Project done for

Zitholele Consulting

Continuous Disposal of Ash at Camden Power Station:

Air Quality Evaluation

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REPORT DETAILS

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List of Acronyms and Symbols

Airshed	Airshed Planning Professionals (Pty) Ltd
Australian EPA	Australian Environmental Protection Agency
Australian NPI	Australian National Pollution Inventory
NAAQS	National Ambient Air Quality Standards
m	metre
m²	Metre squared
m/s	Metre per second
mg/m²/day	Milligram per metre squared per day
mamsl	metres above mean sea level
NAAQS	National Ambient Air Quality Standards
PM_{10}	Particulate Matter with an aerodynamic diameter of less than 10µ
$PM_{2.5}$	Particulate Matter with an aerodynamic diameter of less than 2.5µ
SA	South Africa
SAWS	South African Weather Services
tpa	Tonnes per annum
TSP	Total Suspended Particles
US	United States
US.EPA	United States Environmental Protection Agency
°C	Degrees Celsius

Glossary

"**air pollution**" means any change in the composition of the air caused by smoke, soot, dust (including coal), cinders, solid particles of any kind, gases, fumes, aerosols and odorous substances.

"**ambient air**" is defined as any area not regulated by Occupational Health and Safety regulations.

“atmospheric emission” or **“emission”** means any emission or entrainment process emanating from a point, non-point or mobile source that results in air pollution.

“particulates” comprises a mixture of organic and inorganic substances, ranging in size and shape. These can be divided into coarse and fine particulate matter. The former is called Total Suspended Particulates (TSP), whilst thoracic particles or PM_{10} (particulate matter with an aerodynamic diameter of less than 10 µm) fall in the finer fraction. PM_{10} is associated with health impacts for it represents particles of a size that would be deposited in, and damaging to, the lower airways and gas-exchanging portions of the lung. TSP, on the other hand, is usually of interest in terms of dust deposition (nuisance).

1 Introduction

Camden Power Station, a coal fired power station outside Ermelo in Mpumalanga, is part of Eskom's power generation fleet. Camden Power Station currently disposes of burnt boiler ash with a process called 'wet ashing' which involves disposal of ash by pumping the ash as slurry through a pipeline to the ash facility. Some of the dry ash is also transported to the ash facility with a conveyor belt.

Recent studies have revealed that the current ash disposal facility will not be able to accommodate all the ash to be generated during the remaining operational life of the Camden Power Station. It was determined that the station would require an additional ash disposal facility by 2014. The new ash disposal site will need to cater for an estimated 12,86 million m^3 of ash up to 2023, plus 5 years contingency (2028).

Airshed Planning Professionals (Pty) Ltd was appointed by Zitholele Consulting to determine the potential for dust impacts on the surrounding environment and human health from the proposed operations. Practical mitigation measures need to be considered for the planning/construction and operational phases of the project. The rehabilitation of the site also needs to be assessed.

1.1 Site Description

The proposed activities are primarily surrounded by agricultural small holdings, power generation and mining operations. Major residential areas in the region include Ermelo (~8km northwest). Smaller residential areas in the immediate vicinity of the proposed project include Camden residential. Individual residences (i.e. farm houses) are also in the immediate vicinity of the proposed operations.

1.2 Air Quality Evaluation Approach

The study followed a qualitative approach, using available meteorological data and pollutants typically associated with the proposed activities to evaluate the potential for off-site impacts.

A qualitative assessment is undertaken based on the evaluation of existing windblown dust from ash disposal facility studies, together with the dispersion potential of the site and magnitude of expected impacts from the proposed activities. Based on the qualitative evaluation, mitigation measures are proposed.

1.3 Report Outline

Section 2 of the report provides a description on the site specific dispersion potential through the discussion of near-site surface meteorology.

Section 3 describes the expected process and the associated sources of air pollution followed by the qualitative assessment of the proposed operations on the surrounding environment. A management plan is provided.

Section 4 gives the main findings with recommendation.

The references are provided in Section 5.

2 Air Quality Baseline Evaluation

The baseline evaluation primarily comprises the assessment of near-site surface meteorology. Eskom operate an ambient monitoring station at the Camden Power Station. This information was used to understand the background air pollution in the region.

2.1 Regional Climate and Atmospheric Dispersion Potential

The meteorological characteristics of a site govern the dispersion, transformation and eventual removal of pollutants from the atmosphere (Pasquill and Smith, 1983; Godish, 1990). The extent to which pollution will accumulate or disperse in the atmosphere is dependent on the degree of thermal and mechanical turbulence within the earth's boundary layer. Dispersion comprises vertical and horizontal components of motion. The vertical component is defined by the stability of the atmosphere and the depth of the surface mixing layer. The horizontal dispersion of pollution in the boundary layer is primarily a function of the wind field. The wind speed determines both the distance of downwind transport and the rate of dilution as a result of plume 'stretching'. The generation of mechanical turbulence is similarly a function of the wind speed, in combination with the surface roughness. The wind direction and the variability in wind direction, determine the general path pollutants will follow, and the extent of cross-wind spreading (Shaw and Munn, 1971; Pasquill and Smith, 1983; Oke, 1990).

Pollution concentration levels therefore fluctuate in response to changes in atmospheric stability, to concurrent variations in the mixing depth, and to shifts in the wind field. Spatial variations, and diurnal and seasonal changes in the wind field and stability regime are functions of atmospheric processes operating at various temporal and spatial scales (Goldreich and Tyson, 1988). Atmospheric processes at macro- and meso-scales must be accounted for to accurately parameterise the atmospheric dispersion potential of a particular area. A qualitative description of the synoptic climatology of the study region is provided based on a review of the pertinent literature. The analysis of meteorological data observed for the proposed site, where available, and data for neighbouring sites will provide the basis for the parameterisation of the meso-scale ventilation potential of the site.

The analysis of at least one year of hourly average meteorological data for the study site is required to facilitate a reasonable understanding of the ventilation potential of the site. The most important meteorological parameters to be considered are: wind speed, wind direction, ambient temperature, atmospheric stability and mixing depth. Atmospheric stability and mixing depths are not routinely recorded and frequently need to be calculated from diagnostic approaches and prognostic equations, using as a basis routinely measured data, e.g. temperature, predicted solar radiation and wind speed.

Meteorological data from the Eskom monitoring site at the Camden Power Station was used to describe the dispersion potential at the site for the period 2010-2012.

2.1.1 *Local wind field*

Figure 1 provides period wind roses for the Camden Eskom monitoring station. The predominant wind direction is east to east-southeasterly with more than ~10% frequency of occurrence. Winds from the south are relatively infrequent occurring <3% of the total period. Calm conditions (wind speeds < 1 m/s) occur for 14% of the time.

Winds from the east-southeast increases during day-time conditions. During the night-time an increase in north-northwest flow is observed with a decrease in westerly air flow.

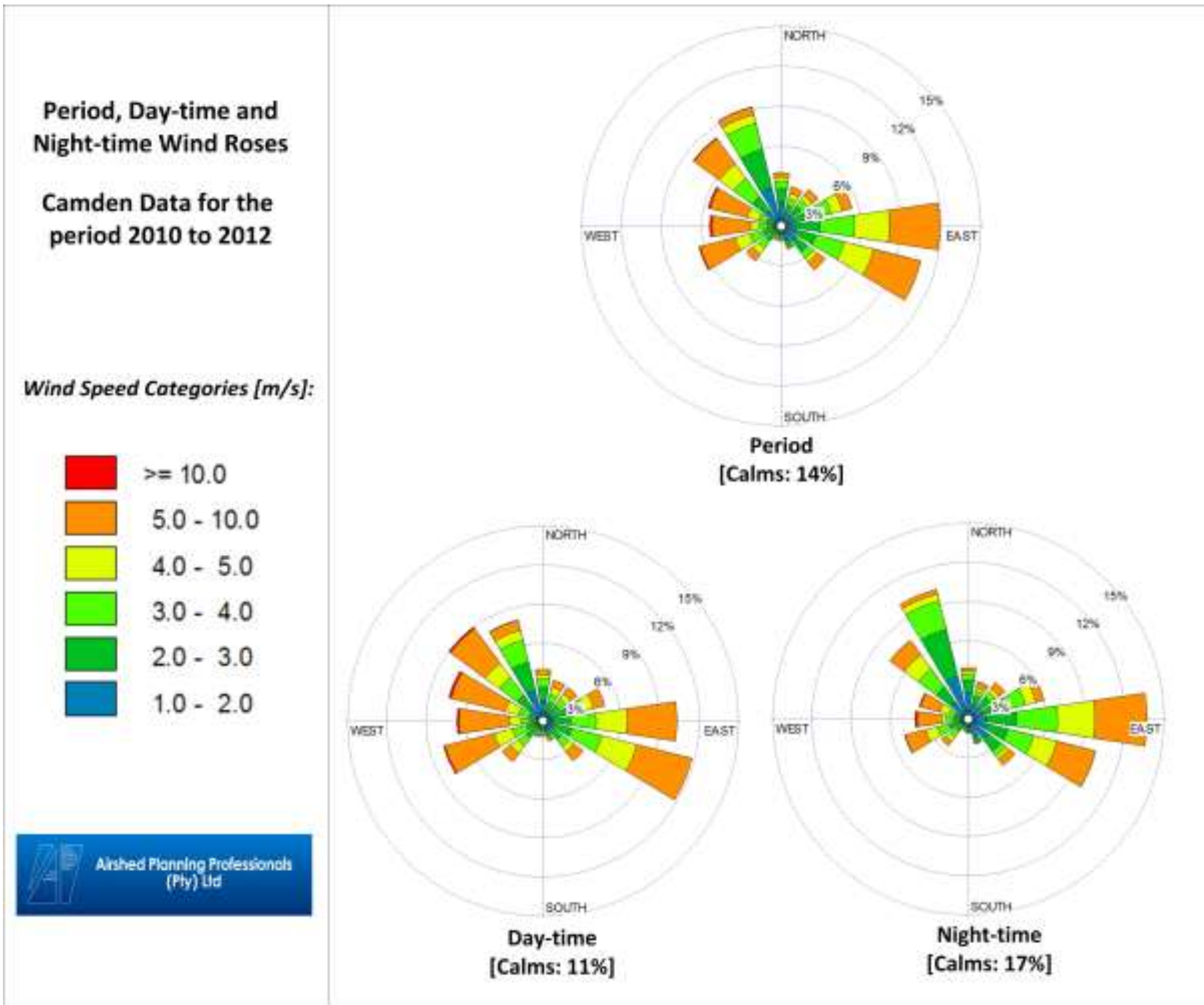

Figure 1: Period, day-time and night-time wind roses for Camden (2010-2012)

2.1.2 *Surface Temperature*

Air temperature has important implications for the buoyancy of plumes; the larger the temperature difference between the plume and the ambient air, the higher the plume is able to rise. Temperature also provides an indication of the extent of insolation, and therefore of the rate of development and dissipation of the mixing layer.

The diurnal temperature profile for the area is given in Figure 2. Annual average maximum, minimum and mean temperatures for the site are given as 30°C, -2°C and 14°C, respectively, based on the measured data at the Eskom Camden monitoring site for the period 2010-2012.

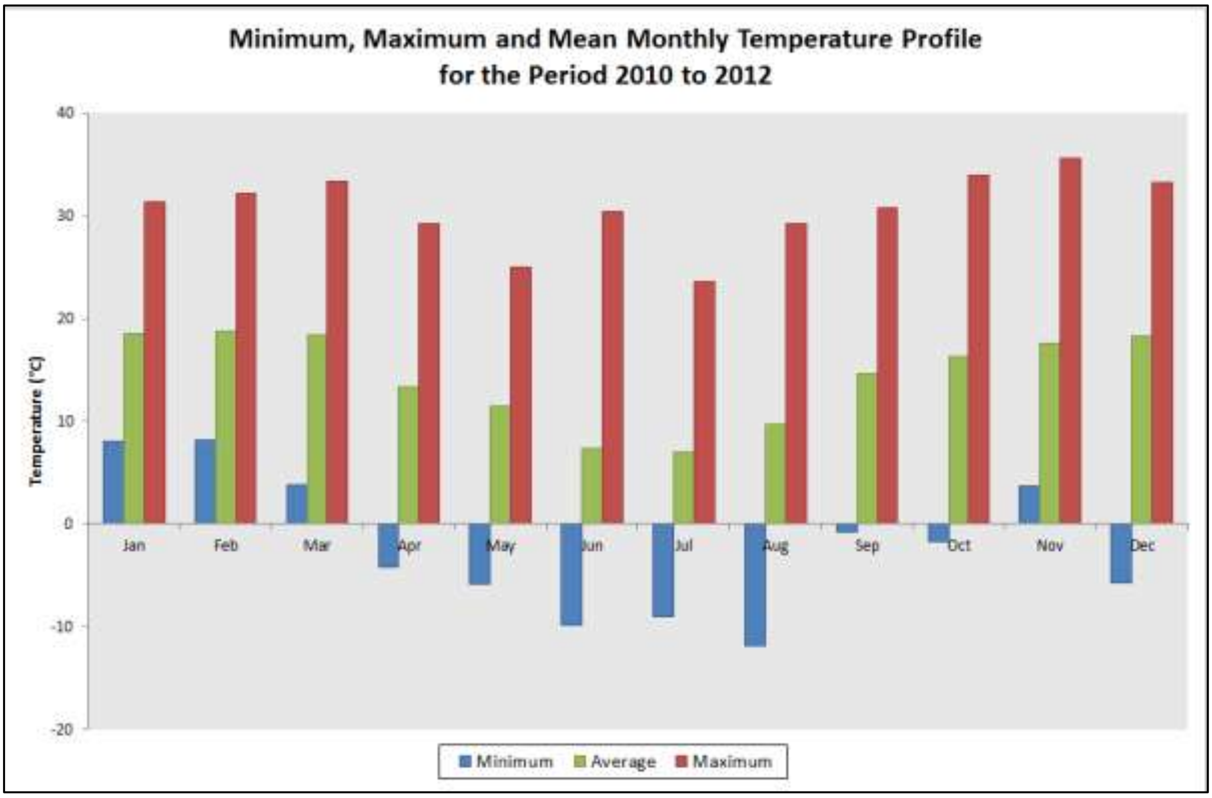

Figure 2: Minimum, maximum and average monthly temperatures for the Camden site during the period 2010-2012

2.1.3 Precipitation

Rainfall represents an effective removal mechanism of atmospheric pollutants and is therefore frequently considered during air pollution studies.

Monthly rainfall for the site for the period 2010-2012 is given in Figure 3. Average monthly rainfall for this period is in the range of 52 mm. The study area falls within a summer rainfall region, with over 70% of the annual rainfall occurring during the October to March period for 2012.

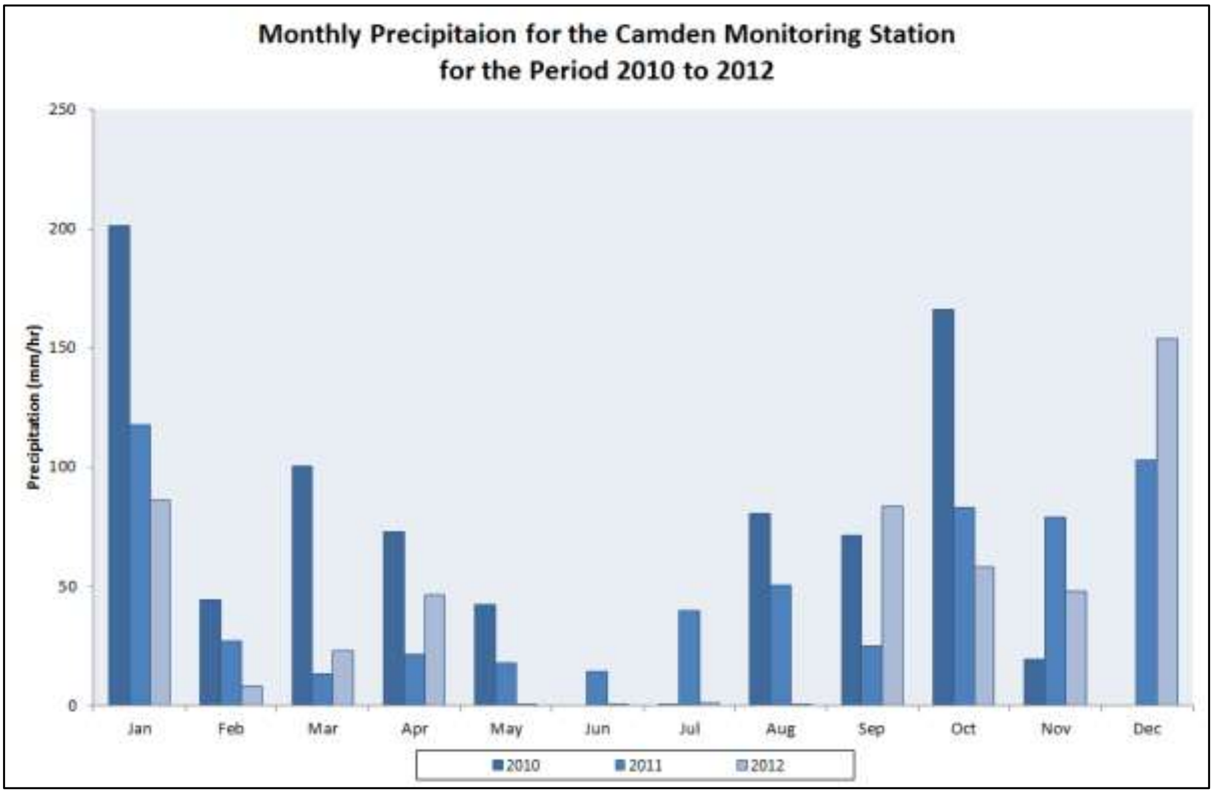

Figure 3: Monthly precipitation for the Camden site during the period 2010-2012

2.1.4 Atmospheric Stability

The vertical component of dispersion is a function of the extent of thermal turbulence and the depth of the surface mixing layer. Unfortunately, the mixing layer is not easily measured, and must therefore often be estimated using prognostic models that derive the depth from some of the other parameters that are routinely measured, e.g. solar radiation and temperature. During the daytime, the atmospheric boundary layer is characterised by thermal turbulence due to the heating of the earth's surface and the extension of the *mixing layer* to the lowest elevated inversion. Radiative flux divergence during the night usually results in the establishment of ground based inversions and the erosion of the mixing layer. The mixing layer ranges in depth from ground level (i.e. only a stable or neutral layer exists) during night-times to the base of the lowest-level elevated inversion during unstable, day-time conditions.

Atmospheric stability is frequently categorised into one of six stability classes. These are briefly described in Table 1.

Table 1: Atmospheric Stability Classes

A	very unstable	calm wind, clear skies, hot daytime conditions
B	moderately unstable	clear skies, daytime conditions
C	unstable	moderate wind, slightly overcast daytime conditions
D	neutral	high winds or cloudy days and nights
E	stable	moderate wind, slightly overcast night-time conditions
F	very stable	low winds, clear skies, cold night-time conditions

The atmospheric boundary layer is normally unstable during the day as a result of the turbulence due to the sun's heating effect on the earth's surface. The thickness of this mixing layer depends predominantly on the extent of solar radiation, growing gradually from sunrise to reach a maximum at about 5-6 hours after sunrise. This situation is more pronounced during the winter months due to strong night-time inversions and a slower developing mixing layer. During the night a stable layer, with limited vertical mixing, exists. During windy and/or cloudy conditions, the atmosphere is normally neutral.

For low level releases, such as due to vehicle entrainment from unpaved roads, the highest ground level concentrations will occur during weak wind speeds and stable (night-time) atmospheric conditions. Wind erosion, on the other hand, requires strong winds together with fairly stable conditions to result in high ground level concentrations i.e. neutral conditions.

2.2 Ambient Air Quality within the Region

The ambient measured daily PM_{10} concentrations for the Eskom Camden monitoring site is provided in Figure 4 for the period 2010 to 2012 with measured frequency of exceedance of NAAQS provided in Table 2. The National Ambient Air Quality Standard (NAAQS) for PM_{10} allows for 4 exceedances per calendar year. The PM_{10} concentrations were measured to exceed the NAAQS at the Camden monitoring station for the period 2010 to 2012.

High ambient particulate concentrations have been found to coincide with low ambient temperatures and low rainfall (Burger, 1994). Increases in domestic coal burning and poor atmospheric dispersion potentials, together with persistent industrial emissions, combine to produce elevated ambient concentrations during winter months. High concentrations during summer months are usually associated with increases in fugitive dust emissions. Rainfall events result in a reduction of airborne concentrations due to reductions in the potential for fugitive dust emissions and due to the removal of particulates in the atmosphere by raindrops.

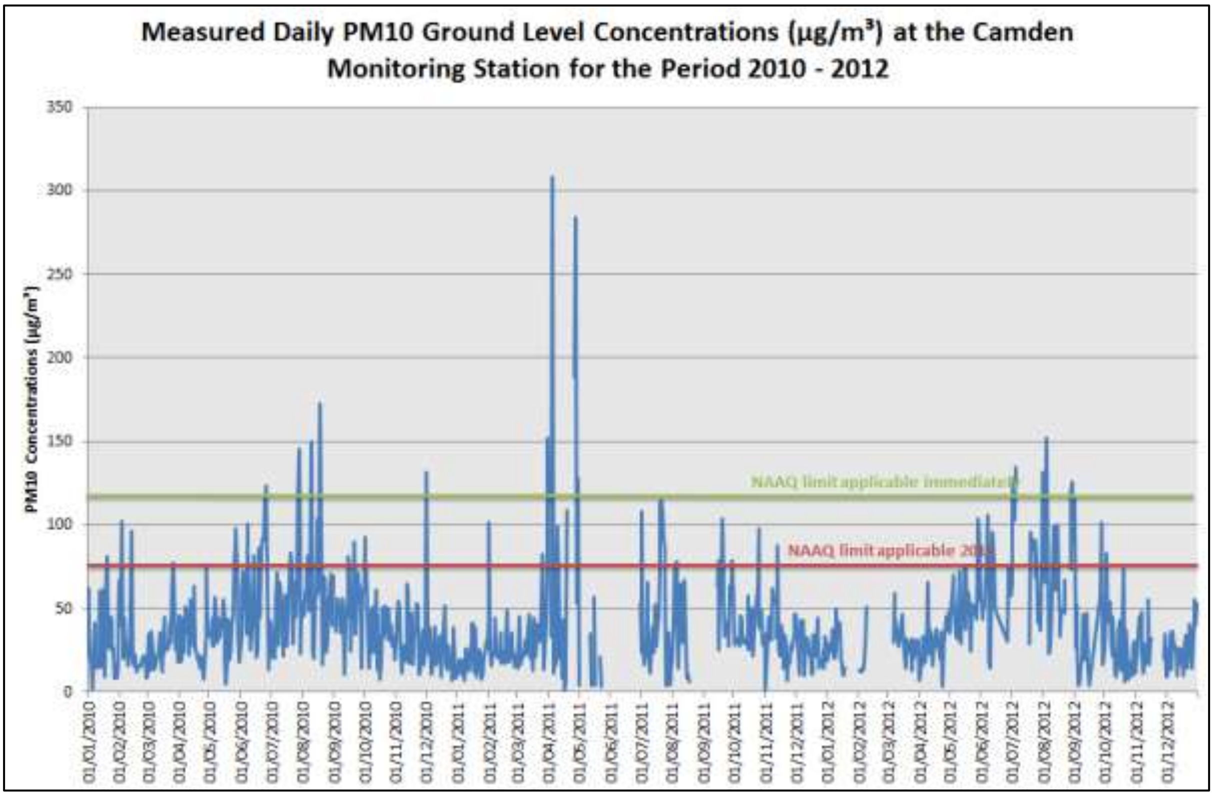

Figure 4: Daily measured PM_{10} and $PM_{2.5}$ ground level concentrations (µg/m³) at the Secunda DEA monitoring station (for the period December 2011) (as downloaded from the SAAQIS website)

Table 2: Measured daily ambient PM_{10} concentrations at Eskom's Camden monitoring station for the period 2010 to 2012

Monitoring Period	Data Availability (%)	Number of Exceedances of the NAAQ limit of 120 µg/m³ (applicable immediately)	Exceedance of the NAAQS (applicable immediately) (Y/N)	Number of Exceedances of the NAAQ limit of 75 µg/m³ (applicable 2015)	Exceedance of the NAAQS (applicable 2015) (Y/N)
2010	95	5	N	34	N
2011	66	5	N	25	N
2012	72	6	N	33	N

3 Air Quality Evaluation

3.1 Source Identification

The project includes the continuous disposal of ash at the Camden Power Station in the Mpumalanga Province.

Closure of the ash disposal facility operations will include rehabilitation of the site through the covering of the ash disposal facility with topsoil before vegetation can take place. Tipping of topsoil onto the cleared areas will generate dust and the freshly exposed topsoil will be prone to wind erosion before vegetation takes over. Movement of vehicles will also be a source of pollution.

The main pollutant of concern associated with operations is particulate matter. Particulates are divided into different particle size categories with Total Suspended Particulates (TSP) associated with nuisance impacts and the finer fractions of PM_{10} (particulates with a diameter less than 10 µm) and $PM_{2.5}$ (diameter less than 2.5 µm) linked with potential health impacts. PM_{10} is primarily associated with mechanically generated dust whereas $PM_{2.5}$ is associated with combustion sources. Gaseous pollutants (such as sulphur dioxide, oxides of nitrogen, carbon monoxide, etc.) derive from vehicle exhausts and other combustions sources such as vehicles. These are however insignificant in relation to the particulate emissions and are not discussed in detail.

Table 3 provides a list of all sources of air pollution associated with the proposed project. The subsequent sections provide a generic description of the parameters influencing dust generation from the various aspects identified.

Table 3: Activities and aspects identified for the construction, operational and closure phases of the proposed operations

Pollutant(s)	Aspect	Activity
Construction Phase		
Particulates	Construction of proposed disposal site	Clearing of groundcover
		Levelling of area
		Wind erosion from topsoil storage piles
		Tipping of topsoil to storage pile
	Vehicle activity on-site	Vehicle and construction equipment activity during construction operations
Gases and particles	Vehicle and construction equipment activity	Tailpipe emissions from vehicles and construction equipment such as graders, scrapers and dozers
Operational Phase		
Particulates	Wind erosion	Exposed ash disposal facility
	Vehicle activity on-site	Vehicle activity at the ash disposal facility

Pollutant(s)	Aspect	Activity
Gases and particles	Vehicle activity	Tailpipe emissions from vehicle activity at the ash disposal facility
Closure/Rehabilitation Phase		
Particulates	Rehabilitation of mined and disturbed areas	Topsoil recovered from stockpiles
		Tipping of topsoil onto ash disposal facility
	Wind erosion	Exposed cleared areas and exposed topsoil during rehabilitation
	Vehicle activity on unpaved roads and on-site	Truck activity at site during rehabilitation
Gases and particles	Vehicle activity	Tailpipe emissions from trucks and equipment used for rehabilitation

3.1.1 Construction Phase

The construction phase normally comprises a series of different operations including land clearing, topsoil removal, road grading, material loading and hauling, stockpiling, compaction, (etc.). Each of these operations has their own duration and potential for dust generation. It is anticipated that the extent of dust emissions would vary substantially from day to day depending on the level of activity, the specific operations, and the prevailing meteorological conditions.

3.1.2 Operation Phase

Wind erosion is a complex process, including three different phases of particle entrainment, transport and deposition. It is primarily influenced by atmospheric conditions (e.g. wind, precipitation and temperature), soil properties (e.g. soil texture, composition and aggregation), land-surface characteristics (e.g. topography, moisture, aerodynamic roughness length, vegetation and non-erodible elements) and land-use practice (e.g. farming, grazing and mining) (Shao, 2008).

Windblown dust generates from natural and anthropogenic sources. For wind erosion to occur, the wind speed needs to exceed a certain threshold, called the threshold velocity. This relates to gravity and the inter-particle cohesion that resists removal. Surface properties such as soil texture, soil moisture and vegetation cover influence the removal potential. Conversely, the friction velocity or wind shear at the surface, is related to atmospheric flow conditions and surface aerodynamic properties. Thus, for particles to become airborne, the wind shear at the surface must exceed the gravitational and cohesive forces acting upon them, called the threshold friction velocity (Shao, 2008).

Estimating the amount of windblown particles to be generated from the proposed ash disposal facility is not a trivial task and requires detailed information on the particle size distribution, moisture content, silt content and bulk density. Dust will only be generated under conditions of high wind speeds (US.EPA, 1995).

3.1.3 Closure Phase

It is assumed that all ashing activities will have ceased during the Closure Phase. The potential for impacts during the closure phase will depend on the extent of rehabilitation efforts on the ash disposal facility. The closure phase will mainly include materials handling activities, wind erosion and to a lesser extent vehicle and equipment movement on site.

3.2 Qualitative Evaluation

3.2.1 Construction Phase

It is not anticipated that the various construction activities will result in higher off-site impacts than the operational phase activities. The temporary nature of the construction activities, and the likelihood that these activities will be localised and for small areas at a time, will reduce the potential for significant off-site impacts.

According to the Australian Environmental Protection Agency on recommended separation distances from various activities, a buffer zone of 300 m from the nearest sensitive receptor is required when extractive industries occur without blasting and a distance of 500 m when blasting will take place (AEPA, 2007).

3.2.2 Operational Phase

The main pollutant of concern from the proposed operations is particulate matter. The impact of particles on human health is largely depended on (i) particle characteristics, particularly particle size and chemical composition, and (ii) the duration, frequency and magnitude of exposure. The potential of particles to be inhaled and deposited in the lung is a function of the aerodynamic characteristics of particles in flow streams. The aerodynamic properties of particles are related to their size, shape and density. The deposition of particles in different regions of the respiratory system depends on their size. The nasal openings permit very large dust particles to enter the nasal region, along with much finer airborne particulates. Larger particles are deposited in the nasal region by impaction on the hairs of the nose or at the bends of the nasal passages. Smaller particles (PM_{10} and $PM_{2.5}$) pass through the nasal region and are deposited in the tracheobronchial and pulmonary regions. Particles are removed by impacting with the wall of the bronchi when they are unable to follow the gaseous streamline flow through subsequent bifurcations of the bronchial tree. As the airflow decreases near the terminal bronchi, the smallest particles are removed by Brownian motion, which pushes them to the alveolar membrane (CEPA/FPAC Working Group, 1998; Dockery and Pope, 1994).

Air quality standards for particulates are given for various particle size fractions, including total suspended particulates (TSP), inhalable particulates or PM_{10} (i.e. particulates with an aerodynamic diameter of less than 10 µm), and respirable particulates of $PM_{2.5}$ (i.e. particulates with an aerodynamic diameter of less than 2.5 µm). Although TSP is defined as all particulates with an aerodynamic diameter of less than 100 µm, and effective upper limit of 30 µm aerodynamic diameter is frequently assigned. PM_{10} and $PM_{2.5}$ are of concern due to their health impact potentials.

The ambient air quality measurements of PM_{10} at the Camden site indicate elevated ambient air quality levels. The ash disposal facility operations will give rise to dust generation. These operations, as discussed under Section 3.1.2, are low level release sources meaning that the dust gets generated at heights of between 0.5 m and 1 m from the ash disposal facility surface.

Wind erosion, will occur during strong wind conditions when wind speeds exceed the critical threshold required to lift and suspend the coal particles. This threshold is determined by the parameters that resist removal such as the particle size distribution of the bed material, moisture content and vegetation. A typical wind speed threshold is given as 5.4 m/s for storage piles (US.EPA, 1995). Wind data for the proposed ash disposal facility site (2009 – 2011) indicate an average wind speed of 3.4 m/s and a maximum of 16.3 m/s.

To provide an indication of the potential distance and significance of impacts from these activities, the US.EPA screening model (TScreen) is used. This model represents a quick method to calculate and "flag" the "worst-case" concentration that might occur. Screening models require very little input and have a built-in set of meteorological conditions based on stability classes (Section 2.1.4). It is a quick screening tool to identify possible sources that might require more detailed modelling. **It is important to note that these models do not use actual meteorological data, but rather set stability classes that will produce the highest impacts**. **The impacts are therefore not related to the actual wind directions or speeds.** More sophisticated Gaussian plume and puff models such as the US.EPA regulatory AERMOD and CALPUFF models use actual meteorological conditions. For the purpose of this study, a screening model is sufficient as the focus of this study is merely to provide an indication of the potential significance of the operations on the surrounding environment.

The particle size distribution of the ash material was based on samples taken from the existing Camden ash disposal facility (Table 4) with the elemental analysis of the material provided in Table 5.

Table 4: Particle size distribution for the ash material

Size (µm)	Fraction
2000	0.1080
1000	0.0740
301	0.0413
140	0.1926
103	0.0911
76	0.0829
56	0.0744
48	0.0334
30	0.0843
16	0.0771
10	0.0407
6	0.0397
3	0.0256
2	0.0119
1	0.0230

Table 5: Elemental analysis of the ash material

Element	Percentage (%)
Silver	0.00002
Aluminium	1.2968
Arsenic	0.00049
Boron	0.0047
Barium	0.0223
Berylium	0.00001
Bismuth	0.00094
Calcium	2.1757
Cadmium	0.00001
Cobalt	0.00049
Chromium	0.0018
Copper	0.0012
Iron	1.7527
Mercury	0.00002
Potassium	0.051
Lithium	0.002
Magnesium	0.3905
Manganese	0.0098
Molybdenum	0.00027
Sodium	0.3766
Nickel	0.001
Phosphorous	0.0978

Element	Percentage (%)
Lead	0.00051
Antimony	0.0004
Selenium	0.00055
Tin	0.0021
Strontium	0.034
Titanium	0.0443
Vanadium	0.0025
Tungsten	0.00072
Zinc	0.0013
Zirconium	0.00066

Figure 5 and Figure 6 provide a graphic representation of the possible highest daily PM_{10} and $PM_{2.5}$ ground level concentrations at set distances from the proposed ash operations. The concentrations are irrespective of actual wind speed and direction and reflect the worst-case scenario. The National Ambient Air Quality Standards (NAAQS) for PM_{10} over a day are 120 µg/m³ at present and 75 µg/m³ from beginning 2015, with four exceedances of these limits allowed over a one year period. The National Ambient Air Quality Standards (NAAQS) for $PM_{2.5}$ over a day are 65 µg/m³ at present, 40 µg/m³ from beginning 2016 to end 2029 and 25 µg/m³ from beginning 2030, with four exceedances of these limits allowed over a one year period. The screening model is not sophisticated enough to indicate the number of exceedances but it provides an indication of the distance at which the limit is exceeded.

With no mitigation in place, the 2015 PM_{10} limit of 75 µg/m³ is exceeded for a distance of ~1700 m from the ash disposal facility. According to the Australian National Pollution Inventory (NPI) wind erosion can be reduced by 50% through water sprays and up to 30% by installing wind breaks. With water sprays enduring 50% reduction from wind erosion, windblown dust will be below the NAAQS limit of 75 µg/m³ at a distance of ~600m from the source.

With no mitigation in place, the 2030 $PM_{2.5}$ limit of 25 µg/m³ is exceeded for a distance of ~1700m from the ash disposal facility. With water sprays enduring 50% reduction from wind erosion, windblown dust will be below the NAAQS limit of 25 µg/m³ at a distance of ~700m from the source.

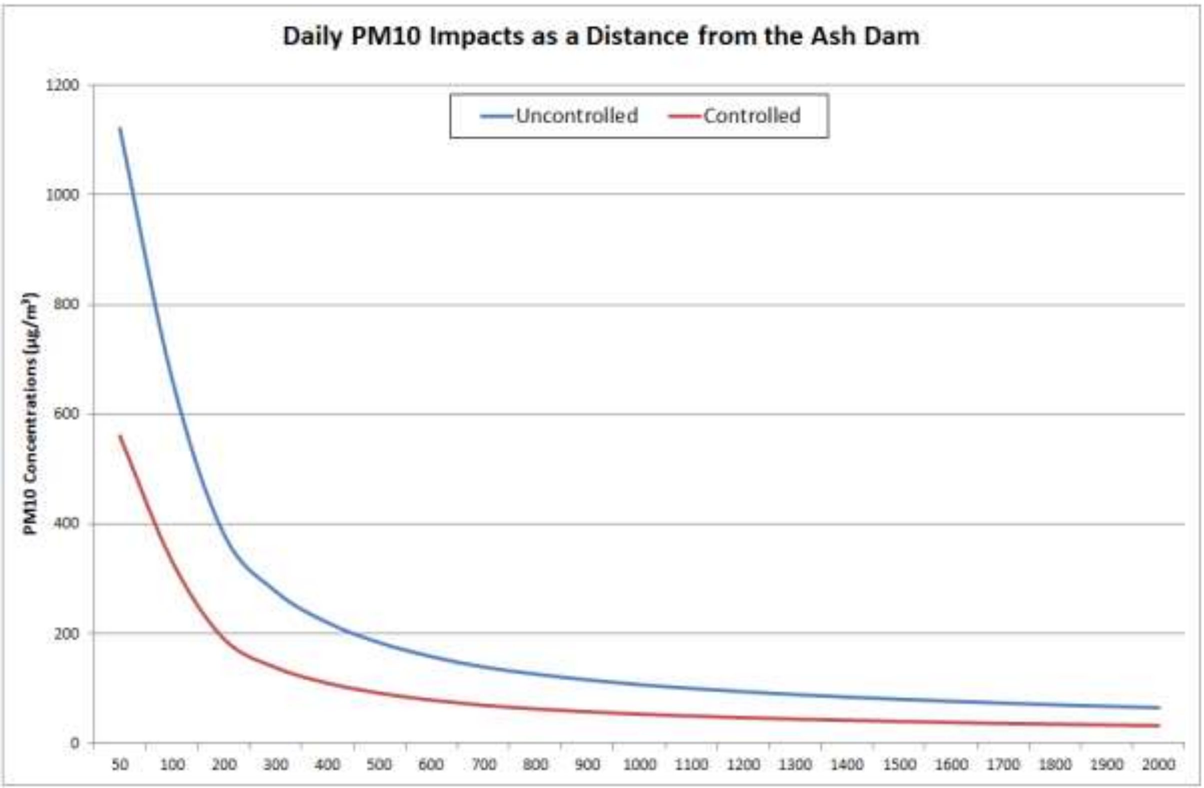

Figure 5: Estimated highest daily PM_{10} ground level concentrations at set distances from the emission source

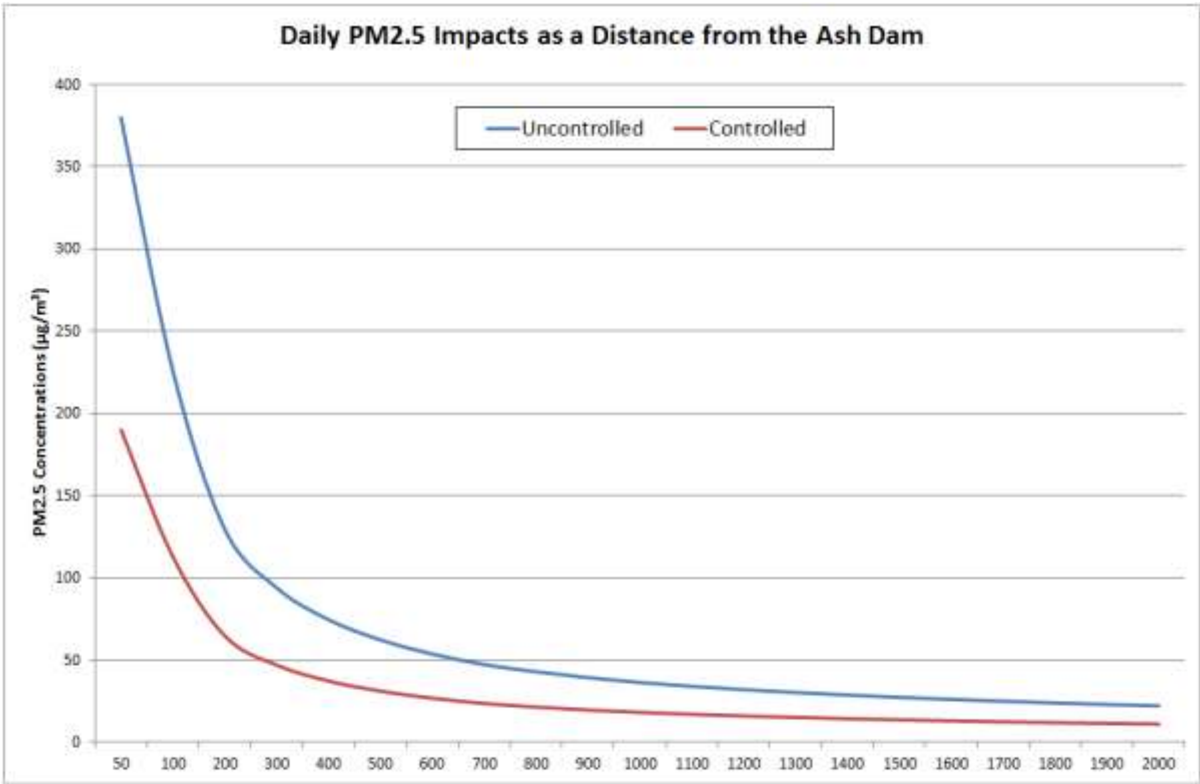

Figure 6: Estimated highest daily $PM_{2.5}$ ground level concentrations at set distances from the emission source

Table 6 and Table 7 provide the predicted elemental concentration due to proposed operations for which health effect screening levels are available. The following assumptions were made for non-criteria pollutants:

- Carcinogenic trivalent arsenic (As^{3+}) was assumed to account for 10% of the total arsenic in the ash sample.
- Cr^{6+} was assumed to represent only 1.1% of the total Cr in the PM_{10} fraction, as per literature.

The elemental concentrations ~100m from the ash disposal facility is predicted to exceed the most stringent effect screening levels (non-carcinogenic effects) for acute exposure for phosphorus. At a distance of 1100m from the ash disposal facility, the elemental concentrations due to proposed unmitigated operations are predicted to be within all effect screening levels (non-carcinogenic effects). With the effective application of water sprayers, the distance at which impacts are within effect screening levels is ~500m. The predicted cancer risk due to windblown elements from the ash disposal facility, are predicted to be very low for unmitigated operations.

Table 6: Predicted elemental concentrations at a distance of 100m from the ash disposal facility source (unmitigated operations)

Element	Predicted concentration		Non-carcinogenic Effects: Most stringent effect screening level		Carcinogenic Effects	
	Acute	Chronic	Acute	Chronic	Predicted Cancer risk (d)	Cancer Risk Description (e)
	µg/m³	µg/m³	µg/m³	µg/m³		
Arsenic (As)	0.1	0.00004	0.2 (a)	0.015 (a)	2 in 10 million	*Very Low*
Selenium (Se)		0.0004		20 (a)		
Titanium (Ti)		0.03		0.1 (b)		
Nickel (Ni)		0.0007		0.014 (a)	3 in 10 million	*Very Low*
Beryllium (Be)		0.00001		0.007 (a)		
Mercury (Hg)	0.03	0.00001	0.6 (a)	0.03 (a)		
Manganese (Mn)		0.007		0.04 (b)		
Chromium (Cr)		0.00001		0.002 (a)	2 in 10 million	*Very Low*
Vanadium (V)		0.002		0.1 (b)		
Boron (B)	6.3		300 (b)			
Phosphorus (P)	**130.9**		20 (b)			
Copper (Cu)	1.6		100 (a)			
Cobalt (Co)		0.0004		0.1 (b)		
Cadmium (Cd)	0.01	0.000007	0.03 (b)	0.005 (c)	6 in 10 million	*Very Low*

a) Source: OEHHA – Office of Environmental Health Hazard Assessment

b) Source: US ATSDR – US Federal Agency for Toxic Substances and Disease Registry

c) Source: WHO – World Health Organisation

d) US-EPA IRIS Unit Risk Factor

e) As applied by New York Department of Health

Table 7: Predicted elemental concentrations at a distance of 1100m from the ash disposal facility source (unmitigated operations)

Element	Predicted concentration		Non-carcinogenic Effects: Most stringent effect screening level		Carcinogenic Effects	
	Acute	Chronic	Acute	Chronic	Predicted Cancer risk [d]	Cancer Risk Description [e]
	µg/m³	µg/m³	µg/m³	µg/m³		
Arsenic (As)	0.01	0.00001	0.2 [a]	0.015 [a]	2 in 100 million	*Very Low*
Selenium (Se)		0.00006		20 [a]		
Titanium (Ti)		0.005		0.1 [b]		
Nickel (Ni)		0.0001		0.014 [a]	5 in 100 million	*Very Low*
Beryllium (Be)		0.000001		0.007 [a]		
Mercury (Hg)	0.004	0.000002	0.6 [a]	0.03 [a]		
Manganese (Mn)		0.001		0.04 [b]		
Chromium (Cr)		0.000002		0.002 [a]	3 in 100 million	*Very Low*
Vanadium (V)		0.0003		0.1 [b]		
Boron (B)	0.9		300 [b]			
Phosphorus (P)	19.8		20 [b]			
Copper (Cu)	0.2		100 [a]			
Cobalt (Co)		0.00005		0.1 [b]		
Cadmium (Cd)	0.002	0.000001	0.03 [b]	0.005 [c]	1 in 10 million	*Very Low*

a) Source: OEHHA – Office of Environmental Health Hazard Assessment

b) Source: US ATSDR – US Federal Agency for Toxic Substances and Disease Registry

c) Source: WHO – World Health Organisation

d) US-EPA IRIS Unit Risk Factor

e) As applied by New York Department of Health

Table 8: Predicted elemental concentrations at a distance of 700m from the ash disposal facility source

Element	Predicted concentration		Non-carcinogenic Effects: Most stringent effect screening level		Carcinogenic Effects	
	Acute	Chronic	Acute	Chronic	Predicted Cancer risk [d]	Cancer Risk Description [e]
	µg/m³	µg/m³	µg/m³	µg/m³		
Unmitigated Operations						
Arsenic (As)	0.01	0.00001	0.2 [a]	0.015 [a]	3 in 100 million	*Very Low*
Selenium (Se)		0.00008		20 [a]		
Titanium (Ti)		0.01		0.1 [b]		
Nickel (Ni)		0.0001		0.014 [a]	7 in 100 million	*Very Low*
Beryllium (Be)		0.000001		0.007 [a]		
Mercury (Hg)	0.01	0.000003	0.6 [a]	0.03 [a]		
Manganese (Mn)		0.001		0.04 [b]		
Chromium (Cr)		0.000003		0.002 [a]	4 in 100 million	*Very Low*
Vanadium (V)		0.0004		0.1 [b]		
Boron (B)	1.3		300 [b]			
Phosphorus (P)	**27.4**		20 [b]			
Copper (Cu)	0.3		100 [a]			
Cobalt (Co)		0.0001		0.1 [b]		
Cadmium (Cd)	0.003	0.000001	0.03 [b]	0.005 [c]	1 in 10 million	*Very Low*
Mitigated Operations						
Arsenic (As)	0.01	0.000004	0.2 [a]	0.015 [a]	2 in 100 million	*Very Low*
Selenium (Se)		0.00004		20 [a]		
Titanium (Ti)		0.003		0.1 [b]		
Nickel (Ni)		0.0001		0.014 [a]	4 in 100 million	*Very Low*
Beryllium (Be)		0.000001		0.007 [a]		
Mercury (Hg)	0.003	0.000001	0.6 [a]	0.03 [a]		
Manganese (Mn)		0.001		0.04 [b]		
Chromium (Cr)		0.000001		0.002 [a]	2 in 100 million	*Very Low*
Vanadium (V)		0.0002		0.1 [b]		
Boron (B)	0.7		300 [b]			
Phosphorus (P)	13.7		20 [b]			
Copper (Cu)	0.2		100 [a]			
Cobalt (Co)		0.00004		0.1 [b]		
Cadmium (Cd)	0.001	0.000001	0.03 [b]	0.005 [c]	7 in 100 million	*Very Low*

a) Source: OEHHA – Office of Environmental Health Hazard Assessment

b) Source: US ATSDR – US Federal Agency for Toxic Substances and Disease Registry

c) Source: WHO – World Health Organisation

d) US-EPA IRIS Unit Risk Factor

e) As applied by New York Department of Health

Taking the preferred site into consideration (Site 1), the predicted daily $PM_{2.5}$ (47 µg/m³) and PM_{10} (140 µg/m³) unmitigated impacts at the sensitive receptor of Camden (~700m from the site) exceed the NAAQS that will come into force in 2016 and 2015 respectively. With mitigated operations, the impacts at the sensitive receptor of Camden are in compliance with $PM_{2.5}$ and PM_{10} NAAQS. The elemental concentrations ~700m from the ash disposal facility (Table 8) due to proposed unmitigated operations are predicted to be within all effect screening levels (non-carcinogenic effects) with the exception of phosphorus. Phosphorus is within health effect screening levels ~700m from the ash disposal facility with mitigated operations. The predicted cancer risk due to windblown elements ~700m from the ash disposal facility due to mitigated and unmitigated operations is predicted to be very low.

3.2.3 Closure Phase

The significance of the closure phase is likely to be linked to impacts from windblown dust. Windblown dust is likely to only impact off-site under conditions of high wind speed with no mitigation in place. If rehabilitation as indicated takes place i.e. vegetation cover, the impacts should be limited to be within the site boundary. As vegetation cover increases, the potential for wind erosion will decrease.

3.3 Dust Management Plan

Based on the qualitative evaluation of the proposed operations, management objectives are considered as summarised in Tables 9 to 11.

Table 9: Air Quality Management Plan: Construction Phase

ASPECT	IMPACT	MANAGEMENT ACTIONS/OBJECTIVES	RESPONSIBLE PERSON(S)	TARGET DATE
Land clearing activities such as dozing and scraping of vegetation and topsoil	PM_{10} concentrations and dust fallout	• Water sprays at area to be cleared. • Moist topsoil will reduce the potential for dust generation when tipped onto stockpiles. • Ensure travel distance between clearing area and topsoil piles to be at a minimum.	Environmental Manager Contractor(s)	Pre- and during construction
Wind erosion from exposed areas at dumpsite	PM_{10} concentrations and dust fallout	• Ensure exposed areas remain moist through regular water spraying. • Dust fallout bucket to be placed to the west and southeast of the ash disposal facilities with monthly dust fallout rates not exceeding 1200 mg/m²/day[a].	Environmental Manager Contractor(s)	On-going and post-operational

Notes:

[a] Draft dust fallout regulation of 1200 mg/m²/day for industrial sites.

Table 10: Air Quality Management Plan: Operational Phase

ASPECT	IMPACT	MANAGEMENT ACTIONS/OBJECTIVES	RESPONSIBLE PERSON(S)	TARGET DATE
Wind erosion	PM_{10} concentrations and dust fallout	• Ensure water sprays at and around the ash disposal facility • Cover ash disposal facility with topsoil as operations commence and ensure vegetation cover on ash disposal facility • Dust fallout bucket to be placed to the west and southeast of the ash disposal facilities with monthly dust fallout rates not exceeding 1200 mg/m²/day[a].	Environmental Manager	On-going and post-operational phase

Notes:

[a] Draft dust fallout regulation of 1200 mg/m²/day for industrial sites.

Table 11: Air Quality Management Plan: Closure Phase

ASPECT	IMPACT	MANAGEMENT ACTIONS/OBJECTIVES	RESPONSIBLE PERSON(S)	TARGET DATE
Wind erosion from exposed areas	PM_{10} concentrations and dust fallout	• Cover ash disposal facility with previously collected topsoil. • Apply water sprays to ensure the material remain moist. • Ensure vegetation cover on the ash disposal facility.	Contractor(s) Environmental Manager	On-going and post-operational

4 Conclusion

PM_{10} concentrations due to unmitigated operations are likely to exceed the NAAQS 2015 limit of 75 µg/m³ for ~1700m from the source. $PM_{2.5}$ concentrations due to unmitigated operations are likely to exceed the NAAQS 2030 limit of 25 µg/m³ for ~1700m from the source. The predicted elemental concentrations from unmitigated windblown ash material is predicted to exceed the most stringent effect screening levels up to a distance of 1100m from the source. With water sprays in place, these impacts will reduce significantly It should be noted that the potential for impacts at the sensitive receptors will also depend on the wind direction and speed which could not be accounted for in this assessment.

Taking the preferred site into consideration (Site 1), the predicted daily $PM_{2.5}$ (47 µg/m³) and PM_{10} (140 µg/m³) unmitigated impacts at the sensitive receptor of Camden (~700m from the site) exceeded the NAAQS that will come into force in 2016 and 2015 respectively. With mitigated operations, the impacts at the sensitive receptor of Camden were in compliance with $PM_{2.5}$ and PM_{10} NAAQS. The elemental concentrations ~700m from the ash disposal facility due to proposed unmitigated operations were predicted to be within all effect screening levels (non-carcinogenic effects) with the exception of phosphorus. Phosphorus was within health effect screening levels ~700m from the ash disposal facility with mitigated operations. The predicted cancer risk due to windblown elements ~700m from the ash disposal facility due to mitigated and unmitigated operations was predicted to be very low.

In conclusion, if unmitigated, the windblown dust from the ash disposal facility may result in exceedances of effect screening levels up to a distance of 1100m from the source with exceedances of PM_{10} NAAQ limits up to a distance of 1700m. As the background ambient PM_{10} ground level concentrations may also be elevated in the area it is recommended that the ash disposal facility be mitigated where possible in order to minimise the impacts from this source on the surrounding environment.

4.1 Recommendation

Concerns of the close proximity of the Camden Village to the proposed ash disposal facility have been raised. In terms of potential air quality health impacts from the ash disposal facility, a buffer zone of at least 1700m for unmitigated ash facility operations and 700m for mitigated ash facility operations is recommended.

Fugitive dust can easily be mitigated. It is recommended that the dust management measures as stipulated in Tables 8, 9 and 10 be applied to ensure the proposed activities have an insignificant impact on the surrounding environment and human health.

It is also recommended that single dust fallout buckets be installed downwind of the ash disposal facility in order to monitor the impacts from this source.

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