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Lidwala Consulting Engineers

Continuous Disposal of Ash at Majuba Power Station:

Air Quality Basic Evaluation

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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
m	metre
m^2	Metre squared
m/s	Metre per second
$mg/m^2/day$	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
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

Majuba Power Station, a coal-fired power generation facility construction started in 1983. The units were commissioned between 1996 and 2001. The power station is located 32 km north-west of Volksrust in the province of Mpumalanga. Majuba Power Station currently disposes of boiler ash in a dry (20% moisture content) format, which is transported by means of conveyors. The ash is distributed onto the ash disposal facility by means of a stacker at a rate of approximately 15 333 tons per day. The ash disposal facility will, at full extent, cover an area of 955 ha with an airspace capacity of 156.2 million m^3. .

The proposed development of the ash disposal facility site has the following specifications:

- 0 to 15 year footprint – 362 ha (current operations)
- 15 to 60 year footprint – 550 ha (full extent of continuous ash disposal facility)
- Ground footprint of 912ha (existing & proposed ash disposal facility and pollution control dams)

Airshed Planning Professionals (Pty) Ltd was appointed by Lidwala Consulting Engineers to determine the potential for dust impacts on the surrounding environment and human health from the proposed operations, with specific reference to air quality. 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 existing ash disposal facilities are primarily surrounded by agricultural small holdings, power generation and neighbouring mining operations. Major residential areas in the region include Amersfoort (~15 km north-east) and Volksrust (~32 km south-east). Smaller residential areas in the region include Perdekop (~14 km south-west) which includes at least two schools. Individual residences (i.e. farm houses) are also in the immediate vicinity of the proposed operations. These residential areas are outside of the 12 km-radius area of interest, centred at the power station.

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 was undertaken based on the evaluation of existing windblown dust from ash dump studies (Burger, 1994), 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 of 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 recommendations.

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 ambient monitoring data from the Majuba 1 monitoring station, 3 km south-east of the Majuba Power Station, provided an indication of the background air pollution in the region (Section 2.2).

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 for the Majuba Power Station site were available for the period 2009-2011.

2.1.1 Local wind field

Figure 1 provides period wind roses for Majuba power station, with Figure 2 including the seasonal wind roses for the same site. The co-dominant wind directions are easterly and west-north-west with a frequency of occurrence approaching 12% for each direction. Winds from the southern and south-western sectors occur relatively infrequently (<4% of the total period). Calm conditions (wind speeds <1 m/s) occur for 8.49% of the time.

A frequent westerly flow dominates day-time conditions with >12% frequency of occurrence. At night, an increase in easterly flow is observed with a decrease in westerly air flow.

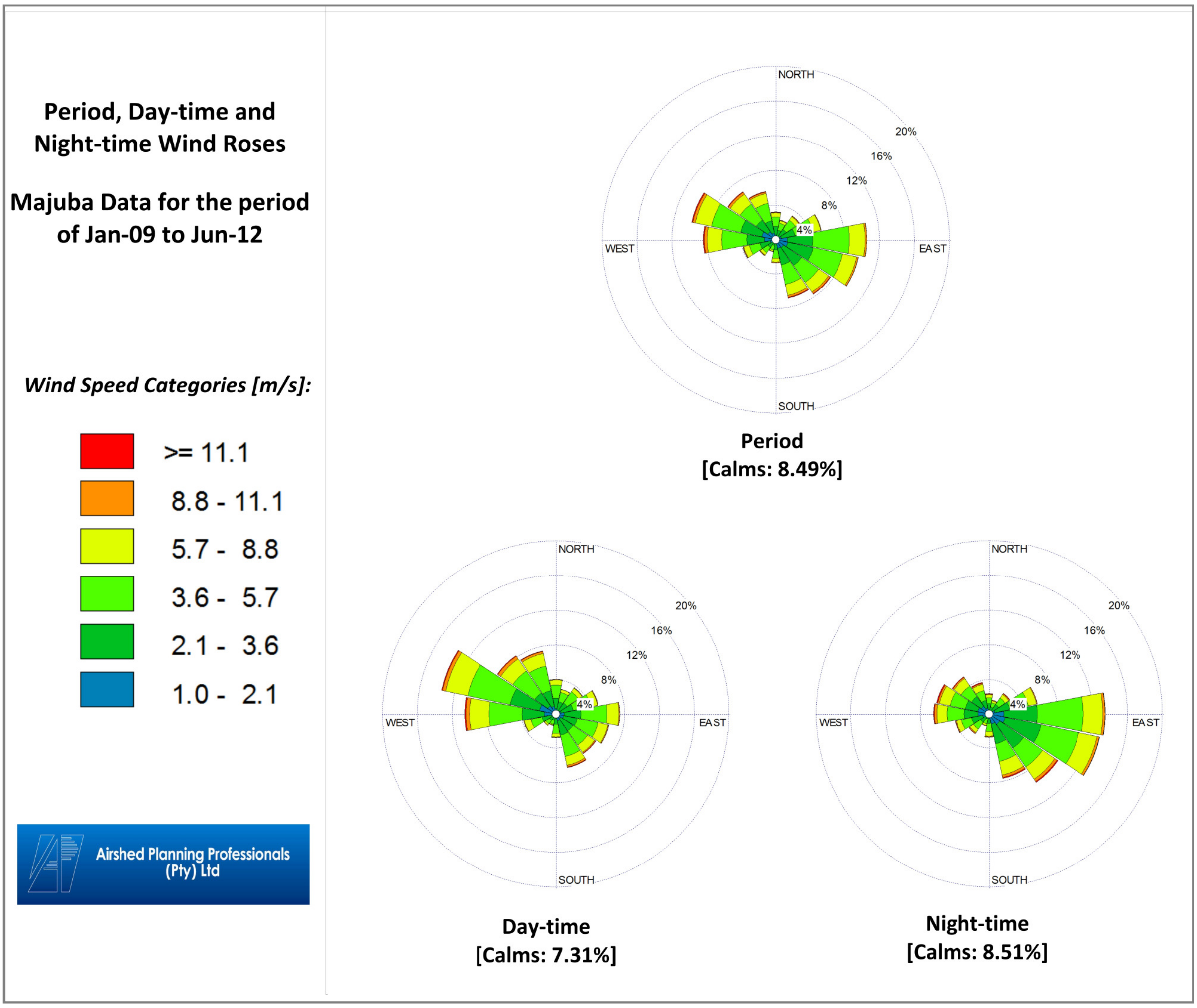

Figure 1: Period, day-time and night-time wind roses for Majuba (January 2009 – June 2012)

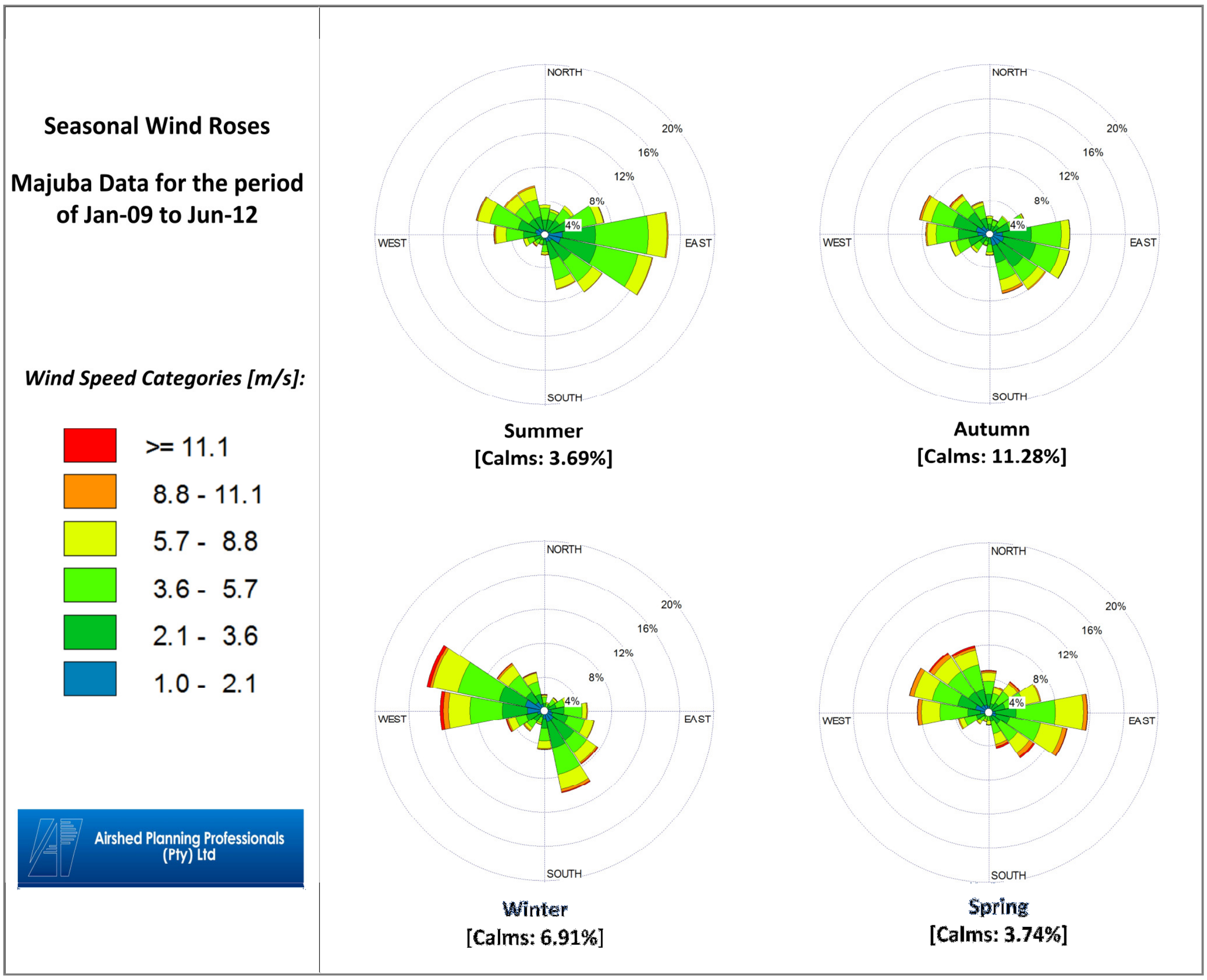

Figure 2: Seasonal wind roses for Majuba (January 2009 – June 2012)

During summer months, winds from the east become more frequent, due to the strengthened influence of the tropical easterlies and the increasing frequency of occurrence of ridging anticyclones off the east coast. There is an increase in the frequency of calm periods (i.e. wind speeds <1 m/s) during the autumn (11.28%) and winter months (6.91%) with an increase in the westerly flow.

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 3. Annual average maximum, minimum and mean temperatures for the site are given as 26.3℃, 0.7℃ and 15.1℃, respectively, based on the measured data at Eskom's Majuba monitoring station for the period 2009-2011. Average daily maximum temperatures range from 25.6℃ in February and December to 16.6℃ in June, with daily minima ranging from 16℃ in January to 0.7℃ in July (Figure 3).

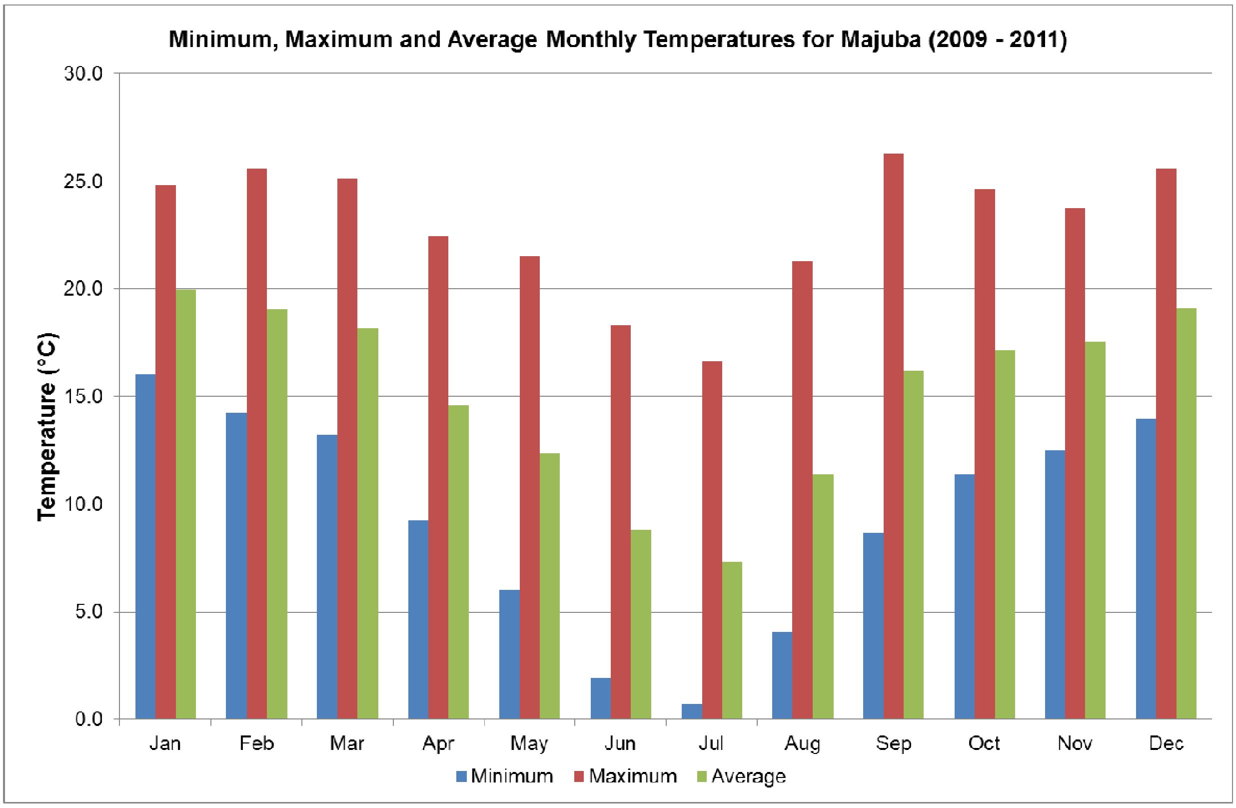

Figure 3: Minimum, maximum and average monthly temperatures near Majuba Power Station during the period 2009-2011

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 (August 2011 to July 2012) is given in Table 1. Average monthly rainfall for this period is in the range of 39 mm. The study area falls within a summer rainfall region, with over 85% of the annual rainfall occurring during the October to March period.

Table 1: Monthly rainfall for the site for the period August 2011 to July 2012

Month	Precipitation (mm)
Aug-11	5
Sep-11	33
Oct-11	43
Nov-11	35
Dec-11	128
Jan-12	49

Month	Precipitation (mm)
Feb-12	125
Mar-12	24
Apr-12	21
May-12	0
Jun-12	10
Jul-12	0

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 2.

Table 2: 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 near Majuba

Eskom manages an ambient air quality monitoring station near Majuba to assess impacts on air quality from Majuba Power Station and other pollution sources in the area (data provided with permission, for the current evaluation study, by Gerhardt de Beer, 2012-09-06). The monitoring station is located 3 km east-south-east of the power station and is equipped for continuous monitoring of ambient concentrations of sulphur dioxide (SO_2), nitrogen dioxide (NO_2), and fine particulate matter of particulate size <10 µm in diameter (PM_{10}). The average daily PM_{10} concentrations for the period January 2009 to June 2012 are presented in Figure 4.

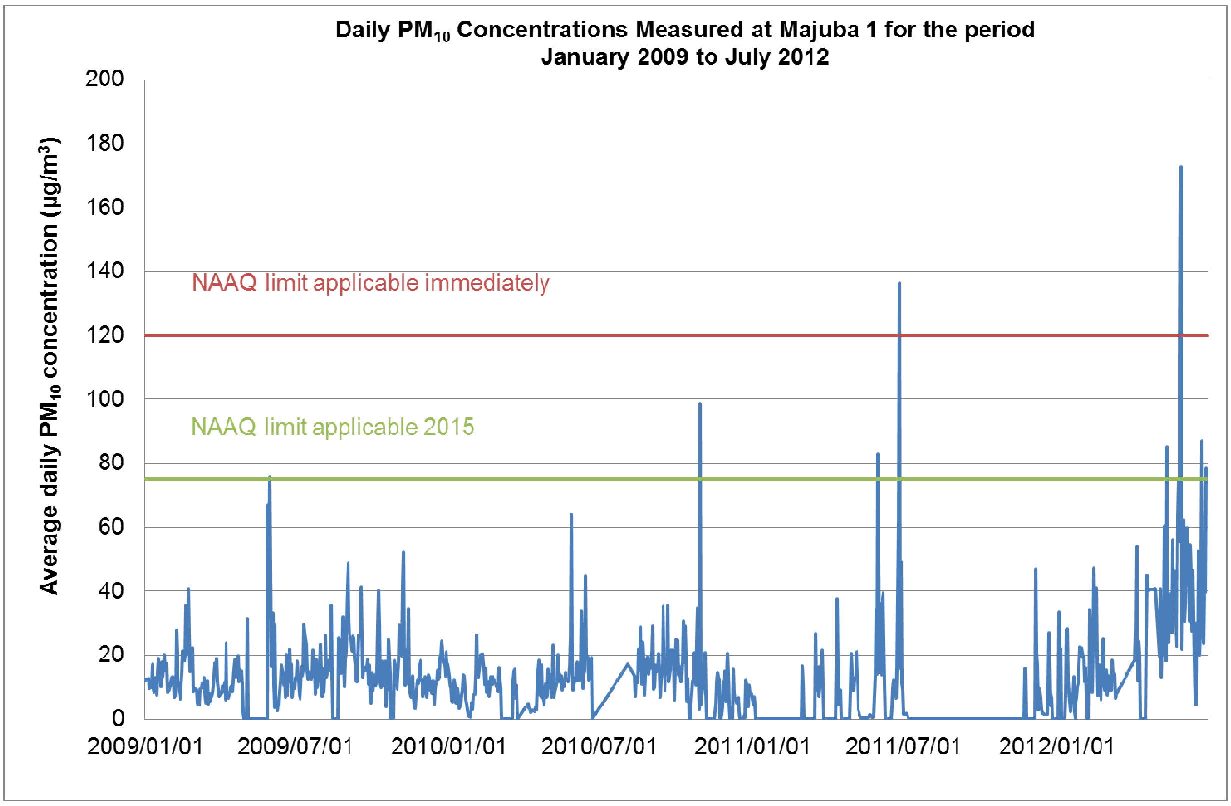

Figure 4: Daily measured PM_{10} ground level concentrations (µg/m³) at the Eskom Majuba 1 monitoring station (for the period January 2009 – June 2012)

The current National Ambient Air Quality limit value for PM_{10} daily concentrations (120 µg/m^3) was exceeded on two occasions during the period reported (once each in 2011 and 2012) (Table 3). The more stringent National Ambient Air Quality limit for PM_{10} daily concentrations effective from 1 January 2015 (75 µg/m^3) would have been exceeded once each in 2009 and 2010, and twice in 2011. In the first six months of 2012 the more stringent 75 µg/m^3 limit value was exceeded on six occasions resulting in non-compliance with the PM_{10} 2015 National Ambient Air Quality Standard (NAAQS), which allows for four daily limit value exceedances. The more stringent standard is mentioned because the operational phase of the proposed Majuba ash disposal facility will continue after the standard becomes enforceable.

Table 3: Measured daily ambient PM_{10} concentrations at Eskom's Majuba 1 monitoring station for the period 2009 to 2011

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)
2009	86	0	N	1	N
2010	82	0	N	1	N
2011	30	1	N	2	N

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.

3 Air Quality Evaluation

3.1 Source Identification

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

Rehabilitation will include the covering of the ash disposal facility with topsoil before vegetation can be established. Land preparation during progression of the ash disposal facility will generate dust as well as any freshly exposed topsoil that 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 the current and proposed 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. These are however insignificant in relation to the particulate emissions and are not discussed in detail.

Table 4 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 4: Activities and aspects identified for the construction, operational and closure phases of the proposed operations

Pollutant(s)	Aspect	Activity
Construction		
Particulates	Construction of progressing ash disposal facility 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
Continuous ash disposal		
Particulates	Wind erosion from ash disposal facility	Exposed dried out portions of the ash disposal facility

Pollutant(s)	Aspect	Activity
	Vehicle activity on-site	Vehicle activity at the ash disposal facility
Gases and particles	Vehicle activity	Tailpipe emissions from vehicle activity at the ash disposal facility
Rehabilitation		
Particulates	Rehabilitation of ash disposal facility	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

The construction phase is relevant as the ash disposal facility progresses and would normally comprise 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 Continuous ash disposal

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 and from areas where the material is exposed and has dried out (US.EPA, 1995).

3.1.3 Rehabilitation

Rehabilitation will be undertaken continuously throughout the operations and will include the removal and tipping of topsoil onto the completed ash disposal facility surface areas. Dust may be generated from the dried out exposed ash surfaces before it is covered with topsoil. Once vegetation is established the potential for dust generation will reduce significantly. The tipping of topsoil and vehicle entrainment on associated unpaved roads will also result in dust generation.

It is assumed that all ash disposal activities will have ceased during closure phase, when the power station has reached end of life. Because most of the rehabilitation is undertaken during the operations, the ash disposal facility should be almost completely rehabilitated by the closure phase. The potential for impacts after closure will depend on the extent of continuous rehabilitation efforts on the ash disposal facility.

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 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-type materials handling activities occur (AEPA, 2007).

3.2.2 Continuous ash disposal

The current air quality at the proposed site is discussed in Section 2.2. The ash disposal facility will continue to give rise to dust generation as the ash disposal operations progress, and as such should not result in any additional emissions relative to present operations provided that the ash disposal facility is properly rehabilitated. 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 to 2012) indicate an average wind speed of 3.79 m/s and a maximum of 15.9 m/s, where the wind speed threshold is exceeded 22.3% of the time.

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 as obtained at the ash disposal facility at Majuba is provided in Table 5 with the elemental analysis of the material provided in Table 6

Table 5: Particle size distribution for the ash material at the Majuba Power Station

Size (µm)	Fraction
2000	0.0339
1000	0.0193
301	0.0000
140	0.0928
103	0.0677
76	0.0796
56	0.0951
48	0.0529
30	0.1674
16	0.1908
10	0.0942
6	0.0590
3	0.0420
2	0.0049
1	0.0004

Table 6: Elemental analysis of the ash material at the Majuba Power Station

Element	ppm
Arsenic (As)	11
Selenium (Se)	<2
Molybdenum (Mo)	3.6
Silver (Ag)	<0.1
Titanium (Ti)	1004
Strontium (Sr)	598
Magnesium (Mg)	6358
Aluminium (Al)	24690
Nickel (Ni)	9.9
Beryllium (Be)	1
Mercury (Hg)	6.5
Manganese (Mn)	126
Iron (Fe)	19525
Chromium (Cr)	37
Vanadium (V)	50
Sodium (Na)	1368
Boron (B)	87
Calcium (Cu)	42861
Zinc (Zn)	12
Phosphorus (P)	1912
Copper (Cu)	11
Antimony (Sb)	1.2
Lead (Pb)	6.4
Lithium (Li)	22
Cobalt (Co)	5
Cadmium (Cd)	0.2
Potassium (K)	744

Figures 5 and 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 will be exceeded within 500 m due to windblown dust from the progressing ash disposal facility only. 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 ensuring 50% reduction from wind erosion, windblown dust will be below the NAAQS limit of 75 µg/m³ at a distance of ~200 m from the source.

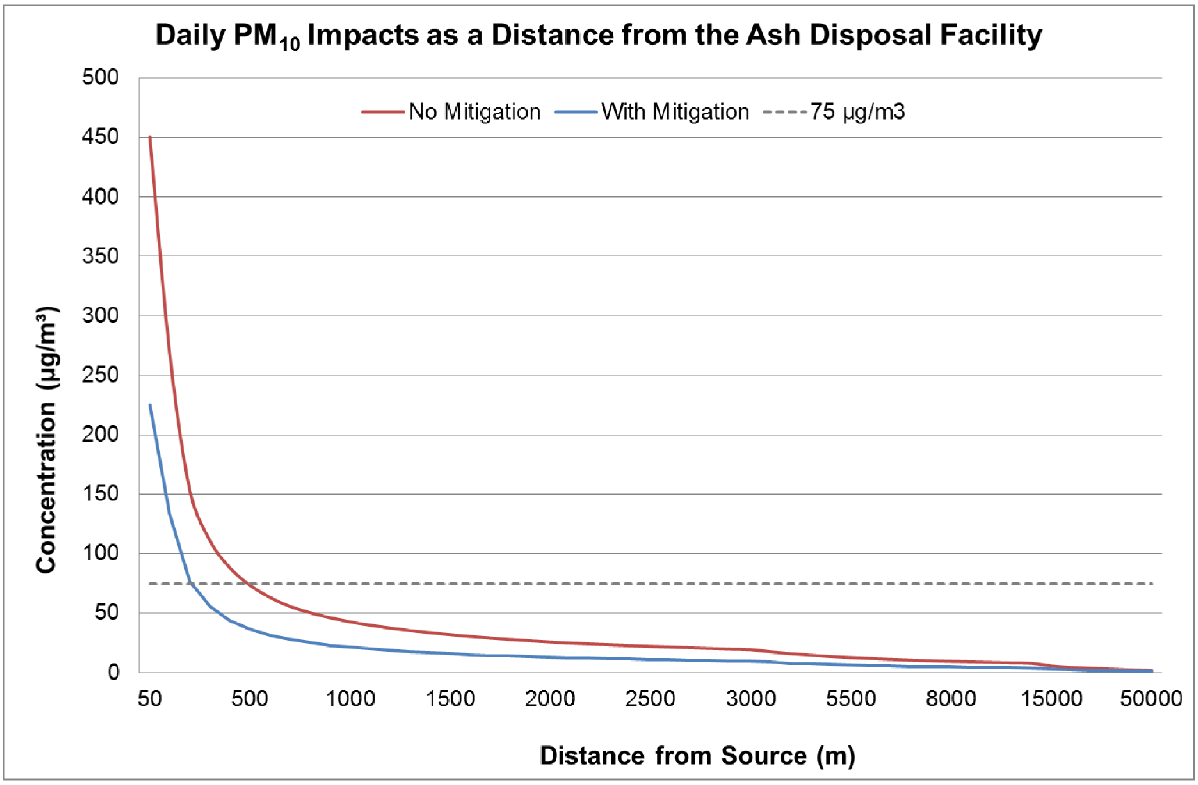

Figure 5: Estimated highest daily PM_{10} ground level concentrations at set distances from the emission source with and without mitigation

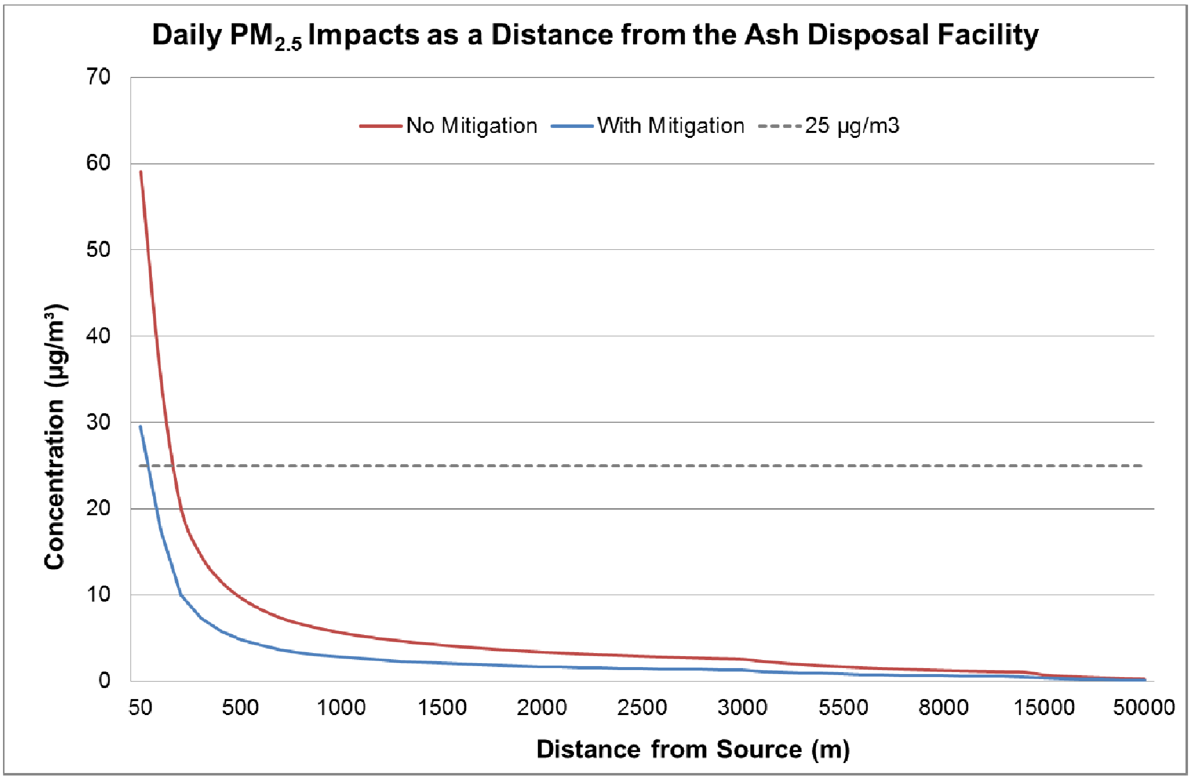

Figure 6: Estimated highest daily $PM_{2.5}$ ground level concentrations at set distances from the emission source, with and without mitigation

Table 7 and Table 8 provide the predicted elemental concentration due to proposed operations for which health effect screening levels are available. The elemental concentrations ~100 m from the ash disposal facility are predicted to exceed the most stringent effect screening levels (non-carcinogenic effects) for acute exposure to arsenic, mercury, and phosphorus (Table 6). It is unlikely that, even at the full extent of the ash disposal facility, human settlements will occur within this buffer. At a distance of 1 500 m from the ash disposal facility, the elemental concentrations due to proposed operations are predicted to be within all effect screening levels for non-carcinogenic effects (Table 7). From aerial photography (Google Earth 2009 image) at least one farmstead occurs within 1 500 m from the ash disposal facility at the full extent. However, with effective application of water sprayers, the distance at which impacts are within effect screening levels is ~600 m away from the source. Therefore the predicted cancer risk, due to windblown elements from the ash disposal facility, is predicted to be low to very low.

Table 7: Predicted elemental concentrations at a distance of 100 m 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		
Arsenic (As)	1.0	0.0005	0.2 (a)	0.015 (a)	2 in 1 million	*Low*
Selenium (Se)		0.0001		20 (a)		
Titanium (Ti)		0.0482		0.1 (b)		
Nickel (Ni)		0.0005		0.014 (a)	2 in 10 million	*Very Low*
Beryllium (Be)		0.00005		0.007 (a)		
Mercury (Hg)	0.6	0.0003	0.6 (a)	0.03 (a)		
Manganese (Mn)		0.0061		0.04 (b)		
Chromium (Cr)		0.0018		0.002 (a)	2 in 100 000	*Low*
Vanadium (V)		0.0024		0.1 (b)		
Boron (B)	7.8		300 (b)			
Phosphorus (P)	171.9		20 (b)			
Copper (Cu)	1.0		100 (a)			
Cobalt (Co)		0.0002		0.1 (b)		
Cadmium (Cd)	0.02	0.00001	0.03 (b)	0.005 (c)	2 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

Table 8: Predicted elemental concentrations at a distance of 1 500 m 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		
Arsenic (As)	0.2	0.0001	0.2 [a]	0.015 [a]	4 in 10 million	*Very Low*
Selenium (Se)		0.00002		20 [a]		
Titanium (Ti)		0.007		0.1 [b]		
Nickel (Ni)		0.0001		0.014 [a]	6 in 100 million	*Very Low*
Beryllium (Be)		0.000007		0.007 [a]		
Mercury (Hg)	0.1	0.00006	0.6 [a]	0.03 [a]		
Manganese (Mn)		0.001		0.04 [b]		
Chromium (Cr)		0.0003		0.002 [a]	3 in 1 million	*Very Low*
Vanadium (V)		0.0003		0.1 [b]		
Boron (B)	1.5		300 [b]			
Phosphorus (P)	10.6		20 [b]			
Copper (Cu)	0.2		100 [a]			
Cobalt (Co)		0.00007		0.1 [b]		
Cadmium (Cd)	0.0	0.000001	0.03 [b]	0.005 [c]	1 in 1 billion	*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

3.2.3 Rehabilitation

The significance of the rehabilitation activities is likely to be linked to impacts from windblown dust from the exposed dried out ash, topsoil and vehicle entrainment during the rehabilitation process. 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 Table 9 to Table 11.

Table 9: Air Quality Management Plan: Construction operations

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 disposal facility	PM_{10} concentrations and dust fallout	• Ensure exposed areas where topsoil has been removed remain moist through regular water spraying. • Dust fallout bucket to be placed within the 1 500 m buffer area to the east and to the west (Figure 1 and Figure 2) of the disposal facility with monthly dust fallout rates not exceeding 1200 mg/m²/day[a].	Environmental Manager Contractor(s)	On-going during continuous ash disposal

Notes:

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

Table 10: Air Quality Management Plan: Continuous ash disposal

ASPECT	IMPACT	MANAGEMENT ACTIONS/OBJECTIVES	RESPONSIBLE PERSON(S)	TARGET DATE
Wind erosion	PM_{10} concentrations and dust fallout	• Ensure water sprays at the exposed and active areas of the ash disposal facility • Ensure continuous rehabilitation of exposed areas during operational activities. • Dust fallout bucket to be placed within the 1 500 m buffer area to the west and to the southeast (dominant wind direction) of the ash dump 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 of 1200 mg/m²/day for industrial sites.

Table 11: Air Quality Management Plan: Rehabilitation activities

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 mitigate dust emissions until vegetation has established. • Ensure vegetation cover on the entire closed ash storage facility.	Contractor(s) Environmental Manager	On-going and post-operational

4 Conclusion

As a result of the activities associated with ash disposal, PM_{10} concentrations are likely to exceed the NAAQS 2015 limit of 75 µg/m³ within ~500 m of the source. $PM_{2.5}$ concentrations are likely to exceed the NAAQS 2030 limit of 25 µg/m³ within ~200 m of the source. The predicted elemental concentrations from the windblown ash material are predicted to exceed the most stringent effect screening levels up to a distance of 1 500 m from the source. With water sprays in place and once vegetation is established, these impacts will reduce significantly. 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.

In conclusion, if unmitigated, windblown dust from the ash disposal facility may result in exceedances of effect screening levels up to a distance of ~1 500 m from the source with exceedances of PM_{10} NAAQ limits up to a distance of 500 m. This applies to the current and proposed future ash disposal facility operations since the "active" area should essentially remain the same irrespective of the total footprint of the ash disposal facility.

4.1 Recommendation

It is recommended that mitigation measures at the ash disposal facility continue and even be improved, where possible, to ensure impacts on the surrounding area remain minimal. Fugitive dust can easily be mitigated and 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.

The following should be considered during the EIA phase:

- Quantitative impact assessment of potential impacts from the proposed expanded ash disposal facility including:
    - calculation of dust emissions resulting from the current and proposed ash disposal facility;
    - simulation of dust emissions applying a Gaussian plume dispersion model such as AERMOD;
    - Evaluation of potential impacts of PM_{10}, $PM_{2.5}$ and dust fallout rates on the surrounding environment and human health. This will include compliance evaluation against the NAAQS and proposed dust fallout limits and health screening for non-carcinogenic and carcinogenic effects; and

- Recommendations on mitigation measures and expansion of the current monitoring network (if needed).

- Confirmation of the location of human settlements within the 1 500 m buffer of the full extent of the ash disposal facility. These will be included in the assessment as receptor points.

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