significant water cost. Mains water required as no access to recycled or process water - potential issue during periods of water restrictions. Potential impact on ground water table and legacy hydrocarbon plume and Port River. Material drag out from storage area onto paved road surfaces and increased dust. Safety implications for vehicles operating in loading area while sprinklers operating and manual handling issues clearing blockages in material handling from wet /sticky materials. Compromises effectiveness of chemical suppressants applied to exposed areas / roads. Engineering design Development approval may be needed Financing approval.	5	5	1	5 (3.6 µg/m³)	21
		Fogger cannon system	Use of portable fogger cannons to continually apply water to surface areas of limestone stockpile.	As above for sprinklers	5	5	1	5 (3.6 µg/m³)	21
Stockpiles	Enclosure	Enclose Limestone Stockpile	Enclose limestone stockpile in shed, 200m x 100mx 32m. 1250t/hr automated stockpile build and reclaim system.	Engineering design required Significant cost to build May not be structurally feasible • partly filled/reclaimed sandy substrate • high water table 2 m below ground level • legacy free phase hydrocarbon plume 70% reduction in limestone storage capacity Development approval needed Approval from landowner Financing approval High site remediation costs on termination of property lease Permanent structure – no flexibility to change	1	1	1	10 (7.8 µg/m³)	23

Table 2 : Assessment of Identified Options

Fugitive Dust Source	Dust Control Measure	Option	Description	Factors to consider	Feasibility to Implement (a)	Capital Required (b)	Annual Mainten-ance + operating cost (c)	Predicted PM_{10} reduction $\mu g/m^3$ & Score (d)	Ranking Score = (a+b+c)+2*d
Exposed unsealed areas	Paving exposed areas	Paving exposed areas MM block	Bituminise 3000m² of currently unsealed surface near Southern Stockpile & MM block	Sealed area to be maintained with a sweeper/ water cart as required. Substrate design and bitumen layers to be designed for front end loader and heavy truck operations Development approval may be needed Financing approval.	10	5	10	1 (0.8 $\mu g/m^3$)	27
Transfers	Wheel wash	MM transfer wheel wash	Provide MM system wheel wash to reduce track out of dust onto paved surfaces	Install wheel wash to reduce track out Engineering design Development approval may be needed Financing approval.	10	10	10	1 (0.11 $\mu g/m^3$)	32
Transfers	Wind Shielding	Full enclosure MM transfer	Fully enclose MM system - extend existing enclosure, install second rapid raise door	The system has a high level of control with three-sided enclosure, entry rapid raise door and foam suppression system on hopper Engineering design Development approval may be needed Financing approval	5	1	5	1 (0.0003 $\mu g/m^3$)	13
Conveyors	Wind shielding	Wind shielding	Provide wind shielding on one side of CS2 CR2 /CR3 conveyors to reduce potential for dust lift off	Materials conveyed are hot, enclosing conveyor will require safety consideration for operators Engineering design Development approval may be needed Financing approval.	5	10	10	1 (NQ)	27
Dust collectors	Redirection of Cement Mill 1 Dust Collector outlet	Redirection of Cement Mill 1 Dust Collector outlet	Change horizontal release from CM1 dust collector to a vertical release	Reduced Noise impacts Engineering design Development approval may be needed Mill shutdown for installation Financing Approval	5	10	10	1 (0.45 $\mu g/m^3$)	27

Table 2 : Assessment of Identified Options

Fugitive Dust Source	Dust Control Measure	Option	Description	Factors to consider	Feasibility to Implement (a)	Capital Required (b)	Annual Mainten-ance + operating cost (c)	Predicted PM_{10} reduction $\mu g/m^3$ & Score (d)	Ranking Score = (a+b+c)+2*d
Storage / processing buildings	Dust collection	Dust Collection	Dust collector for clinker transfer system in CM6 building	The transfer point is enclosed; Application of dust collection will reduce the dust loading within building Potential to lower overall emissions from the building and site Engineering design Development approval may be needed Financing approval	10	10	10	1 (NQ)	32
Storage / processing buildings	Sealing	Air knives / Blowers on entrance to Clinker Gantry	Install Air knife/blower on CM6 clinker gantry	CM 6 Clinker gantry stockpile already has significant dust control measures in place. Enclosed building, dust collection and rapid raise doors. Application of blowers will reduce potential for dust escape when vehicles pass through entrance doors Engineering design Development approval may be needed Financing approval	10	10	10	1 (NQ)	32
Storage / processing buildings	Sealing	Maintain cladding on CM6 gantry	Upgrade cladding to ensure building maintains high standards of dust control	CM6 gantry building has good standard of dust control - rapid-raise door, annex for vehicle entry and dust collection Engineering design Development approval may be needed Financing approval	10	10	10	1 (NQ)	32
Storage / processing buildings	Sealing	Upgrade cladding on CM6 building	Upgrade cladding on CM6 building to improve capture of dust generated from the activities inside	Upgrade cladding to better seal CM6 building Engineering design Development approval may be needed Financing approval	10	10	10	1 (NQ)	32

NQ: Where off site dust reduction has not been quantified, it is estimated PM_{10} reduction is < 2 $\mu g/m^3$ for scoring purposes

6.0 Recommendations of Proposed Options to be taken

The potential off site PM_{10} dust impacts associated with each option has been considered independently (without consideration of other options). Therefore implementing more than one option on a single source will reduce the assessed benefit associated with each subsequent option. Further, some of the options are alternatives to one another, so that if one alternative is implemented, the other alternatives will no longer be available for implementation.

The recommended proposed options to be taken are summarised in Table 3: Recommended Proposed Options to be Taken.

The recommended proposed options to be taken will be incorporated into a staged environmental improvement program to be approved by the EPA. The environmental improvement program will need to be staged for each option, to ensure further investigation and satisfactory completion of detailed engineering design to enable investment decisions to be made; seeking appropriate approvals; planning and timing for implementation; construction and commissioning phases.

Table 3: Recommended Proposed Options to be Taken

Fugitive Dust Source	Dust Control Measure	Option	Description	Factors to consider	Predicted PM_{10} reduction $\mu g/m^3$ *
Stockpiles	Wind break applied to external limestone storage on Shell block	Curtain	Install 15 m high windbreak curtain to western perimeter of external Limestone Stockpile - (Shell block)	Engineering design required Windbreak curtain supported on poles typically 18m apart over 350 metres Minor foundation work required to support poles (guys, bracing, can be used to minimise civil/foundation requirements) Flexibility of lay out – ability to reconfigure Development approval needed Approval required from landowner Minimal site remediation costs on termination of property lease Financing approval	2.3 $\mu g/m^3$
Stockpiles	Surface stabilisation of inactive stock piles on shell block	Geo-fabric	Geo- fabric cover to be applied to 11,500 m^2 on inactive areas of limestone stockpiles on shell block	Limestone stockpile on shell block is progressively built over 5 years - emergency stock pile for ship dry dock maintenance period Low cost surface stabilisation Flexibility – Can be progressively applied and removed as stockpile is built/reclaimed Can be used in conjunction with wind breaks and chemical suppressants which mitigate dust from worked areas of stockpiles Fixing arrangements for geo-fabric textiles Development approval may be needed Financing approval	0.9 $\mu g/m^3$

Table 3: Recommended Proposed Options to be Taken

Fugitive Dust Source	Dust Control Measure	Option	Description	Factors to consider	Predicted PM_{10} reduction µg/m³ *
Stockpiles	Reduced vehicle movements relocate stockpile closer to process entry point and apply wind shielding	Relocate Bauxite stockpile	Relocate bauxite stockpile from shell block close to MM Pit area and cover inactive area with Geo- fabric	Reduced vehicle movement stockpile closer to MM pit Low cost surface stabilisation Flexibility – Can be progressively applied & removed as stockpile is built/reclaimed Can be used in conjunction with wind breaks and chemical suppressants which mitigate dust from worked areas of stockpiles Cost effective to relocate stockpile when new shipment of Bauxite received Development approval may be needed Financing approval	0.2 µg/m³
Exposed unsealed areas	Paving exposed areas	Paving exposed areas MM block	Bituminise 3000m² of currently unsealed surface near Southern Stockpile & MM block	Sealed area to be maintained with a sweeper/ water cart as required Substrate design and bitumen layers to be designed for front end loader and heavy truck operations Development approval may be needed Financing approval.	0.8 µg/m³
Transfers	Wheel wash	MM transfer wheel wash	Provide MM system wheel wash to reduce track out of dust onto paved surfaces	Install wheel wash to reduce track out Engineering design Development approval may be needed Financing approval.	0.11 µg/m³
Conveyors	Wind shielding	Wind shielding	Provide wind shielding on one side of CS2 CR2 /CR3 conveyors to reduce potential for dust lift off	Materials conveyed are hot, enclosing conveyor will require safety consideration for operators Engineering design Development approval may be needed Financing approval.	NQ
Dust collectors	Redirection of Cement Mill 1 Dust Collector outlet	Redirection of Cement Mill 1 Dust Collector outlet	Change horizontal release from CM1 dust collector to a vertical release	Reduced Noise impacts Engineering design Development approval may be needed Mill shutdown for installation Financing approval	0.45 µg/m³
Storage / processing buildings	Dust collection	Dust Collection	Dust collector for clinker transfer system in CM6 building	The transfer point is enclosed; Application of dust collection will reduce the dust loading within building Potential to lower overall emissions from the building and site. Engineering design Development approval may be needed Financing approval.	NQ

Table 3: Recommended Proposed Options to be Taken

Fugitive Dust Source	Dust Control Measure	Option	Description	Factors to consider	Predicted PM_{10} reduction $\mu g/m^3$ *
Storage / processing buildings	Sealing	Air knives / Blowers on entrance to Clinker Gantry	Install Air knife/blower on CM6 clinker gantry	CM 6 Clinker gantry stockpile already has significant dust control measures in place. Enclosed building, dust collection and rapid raise doors. Application of blowers will reduce potential for dust escape when vehicles pass through entrance doors Engineering design Development approval may be needed Financing approval.	NQ
Storage / processing buildings	Sealing	Upgrade cladding on CM6 gantry	Upgrade cladding to ensure building maintains high standards of dust control	CM6 gantry building has good standard of dust control - rapid-raise door, annex for vehicle entry and dust collection Engineering design Development approval may be needed Financing approval	NQ
Storage / processing buildings	Sealing	Upgrade cladding on CM6 building	Upgrade cladding on CM6 building to improve capture of dust generated from the activities inside	Upgrade cladding to better seal CM6 building Engineering design Development approval may be needed Financing approval	NQ

***NQ: Where off site dust reduction has not been quantified it is estimated PM_{10} reduction < 2 $\mu g/m^3$**

7.0 Plan Submission

Submitted by:

Name

Position

Authorised on behalf of

ADELAIDE BRIGHTON CEMENT LTD.

Signed : ……………………………..

Dated : ………/………../…………...

8.0 Plan Approval

Approved by:

………………………………..

DELEGATE OF THE ENVIRONMENT PROTECTION AUTHORITY

Signed : ……………………………..

Dated : ………/………../…………...

Appendix A

Birkenhead Cement Plant – Options Assessment Report

Prepared for:

Adelaide Brighton Cement Ltd

August 2018

Final

Prepared by:

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Prepared by:	Michael Burchill & Sarah-Jane Donnelly
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Disclaimer

http://katestone.com.au/disclaimer/

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m^3	cubic metres
m^3/s	cubic metres per second
Nomenclature	**Definition**
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PM_{10}	particulate matter with a diameter less than 10 micrometres
$PM_{2.5}$	particulate matter with a diameter less than 2.5 micrometres
Abbreviations	**Definition**
Air EPP	Environment Protection (Air Quality) Policy 2016
CKD	Clinker Kiln Dust
EET	Emission Estimation Technique
EP Act	Environment Protection Act 1993
EF	Emission factor
EPA	Environment Protection Authority
MM	Fringe Materials Management System
NPI	National Pollutant Inventory database

EXECUTIVE SUMMARY

Katestone Environmental Pty Ltd (Katestone) was commissioned by Adelaide Brighton Cement (ABC) to complete an Assessment of Options Study into dust management at the Birkenhead Cement Plant (the Facility) and to produce an Options Assessment Report.

The existing dust emissions and controls from the site were quantified. Best practice control technology was identified for each area of the Facility that contributes to fugitive dust emissions.

The expected environmental outcomes that could be achieved by the various options were identified in terms of the change in emission rate of PM_{10} and predicted change in concentrations at the Community Park and Gunn Street locations.

1. INTRODUCTION

Katestone Environmental Pty Ltd (Katestone) was commissioned by Adelaide Brighton Cement (ABC) to complete an Assessment of Options Study into dust management at the Birkenhead Cement Plant (the Facility) and to produce an Options Assessment Report.

The Facility is located in the suburb of Birkenhead in South Australia and is around 13 kilometres from the Adelaide CBD. Birkenhead is a predominantly residential suburb situated between port facilities occupying the adjacent banks of the Port River to the east and the suburbs of Exeter and Peterhead to the west. The Facility has operated since 1913. The Facility manufactures cement that is used in the construction and mining industry.

Under the *Environment Protection Act 1993* (EP Act), ABC's activities are managed through an EPA Licence that authorises the carrying out of prescribed activities including: *cement works and bulk shipping facilities*. The Facility operates under Licence Number 1126 (the licence), issued by the SA Environment Protection Authority (SA EPA) on 1 November 2017. This report satisfies the condition *U-730 Assessment of Options* in the licence which requires a 'detailed assessment of options to prevent or minimise particulate emissions.'

The scope of work for this Options Assessment Report is as follows:

- Conduct a Best Management Practice Study to identify the most practicable means to reduce particulate emissions at the Facility.
- Prepare a report of the study that includes the following:
    - Identification, quantification and justification of existing measures that are being used to minimise particulate emissions at the Facility
    - Identification, quantification and justification of best practice measures that could be used to minimise particulate emissions at the Facility
    - Evaluation of the expected environmental (air quality) outcomes of implementing these best practice measures at the Facility.

2. ABC OVERVIEW

2.1 Operations

The following prescribed activities are conducted at the Facility:

- Cement Works
- Activities producing listed waste
- Bulk shipping facilities
- Crushing, grinding or milling; rock, ores or minerals
- Fuel burning.

2.2 Obligations under ABC's Licence

ABC was issued a revised licence for the Facility (Licence No 1126) on 1 November 2017.

Condition 4.1 of the Licence requires ABC to commission a suitably qualified expert to undertake the Assessment of Options study. This report fulfils the requirements of the condition 4.1.1 of ABC's licence to prepare an Options Assessment Report.

4.1 ASSESSMENT OF OPTIONS (U - 730)

The Licensee must:

4.1.1 ensure a suitably qualified expert:

a undertakes a detailed assessment of options to prevent or minimise particulate emissions from the following sources at the Premises:

i exposed and unsealed areas;

ii external material stockpiles;

iii vehicle movements;

iv material conveyor and transfer systems; and

v dust collector units associated with processing and storage facilities.

4.1.2 submit to the EPA for its approval, by the date listed below, an 'Options Assessment Report', ensuring the report contains but is not limited to:

a the details of the options assessed under sub paragraph 1 of this condition;

b a feasibility assessment of each option;

c the expected environmental outcomes of the options identified;

d the methodology used and considerations made in selecting the preferred measure(s) or action(s); and

e recommendation(s) of proposed options to be taken to prevent or minimise particulate emissions.

3. EXISTING ACTIVITIES AND CONTROL MEASURES

3.1 Sources of emissions of particulate matter

Emissions of particulate matter at the Facility may occur at any point where material is handled, processed, conveyed or open to erosion by the wind. There are a number of different types of emission sources of particulate matter including:

- Stack sources
- Dust collectors
- Fugitive sources.

The Facility has three stack emission sources as follows:

- Dry process kiln main stack (4A)
- Pre-calciner plant stack (4B)
- Slag processing plant (SPP).

There are more than 70 dust collectors installed throughout the facility that remove particulate matter from air before it is vented to the environment or reintroduced into a building. Dust collectors that vent inside a building are not considered sources of emissions to the environment. The three dust collectors attached to the cement mill sheds account for approximately half of all emissions from the dust collectors (Katestone, 2017).

There are a number of fugitive emission sources at the Facility, including:

- Unloading of limestone from ships
- Onsite transfers of limestone, gypsum, shale, black sand, mill scale, bauxite and slag
- Wind erosion of stockpiles
- Wind erosion of exposed unsealed areas
- Vehicle movements on paved and unpaved areas
- Combustion emissions from vehicles onsite.

A schematic showing the location of fugitive dust sources as well as the stacks and dust collectors is presented in Figure 1.

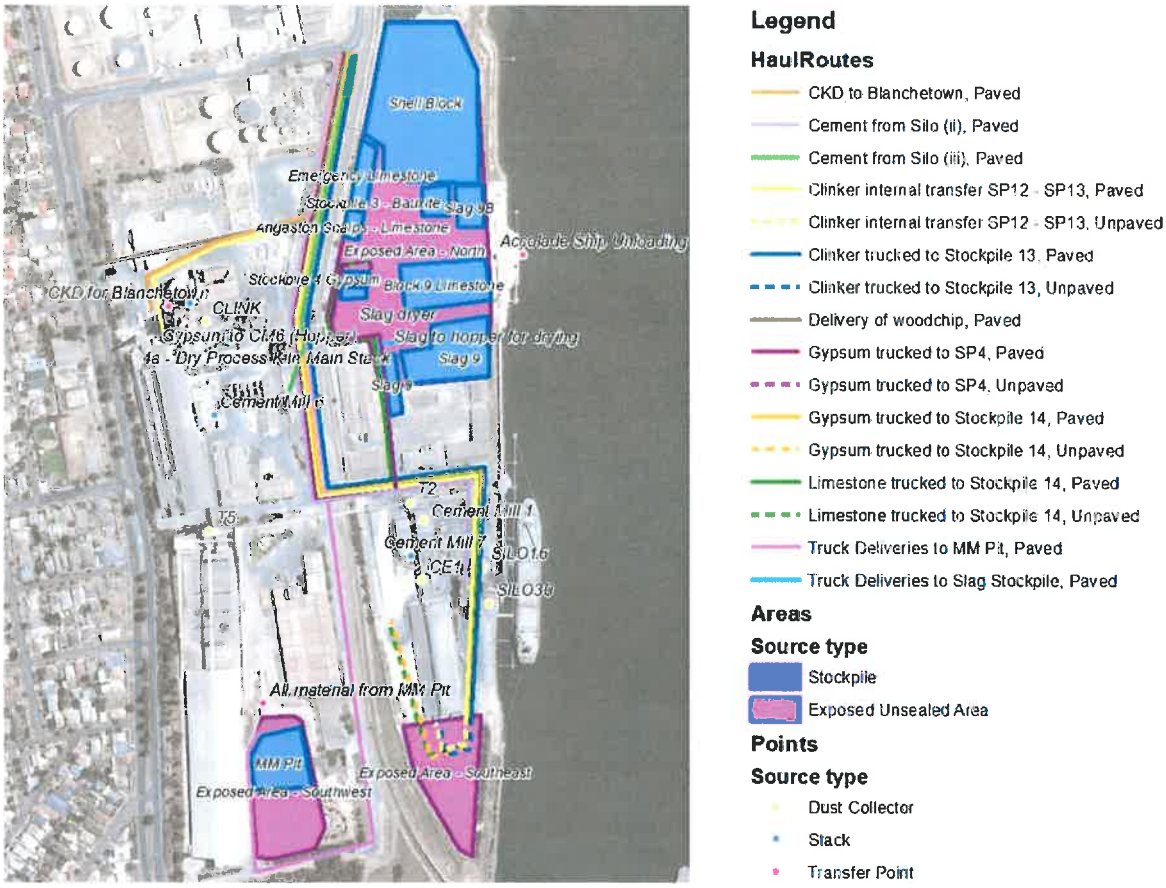

Figure 1 **Schematic of Facility showing locations of stacks, dust collectors and fugitive dust sources**

3.2 Existing particulate matter control measures

The control measures currently in place at the Facility and their estimated efficiency are shown in Table 1.

Table 1 **Dust controls in place at the facility**

Control	Activities	Control efficiency
4-sided enclosure with water sprays	Ship unloading	95%
3-sided hopper	Limestone hopper, Slag hopper	90%
Enclosure with dust suppression	Transfer of miscellaneous materials (MM)	98%
3-sided bunkers with wind canopies	MM Pit stockpiles	90%
3-sided bunkers with hard stand base	Slag stockpile	90%
Chemical suppressant	Stockpiles (limestone, slag, bauxite, gypsum), exposed unsealed areas	80%
Chemical suppressant	Unpaved roads	80%
Water cart	Paved roads	75%
Watering	Limestone stockpile	50%

Control	Activities	Control efficiency
Shade cloth – reduce wind speed and collect dust	Whole of site	Unquantified
Wheel wash	Import/export of bulk material in pneumatic tankers	Unquantified

3.3 Estimated emissions of TSP, PM_{10} and $PM_{2.5}$

A complete emissions inventory was prepared as part of the *Air Quality Assessment of the Birkenhead Cement Plant* (Katestone, 2017) (the Air Quality Assessment). All activities with the potential to generate emissions of TSP, PM_{10} and $PM_{2.5}$ were identified and their emission rates estimated for the 2015/16 financial year accounting for existing emission control measures. Emissions have been calculated primarily using the NPI Emissions Estimation Technique (EET) Manual for Cement Manufacturing v2.1 (NPI, 2008). Emissions from vehicle movements have been calculated using NPI EET Manual for mining (NPI, 2012) and the US EPA AP42 Paved Roads handbook (US EPA, 2011). These emission rate estimates are reproduced in Table 2 and have been used as a baseline from which to quantify the potential benefits that may be achieved by adopting alternative particulate matter controls.

The Facility's dust inventory is dominated by emissions from the cement kiln stacks 4A and 4B, which are presented for comparison purposes only because the options assessment is principally concerned with sources of fugitive particulate matter. The proportions of PM_{10} emissions by source are shown graphically in Figure 2. The kiln stacks have not been included in this figure to focus attention on the contribution of fugitive emissions.

To simplify the presentation in Figure 2 and the subsequent analysis in Section 4 and Section 5, PM_{10} is presented as representative of all particulate matter. The TSP:PM_{10} and PM_{10}:$PM_{2.5}$ ratios are relatively consistent across fugitive sources, and importantly, controlling PM_{10} emissions will lead to similar reductions of TSP and $PM_{2.5}$ size fractions as well.

Table 2 Summary of normal operations emissions inventory

Activity	Emission rate (g/s)			Emission rate (kg/year)		
	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
Handling - Transfer points	0.003	0.001	0.000	51	24	4
Handling - Stockpiles	0.012	0.006	0.001	272	128	19
Stockpile wind erosion	0.156	0.078	0.012	4,907	2,454	368
Exposed unsealed areas wind erosion	0.293	0.147	0.022	9,248	4,624	694
Dust collectors	0.508	0.170	0.132	16,011	5,363	4,164
Vehicle movements - unpaved	0.077	0.021	0.002	2,415	666	67
Vehicle movements - paved	0.398	0.076	0.018	12,554	2,410	583
Combustion emissions – vehicles/stationary engines	0.039	0.039	0.035	1,233	1,233	1,118
Stacks [a]	4.749	3.049	1.199	149,775	96,164	37,822
Total	**6.2**	**3.6**	**1.4**	**196,466**	**113,066**	**44,839**

Table note:
[a] Stack emissions are presented here for comparison purposes. The options assessment is concerned with fugitive particulate emissions only

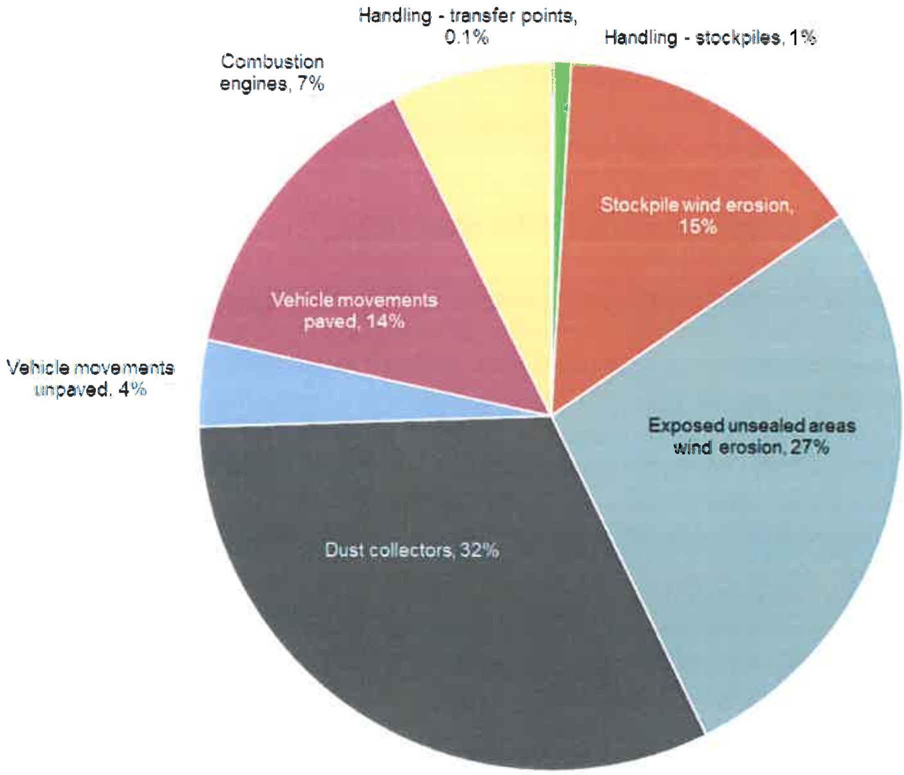

Figure 2 Emissions of PM_{10} by source for normal operations (excluding stacks)

Predicted contributions of each source group to PM_{10} concentrations at the Community Park and Gunn Street were estimated in the Air Quality Assessment and are reproduced in Figure 3 and Figure 4. The Community Park and Gunn Street monitors are located between the Facility and the residential area to the west. They are therefore representative of the maximum potential concentrations of fugitive particulates within the residential area.

The figures show that the contributions of sources during each of the 25 highest days are relatively consistent. The analysis of options in Section 5 considers the potential change in concentrations predicted by modelling at the two monitoring locations. In this analysis, the change in concentration on the worst-case predicted day is presented, as well on the 99^{th}, 95^{th} and 90^{th} percentile days.

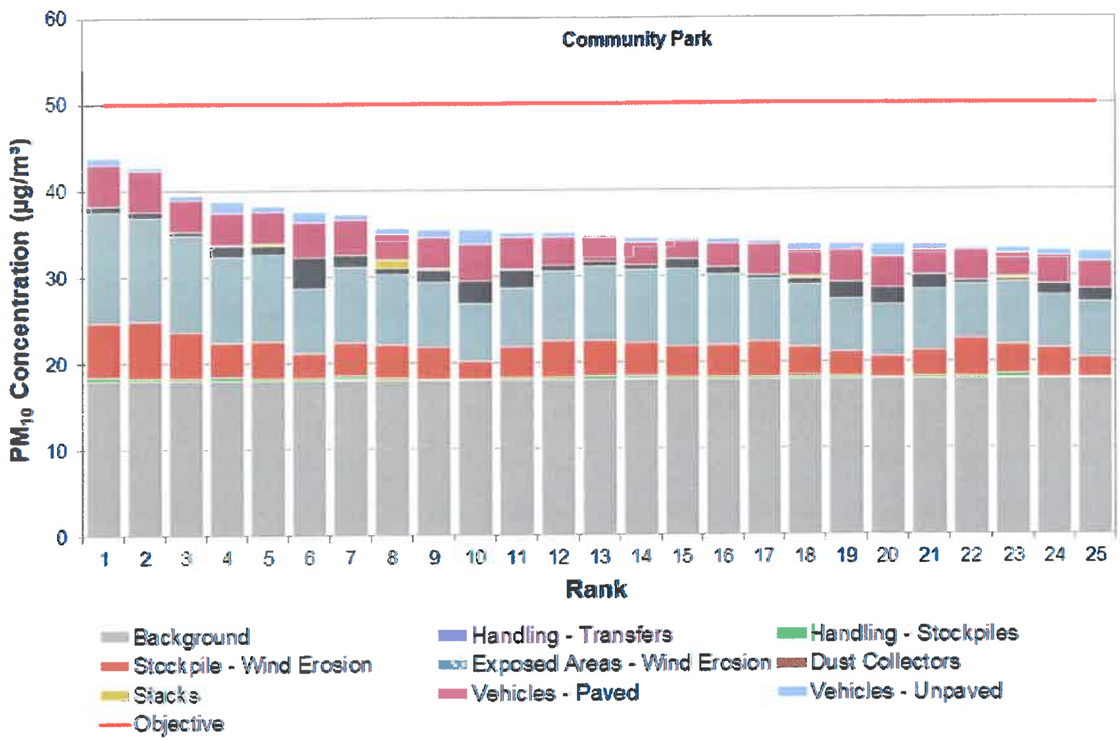

Figure 3 Source contributions for the top 25 predicted 24-hour average concentrations of PM_{10} at the Community Park

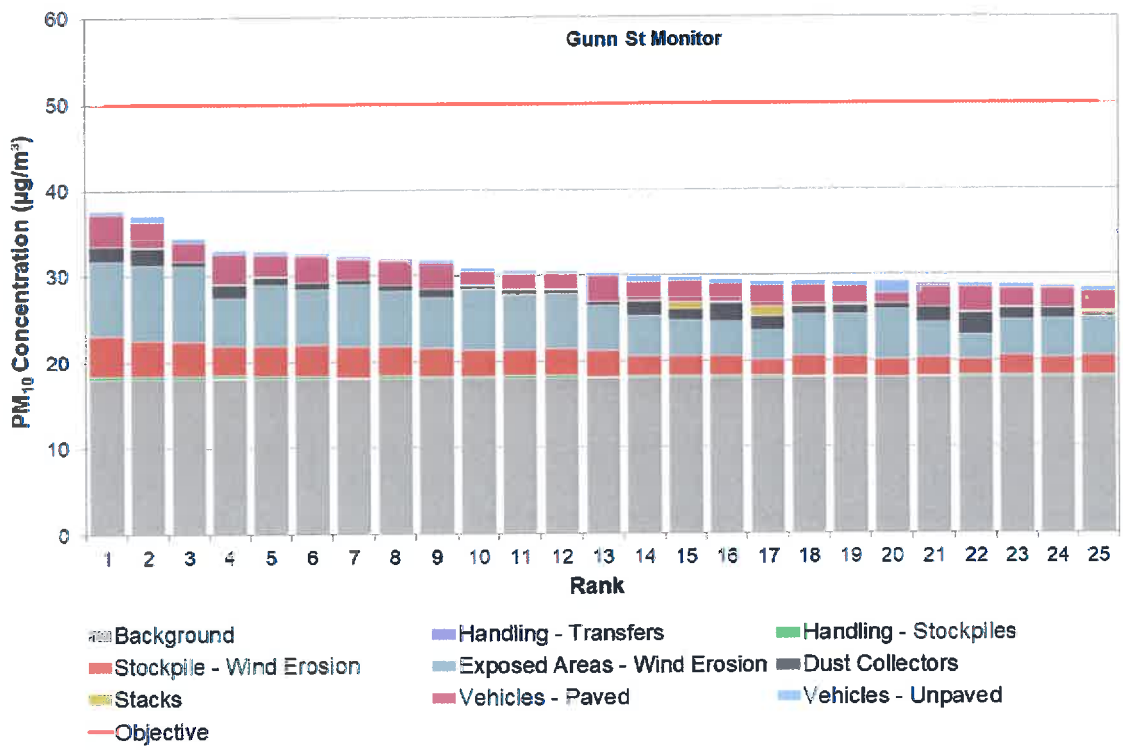

Figure 4 Source contributions for the top 25 predicted 24-hour average concentrations of PM_{10} at Gunn Street

4. BEST PRACTICE MEASURES TO MINIMISE PARTICULATE EMISSIONS

The following section describes best practice measures to minimise particulate emissions from fugitive dust sources that have been identified from relevant literature and industry experience, which may be applicable to emissions sources at the Facility.

4.1 Exposed unsealed areas

Three exposed and unsealed areas are located at the Facility and are included in the Facility's dust inventory:

- North (near Shell block)
- Southeast (near stockpile 13 shed)
- Southwest (Swigg St).

The breakdown of the Facility's dust inventory by area is shown in Figure 5. Since the Facility's dust inventory was completed, the southeast exposed area has been resurfaced with bitumen, significantly reducing its contribution to emissions. Therefore, the northern exposed area is estimated to be the most significant exposed area. Emissions from the exposed unsealed areas were estimated to account for 27% of fugitive emissions.

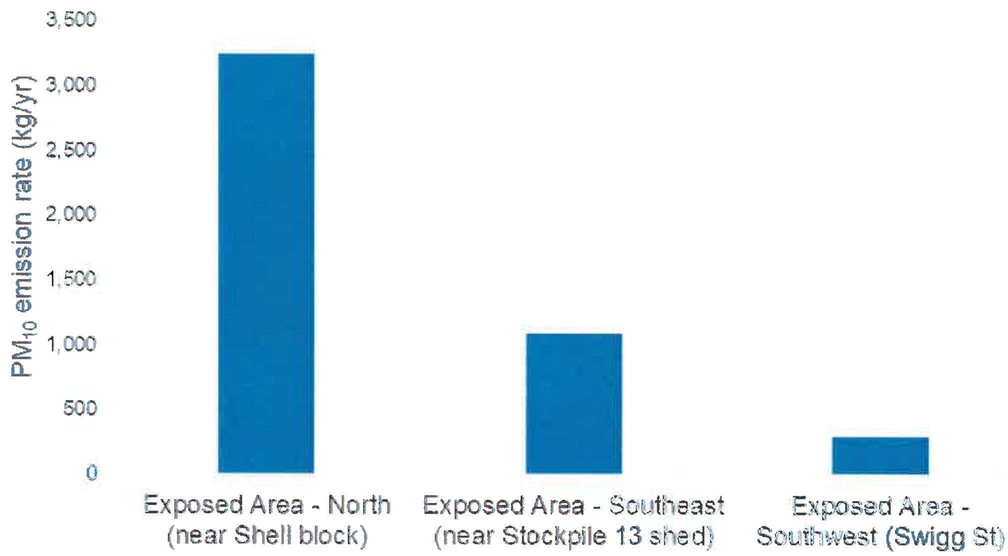

Figure 5 Emissions of PM_{10} by exposed area (kg/yr)

Chemical suppressants and watering are currently used to control emissions from exposed unsealed areas at the Facility. Due to the constantly changing configuration of the areas, as stockpiles are created, worked and removed, chemical suppressants cannot be applied to the entire exposed area.

The following methods can be used to control dust emissions from exposed unsealed areas:

- Stabilise erodible surface:
  - Watering including water cart or automated systems
  - Application of chemical suppressants
  - Permanently stabilise surface e.g. bitumen, hard stand.

- Shield erodible surface:
    - Wind breaks
    - Vegetated wind breaks.
- Management/housekeeping:
    - Clean-up dusty surfaces
    - Reduce spillages
    - Investigate cause of spillages
    - Site based management plan to identity clean-up of spillage.

Wind erosion of exposed areas of spillage is minimised through good housekeeping practices that minimise spillage of material in the first instance or reduce the time before spilled material is cleaned. Good housekeeping practices identified in the literature include:

- Cleaning up spillages when they occur
- Wetting down hard stand areas
- Utilising mobile water carts
- Investigating causes of spillage
- Implementing a site management plan that includes protocols for identification and clean-up of spillage.

The literature does not quantify the effectiveness of implementing good housekeeping practices because the effectiveness will depend the current state of housekeeping and on the specific improvements that are implemented. In some instances, the effectiveness of certain interventions can be inferred from experience with other activities. For example, a 50% effectiveness could be applied to the action of wetting down hard stand areas based on the literature for stockpile control measures.

A summary of management and control measures for exposed areas is presented in Table 3.

Table 3 ABC benchmarking against best practice for exposed unsealed areas

Activity / management approach	Best practice example	Current ABC implementation
Surface stabilisation	Watering	Watering
	Suppressants	Suppressants
	Re-surfacing	Re-surfacing of some areas has occurred
Wind speed reduction	Wind break	Wind breaks (Shade cloth)
	Vegetated wind break	Vegetated wind break (southwest area and along Victoria Road)
Management	Spill minimisation	Spill minimisation
	Wetting down working area	Wetting down working area
	Site management plan	Site management plan

4.2 External material stockpiles

Emissions from stockpiles account for 15% of fugitive particulate emissions from the Facility.

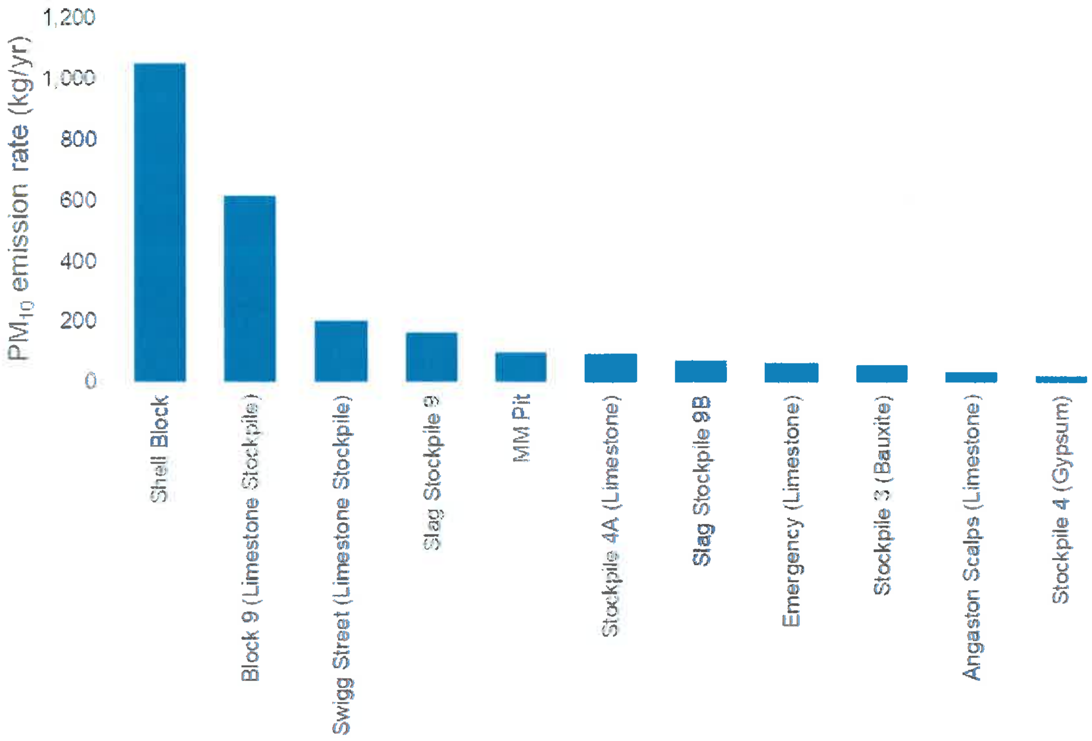

Figure 6 **A breakdown of PM_{10} emissions per year for each stockpile (kg/yr)**

Material stockpiles have a large erodible surface area that is susceptible to generation of emissions of particulate matter by the wind (wind erosion). In addition to stockpile surface area, height, shape and configuration, emissions generated by wind erosion are also dependent on the frequency of disturbance of the erodible surface and the characteristics of the material in the stockpile.

The NSW Coal Mining Benchmarking Study (Katestone, 2011) identified control measures in use at coal mines, but these controls are expected to be broadly applicable to all stockpiled materials. The study identified the following control measures in the literature to minimise stockpile emissions:

- Bypassing stockpiles (through loading)
- Watering to minimise lift-off with automatic control through continuous cycling and increased application based on meteorological conditions
- Chemical suppressants to bind loose fine surface material in response to adverse weather conditions
- Enclose, tarp, fence, bund or build shelterbelts to reduce ambient wind speeds over stockpiles
- Minimise the residence time of material in stockpiles.

Note that these control measures have been listed without regard to whether their application may be feasible at the Facility.

The NSW Coal Mining Benchmarking Study (Katestone, 2011) identified that the current best practice measures to control emissions of particulate matter from stockpiles include:

- Shaping and orientation to minimise emissions of particulate matter, e.g. aligning with predominant wind direction to minimise area directly exposed.

- Stockpile watering on continuous cycle with modification of cycle depending on prevailing weather conditions to allow greater or lesser watering intensity.

A summary of management and control measures for stockpiles at the Facility is presented in Table 4.

Table 4 ABC benchmarking against best practice for stockpiles

Activity / management approach	Best practice example	Current ABC implementation
Avoidance	Minimise residence time/stockpile size	Residence time and stockpile size minimised where possible subject to economic and process related constraints
	Maximise through loading	Through loading occurs when possible
	Enclosure	A significant amount of stockpiled material on site is already fully enclosed
Surface stabilisation	Chemical dust suppressant	Chemical dust suppressant
	Stockpile watering on continuous cycle with modification of cycle depending on prevailing weather conditions to allow greater or lesser watering intensity	Stockpile watering by watercart Stockpile watering by automated sprinkler system (MM Pit)
Wind speed reduction	Shape/orientation	Stockpile shape and orientation dictated by site constraints, i.e. stockpiles generally fill the available space
	Bunds/walls	MM and Slag stockpiles are enclosed in 3-sided bunkers Northern stockpile area has small bund
	Reduced pile height	Shell block is constructed in tiers minimising stockpile height

4.3 Vehicle movements

Emissions generated by vehicle movements are a large source of emissions at ABC at 18% of fugitive emissions with emissions from paved roads being the larger source at 14% of fugitive emissions. Since the Air Quality Assessment, sections of unpaved road on the southeast corner of the site have been paved with bitumen, further reducing the importance of that source. A further 7% of emissions from the Facility are related to combustion of fuel in vehicles. A breakdown of the paved road emissions inventory by road, vehicle type and material moved is presented in Figure 7.

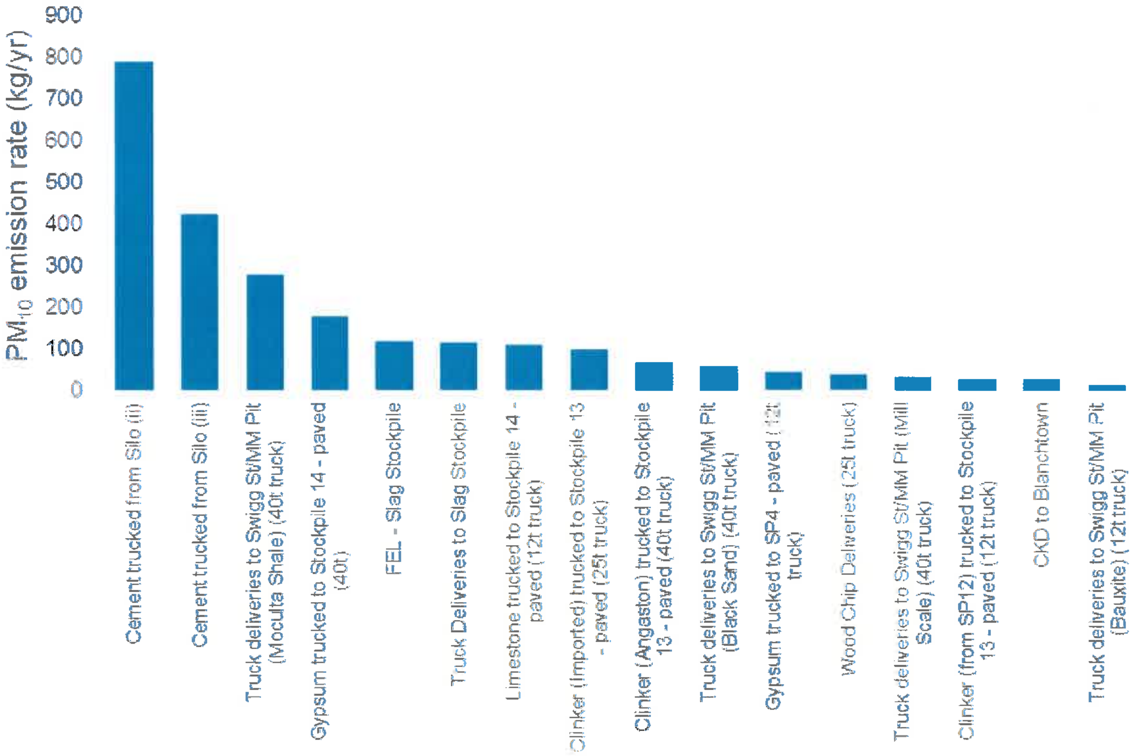

Figure 7 Annual PM_{10} emissions for paved roads (kg/yr)

Methods of dust minimisation for vehicle movements include:

- Surface stabilisation
  - Watering
  - Chemical suppressant
  - Re-surfacing.
- Operations management
  - Road sweeping
  - Truck wash
  - Optimise vehicle movements
  - Reduce unnecessary trips.
- Housekeeping
  - Clean dusty road surfaces
  - Reduce spillages
  - Investigate cause of spillages
  - Site based management plan.

ABC currently uses chemical dust suppressants on unpaved roads and operates a street-sweeper and watercart on the paved roads. The size of trucks and front-end loaders has been optimised to maximise efficiency, which minimises vehicle movements.

A summary of management and control measures for vehicle movements at ABC is presented in Table 5.

Table 5 ABC benchmarking against best practice for vehicle movements

Activity / management approach	Best practice example	Current ABC implementation
Surface stabilisation	Watering	Watering (paved roads)
	Chemical suppressant	Chemical suppressant (unpaved roads)
	Re-surfacing	Most roads are paved
Operations management	Road sweeping	Road sweeping
	Truck wash	Truck wash
	Optimise vehicle movements	Optimise vehicle movements
	Reduce unnecessary trips	Reduce unnecessary trips
Housekeeping	Clean dusty road surfaces	Clean dusty road surfaces
	Reduce spillages	Reduce spillages
	Investigate area of spillage	Investigate area of spillage
	Site based management plan	Site based management plan

4.4 Conveyors and transfers

The NSW Coal Mining Benchmarking Study (Katestone, 2011) identified that the design of conveyors within a material transport system has a large bearing upon their potential to emit particulate matter. Water application and wind shielding were the most important items in reducing the quantity of particulate matter emitted. Table 6 summarises the best practice control measures identified for conveyors.

Table 6 Effectiveness of best practice control measures to reduce particulate matter emissions from conveyors

Control Measure	Effectiveness
Application of water at transfer between conveyors	50%
Wind shielding – roof or side wall	40%
Wind shielding – roof and side wall	70%

Water application is the most commonly applied control for the reduction of particulate matter emissions. Surface addition of water at each point of material disturbance (such as a transfer from one conveyor to another) reduces the emission of particulate matter. However, the addition of water is not appropriate for all materials. At the Facility, water can be applied to transfers of limestone, bauxite and other raw materials but cannot be used on slag and clinker transfers.

To minimise lift-off of particulate matter from the conveyors, wind shielding and enclosure of the conveyors are beneficial. Other solutions to reduce the particulate matter generated by the conveyor system are centred upon avoiding spillage and diligent clean-up of spillage when it occurs. Other items include: clean-up launders under conveyors, integrated control systems to prevent overloading of conveyors to prevent spillage, belt washing stations on heads of belts and wind shielding.

A summary of management and control measures for conveyors is presented in Table 7.

Table 7 ABC benchmarking against best practice for conveyors

Activity / management approach	Best practice example	Current ABC implementation
Conveyors	Enclosure	Enclosed conveyors
	Wind shielding	Two sides and a roof
	Application of water at transfers	Unloading of limestone from ships Transfer of limestone to Block 9
	Clean-up launders under conveyors	Not required due to enclosures

4.5 Dust collectors

Dust collectors are a large source of emissions at the Facility at 32% of fugitive emissions. The three dust collectors attached to the cement mill sheds account for approximately half of all emissions from the dust collectors (Katestone, 2017).

The two main ways to maintain a good efficiency and operating performance with a dust collector is:

- Good housekeeping, for example, keeping the unit and the filters clean
- Upgrading old technology.

Dust collectors are regularly maintained and the largest have continuous monitoring to alert ABC to any operating issues, such as torn filter bags.

Dust loads inside main operating buildings may be reduced by the installation and operation of a permanent vacuum system, to allow immediate and effective clean-up of any spills or other deposited dust.

If emissions cannot be practically reduced further at the source, then enhanced dispersion may assist in minimising the effect of a source on the receiving environment. Of the three largest dust collectors, two have vertical releases with significant vertical velocities to assist in dispersion. The third (Cement Mill 1) has a horizontal release that will not assist in dispersing the emissions from this source. Best practice for any significant release would be to ensure a vertical release.

Table 8 ABC benchmarking against best practice for dust collectors

Activity / management approach	Best practice example	Current ABC implementation
Dust collectors	Good housekeeping	Good housekeeping Routine maintenance of dust collectors
	Upgrading old technology	Current technology appropriate
	Vertical release	Cement Mill 6, Cement Mill 7 DCs are vertical

5. PRACTICABILITY OF IMPLEMENTATION OF CONTROL OPTIONS

Individual options identified in Section 4 have been considered in more detail in the section below. The potential environmental benefit of implementing each option has been estimated in two ways relative to the Air Quality Assessment:

- Reduction in emissions, calculated as the reduction in kg of PM_{10} emitted per annum.
- Reduction in potential offsite impacts, calculated as the reduction in 24-hour average PM_{10} concentrations predicted by dispersion modelling at the Community Park, as an average over the 25 highest days.

The benefit associated with each option has been considered independently. Implementing more than one option on a single source will reduce the benefit associated with each subsequent option.

5.1 Bituminise exposed unsealed areas

Paving an exposed surface, with bitumen or concrete, effectively removes the erodible surface and eliminates the potential for dust generation. This may be mitigated by material accumulating on the paved surface from other sources; however, good housekeeping and management practices can minimise this. The type of surface that is used may depend on the activities taking place in an area, not all surfaces may be appropriate for heavy vehicle movements for example, and in some cases, paving may not be a viable long-term option.

While a large proportion of the Facility's area is already sealed, this assessment has assumed that an additional 3,000 m^2 could be found to be paved. This is most likely to be located at the southern end of the site.

The Facility currently has a number of paved areas, both bitumen and hard stand. No additional regulatory or safety implications are related to the paving of more areas.

The benefits to air quality associated with paving exposed areas were determined. The analysis indicates that paving:

- May reduce emissions of PM_{10} by 440 kg/year.
- May reduce maximum 24-hour average concentrations of PM_{10} at the Community Park by 0.8 $\mu g/m^3$.

5.2 Automated sprinkler system

Application of water to exposed unsealed surfaces or material stockpiles is an effective technique for dust control; however, as water evaporates from the surface, materials become more susceptible to dust generation by wind erosion and so water needs to be continually applied to maintain dust suppression. An automated sprinkler system can ensure water is applied where and when required. More frequent applications of less water may achieve greater benefits in dust reduction for less relative water usage. Automated systems may also have the added benefit of not requiring as much labour as a watercart. A benefit of an automated sprinkler system is that it will control the unsealed areas as well as stockpiles.

An example automated sprinkler system applied to the northern stockpile might have the following features:

- 26 individual sprinklers (configuration of 10 along the east and west edges and 6 along the northern boundary) to provide coverage over entire area.

There may be regulatory implications regarding the discharge of runoff to drains or directly to the Port River. Further investigation into these requirements should be undertaken in the detailed design phase. There may be additional safety implications due to the operation of an automated sprinkler system related to operation of the sprinklers while vehicles are operating within the area. Care must be taken that the ground does not become difficult to traverse due to excess water. Excess water on trafficked areas may also lead to track-out of mud on the vehicle tyres. As this material dries, it may be resuspended via vehicles or wind erosion, counteracting the benefits of the

watering. Watering of areas that have chemical dust suppressant will decrease or eliminate the effectiveness of the suppressant. Appropriate configuration of the sprinkler system can effectively mitigate these risks.

The benefits to air quality associated with implementing an automated sprinkler system to control dust from exposed unsealed areas and stockpiles in the northern stockpile area were determined. The analysis indicates that a sprinkler system:

- May reduce emissions of PM_{10} by 2,000 kg/year.
- May reduce maximum 24-hour average concentrations of PM_{10} at the Community Park by 3.6 µg/m³.

5.3 Fogger cannons

Application of water to exposed unsealed surfaces or material stockpiles is an effective technique for dust control; however, as water evaporates from the surface, materials become more susceptible to dust generation by wind erosion and so water needs to be continually applied to maintain dust suppression. A portable fogger system can ensure water is applied where and when required. Applications of water from a fogger may achieve greater benefits in dust reduction for less water usage relative to a watercart or sprinkler. A benefit of a portable fogger system is that it will control the unsealed areas as well as stockpiles.

A portable fogger system might include 2 fogger cannons to provide suitable coverage.

There may be regulatory implications regarding the discharge of runoff to drains or directly to the Port River. Further investigation into these requirements should be undertaken in the detailed design phase. There may be additional safety implications due to the operation of the fogger system while vehicles are operating within the area. Care must be taken that the ground does not become difficult to traverse due to excess water. Excess water on trafficked areas may also lead to track-out of mud on the vehicle tyres. As this material dries, it may be resuspended via vehicles or wind erosion, counteracting the benefits of the watering. Appropriate configuration and operation of the foggers will mitigate this risk.

The benefits to air quality associated with implementing a fogger system to control dust from exposed areas and stockpiles in the northern stockpile area were determined. The analysis indicates that a fogger system:

- May reduce emissions of PM_{10} by 2,000 kg/year.
- May reduce maximum 24-hour average concentrations of PM_{10} at the Community Park by 3.6 µg/m³.

5.4 Geofabric cover on stockpiles

A geofabric cover is an impermeable fabric sheet that can be used to line stockpile surfaces or line landfill pits. Applying a geofabric cover to an inactive stockpile will prevent wind erosion from the surface while also reducing the requirement for chemical suppressant and water. The geofabric is applied to the finished stockpile, therefore, dust control methods need to be applied whilst the stockpile is being constructed, such as watering. Geofabrics may have limited applicability at the site due to stockpile turnover.

There are no safety implications related to the use of geofabric covers on stockpiles. However, development approval may be required.

The benefits to air quality associated with applying geofabric covers to 11,500 m² of inactive stockpiles within the northern limestone stockpile area were determined. The analysis indicates that use of geofabric covers:

- May reduce emissions of PM_{10} by 100 kg/year.
- May reduce maximum 24-hour average concentrations of PM_{10} at the Community Park by 0.9 µg/m³.

5.5 Relocate bauxite stockpile to an area adjacent to MM area

Optimisation of the location of raw material stockpiles may lead to the following benefits:

- Reduced vehicle movements if stockpile is closer to entry point to the process.
- Separation of high frequency and low frequency stockpiles may allow more appropriate controls to be more widely applied, e.g. greater area of chemical suppressants applied to low frequency stockpile and more watering on high frequency stockpile

Installing a dedicated bauxite storage bunker at the southern end of the site, adjacent to the MM Pit, will likely provide these benefits, in addition to the benefit provided by the bunker walls. Alternatively, as the bauxite stockpile is not a high-turnover stockpile, a geofabric cover may be used.

There are no additional safety implications related to the relocation of a stockpile, an additional bunker within the Facility or the use of geofabric covers. However, development approval may be required.

The benefits to air quality associated with relocating the bauxite stockpile to a dedicated storage bunker were determined. The analysis indicates that the new bunker:

- May reduce emissions of PM_{10} by 120 kg/year.
- May reduce maximum 24-hour average concentrations of PM_{10} at the Community Park by 0.2 µg/m³.

The benefits to air quality associated with relocating the bauxite stockpile and covering with geofabric were determined. The analysis indicates that the geofabric:

- May reduce emissions of PM_{10} by 130 kg/year.
- May reduce maximum 24-hour average concentrations of PM_{10} at the Community Park by 0.2 µg/m³.

5.6 Windbreak – bunker walls

A windbreak or wind fence around a stockpile can be used to slow down the wind and reduce the potential for generation of dust lift-off. Windbreaks can reduce wind speeds by over 60% of the incoming wind speed over large areas. This in turn greatly reduces that amount of dust generated by stockpile wind erosion as dust generation is a function of the wind speed.

Wind breaks for stockpiles may take the form of fixed barriers, porous barriers such as shade cloth or vegetation. Currently, the Facility has examples of all three of these wind breaks in different locations. Effective wind breaks may take up land that may otherwise be used for productive purposes e.g. stockpiles.

No additional safety implications are related to the presence of well designed and constructed wind breaks. However, development approval may be required.

The analysis considered bunker walls around and inside the Shell Block stockpile area as well as a wall along the edge of the Block 9 stockpile. The Block 9 wall was ultimately determined to not be feasible due to a lack of available space.

The benefits to air quality associated with installing wind breaks to control dust from exposed areas and stockpiles were determined.

The analysis indicates that bunker walls at Shell Block:

- May reduce emissions of PM_{10} by 3,500 kg/year.
- May reduce maximum 24-hour average concentrations of PM_{10} at the Community Park by 7.0 µg/m³.

5.7 Windbreak - curtain

A porous wind break or mesh curtain can reduce wind speeds minimising dust liftoff and transport. A porous wind break of an appropriate material can reduce wind speed without causing additional turbulence. The wind break will be most effective if it reaches above the height of the stockpiles.

If installed at the shell block, a height of approximately 15 m may be required. In this instance significant structural support may be required to ensure stability in high winds. Due to the height of the curtains, visual amenity will need to be considered, however appropriate selection of curtain colour and style may provide a positive change to amenity. Development approval may be required.

The benefits to air quality associated with installing a wind break curtain on one side of the shell block were determined. The analysis indicates that a wind break curtain:

- May reduce emissions of PM_{10} by 1,200 kg/year.
- May reduce maximum 24-hour average concentrations of PM_{10} at the Community Park by 2.3 µg/m³.

5.8 Windbreak - vegetation

A vegetation wind break can reduce wind speeds minimising dust liftoff and transport. An appropriately sized vegetated area can reduce wind speed without causing additional turbulence and also serve to trap airborne dust before it leaves the site. The wind break will be most effective if it reaches above the height of the stockpiles.

A vegetation barrier is likely to require more land than an artificial windbreak such as a wall or curtain. This will lead to a reduction in the available land for stockpiling. A vegetation barrier will also take a number of years to develop to its maximum efficiency of dust control.

There are already vegetated areas within the Facility boundary. There are no additional regulatory or health and safety implications.

The benefits to air quality associated with installing a vegetated wind break on one side of the shell block were determined. The analysis indicates that a vegetated wind break:

- May reduce emissions of PM_{10} by 1,200 kg/year.
- May reduce maximum 24-hour average concentrations of PM_{10} at the Community Park by 2.3 µg/m³.

5.9 Stockpile enclosure

Complete enclosure of a stockpile may effectively eliminate it as a dust source, including wind erosion of the stockpile surface as well as the emissions related to transfer of material to and from the stockpile.

The installation and operating cost of a structure that is large enough to cover a stockpile is likely to be prohibitive. Operating costs would likely include lighting, ventilation and maintenance. Other considerations are the loss of available stockpile area and reduced movement efficiency due to opening/closing doors.

The Facility currently has a number of stockpiles within buildings. The safety implications related to the complete enclosure of stockpiles would be the same as the existing enclosures, i.e. adequate ventilation and lighting would be required. Development approval may be required.

The benefits to air quality associated with the full enclosure of the stockpiles in the northern stockpile area were determined, assuming total control of stockpile wind erosion and transfers in that area. The analysis indicates that full enclosure:

- May reduce emissions of PM_{10} by 4,300 kg/year.

- May reduce maximum 24-hour average concentrations of PM_{10} at the Community Park by 7.8 µg/m³.

5.10 Revegetation of inactive stockpiles

Vegetation lowers wind speeds on a surface and binds the soil effectively eliminating wind erosion. Revegetating an exposed area or inactive stockpile is an effective means of controlling dust emissions. An additional layer of topsoil is often applied and seeded. A surface with low ground cover can be revegetated relatively quickly. The vegetation may require ongoing watering. The vegetation cover is applied to the finished stockpile therefore alternative dust control methods need to be applied as the stockpile is being constructed, such as watering. To be a feasible method of dust control, the vegetation would require a minimum area and a stockpile that will remain inactive for a time.

There may be regulations associated with the selection of vegetation type, e.g. plants may be required to be native to the area. There are no safety implications associated with revegetation of a stockpiles surface.

The benefits to air quality associated with revegetating 2,000 m² of inactive stockpiles within the northern stockpile area were determined. The analysis indicates that revegetation:

- May reduce emissions of PM_{10} by 100 kg/year.
- May reduce maximum 24-hour average concentrations of PM_{10} at the Community Park by 0.2 µg/m³.

5.11 MM transfer enclosure

The MM transfer system currently has a high level of control: rapid raise door, three-sided enclosure with roof and foam suppression sprays on the receival hopper. This system could be improved; however, by extending the enclosure and installing a second rapid-raise door on the exit. This would ensure that one door could be closed at all times, even with long trucks which sometimes use the system, thereby eliminating wind flowing through the enclosure picking up material as it is transferred or material that has been left on the ground. To maintain a suitable working environment within the shed, a dust collector should be installed.

The Facility already has a number of buildings with rapid-raise doors. No additional safety implications are related to the full enclosure of the MM transfer system. However, development approval may be required.

The benefits to air quality associated with enclosing the MM transfer system were determined. The analysis indicates that enclosing the MM transfer:

- May reduce emissions of PM_{10} by 0.4 kg/year.
- May reduce maximum 24-hour average concentrations of PM_{10} at the Community Park by less than 0.001 µg/m³.

5.12 MM wheel wash

Track-out of material carried on the wheels of a vehicles has been observed to occur at the MM transfer system resulting in subsequent resuspension as dust. Installing a wheel wash at the exit of the MM transfer system would eliminate track-out from the system.

The water used in the wheel wash could be captured and held in the existing settling pond close to the MM system. There are no safety implications associated with a wheel wash. However, development approval may be required.

The benefits to air quality associated with installing a wheel wash at the MM transfer system were determined. The analysis indicates that a wheel wash:

- May reduce emissions of PM_{10} by 147 kg/year.
- May reduce maximum 24-hour average concentrations of PM_{10} at the Community Park by 0.1 µg/m³.

5.13 Paving of unsealed roads

Paving an unpaved road effectively removes the erodible surface and eliminates the potential for dust generation. This improvement in emissions may be counteracted by material accumulating on the paved surface from other sources; however, good housekeeping and management practices can minimise this. The type of surface that is used may depend on the activities taking place in an area. Not all surfaces may be appropriate for heavy vehicle movements, for example, and in some cases, paving may not be a viable long-term option. Paving may include covering a surface with bitumen or concrete.

There are very few regularly trafficked unsealed sections of road remaining within the Facility. Therefore, there is no scope for this control option at this current point in time. If haul routes change in the future to include significant movements on unpaved areas, paving should be reconsidered at that time.

5.14 Airknives/blowers on entrance to Clinker Gantries CM1/CM6

The Cement Mill 1 and Cement Mill 6 clinker gantries are stockpiles with significant dust control measures already in place: they are fully enclosed with dust collection and rapid raise doors. Additionally, Cement Mill 6 has an annexe on the vehicle entry point. To further improve the dust control from these sources a high-speed air blower/airknife system could be placed on the doors to ensure clinker dust is not emitted as vehicles pass through.

There are no regulatory requirements associated with the installation of a blower system. There are no safety implications related to the operation of the blowers. Due to the location of the entrance of the Cement Mill 6 gantry, noise impacts may need to be considered.

The benefits associated with the installation of blowers on the entrances to the clinker gantries in terms of emissions and off-site concentrations of PM_{10} have not been quantified. The source of dust is intermittent (only while vehicles are entering or exiting the building) and is mitigated by the dust collection on the buildings and good housekeeping. Nonetheless, anecdotally the gantry entrances are noted to be sources of dust and this option is identified as a relatively inexpensive form of control.

5.15 Enclose CS2, CR2 and CR3

The majority of Facility conveyors are enclosed with two sides and a roof. Conveyors that are not fully enclosed are CS2, CR2 and CR3 conveyors. Installing additional wind shielding on one or both sides of these conveyors would reduce wind speeds over the conveyors and minimise dust lift-off.

Development approval may be required for enclosure of conveyors. Health and safety implications will be important to ensure that the environment within the enclosure is suitable for access for maintenance activities, particularly when considering the enclosure of conveyors that carry heated material and water sprays. In this instance, a single side may be more appropriate.

The benefits associated with the enclosure of CS2, CR2 and CR3 conveyors in terms of emissions and off-site concentrations of PM_{10} have not been quantified.

5.16 Redirection of CM1 Dust Collector

If the emissions cannot be reduced at the source, dispersion may be used to reduce the potential impact of those emissions. The dust collector on Cement Mill 1 (CM1) has a horizontal release, which could be reconfigured to be

a vertical release to improve dispersion. Ideally, the release point should be elevated to be above the height of the CM1 building. This option may have additional benefits in relation to noise from the outlet.

The Facility currently has vertical release points from other dust collectors. No additional safety implications are related to the conversion of the CM1 outlet to a vertical release. However, development approval may be required.

The benefits to air quality associated with the redirection of the CM1 outlet were determined. The analysis indicates that redirecting the CM1 outlet:

- Will have no change on the emissions from the outlet.
- May reduce maximum 24-hour average concentrations of PM_{10} at the Community Park by 0.45 µg/m³.

5.17 Dust collector on the CM6 clinker transfer system

The CM6 clinker transfer system does not currently have a dust collector. Whilst this transfer point is enclosed, application of dust collection will reduce the dust loading within the system. This will lead directly to lower overall emissions from the building and lower the overall dust load from the site.

The benefits in terms of emissions and off-site concentrations of PM_{10} have not been quantified. The primary reason for installing a dust collector is to improve conditions within the building for staff. The additional benefits in reducing emissions of dust are a secondary benefit.

5.18 Upgrade cladding on CM6 building

Operations within the Cement Mill 6 (CM6) building are effectively shielded by its existing cladding but the building is not air tight. Upgrading the cladding on the CM6 building would improve capture of dust generated from the activities inside. Improved cladding may also allow more efficient dust collection and housekeeping activities.

No additional safety implications are related to the upgrade of cladding on the CM6 building. However, development approval may be required.

The benefits in terms of emissions and off-site concentrations of PM_{10} have not been quantified.

5.19 Upgrade CM6 gantry cladding

Maintaining the cladding of the CM6 gantry would ensure the building can maintain high standards of dust control into the future. The CM6 gantry has a number of dust control measures currently in place in addition to the building itself: rapid-raise door, annexe for vehicle entry and dust collection. These systems operate most efficiently with a fully sealed building. Maintaining the existing cladding to seal any small holes would maximise the level of capture and control of dust.

The benefits in terms of emissions and off-site concentrations of PM_{10} have not been quantified. Upgrading the cladding is unlikely to lead to a direct reduction in dust emissions as the building is currently well sealed. Nonetheless, this option is recommended to maintain this high level of control.

6. COMPARISON OF OPTIONS

A summary of the options identified in Section 5 and their predicted reduction in PM_{10} emissions is presented in Table 9. The predicted reduction in peak concentrations at the Community Park and Gunn Street due to the identified options are presented in Table 10.

The benefit associated with each option has been considered independently. Implementing more than one option on a single source will reduce the benefit associated with each subsequent option.

Table 9 Reduction in emissions due to identified control options

Dust Control Measure	Implementation option	PM_{10} reduction (kg/yr)
Windbreak – Shell Block	Full enclosure (Section 5.9), or	4,300
	Bunker walls (Section 5.6), or	3,500
	Curtain (Section 5.7), or	1,200
	Vegetation (Section 5.8)	1,200
Improved water delivery	Automated sprinkler system (Section 5.2), or	2,000
	Fogger cannon system (Section 5.3)	2,000
Surface stabilisation of inactive stockpiles	Geofabric (Section 5.4), or	600
	Revegetation (Section 5.10)	110
Paving exposed areas	Paving exposed areas (Section 5.1)	440
Relocate bauxite stockpile	Bunker walls (Section 5.5), or	120
	Geofabric (Section 5.5)	130
Dust collectors	Redirection of Cement Mill 1 DC (Section 5.16)	0
Transfers	MM transfer wheel wash (Section 5.12)	147
Transfers	Full enclosure MM transfer (Section 5.11)	0.39

Table 10 Reduction in predicted offsite concentrations due to identified control options

Receptor		Community Park									Gunn Street								
Pollutant / Averaging Period		PM_{10} 1-hour average (µg/m³)				PM_{10} 24-hour average (µg/m³)				Dust dep monthly (mg/m²/day)	PM_{10} 1-hour average (µg/m³)				PM_{10} 24-hour average (µg/m³)				Dust dep monthly (mg/m²/day)
Percentile		100	99	95	90	100	99	95	90	100	100	99	95	90	100	99	95	90	100
Dust Control Measure	**Implementation option**																		
Windbreak – Shell Block	Full enclosure (Section 5.9), or	54.8	34.8	8.4	1.8	15.0	9.5	6.9	4.8	4.0	35.3	22.7	5.1	1.3	9.6	7.7	4.2	3.0	2.5
	Bunker walls (Section 5.6), or	49.3	31.4	7.5	1.6	13.5	8.6	6.2	4.3	3.6	31.8	20.4	4.6	1.2	8.6	6.9	3.7	2.7	2.3
	Curtain (Section 5.7), or	16.4	10.5	2.5	0.5	4.5	2.9	2.1	1.4	1.2	10.6	6.8	1.5	0.4	2.9	2.3	1.2	0.9	0.8
	Vegetation (Section 5.8)	16.4	10.5	2.5	0.5	4.5	2.9	2.1	1.4	1.2	10.6	6.8	1.5	0.4	2.9	2.3	1.2	0.9	0.8
Improved water delivery	Automated sprinkler system (Section 5.2), or	25.6	16.3	3.9	0.8	7.0	4.4	3.2	2.2	1.9	16.5	10.6	2.4	0.6	4.5	3.6	1.9	1.4	1.2
	Fogger cannon system (Section 5.3)	25.6	16.3	3.9	0.8	7.0	4.4	3.2	2.2	1.9	16.5	10.6	2.4	0.6	4.5	3.6	1.9	1.4	1.2
Surface stabilisation of inactive stockpiles	Geofabric (Section 5.4), or	7.3	4.6	1.3	0.3	2.4	1.4	1.0	0.7	0.6	4.8	2.9	0.5	0.1	1.3	1.0	0.5	0.3	0.3
	Revegetation (Section 5.10)	1.3	0.8	0.2	0.05	0.4	0.2	0.2	0.1	0.1	0.8	0.5	0.1	0.02	0.2	0.2	0.1	0.1	0.05
Paving exposed areas	Paving exposed areas (Section 5.1)	5.2	3.4	1.0	0.4	1.2	1.0	0.7	0.5	0.3	3.1	2.1	1.0	0.3	0.9	0.7	0.5	0.3	0.3
Relocate bauxite stockpile	Bunker walls (Section 5.5), or	1.7	1.1	0.1	0.02	0.4	0.3	0.2	0.1	0.1	0.8	0.5	0.1	0.04	0.2	0.2	0.1	0.1	0.1
	Geofabric (Section 5.5)	1.9	1.3	0.1	0.02	0.5	0.3	0.2	0.1	0.1	1.1	0.8	0.2	0.04	0.3	0.3	0.1	0.1	0.1

Receptor		Community Park									Gunn Street								
Pollutant / Averaging Period		PM_{10} 1-hour average (µg/m³)				PM_{10} 24-hour average (µg/m³)				Dust dep monthly (mg/m²/day)	PM_{10} 1-hour average (µg/m³)				PM_{10} 24-hour average (µg/m³)				Dust dep monthly (mg/m²/day)
Percentile		100	99	95	90	100	99	95	90	100	100	99	95	90	100	99	95	90	100
Dust Control Measure	Implementation option																		
Dust collectors	Redirection of Cement Mill 1 DC (Section 5.16)	15.9	8.2	0.5	0.01	3.0	1.9	1.1	0.7	1.7	15.4	5.9	0.6	0.1	1.6	1.4	0.9	0.7	1.6
Transfers	MM transfer wheel wash (Section 5.12)	2.9	2.4	0.4	0.1	1.0	0.6	0.4	0.3	0.4	3.9	2.4	0.2	0.03	0.9	0.6	0.4	0.3	0.4
Transfers	Full enclosure MM transfer (Section 5.11)	0.008	0.006	0.001	0.000	0.003	0.002	0.001	0.001	0.001	0.010	0.006	0.001	0.000	0.002	0.002	0.001	0.001	0.001

The environmental benefits of the following options were not able to be quantified, nonetheless they may provide reductions in dust emissions and should be evaluated further:

- Airknives/blowers on entrance to Clinker Gantry
- Enclosure of conveyors
- Dust collector on CM6 clinker transfer system
- Upgrade cladding on CM6 building
- Upgrade cladding on CM6 gantry.

7. CONCLUSIONS

Katestone Environmental Pty Ltd (Katestone) was commissioned by Adelaide Brighton Cement (ABC) to complete an Assessment of Options Study into dust management at the Birkenhead Cement Plant (the Facility) and to produce an Options Assessment Report.

The existing dust emissions and controls from the site were quantified. Best practice control technology and practice was identified for each area of the Facility contributing to fugitive dust.

The expected environmental outcomes that could be achieved by the various options were identified in terms of the change in emission rate of PM_{10} and predicted change in concentrations at the Community Park and Gunn Street locations.

8. REFERENCES

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