TRANSNET

SCOPING AND ENVIRONMENTAL IMPACT ASSESSMENT

Scoping and Environmental Impact Assessment for the proposed Manganese Export Facility and Associated Infrastructure in the Coega Industrial Development Zone, Port of Ngqura and Tankatara area

DRAFT EIA REPORT

CHAPTER 5:

AIR QUALITY SPECIALIST STUDY

Summary

Transnet SOC Ltd plans to construct and operate a Manganese Ore Export Facility in the Coega Industrial Development Zone (IDZ) and on the adjacent property Tankatara Farm. The proposed project will mainly consist of a rail compilation yard, a manganese ore stockyard with a tippler, stackers and reclaimers, a conveyor system and ship-loader. The storage and handling of more than 100 000 tons of ore at a facility other than a mine is a Listed Activity in terms of NEM: Air Quality Act (Act No. 39 of 2004 (Government Notice 248 of 31 March 2010). As such, the facility requires an Atmospheric Emission License (AEL) in order to operate. An air quality specialist study is required firstly to assess the potential impact of the facility on ambient air quality and to support the AEL application. The terms of reference for this air quality specialist study are:

- Detailed quantification of atmospheric emissions of particulate matter from the proposed Manganese Ore Export Facility during construction and operation, including upset conditions;
- Detailed assessment of the associated atmospheric impacts on human health in the Coega IDZ and the surrounding environment.

The pollutants identified in the emission inventory that pose a risk to human health and other ecological receptors are particulates, including TSP, PM_{10} and $PM_{2.5}$ from construction activities as well as ore handling and storage; and NO_x and BTEX from diesel locomotives and other vehicles. The emissions of these pollutants are estimated using activity and consumption data, and emission factors. The resultant ambient concentrations are predicted using three years of site specific hourly meteorological data and the US-EPA approved CALPUFF suite of models. The populations of concern are those living within the 40 X 40 km area for which modelling was done with the focus on the identified sensitive receptor areas. Eighteen sensitive receptor sites were identified in the modelling domain in the Nelson Mandela Bay Municipality at which a human health risk assessment was undertaken.

The main emissions to air from operations at the proposed Manganese Ore Export Facility result from wind-entrained dust, materials handling and fuel combustion from diesel locomotives at the compilation yard. These emissions are estimated using emission factors combined with site-specific information such as the silt and moisture content of the material being handled and the proposed dust control technologies. With regard to dust control, the Manganese Ore Export Facility design includes accepted best practice at all stages of the ore handling process. Estimates for the proposed Manganese Ore Export Facility compare the emission from the different activities with installed dust control equipment (standard mitigation) and with the addition of dust management using water and chemical surfactants (full mitigation). The added controls show a marked reduction in the estimated emission for dust. In both cases the stockyard is the biggest emitter of dust, with the stockpiles the largest source followed by stacking and reclaiming. A summary of emissions are shown in Table E-1.

Table E-1: Summary of emissions from the proposed Manganese Ore Export Facility (tons per annum)

Pollutants	Compilation Yard	Manganese Ore Export Facility	
		Standard mitigation	*Full mitigation*
Benzene	0.337	0.00	0.00
Toluene	0.073	0.00	0.00
Ethyl benzene	0.003	0.00	0.00
Xylene	0.013	0.00	0.00
Oxides of nitrogen (NO_x)	90.19	0.00	0.00
TSP (dust)	0.00	25 852.7	1 058.5
PM_{10}	1.27	4 252.6	172.5
$PM_{2.5}$	1.27	10.0	1.3

With the proposed mitigation measures fully implemented (full mitigation scenario), the significance of the impacts on air quality resulting from the Manganese Ore Export Facility are predicted to be low to very low. The impacts are summarised in Table E-2.

Construction phase

Potential impact 1: Increased dust and other pollutants during construction

Most civil construction activities generate dust and the emission of particulates into the atmosphere is through vehicle dust entrainment, demolition, excavation, ground levelling, etc. The dust is generally coarse, but may include respireable particles ($PM_{2.5}$). Exhaust emissions from construction vehicles and equipment typically include particulates (including PM_{10} and $PM_{2.5}$), carbon monoxide (CO), nitrogen oxides (NO_x), sulphur dioxide (SO_2) and volatile organic compounds (VOCs) including benzene. The construction activities are typically short lived and the pollutants are released close to ground level with little or no buoyancy which limits their dispersion and the potential impacts to the site. The significance of the potential air quality impacts on human health from construction is expected to be very low.

Operational phase

Potential impact 2: Dust deposition from the Manganese Ore Export Facility in the neighbouring environment

Design consideration in all aspects of the proposed Manganese Ore Export Facility and the proposed dust suppression approach ensures that the national dust deposition limit value for residential areas of 600 mg/m^2/day is not predicted to be exceeded anywhere in the modelling domain. However, the generically black dust from the manganese ore may result in nuisance and possibly health impacts at neighbouring facilities such as the nearby Coega salt pans. Impacts relating to deposition of Manganese ore dust will endure for the life time of the proposed Manganese Ore Export Facility. Although it is predicted to be of relatively low significance, dust deposition potentially affects the whole of the IDZ, but mostly immediately adjacent to the stockyard. With full mitigation the impact is expected to be of low significance. The significance of the potential dust deposition impacts on human health from dust deposition is expected to be low.

Potential impact 3: Ambient PM_{10} concentrations exceed ambient standards

The predicted average annual ambient PM_{10} concentrations resulting from the Manganese Ore Export Facility are below the current and future national ambient standard when the proposed mitigation measures are fully implemented. Exceedances of the 24-hour ambient standard are predicted at the stockyard and the immediate surrounding environment if dust suppression with water and chemical surfactants does not take place. No adverse effects from exposure to modelled 24-hour or annual PM concentrations (PM$_{10}$ and PM$_{2.5}$) are expected at any of the 18 sensitive receptor areas under upset conditions (which in this study is defined as conditions during no mitigation measures) or normal operating conditions. There is a possibility that 24 h cumulative PM$_{10}$ concentrations could pose a risk of respiratory effects at Cerebos - Coega evaporation area (northern boundary) but only under a "no mitigation" scenario. Impacts relating to ambient PM$_{10}$ concentrations will endure for the life time of the proposed Manganese Ore Export Facility. They will be limited to the stockyard and the area immediately surrounding it. The intensity of the impact is expected to be low for the standard mitigation scenario and very low for the full mitigation scenario. The significance of the potential impacts of exposure to PM$_{10}$ on human health is expected to be low.

Potential impact 4: Ambient PM$_{2.5}$ concentrations exceed ambient standards
The predicted average annual ambient PM$_{2.5}$ concentrations are not exceeded anywhere in the study area for either the standard mitigation or the full mitigation scenarios. Impacts relating to ambient PM$_{2.5}$ concentrations will however endure for the life time of the proposed Manganese Ore Export Facility. They will be limited to the immediate stockyard area. The intensity of the impact is expected to be low and very low for the standard mitigation scenario and the full mitigation scenario respectively. The significance of the potential impacts of exposure to PM$_{2.5}$ on human health is expected to be low.

Potential impact 5: Exposure to manganese ore dust in the neighbouring environment
Concentrations of manganese were modelled in the respireable fraction of particulate matter (PM$_{2.5}$) predicted for the 18 sensitive receptor sites. Under the "standard mitigation" scenario and taking into account the conversion factor (Mn vs MnO), three sites were found where predicted concentrations were elevated. However, the Hazard Quotient for Cerebos' Coega evaporation area (centre of site) decreased from 2.0 for standard mitigation to 0.3 for full mitigation (from moderate to low). At the northern boundary Cerebos' Coega evaporation area, the HQ decreased from 13.1 (high risk) to 2.8 (moderate) and at Cerebos PVD Salt Plant the risk remained low but the HQ decreased from 0.73 to 0.12.

HQs calculated for the rest of the 18 sensitive receptor areas were all below 0.45, without mitigation, and below 0.05 with mitigation, indicating that it would be unlikely for any individual chronically exposed at these sites to develop neurological effects due to manganese exposure.

In summary, the risk estimates calculated for manganese in this study suggest a moderate to high risk at certain receptor points within the industrial area for neurological effects under the standard operating (no mitigation) scenario. However, with full mitigation, the risk will be low within the neighbouring environment and IDZ, except at one area within the IDZ where it will be moderate (Cerebos' Coega evaporation area (northern boundary).

Potential impact 6: Ambient NO$_x$ concentrations exceed ambient standards
The highest 1-hour maximum concentration resulting from locomotive emissions occur at the compilation yard where the maximum predicted value of 1 563 µg/m^3 exceeds the national ambient standard for NO$_2$ but not the SA occupational standard of 5 000 µg/m^3. The exceedances occur over a relatively large area of the IDZ and the Tankatara Farm. However the area where the permitted number of exceedances is predicted is limited to the immediate compilation yard area. Therefore, the 1-hour ambient air quality standard for NO$_2$ is predicted to be exceeded only in the compilation yard. Calculations for acute, chronic and cumulative risks from exposure to NO$_2$ showed that it would be unlikely for any individual to develop adverse health effects as a result of exposure to the concentrations considered. Impacts relating to ambient NO$_x$ concentrations will endure for the life time of the Manganese Ore Export Facility, but will be limited to the compilation yard. The intensity of the impact is expected to be low. The significance of the potential impacts of exposure to NO$_x$ on human health is expected to be low.

Potential impact 7: Ambient BTEX concentrations exceed ambient standards
Predicted ambient concentrations for benzene, toluene, ethylbenzene and xylene (BTEX) from diesel combustion by locomotives are not predicted to exceed ambient standards and guidelines anywhere in the study area. The acute risks for predicted concentrations of toluene, ethylbenzene and xylene are negligible even under a "no mitigation" scenario. The incremental cancer risk is below the acceptable risk of 1 in a million at all 18 sensitive receptor sites. Impacts will however endure for the life time of the proposed Manganese Ore Export Facility. The intensity of the impact is expected to be very low. The significance of the potential BTEX impacts on human health is expected to be very low.

Potential impact 8: Cumulative impacts
There are no other bulk ore terminals in the Coega IDZ. As a result, the assessment of cumulative effects with respect to manganese ore dust is irrelevant. There are however other combustion sources of SO_2, NO_x and BTEX including port side equipment, trucks and shipping. Ambient monitoring has however shown that existing ambient concentrations for these compounds are well below the ambient standards and the dispersion modelling for this study has shown that the spatial distribution of these pollutants from diesel locomotives is limited to the compilation yard and rail track to the tippler. It is therefore unlikely that they will add significantly to the current ambient concentrations beyond the immediate project site. The significance of the potential cumulative impacts on human health is expected to be low.

Table E-2: Impact summary

Impact description	Extent	Duration	Intensity	Probability	Significance	
					Standard mitigation	***Full mitigation***
Increased dust and other pollutants during construction	Site specific	Short	Low	Probable	Low	Very low
Dust deposition from the Manganese Ore Export Facility in the neighbouring environment	Local	Long	Low	Highly probable	Medium	Low
Ambient PM_{10} concentrations exceed ambient standards	Local	Long	Low	Highly probable	Low	Very low
Ambient $PM_{2.5}$ concentrations exceed ambient standards	Site specific	Long	Low	Probable	Low	Very low
Exposure to Mn ore dust in the neighbouring environment	Local	Long	Medium	Probable	Medium	Low
Ambient NO_x concentrations exceed ambient standards	Site specific	Long	Low	Probable	Low	Low
Ambient BTEX concentrations exceed ambient standards	Site specific	Long	Low	Improbable	Very low	Very low
Cumulative impacts of dust, PM_{10}, $PM_{2.5}$, NO_x and BTEX	Local	Long	Low	Probable	Low	Low

The potential impacts associated with the different manganese ore storage and handling activities will endure for the life of the operation and are compared in Table E-3 for the standard mitigation scenario and the full mitigation scenario. Other than the stockpiles, the tippler and the surge bins, the significance of the impacts with full mitigation is very low. The significance of impacts from the tippler, stockpiles and the surge bins is medium for standard mitigation, but reduces to low for full mitigation.

The control of dust is not only dependent on the design and technologies, but is also dependent on optimum operations and management at the facility. It is therefore critically important that operators are appropriately trained and are aware of the dust control requirement and that Standard Operating Procedures (SOPs) for the respective activities consider the control of dust. It is also important that

SOPs are developed and implemented for the management of spills and general site maintenance such as road sweeping which will decrease the amount of wind-blown dust generated on site.

Table E-3: Impact significance of ore storage and handling activities for standard and full mitigation and project alternatives

Activity description	Mitigation scenario	Comment	Extent	Intensity	Probability	Significance
Tippler	Standard mitigation	Enclosed	Local	Low	Highly probable	Medium
	Full mitigation	Enclosed with water sprays	Site only	Very low	Probable	Low
Stockpiles	Standard mitigation	Low position	Regional	Medium	Highly probable	Medium
	Full mitigation	Chemical sprays	Local	Medium/low	Highly probable	Low
Stacking and reclaiming	Standard mitigation	Low drop heights	Local	Low	Highly probable	Low
	Full mitigation	Water sprays and stockpile dampened prior to reclaiming	Site only	Very low	Probable	Very low
Conveyor system incl. transfer points[1]	Standard mitigation: Proposed route	Enclosed conveyor and transfer points	Site only	Very low	Probable	Low
	Full mitigation: Proposed route	Enclosed with transfer point water sprays	Site only	Very low	Probable	Very low
	Standard mitigation: Alternative route	Enclosed conveyor and transfer points	Site only	Very low	Probable	Low
	Full mitigation: Alternative route	Enclosed with transfer point water sprays	Site only	Very low	Probable	Very low
Surge bins	Standard mitigation	Enclosed	Local	Low	Highly probable	Low
	Full mitigation	Enclosed with water sprays	Site only	Very low	Probable	Very low
Ship Loader	Standard mitigation	Low drop heights	Site only	Low	Probable	Low
	Full mitigation	Low drop heights and water sprays	Site only	Very low	Probable	Very low
Compilation Yard[2]	Standard mitigation (preferred)	No mitigation	Site only	Very low	Improbable	Very low
	Standard mitigation (alternative)	No mitigation	Site only	Very low	Improbable	Very low
Retention and attenuation ponds	Standard mitigation	No mitigation	Site only	Very low	Improbable	Very low

1: The predicted significance of impact for the preferred and alternative routes for the conveyor are both very low
2: The predicted significance of impact for the preferred and alternative configuration are both very low

Contents

TABLES AND FIGURES

CHAPTER 5: AIR QUALITY AND HUMAN HEALTH RISK SPECIALIST STUDY

This chapter presents the Air Quality and Human Health Risk Specialist Study undertaken by Dr Mark Zunckel and Atham Raghunandan from uMoya-NILU Consulting (Pty) Ltd, under appointment to CSIR, and Riëtha Oosthuizen of CSIR as part of the Environmental Impact Assessment for the proposed Manganese Ore Export Facility and associated infrastructure in the Coega Industrial Development Zone, Port of Ngqura and Tankatara area.

5.1 INTRODUCTION AND METHODOLOGY

5.1.1 Scope and Objectives

The storage and handling of more than 100 000 tons of ore at a facility other than a mine is a Listed Activity in terms of NEM: Air Quality Act (Act No. 39 of 2004 (Government Notice 248 of 31 March 2010). As such, the facility requires an Atmospheric Emission License (AEL) in order to operate. An air quality specialist study is required firstly to assess the potential impact of the facility on ambient air quality and to support the AEL application.

The scope of the air quality specialist study is to:

- Describe the relevant legal context including air quality standards and permits required in terms of air quality for the operation of the proposed facilities.
- Describe the general surrounding and the site-specific environment with respect to air quality including existing sources of atmospheric particulate emissions and baseline ambient air quality relative to particulates;
- Identify and characterise sensitive potential receptors, including human and ecological receptors;
- Characterise and quantify all forms of atmospheric emissions during the construction and operation phases of the project.
- Using an internationally recognised dispersion model, model the potential dispersion of these pollutants and compare predicted ambient concentrations with internationally and locally defined standards, limits or other appropriate thresholds;
- Assess potential impacts on the environment and the significance of the impacts;
- Assess the efficiency of proposed/recommended mitigation measures and provide site specific mitigation measures to reduce or prevent such impacts;
- Describe how significant other sources may act cumulatively in the manifestation of potential impacts;
- Characterise and quantify, where possible, these risks coordinating as required with other specialists.

5.1.2 Terms of Reference

The terms of reference for the air quality specialist study are for:

- Detailed quantification of atmospheric emissions of particulate matter from the proposed Manganese Ore Export Facility during construction and operation, including upset conditions;
- Detailed assessment of the associated atmospheric impacts on human health and ecological receptors in the Coega IDZ and the surrounding environment.

5.1.3 Approach and Methodology

The methodology that was applied to address the defined terms of reference is described in this section:

The ***legal context*** of the project regarding air quality was described in terms of the following:

- The National Environmental Management Act (No. 107 of 1998);
- The National Environmental Management: Air Quality Act (No. 39 of 2004) and the supporting regulations regarding:
  - Ambient air quality standards (Republic of South Africa, 2009 and 2012).
  - Listed activities and minimum emission standards (Republic of South Africa, 2010).
  - Controlled emitters (Republic of South Africa, 2011).
  - The Air Quality Management Plan (AQMP) for the NMBM (C&M Consulting Engineers, 2011).

A discussion was held with the NMBM AEL Authority (AELA) early in the project to discuss the requirements of the AEL application. The intention to apply for an AEL was published in two local newspapers as required by the AQA. With the completion of this air quality assessment the AEL application will be drafted and submitted to AELA with the air quality specialist study report. Following the 30-day comment period the AEL application will be finalised and re-submitted to the AELA.

Available information was used to describe the ***current state of air quality*** in the Coega IDZ, including:

- Recently completed or current environmental studies for the Coega IDZ/Port of Ngqura.
- Existing air quality and meteorological data for the proposed areas from the Coega Development Corporation (CDC) and other sources such as the South African Weather Services (SAWS).
- Observations made during site inspection visits to the Coega IDZ and discussions with CDC personnel.

Sensitive receptors were identified and included residential areas, potentially sensitive industrial sites and agricultural areas.

An ***emissions inventory*** for particulate matter (including respireable PM_{10} and $PM_{2.5}$) from wind-blown dust from the construction and operational phases of the proposed manganese ore handling facility and the compilation yard was compiled. This phase therefore involved close collaboration with Transnet to discuss the project, agree on emission parameters for the proposed Manganese Ore Export Facility and other emissions in the study area and to discuss feasible mitigation options for the development. Use was made of internationally accepted resources such as the US EPA emission factors. Ore samples from the existing export facilities were collected for particle size analysis to calculate the percentage of wind-entrained dust.

Dispersion modelling provided an estimation of the ambient concentrations of particulate matter. The US EPA approved CALPUFF suite of models (http://www.src.com/calpuff/calpuff1.htm) were used. CALPUFF is also recommended by the DEA for dispersion modelling for regulatory purposes (DEA, 2011). Modelling used three years of meteorological data, which takes varying climatic conditions for different times of the day and year into consideration. Data from the South African Weather Service (SAWS) and CDC were used with modelled data using TAPM (Hurley, 2000; Hurley *et al*, 2001 & 2002) for the surface and upper air. The physical modelling domain is sufficiently large for a detailed understanding of predicted ambient concentrations and deposition rates in all receptor areas of interest and potential concern.

Risk assessment was used as a tool to link environmental exposure to potential human health effects. Risk assessment is the general process of identifying the probable negative effects of exposure to a hazardous agent or situation (NRC, 1994). A risk may be defined as the potential adverse effect that would be caused by a hazard (Brock Neely, 1994). Therefore, the hazard is the chemical, physical or biological agent or set of conditions that has the potential to cause harm. The combined nature of the hazard, exposure potential, population characteristics, and likelihood of occurrence and magnitude of exposure determine risk.

A human health risk assessment (HHRA) is a qualitative and / or quantitative process conducted to characterise risks to public health from exposure to hazardous substances released from specific sites. The advantage of a HHRA over other environmental health linkage methods (such as observational studies or analytical epidemiology studies) is that a HHRA is predictive in nature and uses existing toxicological and exposure data to quantify health risks of exposure to a certain substance (Briggs *et al*., 1996). HHRAs may therefore be conducted in a much shorter period of time than other methods.

Any HHRA follows a defined procedure to determine the potential or actual risk. The procedure developed by the National Academy of Science (NAS) in the USA (US-EPA, 1986) was followed in this study and comprises the following steps:

- Hazard identification;
- Exposure assessment;
- Dose-response assessment or toxicity assessment; and
- Risk characterisation or risk estimation

Hazard identification is aimed at determining whether exposure to a particular substance may result in adverse human health effects. It typically focuses on agent-specific data such as:

- Physico-chemical properties relevant to exposure;
- Sources, routes and patterns of exposure;
- Structure-activity relationships;
- Metabolic and pharmacokinetic properties (how the body absorbs, distributes and eliminates compounds and the effects it may have on the body);
- Short-term *in vivo* (inside the body) and *in vitro* (in a test tube) tests;
- Long-term animal studies;
- Human exposure studies; and
- Human epidemiology studies

Exposure assessment involves the determination of emissions, pathways and rate of movement of a substance as well as its transformation and degradation in the environment. This information is used to estimate the concentration to which human populations of concern are, or may be, exposed. The media (i.e. air, water, soil, food) to which individuals may be exposed to are considered, as well as the route (via inhalation, ingestion or dermal contact) of exposure.

Monitored or modelled environmental data for various media are used to calculate a numeric estimate of the pollutant exposure or dose individuals are likely to receive. Quantitative exposure assessment focuses on the following areas:

- Determination of environmental concentrations through source and emissions characterization, monitoring, and / or environmental fate, transport, and deposition modelling.
- Estimation of the magnitude (concentration), duration (how long), and frequency (how often) of human exposure for relevant subpopulations according to geographic distribution, activity patterns and population estimates.
- Estimation of the dose received, usually expressed as an oral / dermal maximum / Average Daily Dose (ADD) for acute, sub-chronic, or chronic exposures to non-carcinogens, or as an oral / dermal Lifetime Average Daily Dose (LADD) or adjusted inhalation concentration for carcinogens.

Exposure may be influenced by patterns of behaviour that vary greatly among sub-populations in different countries or regions according to culture, education and climate. When conducting an exposure assessment, time-activity patterns (i.e. the time people spend in different micro-environments and their activities in those environments) should ideally be evaluated. Important patterns to consider include spatial distributions (e.g. commuting), food consumption (e.g. quantities consumed and sources, such as home-grown vegetables), time spent outdoors versus indoors, and specific activities (such as swimming). Specific behaviours may also contribute to or minimise exposure, for example, smoking habits or personal hygiene. Exposure assessment is typically the most difficult part of the HHRA and is most prone to uncertainties.

Dose-response assessment is the estimation of the relationship between dose, or level of intake of a substance, and the incidence and severity of an effect. The dose-response relationship is ascertained from toxicological information supplied from:

- Human epidemiological studies;
- Human exposure studies;
- Animal exposure studies; and
- Short-term *in vivo* and *in vitro* tests.

Although dose-response estimates based on human data are preferable, those derived from animal data are often used when appropriate human studies are limited or not available. Modifying factors such as pre-existing illness, exposure to other stressors and nutritional status should ideally be considered for the dose-response estimate calculations.

Several agencies such as the US-EPA, World Health Organization (WHO) and the Centre for Disease Control (CDC) and the Agency for Toxic Substances and Disease Registry (ATSDR) have developed databases for toxicity values or benchmarks, which are used to describe the dose-response relationships for various chemicals. Benchmark values that are based on health effects in human beings are preferred to those incorporating economic or social factors. The US-EPA databases are often consulted for toxicity values. However, in the absence of existing or proposed benchmarks for a specific pollutant or exposure period, other guidelines that are also based on human health, such as those from the WHO, are used. The benchmark values most commonly used are:

For non-cancer effects:

- **Reference dose (RfD) for ingestion and reference concentration (RfC) for inhalation.** These benchmark values represent the pollutant levels that, if ingested (RfD) or inhaled (RfC) over a specified time period no adverse **non-cancer** health effects are likely to occur (US-EPA, 2012).

The Californian EPA's equivalent is the Reference Exposure Level (REL) and that of the Centre for Disease Control is the Minimum Risk Level (MRL).

For cancer effects:

- **The oral slope factor and inhalation unit risk benchmark values** are used to describe the cancer potency of ingested or inhaled pollutants, respectively. Slope factors generally rely on a linear multistage model, which conservatively assumes that there is no threshold, i.e. a carcinogen may cause cancer at any level of exposure and the likelihood of developing cancer increases as the exposure increases. It should be noted that some scientists are of the opinion that some chemicals have the potential to cause cancer only when some minimum threshold level of exposure has been exceeded.

Risk characterisation combines all the information obtained in the previous three steps of the risk assessment to describe whether the predicted risk(s) from exposure to the pollutant(s) of concern may have an adverse effect on public health. This process may be qualitative or quantitative.

Whereas a qualitative risk characterisation is purely a descriptive assessment, the product of a quantitative risk characterisation is a numeric estimate of the public health consequences of exposure to the pollutant. Two types of risk estimates are calculated in a quantitative health risk assessment:

For non-cancer risks:

- **The hazard quotient (HQ)** is determined by the relation between the concentration of the pollutant and the benchmark value for that pollutant. An HQ indicates the potential for developing toxic effects (other than cancer) from exposure to a hazardous substance,

For cancer risks:

- **The incremental cancer risk** is estimated, which is the probability of individuals developing cancer from exposure to a hazardous substance over-and-above the background cancer prevalence.

Risk characterization in a quantitative health risk assessment may vary from a single exposure medium (air, water or soil), single exposure pathway (inhalation, ingestion or dermal) through to multi-media and multi-pathway exposure. A multi-pathway, multi-media health risk assessment refers to a health risk assessment in which risk of exposure to pollutants present in multiple environmental media (i.e. soil, water, food, air, plants) and all possible routes in which these pollutants may enter the human body (i.e. inhalation, ingestion, dermal) are evaluated. The environmental pollutants commonly assessed in a multi-media / multi-pathway health risk assessment are metals, polycyclic aromatic hydrocarbons (PAHs), chlorinated hydrocarbons and pesticides.

In this study, risk characterisation is mainly quantitative, although certain scenarios are addressed qualitatively, for example the construction and the decommissioning phase.

Acceptability of risk

In the case of pollutants that may cause cancer, 1 in a million incremental (over and above the background level) risk is considered "acceptable". However, despite widespread acceptance of the use of a 1 in a million incremental cancer risk as an acceptable risk, its origin was determined to be a completely arbitrary figure adopted by the US Food and Drug Administration (FDA) as an essentially zero level of risk for residues of animal drugs (Kelly, 1994).

For carcinogenic substances, it is assumed that there is some probability of harm to human health at any level of exposure (TERA, 2000). Some risks may, however, be perceived as being acceptable –

usually when they are voluntary – while others are clearly unacceptable. For example, if the odds are 1 in a billion that a person will die from a certain exposure, the risk clearly could not be considered significant, whereas if the odds were 1 in a thousand, the risk might well be considered significant (OSHA, 2000).

It is believed that a single metric as a measure of acceptable risk should not be used (NRC, 1994). Instead, there is a general presumption that a lifetime excess (incremental) cancer risk of approximately 1 in 10 000 for the most exposed person will be acceptable and that the margin of safety should reduce the risk for the greatest possible number of people to an individual lifetime incremental risk that is not higher than 1 in a million.

The Superfund Programme in America has defined acceptable risk as a range from 1 in 10 000 to 1 in a million. (Alberta Environment in the USA considers 1 in 100 000 as an “acceptable level of lifetime cancer risk” (AE, 2004)). The EPA’s air office strives to reduce risk for as many people as possible to 1 in a million, while assuming that the maximally exposed individual is protected against risks greater than 1 in 10 000 (Graham, 1993).

For health effects other than cancer, a Hazard Quotient is determined from exposure to a single chemical. An HQ below 1 indicates that the risk is low enough to be acceptable, while an HQ below 0.1 indicates no risk (Lemley, 1996).

Impact Assessment

It must be noted from the outset that the air quality impact assessment is based on concentrations of dust (including manganese ore) generated, while the human health impact assessment is based on the concentrations of manganese as Mn in the respirable fraction of the manganese ore dust. The reason for the difference is that air quality impact is based on standards set for ambient concentrations of total dust (total particulate matter), and particulate matter of specific sizes (PM_{10} and $PM_{2.5}$), regardless of the chemical composition of the dust (particulate matter). Health risk assessment, on the other hand, not only takes into account the concentrations and the particle size of particulate matter, but also the specific chemicals involved.

In the case of manganese ore, the human health risk assessment is based on:

- the respirable fraction of the dust ($PM_{2.5}$), because that is what is inhaled deep into the respiratory system, and
- the manganese (as Mn) in the respireable fraction, because health guidelines and standards for manganese and compounds are set based on Mn.

The impact assessment involved:

- Assessment of the predicted ambient air pollution concentrations with consideration of South African standards for particulates (total dust, PM_{10} and $PM_{2.5}$) and international ambient air quality guidelines (for manganese (Mn));
- Assessment of the predicted ambient concentrations and deposition rates of Mn ore resulting from the handling and storage of manganese ore on sensitive receptors (the Coega IDZ, agriculture, etc.) using international ambient guidelines;
- Assessment of the nature, extent, duration, probability and significance (in terms of EIA guidelines definitions) of identified impacts requiring further investigation;

Based on the proposed dust control measures and the predicted ambient concentrations, appropriate **management and mitigation measures** are proposed to reduce the associated risks considering international best practice for dust control and management at bulk terminals. Experience in the project team with similar bulk ore operations within South Africa is applied. In addition, recommendations are made for ambient air quality monitoring.

5.1.4 Assumptions, Uncertainties and Limitations

This study addresses the impact on air quality from dust emissions from the construction and operation of the proposed manganese ore handling facility and compilation yard as well as locomotive emissions. The emissions and dispersion modelling considers particulate matter (including PM_{10} and $PM_{2.5}$) from wind-blown dust and handling activities at the Manganese Ore Export Facility, and diesel emissions from locomotives at the compilation yard.

The emission inventory was compiled by the air quality specialist and reviewed by the project team and confirmed as correct.

Manganese ore, collected from the existing export facilities, was analysed for particle size distribution and Mn content. It is assumed that the particle size distribution and the Mn content of the ore at the existing export facilities is the same as that at the proposed Manganese Ore Export Facility at Ngqura due to the common origin of the bulk of the ore; and similar storage and handling procedures.

The DEA (2012) dispersion modelling guidelines recommend that three years of meteorological data is used and the data should be no older than five years to the year of assessment The three years of meteorological data (2009-2011) used for the dispersion modelling with CALPUFF are representative and meet these requirements.

Cumulative impacts are assessed by adding background concentrations of PM_{10} to the predicted concentration, i.e. qualification of emissions from other sources is not included in this study.

The actual risk associated with a hazard can only be assessed and measured once damage from exposure to that hazard has occurred. HHRA is a *predictive* process that is able to assess the likelihood of adverse health effects occurring as a result of exposure to a hazardous substance. The risks can, therefore, only be *estimations* of what could occur, and as such have uncertainties associated with them.

Uncertainty in health risk assessments may be classified into three types:

- Variable uncertainty;
- Model uncertainty; and
- Decision-rule uncertainty.

Variable uncertainty occurs when variables appearing in equations cannot be measured precisely or accurately, either due to equipment limitations or spatial or temporal variances in the quantities being measured. Areas in which variable uncertainty may occur include:

- The determination of pollutant emissions.
- The use of population demographics or statistics.
- The determination of activity patterns and health status of individuals.
- The determination of ambient levels of the pollutants under consideration.

Model uncertainty is associated with all models (and equations) used in all phases of the risk assessment, including:

- Animal models used as surrogates for testing human health effects, including carcinogenicity. (these are the models used in the original toxicology studies on the specific chemical, to determine health effects)
- The dose-response models used in extrapolations in the determination of health benchmark values such as RfDs, RfCs, RELs and MRLs.
- The use of computer models to quantify exposure and risk.

Decision-rule uncertainty is associated with the manner in which the risk assessor conducts the study. This may include:

- The selection of the compounds of potential concern to be included in the risk assessment.
- The use of national and international ambient pollutant guidelines / standards as significant values with which health effects may be associated.
- The decision as to which exposure pathways are most significant.
- Decision on the size distribution and concentrations of particles.

These uncertainties will be considered when applying the HHRA framework in this report.

5.1.5 Sources of Information

Information used in this air quality assessment includes:

- Meteorological data and ambient air quality data at Amsterdamplein, Motherwell and Saltworks for 2009-2011 sourced from the CDC;
- Meteorological data at the Port Elizabeth Airport sourced from the South African Weather Service;

Manganese ore from the existing export facilities was analysed for particle size distribution and Mn content. Information on the proposed infrastructure and ore handling activities at the Manganese Ore Export Facility were extracted from the Final Scoping report and supplemented by Transnet.

5.1.6 Declaration of independence

I MARK ZUNCKEL declare that I am an independent consultant and have no business, financial, personal or other interest in the Proposed Manganese Ore Export Facility, Port of Ngqura, application or appeal in respect of which I was appointed, other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of my performing such work.

Signature:

Name: MARK ZUNCKEL PhD
Professional Natural Scientist, Reg no 4004490/04

5.2 LEGISLATIVE REQUIREMENTS

5.2.1 Air Quality Management Plan for the NMBM

The vision of the Air Quality Management Plan (AQMP) for the Nelson Mandela Bay Metropolitan Municipality (C&M, 2011) is to minimise the impact of air pollutants on human health and wellbeing and the natural environment through nine specific objectives. These are to:

i. Set air quality goals;
ii. Set up air quality management system;
iii. Carry out risk assessments;
iv. Assess and select control measures;
v. Implement interventions and monitor the effect of the interventions;
vi. Revise air quality goals.
vii. Integrate the AQMP into the IDP;
viii. Undertake compliance monitoring, enforcement and control; and
ix. Review the air quality management plan.

It is important that the Ngqura Manganese Ore Export Facility project is cognisant of the vision of the NMBM AQMP and of these objectives in planning and operation.

5.2.2 Atmospheric Emission License

Section 21 of the National Environmental management: Air Quality Act (Act 39 of 2004), the AQA, defines Listed Activities as those that the Minister reasonably believes have or may have a significant detrimental effect on the environment. Government Notice 248 (DEA, 2010) defines the Listed Activities and where applicable, minimum emission standards and special conditions. According to Section 37 of the AQA, an application for and Atmospheric Emission License is required for all Listed Activities.

Transnet proposes to store and handle more than 16 Mt Mn ore per annum. According to Category 5 (Mineral processing, storage and Handling and sub-category 5.1 (Storage and handling of ore or coal) of the list of activities, all installations that are not situated on a mine and hold more than 100 000 tons of ore or coal are classified as a Listed Activity. Transnet is therefore required to apply for an AEL and this should be supported by an atmospheric impact report (Section 30 of the AQA). The application has been lodged with the AEL Authority at the NMBM (refer to Appendix B).

The principal condition of sub-category 5.1 is that dust fall is measured in eight principal wind directions and the 3-month running average does not exceed the limit values for the adjacent land-use, according to the Draft National Dust Control Regulation (DEA, 2011b) (published on 27 May 2011) for public comment) which formalises the SANS recommendations.

This regulation states that no person may conduct any activity in such a way as to give rise to dust in such quantities and concentrations that:

a) The dust, or dust fall, has a detrimental effect on the environment, including health, social conditions, economic conditions, ecological conditions or cultural heritage, or has contributed to the degradation of ambient air quality beyond the premises where it originates; or
b) The dust remains visible in the ambient air beyond the premises where it originates; or
c) The dust fall at the boundary and beyond the boundary of the premises where it originates exceeds:

i) 600 mg/m^2/day averaged over 30 days in residential or light commercial areas measured using reference method ASTM D1739; or
ii) 1200 mg/m^2/day averaged over 30 days in areas other than residential and light commercial areas measured using reference method ASTM D1739.

There is no provision in the regulation for listed activities and minimum emissions for emissions limits for tipplers.

5.2.3 Pollutants potentially emitted and their ambient air quality standards and guidelines

5.2.3.1 Particulate Matter (PM)

In the ambient environment airborne particulates are ranked according to size. Coarse particles are associated with dust fallout or deposition and are regarded as nuisance impacts through accumulation and possible discolouration. Finer dust is categorised into sub-classes depending on its size and the associated human health impacts. The coarsest of the fine dust refers to all dust with a diameter of less than 100 μm, known as total suspended particulates (TSP). The fraction of TSP that is inhalable and is associated with health impacts has a diameter equal to or smaller than 10 μm and is known as PM_{10}. When exposed to particulate matter through normal nasal breathing, particles larger than 10 μm would be removed in the passage of the air stream through the nose and upper respiratory airways, and particles between 3 μm and 10 μm would be deposited in the upper airways. Finer particles with a diameter equal to or less than 2.5 μm ($PM_{2.5}$) have yielded stronger associations with health impacts than PM_{10} as it can enter deeper into the lung. Sources of $PM_{2.5}$ include combustion processes and the formation of atmospheric aerosols in chemical transformations in the atmosphere. Health effects of PM depend on size and chemical composition.

Deposition of particulates on to surfaces may pose a nuisance as well as a potential risk in terms of runoff into drinking water or accumulation on vegetation depending on the chemical nature of the particulate matter and bioavailability of the metals. The South African ambient air quality standards for PM_{10} and $PM_{2.5}$ and dust fallout limits are shown in Table 5-1.

5.2.3.2 Sulphur dioxide (SO_2)

The major source of SO_2 is the combustion of sulphur containing fossil fuels such coal, oil and diesel. On inhalation, most SO_2 only penetrates as far as the nose and throat (because it is readily soluble in the moist lining of the upper respiratory system), with minimal amounts reaching the lungs, unless the person is breathing heavily, breathing only through the mouth, or if the concentration of SO_2 is high (CCINFO, 1998). The acute response to SO_2 is rapid, within 10 minutes in people suffering from asthma (WHO, 2005). Effects such as a reduction in lung function, an increase in airway resistance, wheezing and shortness of breath, are enhanced by exercise that increases the volume of air inspired, as it allows SO_2 to penetrate further into the respiratory tract (WHO, 2000).SO_2 reacts with cell moisture in the respiratory system to form sulphuric acid. This can lead to impaired cell function and effects such as coughing, broncho-constriction (narrowing of the bronchi), exacerbation of asthma and reduced lung function.

SO_2 has the potential to form sulphurous acid or slowly form sulphuric acid in the atmosphere via oxidation by the hydroxyl radical. The sulphuric acid may then dissolve in water droplets and fall as precipitation, thereby contributing to acid rain. Acid rain may cause the acidification of soils, lakes, and streams, accelerated corrosion of buildings and monuments and damages paintwork. The South African ambient air quality standards for SO_2 are shown in Table 5-1.

5.2.3.3 Oxides of nitrogen (NO_x= NO + NO_2)

Nitrogen dioxide (NO_2) and nitric oxide (NO) are formed simultaneously in combustion processes and other high temperature operations such as metallurgical furnaces, blast furnaces, and internal combustion engines. NO oxidises rapidly to NO_2 in the atmosphere and NO_x is a term commonly used to refer to the combination of NO and NO_2. The route of exposure to NO_2 is inhalation and the seriousness of the effects depend more on the concentration than the length of exposure. The site of deposition for NO_2 is the distal lung (because NO_2 does not readily dissolve in the moist upper respiratory system) where NO_2 reacts with moisture in the fluids of the lower respiratory tract to form nitrous and nitric acids (WHO, 1997). About 80 to 90% of inhaled nitrogen dioxide is absorbed through the lungs (CCINFO, 1998). Nitrogen dioxide (present in the blood as the nitrite ion) oxidises unsaturated membrane lipids and proteins, which then results in the loss of control of cell permeability. Nitrogen dioxide causes decrements in lung function, particularly increased airway resistance. People with chronic respiratory problems and people who work or exercise outside will be more at risk to NO_2 exposure (EAE, 2006).

In the atmosphere, NO_2 reacts with water vapour to produce nitric acid. This acidic pollution can be transported over long distances by wind and deposited as acid rain, causing the acidification of soils, lakes, and streams, accelerated corrosion of buildings and monuments and damages paintwork. NO_2 is also a major source of secondary fine particulate pollution which decreases visibility, and contributes to surface ozone formation through its reaction with Volatile Organic Compounds (VOCs) in the presence of sunlight. The South African ambient air quality standards for NO_2 are shown in Table 5-1. There are no South African ambient standards for NO.

5.2.3.4 Benzene

Benzene is a natural component of crude oil, petrol, diesel and other liquid fuels and is emitted when these fuels are combusted. Diesel exhaust emissions therefore contain benzene. After exposure to benzene, several factors determine whether harmful health effects will occur, as well as the type and severity of such health effects. These factors include the amount of benzene to which an individual is exposed and the length of time of the exposure. For example, brief exposure (5–10 minutes) to very high levels of benzene (14 000 – 28 000 µg/m^3) can result in death. Lower levels (980 – 4 200µg/m^3) can cause drowsiness, dizziness, rapid heart rate, headaches, tremors, confusion, and unconsciousness. In most cases, people will stop feeling these effects when they are no longer exposed and begin to breathe fresh air. Inhalation of benzene for long periods may result in harmful effects in the tissues that form blood cells, especially the bone marrow. These effects can disrupt normal blood production and cause a decrease in important blood components. Excessive exposure to benzene can be harmful to the immune system, increasing the chance for infection. Both the International Agency for Cancer Research and the Environmental Protection Agency (EPA) have determined that benzene is carcinogenic to humans as long-term exposure to benzene may cause leukaemia, a cancer of the blood-forming organs. The South African ambient air quality standards for benzene are shown in Table 5-1.

5.2.3.5 Manganese

Manganese is a naturally occurring substance found in many types of rocks and soil, for example in manganese ore. Pure manganese has a silver colour, but it does not occur in the environment as a pure metal but requires refinement through a smelting process. Rather, it occurs as a compound combined with other elements. Manganese can exist in both inorganic (for example manganese dioxide (MnO_2) or manganese sulfate ($MnSO_4$)), and organic (for example methylcyclopentadienyl manganese tricarbonyl (MMT)) forms. Manganese is used principally in steel production to improve hardness, stiffness, and strength in products like carbon steel, stainless steel, high-temperature steel, and tool steel, cast iron and superalloys. It is also used in a wide variety of other products, such as fireworks, dry-cell batteries, fertilizer, paints, and cosmetics and as an additive in petrol (MMT).

Manganese occurs naturally in most foods and may be added to food or made available in nutritional supplements, because it is a trace element and is necessary for good health.

The toxicity of manganese compounds depends on concentrations and duration of exposure, but also on the route of exposure. If manganese is ingested it has relatively low toxicity at typical exposure levels and is considered a nutritionally essential trace element. In 2003, no neurological effects were seen in humans ingesting manganese sulphate at an average dose of 0.3 mg/kg body weight/day for eight weeks, but in a study in 2011, it was shown that a dose of 0.104 mg/kg bodyweight/day for about 70 days over a period of 5 years (from drinking water containing manganese), could have neurological effects (CDC, 2012). Another study (in 2007) showed a daily dose of manganese of 0.26 mg/kg bodyweight/day caused an increase in deaths among children below 1 year who drank water contaminated with manganese (CDC, 2012). However, inhalation of manganese is considered the major toxic pathway, mainly also because this route of exposure is more efficient in delivering the metal in high concentrations to the brain (IEH, 2007) and several studies on workers showed adverse effects (CDC, 2012; WHO, 2000).

Inhalation of inorganic manganese (for example MnO_2) can cause an inflammatory reaction in the lungs, as was found in studies on humans (workers) and animals (except rabbits) (CDC, 2012). It is believed that the inflammation was caused by the particles inhaled and not specifically by the manganese (CDC, 2012). Cardiovascular symptoms were found in workers from a ferromanganese plant (CDC, 2012). People with an iron deficiency are more susceptible to the effects of manganese (IEH, 2007).

The main concern about manganese and compounds is the neurological effects (effects on the nervous system) from repeated inhalation (CDC, 2012). In a study by Blond *et al*, (2007) on Danish steel workers, cognitive function could not be distinguished between steel workers exposed to manganese at 0.070 mg/m^3 (70 µg/m^3) and controls but longitudinal analysis showed the workers' ability to perform certain fast movements with their hands and fingers were impaired when compared with controls (CDC, 2012). Concentrations of manganese in air associated with neurological effects in workers who were exposed over a long time, ranged from about 0.07 to 0.97 mg manganese/m^3 (manganese in total dust or inhalable dust) (CDC, 2012).

The Centre for Disease Control in the US, re-evaluated several studies in 2012 to update their reports on manganese and stated that "there is conclusive evidence from studies in humans that inhalation exposure to high levels of manganese compounds (usually manganese dioxide, but also compounds with Mn(II) and Mn(III)) can lead to a disabling syndrome of neurological effects referred to as 'manganism'" (CDC, 2012). Manganism is characterised by various psychiatric and movement disorders, with some general resemblance to Parkinson's disease in terms of difficulties in the fine control of some movements, lack of facial expression, and involvement of underlying neurological systems (Roels, 1992; Mergler, 1994, CDC, 2012). However, different areas of the brain are affected in the two diseases (CDC, 2012).

Reproductive dysfunction such as reduced libido in individuals with manganism and impaired reproductivity in individuals exposed to elevated concentrations (0.97 mg/m^3) of manganese were reported (CDC, 2008).

The available evidence is inadequate to determine whether or not manganese is carcinogenic; The US EPA has stated that due to inadequate evidence, manganese cannot currently be classified as carcinogenic or not (IRIS, 2006).

There is no South African ambient air quality standard for manganese, therefore international standards and or guidelines are used. The US-EPA IRIS Reference Concentration for Chronic Inhalation Exposure (RfC) of manganese is 0.05 µg/m^3. The RfC is based on a study with a Lowest Observed Adverse Effect Level (LOAEL) (the lowest concentration at which a health effects was seen) of 0.05 mg/m^3. This study has an uncertainty factor of 1000 (which means the LOAEL of 0.05 mg/m^3 has to be divided by 1000 to get to a “safe” concentration of 0.05 µg/m^3). The EPA has a medium confidence in this RfC.

The World Health Organization (WHO) reports a No Observed Adverse Effect Level (NOAEL) of 0.03 mg/m^3 for manganese (i.e. no health effects identified for a concentration of 0.03 mg/m^3), with an uncertainty factor of 200 (1999). . The study was however of a short duration and the NOAEL was divided by an uncertainty factor of 200 to get a benchmark value. The WHO ambient annual guideline value for manganese is therefore 0.15 µg/m^3 (0.03 mg/m^3 divided by 200) to adjust for continuous exposure and to account for the uncertainty (WHO, 2000).

The Californian Environmental Protection Agency (Cal-EPA) guideline value or Reference Exposure Level (REL) for chronic exposure to manganese and compounds is 0.09 µg/m^3. This value was based on a time adjusted exposure concentration of 26 µg/m^3 and an uncertainty factor of 300 (based on the study by Roels *et al* in 1992 on exposure to MnO_2). The uncertainty factor makes provision for the exposure of children (Cal-EPA, 2008), which means that children exposed to the REL of manganese will be unlikely to develop adverse effects, as their susceptibly due to age, was taken into account when the REL was calculated.

The CDC set a new Minimal Risk Level (MRL) of 0.3 µg/m^3 for manganese in September in 2012. The MRL is based on a concentration of 0.142 mg manganese/m^3 divided by uncertainty factors including a factor of 10 for the use of different forms of manganese.

Given that guidelines and standards are only available for Mn and not manganese ore, and that the proposed Manganese Ore Export Facility would handle and store Manganese ore (mainly consisting of MnO), a conversion factor of 1.29 for manganese was used when assessing health risks associated with the ore. Similarly, a conversion factor of 2.139 was used for silicon. Ore samples from the existing export facilities were analysed[1] as the ore originates from the same area in the Northern Cape and results showed that the ore contains 53% MnO. A conversion factor is based on the mass percentage of Mn in the ore. The aforementioned information was used to determine the mass of Mn per volume (µg/m^3) in the modelled $PM_{2.5.}$ because $PM_{2.5}$ is the respireable fraction of PM. These concentrations of Mn were then used in the human health risk assessment.

A literature survey on the health effects of manganese is presented in Appendix 5.A.

5.2.3.6 Ambient air quality standards and guidelines

Health-based ambient air quality standards have been established for criteria pollutants and one toxic air pollutant in South Africa. Being health-based, these standards imply that the ambient concentrations less than the standard do not pose a health risk, while concentrations above the standard may pose a risk. The national ambient air quality standard consists of a limit value and a permitted frequency of exceedance. The limit value is the fixed concentration level aimed at reducing the harmful effects of a pollutant. The permitted frequency of exceedance represents the tolerated exceedance of the limit value and accounts for high concentrations as a result of process upsets and meteorological variation. Compliance with the ambient standard therefore implies that ambient concentrations are below the limit value and the frequency of exceedance does not exceed the permitted tolerance. The criteria pollutants that are of concern in this assessment are SO_2, NO_2, PM_{10},

---

[1] Samples were analysed by UIS Analytical Services Pty (Ltd)

$PM_{2.5}$ and benzene. These pollutants will be emitted from diesel locomotives, ore handling and storage and the stormwater retention ponds. The ambient standards are listed in Table 5.1. The annual ambient guideline values for Mn are listed in Table 5-2.

There are no South African ambient air guidelines for toluene, ethylbenzene and xylene. For toluene the WHO non-cancer 30-minute guideline of 1000 µg/m^3 is based on odour annoyance and the 24-hour guideline is 7 500 µg/m^3 assessment is based on CNS effects in workers (WHO, 2000). A health-based hourly average guideline for ethyl benzene of 2 000 µg/m^3 is applied (Government of Alberta, 2011). For xylene the hourly guideline value of 2 300 µg/m^3 and 24-hour guideline of 700 µg/m^3 are used in this assessment (Government of Alberta, 2011).

Table 5.1: National Ambient air quality standards (Republic of South Africa, 2009 and 2012)

Pollutants	Averaging period	Limit value µg/m^3	Frequency of exceedance	Compliance date
SO_2	10 min	500	526	-
	1-hour	350	88	-
	24-hour	125	4	-
	Annual	50	0	-
NO_2	1-hour	200	88	-
	Annual	40	0	-
PM_{10}	24-hour	120	4	-
	24-hour	75	4	1 Jan 2015
	Annual	50	0	-
	Annual	40	0	1 Jan 2015
$PM_{2.5}$	24-hour	65	0	-
		40	0	1 Jan 2016–31 Dec 2029
		25	0	1 Jan 2030
	Annual	25	0	-
		20	0	1 Jan 2016–31 Dec 2029
		15	0	1 Jan 2030
Benzene	Annual	10	0	-
		5	0	1 Jan 2015

Table 5-2: Ambient air quality guidelines for Mn

Averaging Period	Concentration ($\mu g/m^3$)
Annual average	0.15

Inhalation benchmark values for manganese dust.

Inst	Benchmark ($\mu g/m^3$)	Exposure duration (Acute/ Chronic)	Uncertainty* factor	Health effect	Study population	LOAEL/ NOAEL ($\mu g/m^3$)	Occ Std (mg/m^3)
EPA (IRIS)[1]	0.05	Chronic	1000	Neuro-behaviour function	Workers exposed to MnO_2	50 (LOAEL)	
CDC (ATSDR)[2] (MRL)	0.30	Chronic	500	Neuro-logical effects	Workers exposed to Mn oxides	$BMCL_{10}$ of 142	
WHO[3]	0.15	Chronic	200	Neurotoxic effects	Study on workers	30 (NOAEL)	
South Africa (OEL)[4]		Occupational		Effect not stipulated			1.0
Cal-EPA[5] (REL)	0.09	Chronic	300	Neuro-logical effects	Workers	$BMDL_{10}$ of 74 $\mu g/m^3$	

*indicate the confidence in the benchmark value and is described below

[1] IRIS: http://cfpub.epa.gov/ncea/iris/index.cfm?fuseaction=iris.showQuickView&substance_nmbr=0373#refinhal

[2] CDC: http://www.atsdr.cdc.gov/mrls/index.html

[3] WHO: http://www.who.int/peh/air/Airqualitygd.htm

[4] SA OEL: DoL Government Gazette number 29276 5 October 2006

[5] Cal-EPA: http://www.oehha.ca.gov/air/hot_spots/2008/AppendixD1_final.pdf#page=170

5.3 DESCRIPTION OF PROJECT ASPECTS RELEVANT TO AMBIENT AIR QUALITY IMPACTS

A number of aspects in the construction and operations at bulk ore handling facilities are potential sources of dust that may result in air quality impacts, both nuisance effects and health impacts. Emissions from diesel locomotives include NO_x, particulates, VOCs that pose potential risks to human health. The respective aspects of the ore handling process and rail are discussed with the emphasis on their potential to impact on ambient air quality.

5.3.1 Proposed Manganese Ore Export Facility

Manganese ore will be transported via the existing Hotazel-Ngqura rail system from the mines in Hotazel in the Northern Cape to the proposed facility at the Port of Ngqura. The ore will be transported in 200-wagon train consignments, with each rail wagon containing a payload of 63 tons. The proposed facility will be constructed in Zone 9 of the Coega IDZ with a maximum throughput capacity of 16 Mtpa and up to 25 grades of ore. It is anticipated that four 200-wagon trains will arrive daily at the compilation yard, 349 days per annum. The Manganese Ore Export Facility will operate on a 24-hour, 365 days per year basis.

The proposed Ngqura Manganese Ore Export Facility consists of a rail compilation yard, a tippler, stockyard with stackers and reclaimers, conveyor system and a ship loader.

5.3.2 Construction

The construction phase will involve the transportation of personnel, construction material and equipment to the site, and personnel and waste away from the site. The construction phase is anticipated to last for 36 months although the construction activities will not be the same over this period.

The main initial construction activity will involve site clearance and the construction of a platform for the establishment of permanent construction camps. In so doing, it is expected that bulk earthworks will be required for the following components of the proposed project:

- Stockyard terracing and associated facilities,
- Administration buildings,
- Tippler,
- Quay,
- Access and service roads,
- Rail compilation yard as well as the loop and link lines and
- The doubling of the line between the tippler rail yard and the compilation yard

Upon completion of construction and removal of equipment, the temporary works areas will be rehabilitated.

Most civil construction activities generate dust and the emission of particulates into the atmosphere is through vehicle dust entrainment, vegetation removal, excavation, ground levelling, etc. In most cases the dust is relatively course, but may include fine particles (PM_{10}). The emissions are generally released close to ground level and have no buoyancy. As a result the coarse particulates will settle relatively close to the emission source while finer particulates may be transported further from the point of release as they are easily carried by wind. Exhaust emissions from construction vehicles and equipment typically include particulates (including PM_{10} and $PM_{2.5}$), carbon monoxide (CO), nitrogen oxides (NO_x) and volatile organic compounds (VOCs) including benzene. These pollutants are also released close to ground level which limits their dispersion. The health risks and ambient standards of these pollutants are discussed in Section 5.2.3.6.

5.3.3 Tippler

Each rail wagon will be tipped at the tippler station via one dual rotary car tippler into the tippler hoppers (Figure 5-1). The tippler will have a capacity of 5 100 tons per hour. From there ore will be fed onto a collecting conveyor via a set of apron feeders. The collecting conveyor will then feed the ore onto a short sacrificial conveyor at a rate of 5 100 tons per hour. The sacrificial conveyors will feed the ore onto the two unloading discharge conveyors that exit from under the tippler and route up to ground level, eventually reaching an elevated level over the servitude to feed onto the stockyard feed conveyors.

Little or no dust is expected to be blown from the ore wagons waiting at the tippler as any fine material will have been displaced en route from the mines. Similarly, no dust will result on the rail line to the tippler from falling through the wagons as they are closed bins. Dust will however be generated when the wagons are tipped. The amount of dust that is generated and emitted to the atmosphere depends on the dust control measures at the tippler and the moisture content of the ore.

Figure 5-1: Typical enclosed rotary tippler (Transnet, 2012)

The tippler will be fully enclosed in a sheeted building. The building will have open gable walls on the entry and exit sides. The partition walls will have an aperture the size of the Transnet Freight Rail "moving structure gauge." Dust will be suppressed within the tippler building including a high pressure water fog system at the tippler hopper vibrating feeder chutes.

The stockyard feed conveyor system will consist of two parallel conveyor systems, each comprising four conveyor transfer points in series. At each transfer point the conveyors will be able to transfer on either the stacker stockyard conveyor or the transfer conveyor. The conveyors in the stockyard will not be covered as they are part of moving equipment that travels on the rail system and covering is not feasible. The transfer points are enclosed.

5.3.4 Stockyard

The stockyard will cover an area of approximately 40 hectares and will have a maximum capacity of up to 1.8 million tons of manganese ore. The ore will be stacked in four stockyard lines spaced 50 m apart. The stockyard will be served by three stackers and two reclaimers. The lines will each be approximately 50 m wide, 800 m long and 17 m high and will be made up of separate stockpiles for up to 25 different grades of ore that will be stacked in separate stockpiles. A minimum of six stockpiles will therefore be required for each of the four stockpile rows and the stockpiles will have gaps of 10 m in between them.

The three stackers will be mounted on rails that run the length of the stockpile, each having a stacking capacity of 5 000 tons per hour. They have a luffing and slewing functionality (i.e. vertical and rotation around the central axis) and are being fed by the stockyard conveyor via a tripper and onto each stacker boom conveyor in order to stack the ore onto the relevant stockpiles. Reclaiming ore will be carried out by two luffing and slewing bucket wheel reclaimers which will feed the overland conveyor system at approximately 5 100 tons per hour.

Dust may be generated during stacking and reclaiming ore as well as by wind entraining dust from the stockpiles and the stockyard in general. The amount of dust that is generated and emitted to the atmosphere from the stockyard and the related activities depends on the dust control measures that are employed and the effectiveness of these measures.

The stockyard is located in a relatively low lying area to reduce the effects of wind. Cannons will be provided to damp down the stockpile surface using water or chemical suppressants. The stackers and reclaimers will all be equipped with a water supply via a trailing cable and cable reeling drum. The stackers will spray water onto the manganese ore as it falls onto the stockpile. The control system will be designed to limit the free fall of manganese ore from the end of the stacker onto the stockpile to a maximum drop of 1.5m, as the primary dust mitigation action. The stacker transfer will incorporate a dynamic chute which reduces noise, ore degradation and dust generation by as much as 80% compared with conventional drop box or bash plate chutes that are commonly used. The reclaimers will also incorporate sprays for water or chemical suppressants onto the reclaimed manganese ore at the bucket wheel and onto the receiving conveyor at the point of contact. The reclaimer will incorporate a dynamic chute.

5.3.5 Conveyor system

The overland conveyor system will link the stockyard to the ship loaders on the existing berths C100and C101 at the Port of Ngqura. The conveyor route will run through the existing rail culvert, adjacent to the rail route. It will then continue in a straight line up to the end of the route. This requires the conveyor to cross the rail and run within a proposed cutting for ~2 km, after which it turns north east towards the berth (refer to Figure 2.13 in Chapter 2 of the draft EIR). . A double ship-loading and overland conveyor system is required, whereby the two conveyors will be positioned side-by-side. The conveyor structure will also allow for walkways on both sides of the conveyors to allow access for maintenance.

The stockyard conveyors will be partially shielded from the wind with a dog house sheeting arrangement, limiting dust that can result from wind blowing across the loaded conveyors. The overland conveyor system will however be covered to reduce windblown dust being emitted from the conveyor. The tippler-reclaim conveyors run in a tunnel. The stockpile conveyors all run at ground level except for a short section at the feed and discharge ends. As such, these conveyors are partially shielded by the stockpiles and run roughly parallel to the prevailing wind direction. The elevated sections will be equipped with wind boards to limit windborne dust generation.

5.3.6 Ship loader

Ore will be conveyed from the surge bin in the stockyard via the overland conveyor to the ship loading conveyors located alongside the C100 and C101 berths. The ore will be loaded onto the ship-loader boom conveyor via a tripper. The ship loaders will contain long travel and luffing movement capabilities, which will ensure that all positions of the ship may be reached during loading. Maintenance bays for the ship loaders will be positioned at the north and south ends of the C100 and C101 quay. It is proposed that the ship loaders will be designed to load Panamax vessels at an average rate of 3 500 tons per hour.

Dust may be generated during ship loading, both from the loaders and from dust escaping from the hold of the ship as a result of air displacement. The amount of dust that is generated and emitted to the atmosphere depends on the dust control measures that are employed and on the loading activity.

The ship loaders will be fitted with loading spouts with an annular air intake at the point of discharge into the ship’s hold. The tripper chutes on the ship-loader feed conveyors will be dynamic. Due to the ship loader trippers moving up and down the ship loader conveyors, these are not covered the ship-loader conveyors will be equipped with wind boards on the sides for wind protection.

5.3.7 Spillage handling

Ore spillages and the accumulation of ore dust may occur at conveyor transfer points. The transfer points include those from the tippler to the stacker conveyors, the reclaimer conveyors to the surge bin, the surge bin to the overland conveyor, and the conveyors to the ship loaders. These points of accumulation may be sources of windblown dust. Similarly, the accumulation of ore dust on roads and open areas may be a source of dust by wind entrainment and vehicle movement.

5.3.8 Rail Compilation Yard

A rail compilation yard will be located in Zone 11 and Zone 13 of the Coega IDZ and the remainder of Farm Tankatara Trust 643. It will comprise five yard lines with crossovers at mid-point, to allow for the consolidation and de-consolidation of four 200-wagon trains per day. A triangle will also be included, to allow for the locomotives to turn around. From the compilation yard, diesel locomotives will haul the 100 wagon sets to and from the tippler. The rail compilation yard will include a diesel locomotive refuelling facility consisting of 2 self-contained aboveground storage tanks with a total capacity of approximately 150 m^3 as well as a locomotive sanding facility. The yard will also include a locomotive wash bay and provision for an oil-water separator for dirty water generated from the wash bay and the maintenance facilities.

Little or no dust is expected to be blown from the ore wagons as any fine material will have been displaced en route from the mines. Similarly, no dust will result on the rail line to the tippler from falling through the wagons as they are closed bins.

The combustion of diesel in the locomotives operating at the compilation yard will result in the emission of NO_x, particulate matter and VOCs. The emissions depend primarily on the power rating and the hours of operation of the locomotives. The emissions are discussed in Section 5.6.3.

5.3.9 Stormwater retention and attenuation pond

A stormwater retention dam will be constructed at the stockyard with a storage capacity of approximately 50 Mℓ and will have a free board of 800mm at full capacity with an additional free board allowance for accommodating a 1:100 year fluid inflow. The main function of the stormwater retention dam will be to collect stormwater runoff from the stockyards and water from the tippler sump via pipes attached on the conveyor structure. Two silt traps or settling ponds leading to the control dam will allow Manganese ore dust and solids to settle out before entering the main retention dam. These ponds will be cleaned regularly and the manganese mud from these ponds will be managed in terms of an onsite waste management policy. A second stormwater retention dam will be constructed near the shiploader with a storage capacity of approximately 10 Mℓ. The main function of this second retention dam will be to prevent runoff from entering the marine environment.

In addition, an attenuation pond will be constructed at the rail compilation yard to collect all stormwater runoffs from this area and will have a storage capacity of approximately 18 Mℓ.

The emission of dust from the retention and attenuation dams is expected to be negligible due to the high moisture content. Similarly, evaporative emissions of VOC collected in the retention and attenuation dams from runoff is expected to be negligible. The effect of the dams on air quality is therefore not assessed further.

5.3.10 Doubling of Railway

Transnet SOC Ltd is intending to double the railway line between the proposed Coega compilation yard and the existing marshalling yard in Zone 9 of the Coega IDZ. This will be a dedicated railway line to allow for the transportation of the rakes between the proposed Coega compilation yard and the tippler. This second railway line will be constructed within the existing reserve, but the additional rail reserve will be required to ensure that the reserve width is sufficient.

Little or no dust is expected to be blown from the ore wagons as any fine material will have been displaced en route from the mines. Similarly, no dust will result on the rail line to the tippler from falling through the wagons as they are closed bins.

The combustion of diesel in the locomotives operating on this line will result in the emission of NO_x, particulate matter and VOCs. The emissions depend on the power rating and hours of operation of the locomotives. The emissions are discussed in Section 5.6.3.

5.3.11 Emissions inventory

The main atmospheric emissions from operations at the proposed Manganese Ore Export Facility result from wind-entrained dust, materials handling and products of combustion from diesel locomotives in the compilation yard. In most cases fugitive air emissions can be estimated using emission factors and the silt content of the material being handled. Most of the work in developing emission factors for fugitive emissions has been undertaken in the United States (US-EPA, 1985; 1998). Some work has been undertaken in Australia by the State Pollution Control Commission (SPCC, 1983) and the National Energy Research and Demonstration Council (NERDDC, 1988).

Emission standards for railway locomotives have been established by the International Union of Railways (Union Internationale des Chemins de fer, UIC), a Paris-based association of European railway companies. The UIC standards are available at http://www.dieselnet.com/standards/inter/uic_loco.php and are binding to member railways. The UIC emission standards apply to diesel engines for railway traction, with the exception of engines for special locomotives and traction engines with an output of less than 100 kW.

Emission factors

Emission factors can be used to estimate emissions of TSP, PM_{10} and $PM_{2.5}$ from various sources. An emission factor is a representative value that relates the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the mass of pollutant divided by a unit mass, volume, distance, or duration of the activity emitting the pollutant (e.g., kg of particulates emitted per ton of ore processed). Such factors facilitate estimation of emissions from various sources of air pollution. In most cases, these factors are simply averages of all available data of acceptable quality, and are generally assumed to be representative of long-term averages for all facilities in the source category (US-EPA, 2009c).

Emission factors are associated with emission factor rating (EFR) codes. An A or B rating indicates a greater degree of certainty than a D or E rating. The main criterion affecting the uncertainty of an emission factor remains the degree of similarity between the equipment/process selected in applying the factor and the target equipment/process from which the factor was derived.

The EFR system is:
A: Excellent
B: Above average
C: Average
D: Below average
E: Poor
U: Unrated

The general equation for emissions estimation is: $E = A \times EF \times (1 - ER/100)$

where:
E = emissions;
A = activity rate;
EF = emission factor; and
ER = overall emission reduction efficiency (%)

Control factors

In this study, some dust control factors are based on the NPI (National Pollutant Inventory) control factors. Emission reduction efficiencies for a range of dust control measures are provided in Table 5-3. Controls are multiplicative when more than one control is applied to a specific operation or activity. For example, using controls from Table 5-3, water sprays used in conjunction with wind breaks give an emission that is (1-0.5) x (1-0.7) = 0.15 of the uncontrolled emission. Dust control factors (Table 5.4) which are based on a field study that was undertaken in 2011 on a nickel processing operation in South Africa (pers. comm. Kenneth Kelly, HATCH). Although the type of product differs from Manganese the results are indicative of the efficiencies that can be achieved on the Ngqura Manganese Ore Export Facility.

Table 5-3: Control factors adopted for various mining operations, adopted for the proposed operations at the Manganese Ore Export Facility (Sources: Holmes Air Sciences (1998) and Greenbase (2009)

Operation/Activity	Control method and emission reduction
Loading stockpiles	50% for water sprays
	25% for variable height stacker
	75% for telescopic chute with water sprays
	99% for total enclosure
Unloading from stockpiles	50% for water sprays (unless underground recovery then, no controls needed)
Wind erosion from stockpiles	50% for water sprays
	30% for wind breaks
	99% for total enclosure
	30% for primary earthworks (reshaping/ profiling, drainage structures installed)
	30% for rock armour and/or topsoil applied
Miscellaneous transfer and conveying	90% control allowed for water sprays with chemicals
	70% for enclosure
	99% for enclosure and use of fabric filters
Metalliferous Mines	30% for windbreaks
	50% water sprays to keep ore wet
	65% for hooding with cyclones
	75% for hooding with scrubbers
	83% for hooding with fabric filters
	100% enclosed or underground

Table 5-4: Control factors based on a field study on a nickel processing operation in South Africa (Source: pers. comm. Kenneth Kelly, HATCH)

Operation	Control method and emission reduction
Wagon Tippler	90.58% for water and surfactant mix
Stockpile Conveyor	96.90% for water and surfactant mix
Silo head chute discharge (incl stacker and ship loader chutes)	98.42% for water and surfactant mix
Stockpiles	96.00% for water and surfactant mix

Particle Size Distribution Analysis (PSD)

Silt is sedimentary material consisting of very fine particles intermediate in size between sand and clay, i.e., between 50 µm and 2 µm. As a proxy for the type of material expected to be railed during the proposed operation of the Coega Manganese Ore Export Facility, six samples of product material from the existing export facilities were analysed. The silt content in each sample was obtained from PSD analysis of the samples collected. The average silt content from the three most representative sites is presented in Table 5-5 as a percentage of all material with a diameter of less than 1 mm.

Table 5-5: Silt content of particulate sources at the existing export facilities

Source	Silt content (% of sample volume)	
	PM_{10} (<10 um)	$PM_{2.5}$ (<2.5 um)
Quay Side, under ship loading conveyor	9.5	4.6
Conveyor transfer points (dust/spillage collected in transfer housing	8.2	2.9
SW outside terminal	9.0	2.7
Average	*8.9*	*3.4*

Based on the above analysis, it is assumed that PM_{10} is 8.9 % of TSP, rounded up to 9% for the emission calculations, to be conservative. Similarly, it is assumed that $PM_{2.5}$ is 3.4 % of TSP.

Particulate emission estimates from ore transport, handling activities and stockpiles

Factors influencing dust emissions

To predict dust concentrations in a realistic matter, hourly dust emissions are required from all major sources in the area (Figure 5-2). Factors which are important for dust generation are (i) the ore type being handled, (ii) moisture content, (iii) the operation occurring, (iv) quantity of ore being moved, (v) size of stockpiles and level of activity and (vi) ambient wind speed.

The type of ore being handled relates to the size distribution of the material, shape and composition of the fine fraction.

Increasing the moisture content decreases the dustiness of the ores with there normally being a moisture threshold above which dust generation by material handling is negligible. This occurs as moisture acts to apply adhesive forces between particles.

Factors which are important in terms of the operation occurring are the drop height, the degree to which the falling ore is exposed to the wind such that winnowing of the air stream can occur and the dust control mechanism used. The quantity of ore being moved; and the size of stockpiles and level of activity are directly proportional to the amount of emissions.

For material handling operations exposed to air, dust emissions increase with the ambient wind speed. For wind erosion, dust emissions are negligible below a wind speed threshold, but increase rapidly above the threshold. Generally material with a large (>50%) fraction of non erodible particles (generally particles greater than 1 mm to 2 mm) will not erode as these particles protect the erodible fraction. As such, lump ores are not erodible by wind erosion though they may be quite dusty during material handling as a result of abbrasion. In this case the small fines fraction can be liberated. Fine ores are generally much more erodible particularly if they have a large fraction of particles in the range from 0.1 mm to 0.25 mm which can be dislodged by wind and then rolled and skipped along the surface (saltation). These larger saltating particles can then dislodge the smaller (<50 μm) dust fraction which can remain suspended in the air.

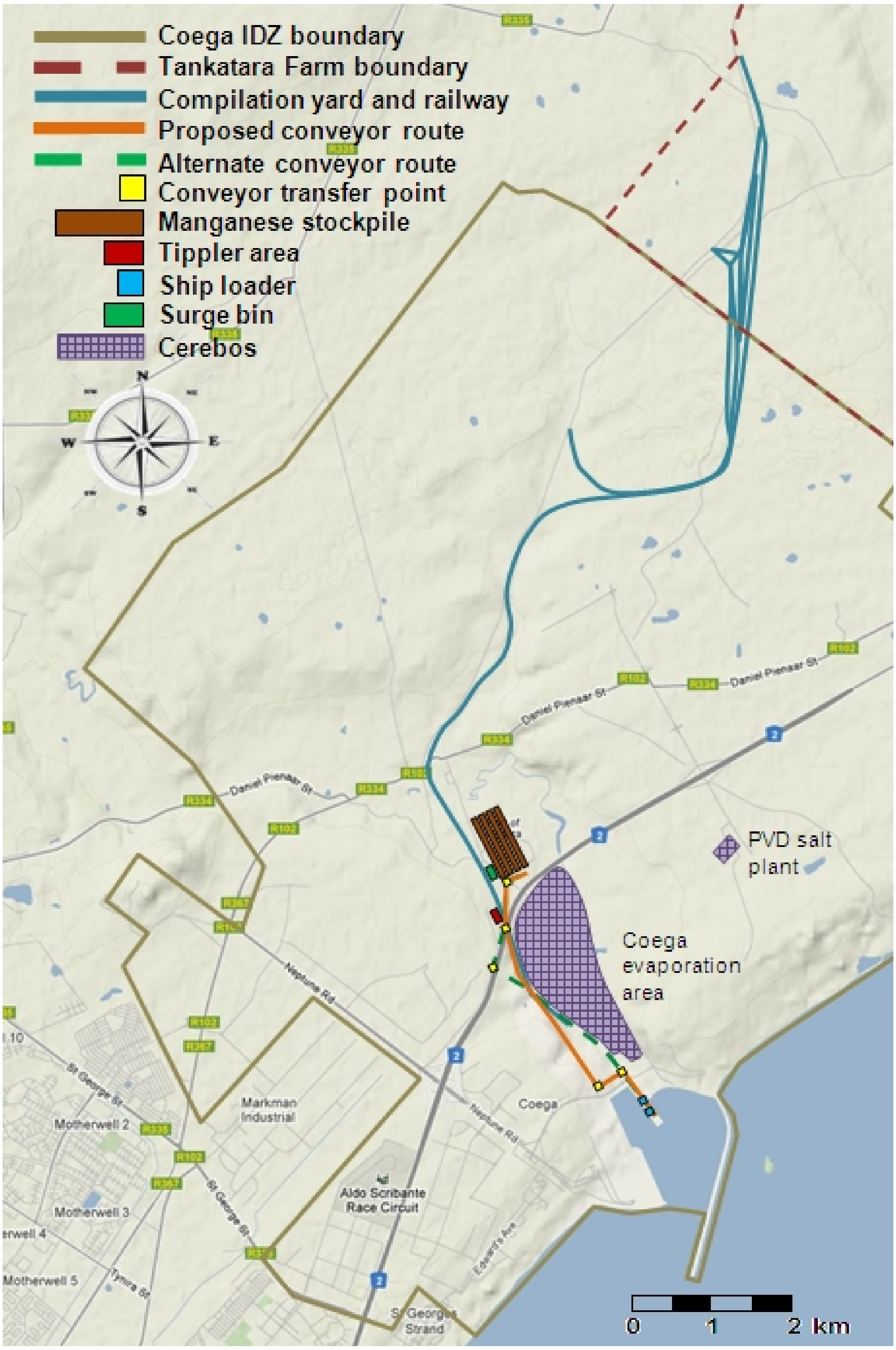


Figure 5-2: Sources of emissions at the Manganese Ore Export Facility in Coega

Dust emissions methodology

The methodology that has been used in this study is based on activity data, emission factors and control factors.

Activity data in terms of estimated throughputs (tonnages) railed and design specifications for the proposed operations were obtained from the Final Scoping Report (CSIR, 2012). The configuration of the port operation in terms of the compilation yard, stockyard, tippler, stackers and reclaimers, conveyor transfer points (proposed and alternate), surge bins and ship loaders is based on the plant layout as provided in the Final Scoping Report (CSIR, 2012).

Dust emissions from material handling operations have been based on the default dust emission factors in the NPI EET manual for “high” moisture content ores. The default factor has been used as the alternative equation for batch/continuous drop operations gives unrealistically low emissions (NPI, 2001) and is not recommended. According to the scoping Report (CSIR, 2012) ore leaving Hotazel will be wet before being railed, and ore arriving at the Manganese Ore Export Facility will be further wetted, and therefore will have a high moisture content and a low dust content such that the dust emissions during material handling should also be very low. The use of the default “high” moisture content ore, though conservative, allows for variation in the moisture content of the ores and failure in control equipment to occur. A summary of the dust emission factors, used in this study are presented in Table 5-6. All emission factor equations and default emission factors listed in Table 5-6 are for uncontrolled emissions.

Table 5-6: ***Dust Emission Factors in kg/ton***

Source	NPI uncontrolled TSP emission factor (high moisture)
Tippler	0.005
Conveyor transfer points	0.005
Stacker/reclaimer	0.005
Surge bin	0.005
Ship loaders	0.005

Dust emission factors are also available for PM_{10} in the NPI EET manual. However, data from the particle size distribution (PSD) analysis was used to determine the percentage of PM_{10} as well as $PM_{2.5}$ in the manganese ore. Control factors for the equipment are based on NPI recommendations HATCH (pers. comm. Kenneth Kelly).

Wind Erosion - Stockpiles

This section describes the methodology used to estimate emission rates of TSP, PM_{10} and $PM_{2.5}$ from the manganese stockpiles, which are exposed to wind erosion.

The estimation of particulate emissions is based on the US-EPA methodology for wind erosion of silt (0.002 mm to 0.063 mm) from open ore or aggregate storage piles and exposed areas in industrial facilities provided in Chapter 13 of the US-EPA 42 (US-EPA, 2006a). The following have been applied:

- The lateral dimensions of the four stockpiles were obtained from the Final Scoping Report (CSIR, 2012);
- A function was developed to determine the relationship between wind speed and the emission rate, or entrainment, based on the approach recommended by the US-EPA (2006a);
- Average daily wind speed and direction measured by the CDC Amsterdamplein meteorological station at the Port is used;
- The wind dependent emission rates of TSP, PM_{10} and $PM_{2.5}$ in $g/m^2/s$ are shown in Table 5-7.

Table 5-7: Wind dependent TSP, PM_{10} and $PM_{2.5}$ emission rates in $g/m^2/s$ from stockpiles

Wind speed (m/s)	TSP	PM_{10}	$PM_{2.5}$
1.54	3.93E-05	1.24E-05	0
3.09	3.66E-04	1.11E-05	9.00E-08
5.14	1.56E-03	1.86E-04	2.14E-06
8.23	5.02E-03	8.32E-04	5.23E-06
10.80	9.41E-03	1.72E-03	7.80E-06
11.00	9.81E-03	1.80E-03	8.00E-06

Estimated emissions

Annual average emissions predicted for the ore transport, handling activities and stockpiles are presented in Table 5-8. The table indicates emission rates for standard operations and with full mitigation operations. Standard operations refer to operations that are going to be in place and are not necessarily a mitigation measure, e.g. enclosed tippler, covered conveyors. The main types of mitigation measures are in the form of water or chemical spraying.

On a per ton basis for standard operations, it is evident that the largest source of particulates (TSP, PM_{10} and $PM_{2.5}$) is the manganese ore stockpiles, followed by the conveyor transfer points, reclaimers, stackers and ship loaders (similar emissions), surge bins and tippler (similar emissions). Table 5-8 clearly demonstrates that large emission reductions can be achieved by implementing the proposed dust reduction methodologies. When mitigation measures are in place, the largest sources are the Mn stockpiles, followed by the reclaimers and surge bins (similar emissions), conveyor transfer points, tippler, ship loaders and stackers (similar emissions). The highest emission reduction is possible for the ship loaders and stackers.

Dispersion modelling has been done for each of the activities in Table 5-8 for both standard operations and when full mitigation measures are in place. The model results are shown as isopleths maps and exceedance maps in Section 5.6.

Table 5-8: Estimated annual average TSP, PM_{10} and $PM_{2.5}$ emissions for uncontrolled and controlled operations, for standard mitigation and full mitigation

		Uncontrolled emissions (tons/year)					**Normal operations – controlled (tons/year)**		
	Operation/Activity	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**Characteristics**	**Reduction efficiency (%)**	**TSP**	**PM_{10}**	**$PM_{2.5}$**
Tippler - with enclosure (standard operations)	Tippler	80.0	7.2	2.8	70% for enclosure	70	24.00	2.16	0.84
Tippler - with enclosure + dust supression	Tippler	80.0	7.2	2.8	90.58% for enclosure and water sprays	90.58	7.54	0.68	0.26
Conveyor - with enclosure (standard operations)	Conveyor transfer point 1	80.0	7.2	2.8	70% for enclosure	70	24.00	2.16	0.84
	Conveyor transfer point 2	80.0	7.2	2.8		70	24.00	2.16	0.84
	Conveyor transfer point 3	80.0	7.2	2.8		70	24.00	2.16	0.84
	Conveyor transfer point 4	80.0	7.2	2.8		70	24.00	2.16	0.84
Conveyor - with enclosure + water sprays	Conveyor transfer point 1	80.0	7.2	2.8	96.9% for enclosure and water sprays	96.9	2.48	0.22	0.09
	Conveyor transfer point 2	80.0	7.2	2.8		96.9	2.48	0.22	0.09
	Conveyor transfer point 3	80.0	7.2	2.8		96.9	2.48	0.22	0.09
	Conveyor transfer point 4	80.0	7.2	2.8		96.9	2.48	0.22	0.09
Stacker - variable stack height + telescopic chute	Stockyard stacker 1	26.7	2.4	0.9	43.75% for variable height stacker & telescopic chute	43.75	15.00	1.35	0.53
	Stockyard stacker 2	26.7	2.4	0.9		43.75	15.00	1.35	0.53
	Stockyard stacker 3	26.7	2.4	0.9		43.75	15.00	1.35	0.53
Reclaimer - no controls	Stockyard reclaimer 1	40.0	3.6	1.4	0%	0	40.00	3.60	1.40
	Stockyard reclaimer 2	40.0	3.6	1.4		0	40.00	3.60	1.40
Stacker - variable stack height + telescopic chute + water	Stockyard stacker 1	26.7	2.4	0.9	98.42% for variable height stacker, telescopic chutes and water)	98.42	0.42	0.04	0.01
	Stockyard stacker 2	26.7	2.4	0.9		98.42	0.42	0.04	0.01
	Stockyard stacker 3	26.7	2.4	0.9		98.42	0.42	0.04	0.01
Reclaimer - water sprays	Stockyard reclaimer 1	40.0	3.6	1.4	Assume 85% since ore is damp,	85	6.00	0.54	0.21

		Uncontrolled emissions (tons/year)					Normal operations – controlled (tons/year)		
	Operation/Activity	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**Characteristics**	**Reduction efficiency (%)**	**TSP**	**PM_{10}**	**$PM_{2.5}$**
	Stockyard reclaimer 2	40.0	3.6	1.4	occassionally spayed with water and chemical, and further sprayed with water during reclaiming	85	6.00	0.54	0.21
Surge Bin - with enclosure (standard operations)	Surge bins	80.0	7.2	2.8	70% for enclosure	70	12.00	1.08	0.42
Surge Bin - with enclosure (standard operations)	Surge bins	80.0	7.2	2.8	70% for enclosure	70	12.00	1.08	0.42
Surge Bin - with enclosure + water sprays	Surge bins	80.0	7.2	2.8	85% for enclosure and water sprays	85	6.00	0.54	0.21
Surge Bin - with enclosure + water sprays	Surge bins	80.0	7.2	2.8	85% for enclosure and water sprays	85	6.00	0.54	0.21
Ship loader - variable stack height + telescopic chute	Ship loader 1 (C100 berth)	40.0	3.6	1.4	43.75% for variable height stacker and telescopic chute	43.75	22.50	2.03	0.79
	Ship loader 2 (C101 berth)	40.0	3.6	1.4		43.75	22.50	2.03	0.79
Ship loader - variable stack height + telescopic chute + water	Ship loader 1 (C100 berth)	40.0	3.6	1.4	98.42% for variable height stacker, telescopic chutes and water)	98.42	0.63	0.06	0.02
	Ship loader 2 (C101 berth)	40.0	3.6	1.4		98.42	0.63	0.06	0.02
Stockpiles - no control	All stockpiles	25575	4228	0.3	0%	0	25575	4228	0.25
Stockpiles - chemical spray	All stockpiles	25575	4228	0.3	96% for water spray with chemical	96	1023	169.10	0.01

Emission estimates from the compilation yard

Within a railway compilation yard and associated workshops, there are many possible emission sources. These operations include surface coating, machining of parts, surface refinishing, cleaning operations, maintenance and general transport operations.

Operation of diesel locomotives
The operation of diesel locomotives in railway compilation yards leads to emissions of combustion products (i.e. NO_x, CO, SO_2, VOCs, PM_{10}, $PM_{2.5}$, and speciated VOCs, i.e. benzene, ethyl benzene, polychlorinated dioxins, xylene and toluene). (NPI emissions factors for SO_2 indicate that a very small amount of SO_2 emissions is released from diesel locomotives. Resultant ambient concentrations will be significantly below ambient standards. SO_2 is therefore not modelled).

Fuel storage
The storage of fuels and organic liquids leads to emissions of VOCs. These emissions may contain a number of substances, including benzene, toluene and xylenes. VOC emissions from storage tanks occur as a result of both standing and working losses. Standing loss is the expulsion of vapour from a tank through vapour expansion and contraction, which are the results of changes in temperature and atmospheric pressure. This loss occurs without any liquid level change in the tank. The combined loss from filling and emptying is called working loss. Evaporation during filling operations is a result of an increase in the liquid level in the tank. As the liquid level increases, the pressure inside the tank exceeds the relief pressure and vapours are expelled from the tank. Evaporative loss during emptying occurs when air drawn into the tank during liquid removal becomes saturated with organic vapour and expands, thus exceeding the capacity of the vapour space (US-EPA, 2006b).

On-site vehicle operation
The operation of on-site vehicles leads to emissions of combustion products. Furthermore, particulate matter is generated from wheel generated dust caused by brake and tyre wear and disturbance of road material from vehicle movements.

Surface coating and solvent usage
Surface coating of materials and the usage of solvents at railway yard facilities leads to emissions of VOCs from evaporation of the volatile component of the surface coating once applied.

Maintenance operations
Maintenance operations encompass a variety of applications from surface coating of rail cars and locomotives and degreasing of bearings or other weathered components.

Of these various activities described above, only emissions from the operation of diesel locomotives and fuel storage were considered in this assessment. Emissions as a result of maintenance operations, abrasive blasting, surface coating and solvent usage and on-site vehicle operation are considered to have negligible impact and are therefore excluded from the modelling. Furthermore, most of these activities do not occur on a routine basis and specific information is not available for these operations, to compile an accurate emissions inventory.

Emissions from diesel powered locomotives in the compilation yard

Emissions from the operation of diesel powered locomotives in the compilation yard are based on their power rating and hours of operation (Table 5-9); and relevant emission factors (Table 5-10). Technical information on the diesel powered locomotives was provided by Evert Jacobs, Robert Bob, and Fanus van Biljon from Hatch and Devendran Govender from Transnet Freight Rail JHB.

Two Class 43 diesel powered shunting locomotives will be in operation at the compilation yard on a daily basis. Each locomotive has a 320 kN continuous tractive effort and maximum power rating of

3200-3500 kW per loco. An average power rating of 3350 kW is therefore assumed for each locomotive.

Table 5-9: Estimated power output for the diesel locomotives

No of shunting locomotives	**2**
Power Rating (kW)	3350
Total hours of operation for the 2 locomotives in combination per day	8
Total power output for the 2 locomotives in combination per year	2920
Total kW for the 2 locomotives per year	9782000

At the 16 Mtpa rate, the diesel locomotive operating hours per day is approximately 30 hours, which is for 2 locomotives operating between the compilation and tippler yards. The 30 hours includes locomotive waiting, idling and hauling activities for the 8 trips is actually less in practice, as this estimation is based on a worst case scenario. The locomotives will work at maximum for very short periods, only on pull away when a loaded or empty 100 wagon set starts moving from stand still. Once the train reaches balancing speed the power required will slack off significantly. The 30 hours comprises of the following type of activities which will have varying degrees of power requirements and thus emissions:

- Idling i.e. standing still not doing anything is a major part of the 30 hours can be approximately 10% of maximum power, and the locomotives will idle for around 30%-50% of the day
- Light locomotive movements – low power required
- Shunting at low speed – less than maximum power required
- Hauling empty 100 wagon trains between port and compilation yard (uphill). Locomotive is hauling empties uphill therefore less than maximum power required
- Hauling loaded 100 wagon trains between compilation and port (downhill). Therefore maximum power on pull away and thereafter the train is braking all the way to the port so little power required.

The 3 350 kW/hr over a continuous period of 15 hours per day for each locomotive may be too high to be truly representative of this operation. The average power required may be anywhere from 20% to 50% of the maximum. The probable amount of time the locomotives will be working at the equivalent maximum power for hauling the 100 wagons up and down is approximately 4 hrs/day between the two locomotives (the calculated 4 hours is only the equivalent at peak for hauling the 100 wagon rake up and down). The idling, yard shunting and light locomotive movements also have to be included. As a worst case scenario, it is therefore assumed that the locomotives will operate for a total of 8 hours per day at the equivalent maximum power for peak operations, which should include sufficient buffer.

Emission factors for NO_x, hydrocarbons, PM_{10} and $PM_{2.5}$ for the diesel locomotives is based on the emission "standards" (factors) for railway locomotives, which has been established by the International Union of Railways (UIC). The UIC locomotive emission factors are listed in Table 5-10 and are based on UIC Duty Cycle Emissions Values- ISO 8178-4:2007(E).

Table 5-10: UIC locomotive emission factors

	NO_x	**Hydrocarbons**	**CO**	**PM**
DC Emissions (g/KW/hr)	9.22	0.42	1.12	0.13

Since there are no emission factors for BTEX provided by the UIC, emission factors for BTEX are based on a ratio of BTEX to hydrocarbons using the Emissions Estimation Technique Manual for

Aggregated emissions from Railways (NPI, 1999a) and Emissions Estimation Technique Manual for Railway Yard Operations (NPI, 1999b) (Table 5-11). The NPI is a source of good emission factors and is developed by the Australian Government - Department of the Environment, Water, Heritage and the Arts. Emissions from the diesel locomotives in the compilation yard are provided in Table 5-12.

Table 5-11: Ratio of BTEX to HC based on the NPI Manuals (NPI, 1999a, 1999b)

	Emission factor (kg/kL or g/L) for BTEX	Emission factor (kg/kL or g/L) for Total volatile organic compounds	Ratio of BTEX to HC	% of BTEX Component
Benzene-HC Ratio	0.35	4.27	0.08	8.20
Toluene-HC Ratio	0.107	6.09	0.02	1.76
Ethyl benzene-HC Ratio	0.00366	6.09	0.00	0.06
Xylenes-HC Ratio	0.0171	6.09	0.00	0.28

Table 5-12: Emissions from the diesel locomotives in the compilation yard

Pollutant	Total KW (for entire year)	Emission factor (g/KW/hr)	Emissions (g/y)	Emissions (tons/y)
HC	9782000	0.42	4108440	4.108
Benzene	9782000	0.03	336757	0.337
Toluene	9782000	0.01	72184	0.072
Ethyl benzene	9782000	0.00	2469	0.002
Xylenes	9782000	0.00	11536	0.012
Carbon monoxide	9782000	1.12	10955840	10.956
Oxides of nitrogen	9782000	9.22	90190040	90.190
Particulate matter 10 µm	9782000	0.13	1271660	1.272
Particulate matter 2.5 µm	9782000	0.13	1271660	1.272

Emissions from diesel refuelling tanks in the compillation yard

The US-EPA Tanks software application was used to estimate emissions from the diesel refuelling tanks (Table 5-13). The equations used in the model were developed by the American Petroleum Institute (API). These are well-documented in Chapter 7 of the US EPA AP-42 (US-EPA, 2005). TANKS allows the input of specific information on storage tanks (e.g. tank type, dimensions, construction, paint condition), liquid fuel contents, handling protocols (e.g. type of fuel, annual product throughput, number of turnovers per year) and site-specific ambient meteorological information. It is assumed that the storage tanks are in excellent condition, well maintained, and that best practice is followed in filling and extracting.

The loss of vapours from filling and extracting activities involving refined petroleum products into and out of the shunting locomotives is the subject of the US EPA's AP-42, Section 5.2, entitled "Transportation and Marketing of Petroleum Liquids". The US EPA has developed expressions for the estimation of petroleum emissions from loading operations with a probable error of ± 30%. Inputs to the expressions include the quantities of products loaded, their vapour pressures and their molecular weights. The expressions also require saturation factors which were determined by the US-EPA through empirical tests. Saturation factors are dependent on the type of loading. The highest saturation factors occur for splash loading, whereas the lowest occur for submerged and bottom loading. Emissions from the loading gantry is based on the annual throughput of fuel used by the locomotives and is based on a worst-case loading method, where fuel is loaded at the top of the locomotive tanks (splash method).

Speciation of emissions into its resultant components is based on the composition of the components in their liquid phases. The compounds selected for reporting are benzene, toluene, ethyl benzene, and xylene, and are generally considered as the main organic pollutants.

The model also requires the input of representative meteorological and climate data. Wind, temperature, pressure and solar radiation data for the South African Weather Service (SAWS) station at Port Elizabeth Airport and climate data from the South African Weather Service WB42 handbook (South African Weather Services, 1992) was used as input for the Tanks Model.

Information on the tank specifications required for emission estimations by TANKS was taken directly from the supplier, Petro Industrial, via Evert Jacobs and Tammy Kruger (Environmental Service Group, Hatch) (pers.comm).

Table 5-13: Emissions from the diesel tanks and loading gantry in the compilation yard in tons per year

	Diesel tanks	Loading gantry	Total
Benzene	3.63E-05	8.09E-10	3.63E-05
Toluene	4.45E-04	3.23E-08	4.45E-04
Ethyl benzene	6.35E-05	1.31E-08	6.35E-05
Xylene	1.13E-03	2.93E-07	1.13E-03

5.4 DESCRIPTION OF THE AFFECTED ENVIRONMENT

5.4.1 Climate

The Port Elizabeth region has a warm temperate climate and the temperature range is not extreme, although high temperatures can occur during summer. Average of daily minimum, maximum and mean temperatures for the period 1961 – 1990 (SAWS, 1998) are presented in Figure 5-5 with little accompanying wind. Very high temperatures may be experienced during berg wind conditions, which occur frequently during the winter, when maximum temperatures my exceed 30°C.

Rain occurs throughout the year, brought about by convective summer rain and winter rain associated with the passage of frontal systems. The area receives an annual average rainfall of 624 mm. Monthly average rainfall data for Port Elizabeth Airport for the climatologically representative period 1961 – 1990 (SAWS, 1998) is presented in Figure 5-3.

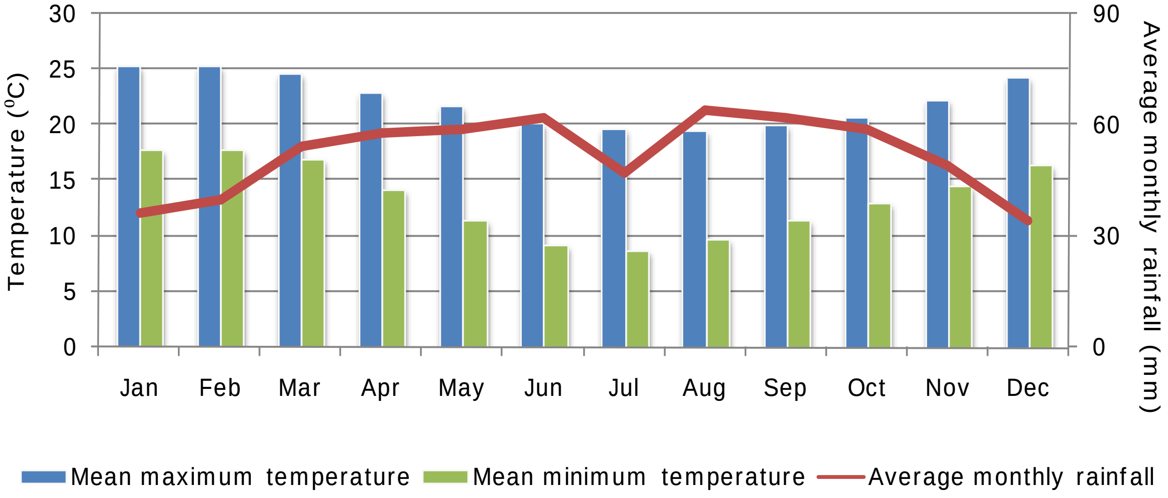


Figure 5-3: ***Average of daily minimum, maximum and mean temperatures (°C) and average monthly precipitation (mm) at Port Elizabeth Airport for the period 1961 – 1990 (SAWS, 1998)***

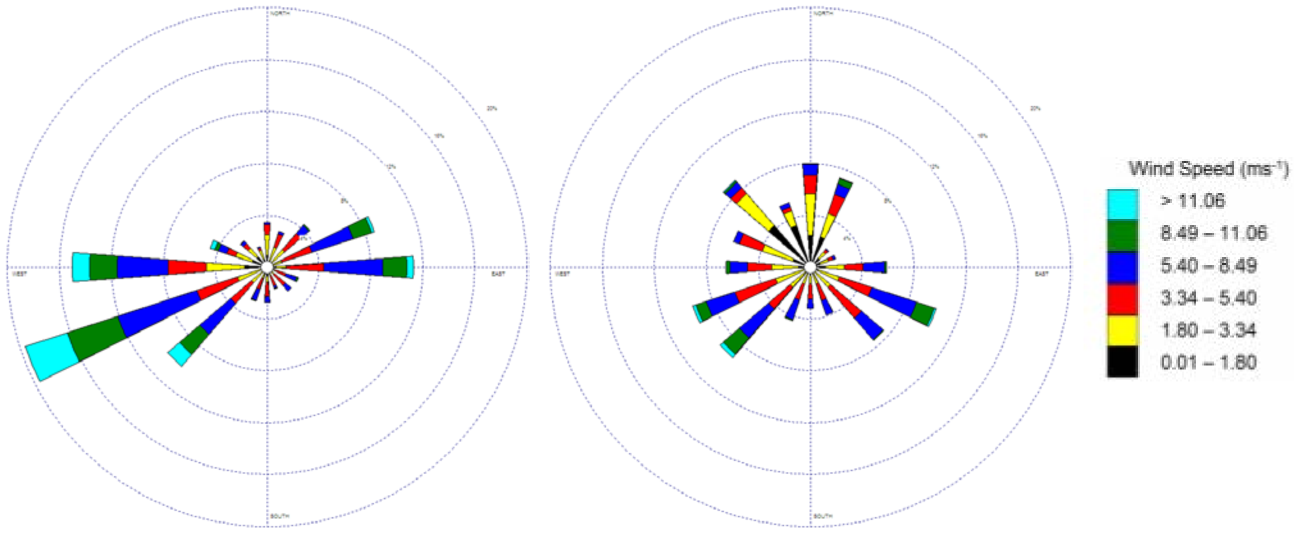
Prevailing wind tends to follow the coastline and the prevailing winds in the Port Elizabeth area are west-southwesterlies and east-northeasterlies. Wind roses are presented for Port Elizabeth Airport, Amsterdamplein, Motherwell and Saltworks in Figure 5-4. Wind roses simultaneously depict the frequency of occurrence of wind from the 16 cardinal wind directions and wind speed classes, for a single site. Wind direction is given as the direction from which the wind blows, i.e. southwesterly winds blow from the southwest. Wind speed is given in meters per second (m/s), and each arc represents a percentage frequency of occurrence (5% in this case).

The airport at Port Elizabeth is the most climatologically representative of the sites and is well exposed to the prevailing synoptic-scale winds, showing a high frequency of winds from the sector west to southwest (more than 50% of all winds). These are also the strongest winds. There is some occurrence of wind from the northeast and east at this site. The annual average wind speed here is 5.7 m/s.

The winds at Amsterdamplein, Motherwell and Saltworks also indicate the occurrence of reasonably strong west to southwesterly synoptic scale winds. At Amsterdamplein, winds are fairly, equally spread from the southwest, southeast, northwest, north and north-northeast, with an average wind speed of 4 m/s. At Motherwell, winds are predominantly from the northwest to southwest and east-southeast, with an average wind speed of 3.4 m/s. At Saltworks, winds are mainly from the west-northwest to southwest, north and east, also with an average wind speed of 3.4 m/s.

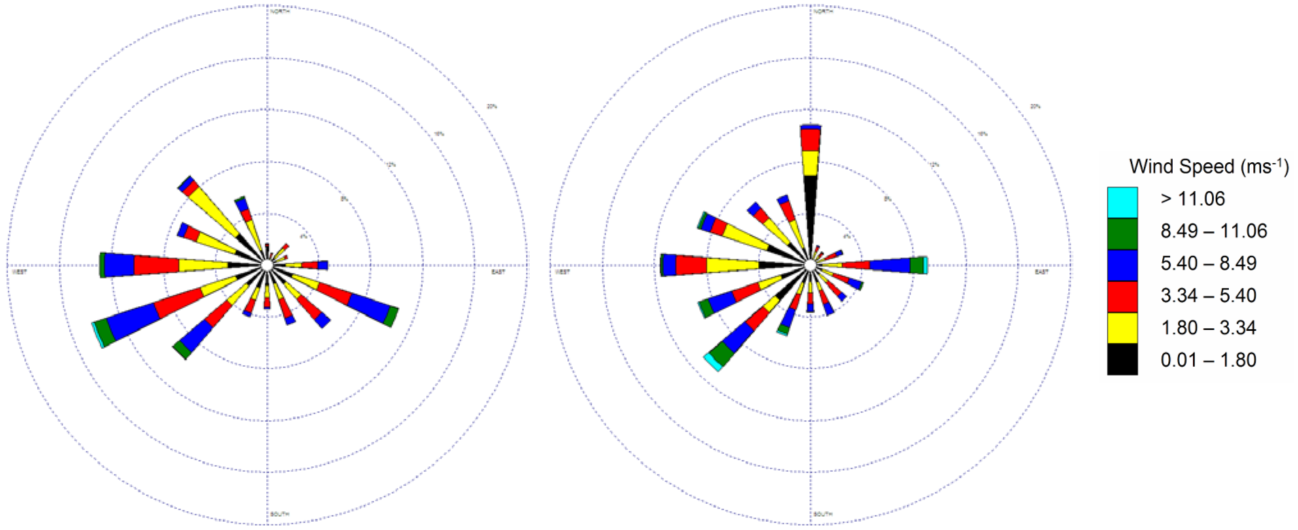
The poorest atmospheric dispersion conditions occur with inversion conditions and calm or light winds. Greater surface cooling in winter is conducive to the formation of surface temperature inversions and a shallow mixing layer, particularly at night. Pollutants that are released into the inversion layer are typically trapped between the surface and the top of the inversion. Under light wind conditions, pollutants will tend to accumulate. It is under these conditions for May to July, when the highest ground level concentrations of pollutants may be expected in the area.

Figure 5.4/…



Port Elizabeth Airport
Total hours: 26116
Avg. wind speed: 5.73 m/s
% Calm Winds: 3.05%

Amsterdamplein
Total hours: 13536
Avg. wind speed: 4.04 m/s
% Calm Winds: 0%



Motherwell
Total hours: 14863
Avg. wind speed: 3.40 m/s
% Calm Winds: 0.09%

Saltworks
Total hours: 16887
Avg. wind speed: 3.42 m/s
% Calm Winds: 0%

Figure 5-4:** **Annual wind roses for Port Elizabeth Airport, Amsterdamplein, Motherwell and Saltworks for 2009-2011. Arcs represent 5% frequency intervals.

5.4.2 Ambient air quality

Current sources of industrial emissions in the Coega IDZ include boilers at Coega Dairy and Cape Concentrates, and a furnace at EC Biomass, all located in Zone 3. Emissions from these facilities will include sulphur dioxide (SO_2), oxides of nitrogen (NO_x) and particulate matter including respireable PM_{10} and $PM_{2.5}$. Construction activities in the IDZ are potential sources of dust. Emissions from ships in the Port of Ngqura will affect ambient air quality in the Coega area. Motor vehicle emissions from the N2 to the east and the old Grahamstown Road to the northwest will have some effect on the current air quality in the IDZ, and activities such as refuse and wood burning in the surrounding communities will also have an effect. The area is well ventilated with a high frequency of strong westerly winds and pollutants seldom accumulate. As a result air quality in the Coega IDZ is relatively good and is complying with ambient air quality standards (C&M Consulting Engineers, 2009; 2010; 2011b).

Unvegetated or sparsely vegetated areas are relatively common in the Coega IDZ and in the surrounding environment. The moderate to strong winds that occur with a high frequency easily liberate sand and dust from these areas. As a result, windblown dust, particularly in winter, has an impact on air quality in the area.

Industrial activity in the Markman Industrial Area, located on the southwestern boundary of the Coega IDZ will also have some effect on air quality in the area, particularly under the prevailing southwesterly wind conditions. These industries are an abattoir, two tanneries and a foundry. Likely pollutants from these sources include SO_2, particulate matter, as well as odorous pollutants from the abattoir and tanneries. Other industries such as cable manufacture and motor assembly plants are likely to have little or no impact on air quality in the Coega IDZ.

Mean, maximum and minimum measured concentrations of SO_2, NO_2, and PM_{10}monitored at Amsterdamplein, Motherwell and Saltworks during 2009, 2010 and 2011, provide an indication of the current ambient air quality status in the Coega IDZ (C&M Consulting Engineers, 2009; 2010; 2011b). Inspection of the average data in the Coega Annual Ambient Air Quality Reports (C&M Consulting Engineers, 2009, 2010 and 2011) shows the occurrence of numerous ‘spikes’ in the data which may be regarded as outliers. In statistics, an outlier is an observation that is numerically distant from the rest of the data. Outliers can occur by chance in any distribution, but they are often indicative of measurement error. Reasons for these occurring in the data have not been justified or reported by the service provider. These spikes distort the data and lead to unrepresentative and higher averages than otherwise. Despite this the actual data are used here and the maximum measured concentrations of SO_2, NO_2, PM_{10} and O_3 measured for the 2009-2011 period are summarised in Table 5-14.

The highest 10-minute SO_2 average measurement in 2009 of 1227.1 $\mu g/m^3$occurred in August at Saltworks and is more than twice the South African 10-minute ambient air quality standard of 500 $\mu g/m^3$. The highest hourly maximum of 476.0 $\mu g/m^3$ occurred in July at Motherwell and is significantly above the South African ambient air quality standard of 350 $\mu g/m^{3.}$ The highest 24-hour maximum of 162.3 $\mu g/m^3$occurred in May 2009 at Saltworks and is also significantly above the South African ambient air quality standard of 125 $\mu g/m^3$. The number of exceedances in each case is below the permitted frequency of exceedances, or tolerance. The highest concentrations typically occur in the winter months, between June and October, and are most likely attributed to local scale biomass burning and the trapping of industrial emissions by stable atmospheric conditions. Despite a few reported spikes in data in 2009, ambient SO_2 concentrations in 2009- 2011 were generally low at all three of the monitoring sites and well below standards for all of the averaging periods.

The highest hourly NO_2 concentration of 839.6 $\mu g/m^3$ occurred in August 2009 at Amsterdamplein and is more than four times the South African ambient air quality standard of 200 $\mu g/m^3$. NO_2 at Saltworks was also in exceedance in 2009. In 2010 and 2011, measured NO_2 concentrations at all sites were well below the relevant South African ambient air quality standards. Despite a few reported spikes in data in 2009, ambient NO_2 concentrations in 2009-2011 were generally low at all three monitoring sites and well below standards for all averaging periods.

Measured 24-hour average PM_{10} concentrations were consistently high at Motherwell in 2009, 2010 and 2011, and exceeded the current and the 2015 South African ambient air quality standards of 120 µg/m^3 and 75 µg/m^3, respectively. The highest 24-hour average of 1233 µg/m^3, measured for PM_{10} at Motherwell in March 2009, is almost twenty times greater than the SA standard of 120 µg/m^3. Concentrations at Saltworks, of 268.6 µg/m^3 in 2009 and 191.2 µg/m^3in 2010, are also in exceedance of the current and 2015 standards. Concentrations at Amsterdamplein were only exceeded in 2011, otherwise were below the current and 2015 standards.

Measured 8-hour average O_3 concentrations at Motherwell are well below the South African ambient air quality standard of 120 µg/m^3. A clear diurnal cycle is observed at Motherwell with day time maxima.

Table 5-14: Mean and maximum measured concentrations of SO_2, NO_2, PM_{10} and O_3 (in ug/m^3) at the CDC monitoring stations for the period 2009-2011(Source: C&M Consulting Engineers, 2009, 2010 and 2011b)

					Motherwell			Amsterdamplein			Saltworks		
	Pollutant	**SA Standard**	**Avg period**	**Permitted no of exceedances**	**Mean**	**Max**	**No of exc.**	**Mean**	**Max**	**No of exc.**	**Mean**	**Max**	**No of exc.**
2009	SO_2	500	10-min	526	2.7	**1098.3**	4	2.7	124.0	0	10.3	**1227.1**	4
		350	1-hr	88	2.3	**476.0**	1	2.6	114.5	0	9.8	**351.7**	0
		125	24-hr	4	2.6	34.8	0	2.5	30.2	0	9.5	**162.3**	1
	NO_2	200	1-hr	88	0.6	75.3	0	4.4	**839.6**	3	10.5	**241.7**	2
	PM_{10}	120 (75)	24-hr	4	166.4	**1233.0**	30	32.4	71.5	0	112.2	**268.6**	84
2010	SO_2	500	10-min	526	13.3	106.0	Not reported	2.1	173.9	Not reported	19.0	219.9	Not reported
		350	1-hr	88	13.2	94.2	Not reported	2.0	157.5	Not reported	18.9	138.5	Not reported
		125	24-hr	4	13.1	82.1	Not reported	2.6	42.0	Not reported	19.2	121.2	Not reported
	NO_2	200	1-hr	88	8.1	72.2	Not reported	2.2	79.6	Not reported	11.4	94.1	Not reported
	PM_{10}	120 (75)	24-hr	4	67.7	**140.9**	Not reported	24.9	57.1	Not reported	62.7	**191.2**	Not reported
2011	SO_2	500	10-min	526	Not reported	236.6	Not reported	Not reported	98.0	Not reported	Not reported	210.0	Not reported
		350	1-hr	88	Not reported	138.3	Not reported	Not reported	25.3	Not reported	Not reported	207.5	Not reported
		125	24-hr	4	Not reported	74.5	Not reported	Not reported	10.9	Not reported	Not reported	71.8	Not reported

					Motherwell			**Amsterdamplein**			**Saltworks**		
	Pollutant	**SA Standard**	**Avg period**	**Permitted no of exceedances**	**Mean**	**Max**	**No of exc.**	**Mean**	**Max**	**No of exc.**	**Mean**	**Max**	**No of exc.**
	NO_2	200	1-hr	88	Not reported	78.3	Not reported	Not reported	64.9	Not reported	Not reported	86.0	Not reported
	PM_{10}	120 (75)	24-hr	4	Not reported	**128.0**	Not reported	Not reported	**225.0**	Not reported	Not reported	72.0	Not reported
	O_3	120	8-hr	11	Not reported	72.0	Not reported	Not measured	Not measured	Not measured	Not measured	Not measured	Not measured

Notes: South African ambient air quality standards in brackets will come into effect in 2015. Maximum values in bold are in exceedance (exc.) of the South African ambient air quality standards. Hourly and 24-hourly values for SO_2, NO_2 and PM_{10} for 2011 are inferred from graphs used in the 2011 C&M Consulting Report.

5.5 IDENTIFICATION OF KEY ISSUES

5.5.1 *Pollutants of concern*

The pollutant associated with emission from construction and Mn ore handling and storage are particulates, including TSP, PM_{10} and $PM_{2.5}$ and SO_2, NO_x and BTEX from diesel locomotives. The potential effects of the pollutants are described in Section 5.2.3.

5.5.2 *Key air quality issues*

The key air quality issues associated with emission from construction and Mn ore handling and storage and identified during the scoping phase are:

- Increased dust and other pollutants during construction
- Deposition of dust, including Mn ore dust in the neighbouring environment from the Manganese Ore Export Facility
- Ambient PM_{10} and $PM_{2.5}$ concentrations resulting from operations exceed ambient standards
- Ambient NO_x and BTEX concentrations from the compilation yard activities exceed ambient standards. NPI emissions factors for SO_2 indicated that a very small amount of SO_2 emissions is released from diesel locomotives. Resultant ambient concentrations will be significantly below ambient standards. SO_2 was therefore not modelled.
- Human health impacts resulting from particulate Mn ore exposure, and ruminants
- Cumulative impacts of dust, PM_{10}, $PM_{2.5}$, NO_x and BTEX exceed ambient standards.

5.6 AIR QUALITY IMPACT ASSESSMENT

5.6.1 *Emission scenarios*

Emission scenarios considered in this modelling exercise include cases for *standard mitigation* and *full-mitigation*. The standard case refers to an operational scenario with all designed dust abatement measures in place, e.g. tippler enclosure, conveyor covers and enclosed transfer points, but without dust suppression using water or chemical suppressants. The full-mitigation scenario refers to an operational scenario with all the designed dust abatement measures in place and with the proposed dust control measures using water and/or chemical suppressants in full operation. Dispersion modelling was done individually for the various activities listed in Table 5-15 for both scenarios.

Table 5-15: Emission Scenarios for dispersion modelling

		TSP, PM_{10}, $PM_{2.5}$															**TSP, PM_{10}, $PM_{2.5}$, BTEX, NO_x**		
		Emission Sources																	
		Tippler	Conveyor transfer point 1	Conveyor transfer point 2	Conveyor transfer point 3	Conveyor transfer point 4	Conveyor transfer point 5	Stockyard stacker 1	Stockyard stacker 2	Stockyard stacker 3	Stockyard reclaimer 1	Stockyard reclaimer 2	Surge bin	Ship loader 1 (C100 berth)	Ship loader 2 (C101 berth)	Stockpiles	Diesel locomotives	Storage tanks	Loading gantry
Modelled emission scenario	Tippler - standard operations	X																	
	Tippler - operations with mitigation	X																	
	Conveyor - standard operations - PROPOSED		X	X		X	X												
	Conveyor - operations with mitigation - PROPOSED		X	X		X	X												
	Conveyor - standard operations - ALTERNATE		X	X	X		X												
	Conveyor - operations with mitigation - ALTERNATE		X	X	X		X												
	Stackers and reclaimers - standard operations							X	X	X	X	X							
	Stackers and reclaimers - operations with mitigation							X	X	X	X	X							
	Surge bin - standard operations												X						
	Surge bin - operations with mitigation												X						

		TSP, PM_{10}, $PM_{2.5}$															**TSP, PM_{10}, $PM_{2.5}$, BTEX, NO_x**		
		Emission Sources																	
		Tippler	Conveyor transfer point 1	Conveyor transfer point 2	Conveyor transfer point 3	Conveyor transfer point 4	Conveyor transfer point 5	Stockyard stacker 1	Stockyard stacker 2	Stockyard stacker 3	Stockyard reclaimer 1	Stockyard reclaimer 2	Surge bin	Ship loader 1 (C100 berth)	Ship loader 2 (C101 berth)	Stockpiles	Diesel locomotives	Storage tanks	Loading gantry
	Ship loader - standard operations													X	X				
	Ship loader - operations with mitigation													X	X				
	Stockpiles - standard operations															X			
	Stockpiles - operations with mitigation															X			
	Compilation yard																X	X	X
	All sources standard operations - PROPOSED	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X
	All sources operations with mitigation - PROPOSED	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X

5.6.2 Maximum predicted ambient concentrations and deposition rates

The maximum predicted concentration of PM_{10} and $PM_{2.5}$ in µg/m^3 and the maximum dust deposition rates in mg/m^2/day resulting from each of the emission sources or activities are listed in Table 5-16. Also shown is the predicted number of exceedances of the limit value of the national ambient standards. The maximum predicted BTEX and NO_x concentrations from diesel combustion are listed in Table 5-17. The values in both tables are the highest predicted concentrations for the respective averaging periods for each source during the three year modelling period, i.e. the maximum hourly or daily value in the three year modelling period.

The highest predicted maximum dust deposition of 502 mg/m^2/day results from the stockpiles when there is no dust suppression. With dust suppression, the maximum deposition from the stockpile decreases dramatically to 20 mg/m^2/day. Without suppression the maximum value is predicted to be below the South African limit value of 600 mg/m^2/day. The maximum predicted deposition resulting from emission from the other sources or activities is significantly lower than from the stockpiles for both scenarios with the mitigated values showing a significant decrease from the standard scenario. For all sources together the contribution of the stockpiles to TSP deposition dominated and the same maximum values are predicted.

Similar to TSP, the highest maximum predicted ambient concentrations of PM_{10} and $PM_{2.5}$ results from emissions from the stockpiles. The maximum predicted annual concentration of 52 µg/m^3 resulting from stockpile emissions for the standard scenario is the only value that exceeds the national standard and is slightly higher than the current national PM_{10} ambient standard of 50, µg/m^3 and the future national standard of 40 µg/m^3. The maximum predicted annual PM_{10} concentration of 57 µg/m^3 for all sources is marginally higher than that for the stockpiles in isolation, also exceeding the current and future ambient standard. The predicted annual concentrations decrease dramatically with full dust suppression and the maximum predicted value for the stockpiles and all sources collectively are well below the ambient standard. The maximum predicted annual concentrations for $PM_{2.5}$ do not exceed the ambient standards.

The maximum predicted 24-hour concentration of PM_{10} resulting individually from emissions from the stockpiles and the conveyor transfer points (proposed and alternate alignment) exceed the limit value of the current national ambient standard of 120 µg/m^3 and the future standard of 75 µg/m^3 for the standard scenario. The future standard of 75 µg/m^3 for the standard mitigation scenario is also exceeded for the stacker and reclaimers and surge bins. In the case of the maximum predicted 24-hour concentration of $PM_{2.5}$, there are no exceedances of the current standard for the standard scenario; and it is only the conveyor transfer points (proposed and alternate alignment) that exceed the limit value of the future standard of 40 µg/m^3. The predicted 24-hour concentrations for both PM_{10} and $PM_{2.5}$ decrease dramatically with full dust suppression and the maximum predicted values are below the ambient standard.

The predicted maximum annual concentration of benzene from the compilation yard is significantly below the national ambient standard of 10 µg/m^3 and the future standard of 5 µg/m^3. NO_x emissions from diesel locomotives result in a predicted hourly maximum concentration of 1 140 µg/m^3 which exceeds the limit value of the national ambient standard.

The area where the maximum concentrations occur for the standard and full mitigation scenarios are shown in the concentration and deposition plots in the following section.

Table 5-16: Maximum modelled concentrations for TSP, PM$_{10}$ and PM$_{2.5}$ for all sources at the Manganese Ore Export Facility and for individual sources, operating under standard conditions and when mitigation measures are in place

		Dust (mg/m^2/day)	**PM$_{10}$ (ug/m^3)**		**PM$_{2.5}$ (ug/m^3)**	
		24-hour average	Annual average	24-hour average	Annual average	24-hour average
Compilation Yard & Refueling	Standard	no TSP	0.5	2.4	0.5	2.4
	Mitigation	No Mitigation				
Tippler	Standard	2.4	4.8	41.8	1.9	16.3
	Mitigation	0.8	1.5	13.1	0.6	5.1
Stockpiles	Standard	502.1	52.1	**547.4** (184)[1] (271)[2]	0.000019	0.000224
	Mitigation	20.1	2.1	21.8	0.000001	0.000009
Stacker and Reclaimer	Standard	3.3	5.9	**78.5** (1)[2]	2.3	30.5
	Mitigation	0.5	0.7	11.4	0.3	4.4
Conveyor Tran Pts (1,2,4,5) - Proposed	Standard	10.12	10.84	**160.3** (5)[1] (30)[2]	4.2	**62.3** (8)[2]
	Mitigation	1.05	1.12	16.5	0.4	6.4
Conveyor Tran Pts (1,2,3,5) - Alternate	Standard	10.12	11.00	**164.2** (5)[1] (31)[2]	4.3	**63.9** (8)[2]
	Mitigation	1.05	1.14	17.0	0.4	6.6
Surge Bin	Standard	3.6	7.2	**77.6** (2)[2]	2.8	30.1
	Mitigation	1.8	3.6	38.8	1.4	15.1
Ship Loaders	Standard	1.2	2.4	26.4	0.9	10.2
	Mitigation	0.03	0.07	0.74	0.03	0.29
All Sources - (Prop ConTransPt&SurBin)	Standard	502.3	**57.4**	**557.3** (190)[1] (288)[2]	9.7	**79.5** (1)[1] (17)[2]
	Mitigation	20.1	6.7	44.5	2.3	16.7
Notes	1 No of exceedances of the current South African Standard					
2 No of exceedances of the future South African Standard						

Table 5-17: Maximum modelled concentrations (ug/m^3) for BTEX and NO$_x$ for all sources at the Manganese Ore Export Facility compilation yard operating under standard conditions

Pollutant	Annual average	24-hour average	1-hour average
Benzene	0.13		
Toluene		0.14	0.91
Ethylbenzene			0.03
Xylene		0.03	0.19
NO$_x$	34.8		**1140.4 (354)**[1]
Notes: 1 – Number of exceedances			

5.6.3 Predicted dust deposition

The predicted 30-day average dust deposition rates in mg/m^2/day are shown in Figure 5.5 for the standard mitigation scenario and the full mitigation scenario for emissions from all sources. The highest deposition of dust is predicted to occur for both scenarios in the vicinity of the stockyard where deposition rates exceed 200 mg/m^2/day and reach a maximum of 502 mg/m^2/day for the standard mitigation scenario. Predicted dust deposition rates decrease rapidly from the main dust source, i.e. the stockpiles, to deposition rates of less than 20 mg/m^2/day on the boundaries of the Coega IDZ for the standard mitigation scenario. For the full mitigation scenario the maximum concentration of 20 mg/m^2/day at the stockyard decreases to deposition rates of less than 2 mg/m^2/day at the IDZ boundary. The relative contribution to dust deposition from the sources other than the stockyard is very low.

The national dust deposition limit value for residential areas of 600 mg/m^2/day is not predicted to be exceeded anywhere in the modelling domain. Despite the relatively low dust deposition rates, the generically black dust from the Mn ore may result in nuisance and possibly health impacts at neighbouring facilities such as the Cerebos salt pans in the IDZ if dust is not adequately controlled. For the standard mitigation scenario dust deposition at the Coega evaporation pans is predicted to range from 200 mg/m^2/day to 20 mg/m^2/day. By contrast, the predicted deposition decreases dramatically to values between 10 mg/m^2/day and 1 mg/m^2/day when all mitigation measures are applied.

At the Sunday's River, PDV and Swartkops evaporation pans the deposition rates of more than 10 mg/m^2/day for the standard mitigation decrease to between 1.5 mg/m^2/day and less than 0.25 mg/m^2/day for full mitigation. Impacts relating to deposition of Mn ore dust will endure for the life time of the proposed Manganese Ore Export Facility. They will be more intense for the standard mitigation scenario (immediately adjacent to the stockyard, in particular), but will affect the whole of the IDZ.

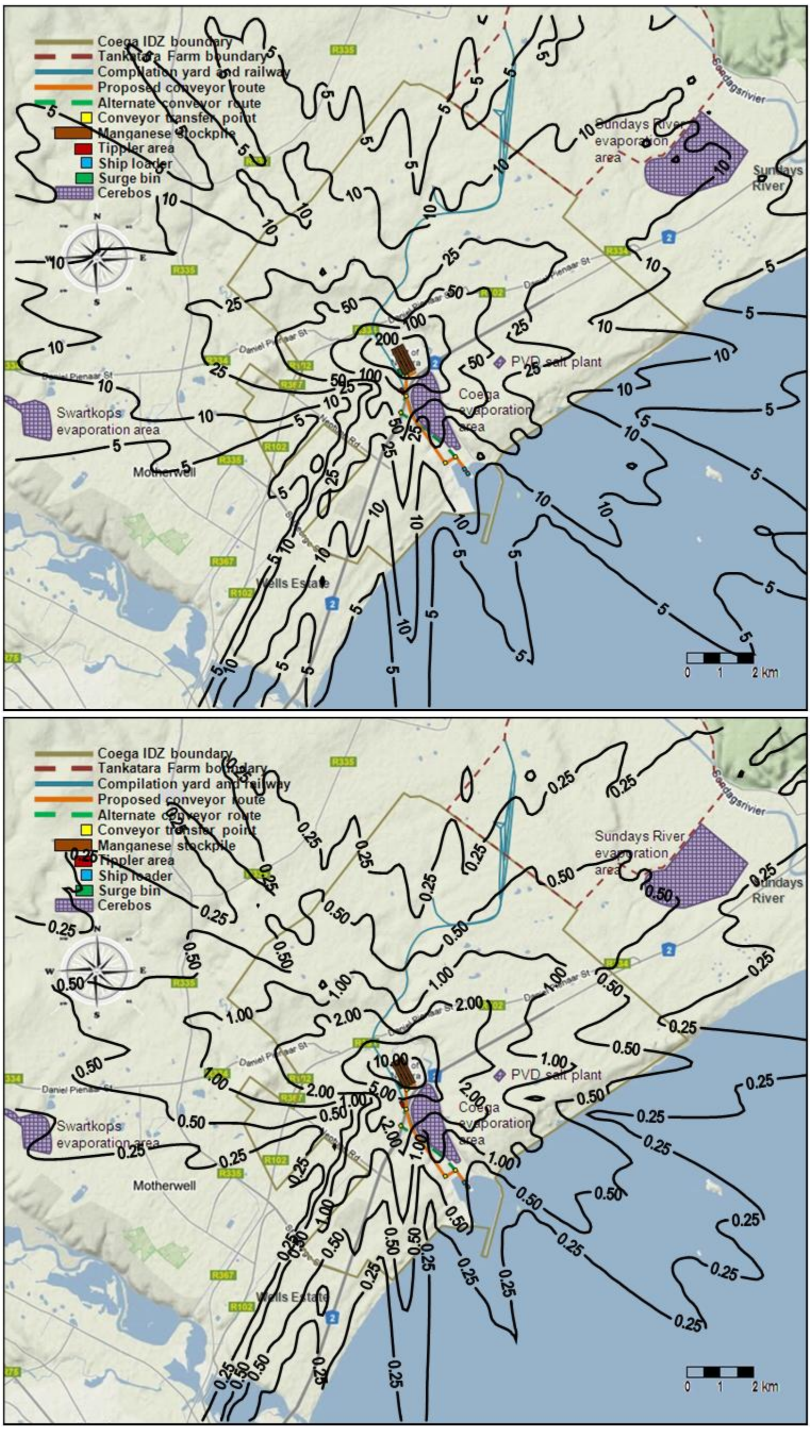


***Figure 5-5:** Predicted 30-day average dust deposition (mg/m²/day) for the proposed Manganese Ore Export Facility operating under standard conditions (top) and with full mitigation measures (bottom)*

5.6.4 Predicted PM_{10} concentrations

Predicted 24-hour maximum ambient PM_{10} concentrations resulting from all sources for the standard mitigation scenario and the full mitigation scenario are shown in Figure 5-6 and are compared with the limit values of the current and future national ambient standard. The number of exceedance of the current and future standard is shown on Figure 5-7 for the standard mitigation scenario.

The maximum concentrations for both cases occur at the stockyard and the surrounding area, as well as in the vicinity of the southern-most conveyor transfer point (close to the ship loaders). For the standard mitigation case the limit value of the current and future standard is exceeded over a relatively large portion of the Coega IDZ. However, the area where the permitted number of exceedances of 4 per annum (12 over 3 years) is exceeded is limited to an area extending approximately 1 000 m from the stockyard to the northeast and southwest. This implies that the 24-hour national ambient standard for PM_{10} is predicted to be exceeded in this area only. For the full mitigation case, there are no exceedances of the current and future standards.

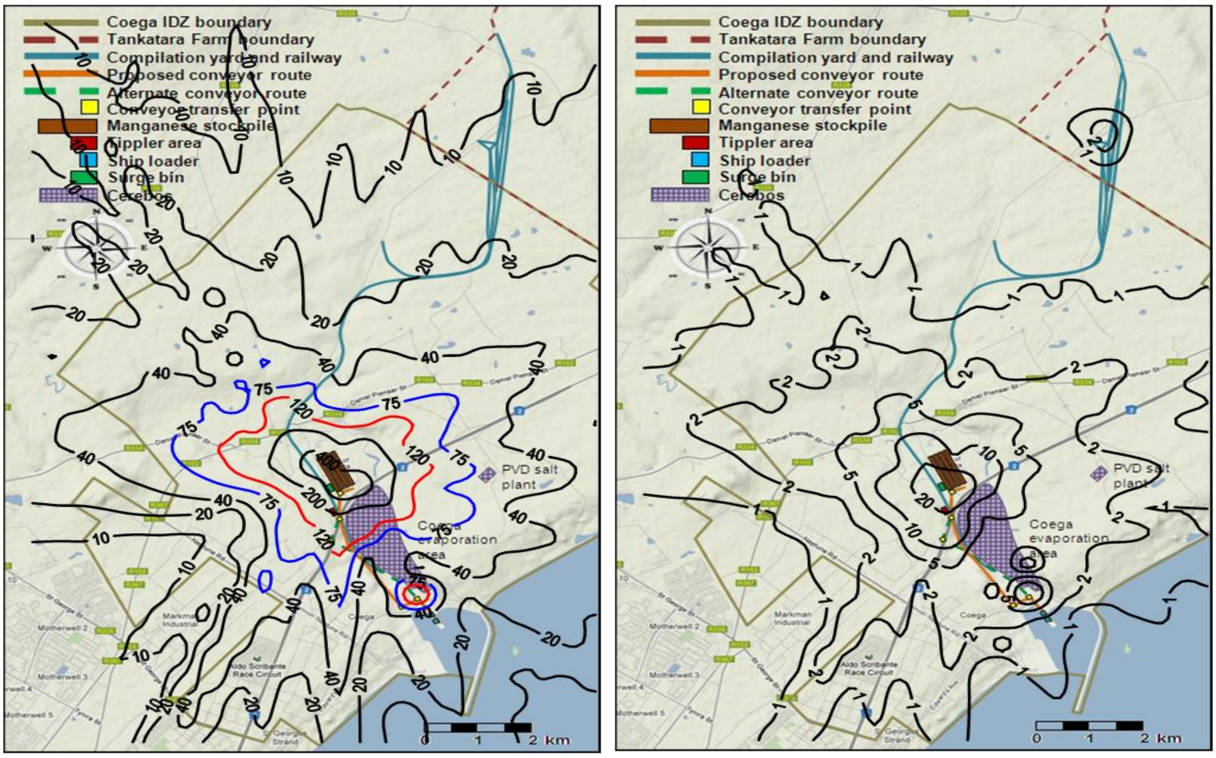


Figure 5-6: Predicted 24-hour PM_{10} concentrations ($\mu g/m^3$) for the proposed Manganese Ore Export Facility operating under standard conditions (left) and with full mitigation measures (right). The current and future South African standards are indicted by the red and blue lines respectively

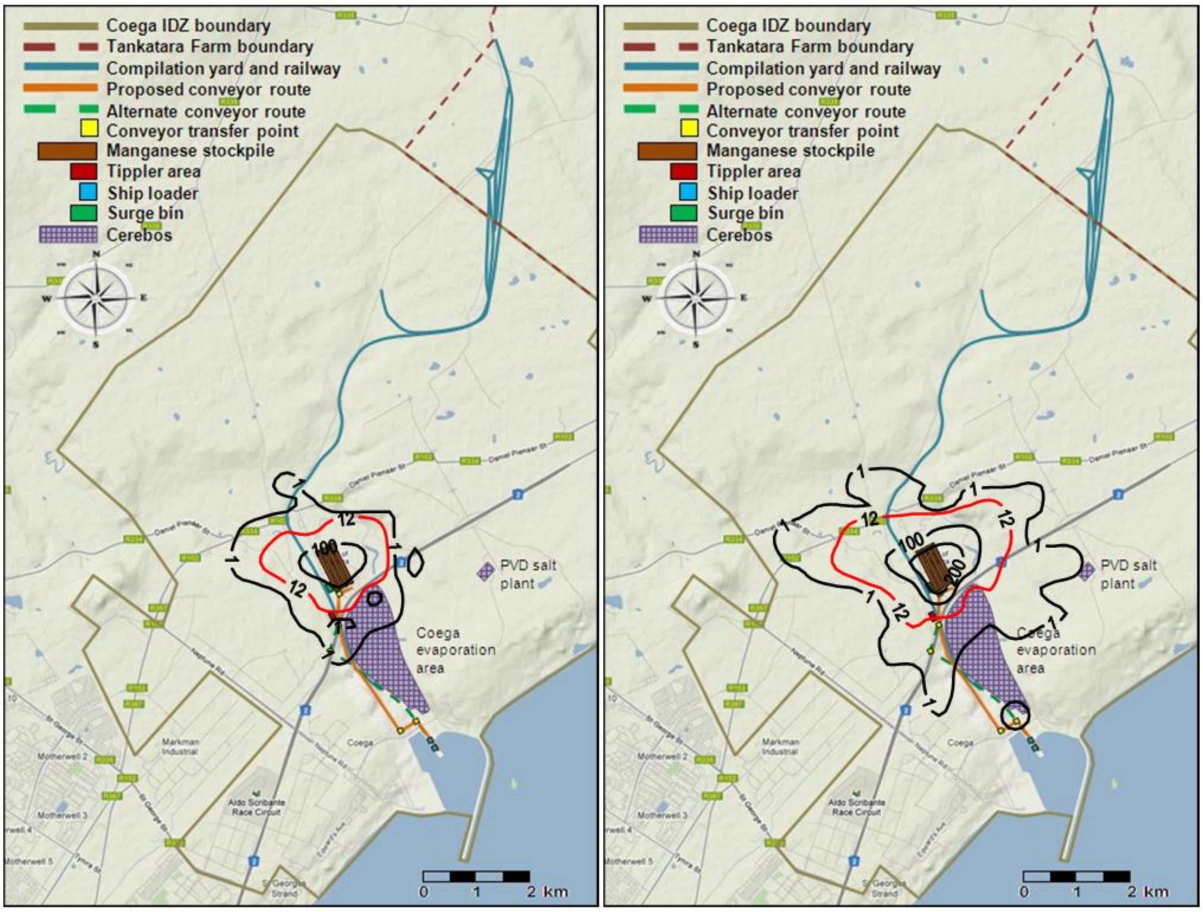


Figure 5-7: Predicted number of exceedances for the 24-hour PM10 concentrations for the proposed Manganese Ore Export Facility operating under standard conditions, for the current standard (left) and for the future standard (right) over a 3-year period

The predicted average annual ambient PM_{10} concentrations resulting from all sources for the standard mitigation scenario and the full mitigation scenario are shown in Figure 5-8 and are compared with the limit values of the current and future national ambient standard. The highest predicted concentrations occur at the stockyard in both cases.

For the standard mitigation scenario the current (50 μg/m^3) and future (40 μg/m^3) limit values of the national ambient standard are exceeded only at the stockpile. No exceedances of the current and future annual ambient standard for PM_{10} are predicted when full mitigation is implemented.

Impacts relating to ambient PM_{10} concentrations will endure for the life time of the proposed Manganese Ore Export Facility. They will be limited to the stockyard and the area immediately surrounding it.

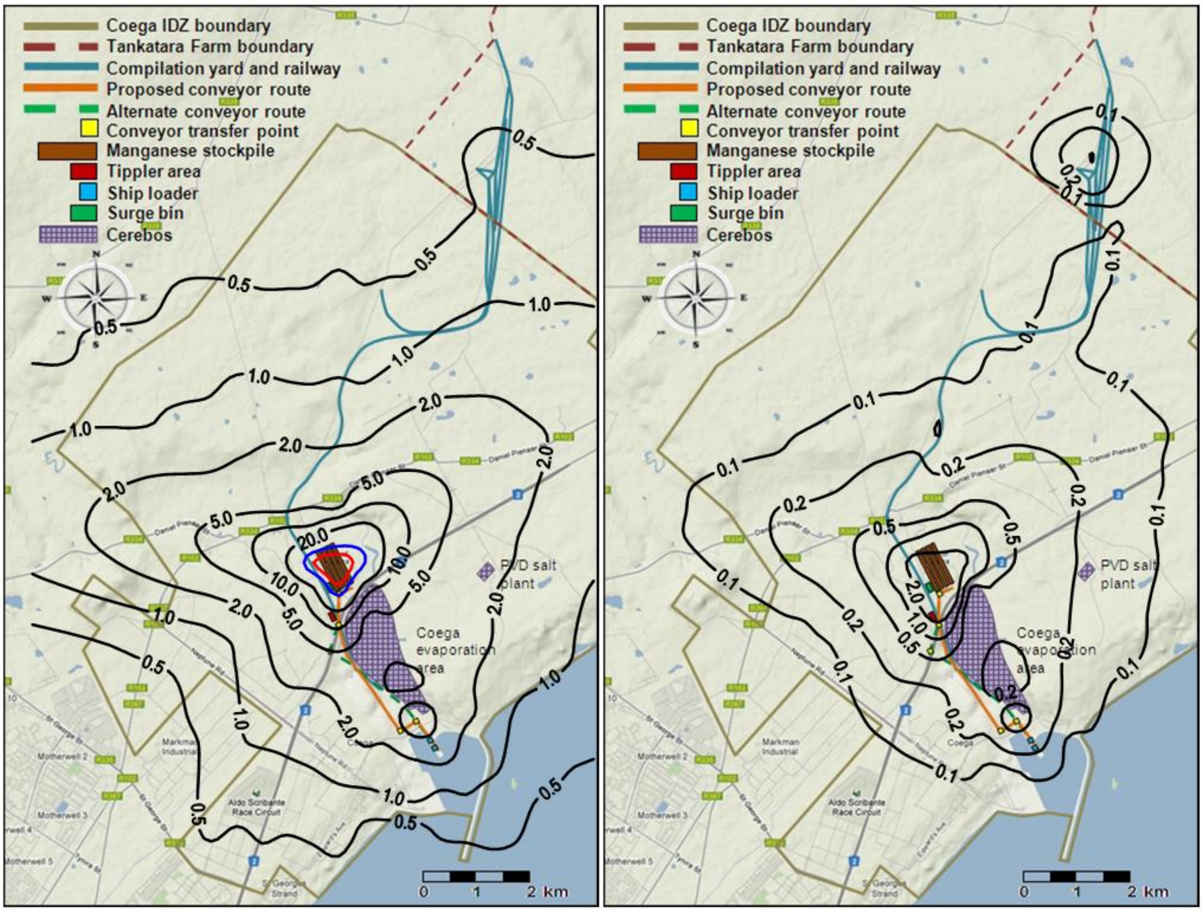


Figure 5-8: Predicted annual average PM_{10} concentrations (µg/m^3) for the proposed Manganese Ore Export Facility operating under standard conditions (left) and with full mitigation measures (right). The current and future South African standards are indicted by the red and blue lines respectively

5.6.5 Predicted $PM_{2.5}$ concentrations

Predicted 24-hour maximum ambient $PM_{2.5}$ concentrations resulting from all sources for the standard mitigation scenario and the full mitigation scenario are shown in Figure 5-9 and are compared with the limit values of the current and future national ambient standard. The number of exceedance of the current and future standard is shown on Figure 5-10 for the standard mitigation scenario.

The maximum concentrations for both cases occur at the stockyard and the surrounding area, as well as in the vicinity of the southern-most conveyor transfer point. For the standard mitigation case the limit value of the current and future ambient standard is exceeded over a very small area immediately at the stockyard. For the standard mitigation scenario one exceedance of the current 24-hour ambient standard is predicted while sixteen exceedances of the future 24-hour standard is predicted. There are no exceedances of the current and future standards for the full mitigation case over the 3-year modelling period.

No exceedances of the $PM_{2.5}$ limit value are permitted. Despite the low number of predicted exceedances this implies that the 24-hour ambient standard is exceeded. The exceedances are limited to the stockyard.

The predicted average annual ambient $PM_{2.5}$ concentrations resulting from all sources for the standard mitigation scenario and the full mitigation scenario are shown in Figure 5-11 and are compared with the limit values of the current and future national ambient standard. The highest predicted concentrations occur at the stockyard. The relatively high predicted $PM_{2.5}$ values over the compilation yard are as a result of diesel locomotives.

For the standard mitigation scenario, the current (25 µg/m³) and future (20 µg/m³) annual limit values of the national ambient standard are not exceeded anywhere in the study area for either the standard mitigation or the full mitigation scenarios.

Impacts relating to ambient $PM_{2.5}$ concentrations will endure for the life time of the proposed Manganese Ore Export Facility. They will be limited to the immediate stockyard area.

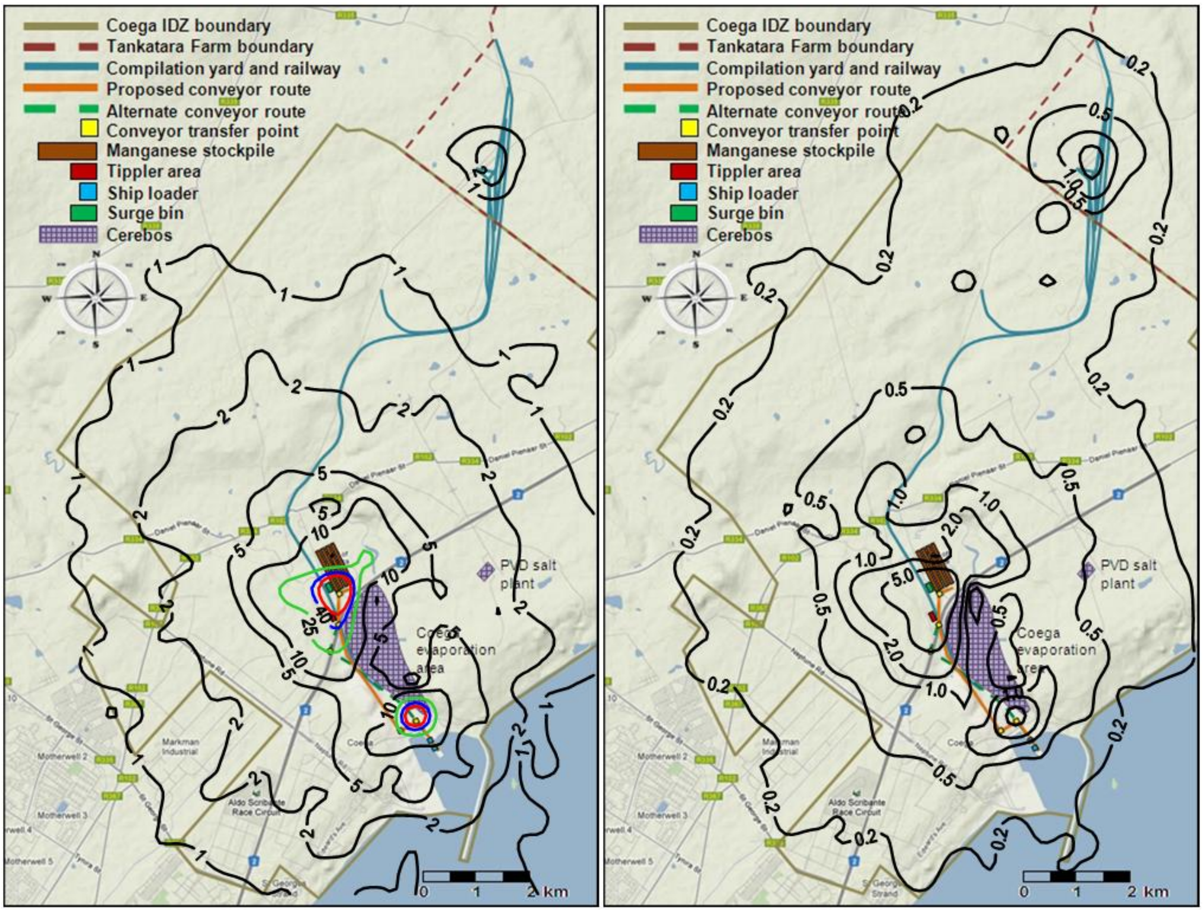


Figure 5-9: Predicted 24-hour $PM_{2.5}$ concentrations (µg/m³) for the proposed Manganese Ore Export Facility operating under standard conditions (left) and with full mitigation measures (right). The current South African standard is indicated by the red line while the two future standards (2016-2029 and 2030) are indicted by the blue and green lines respectively

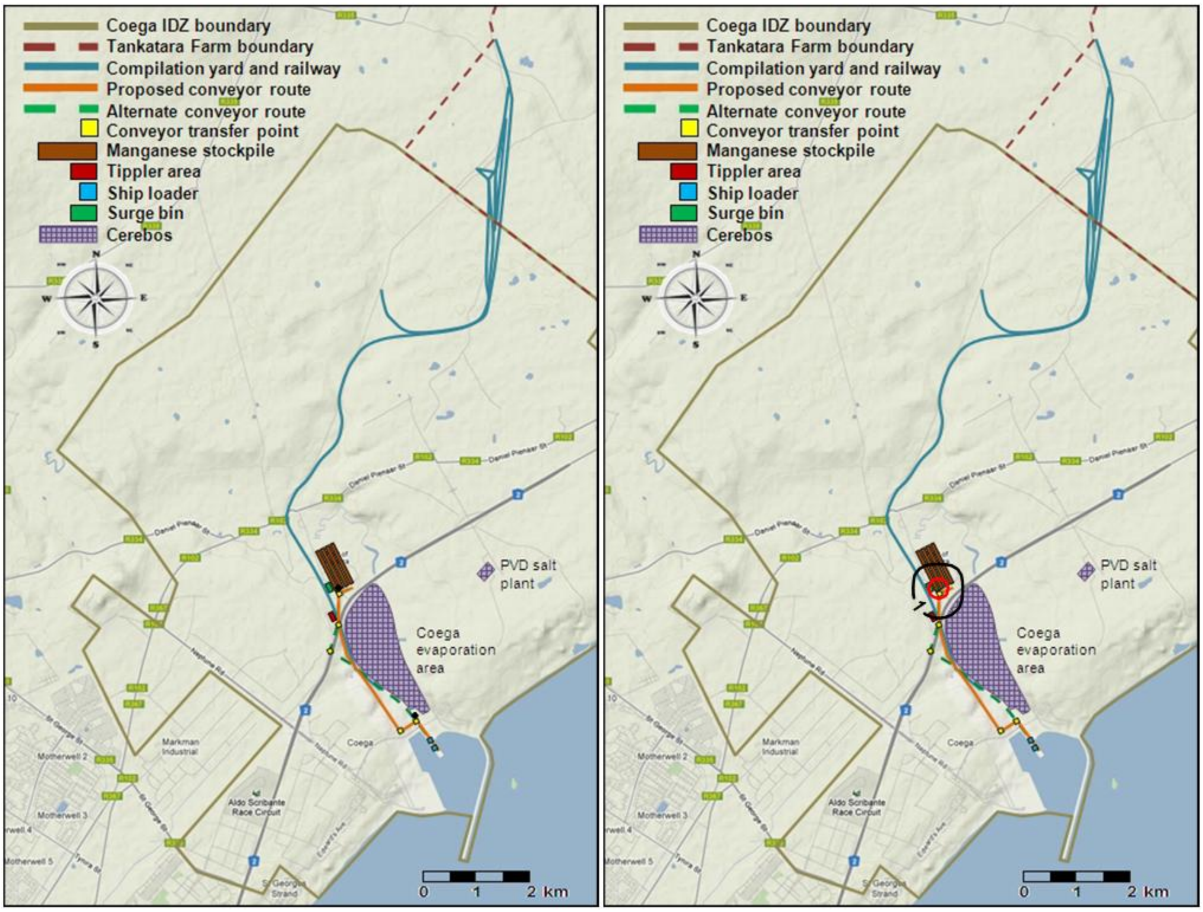


Figure 5-10: Predicted number of exceedances for the 24-hour PM$_{2.5}$ concentrations for the proposed Manganese Ore Export Facility operating under standard conditions, for the current standard (left) and for the future standard (right) over a 3-year period. The red line in the figure on the right indicates 16 exceedances

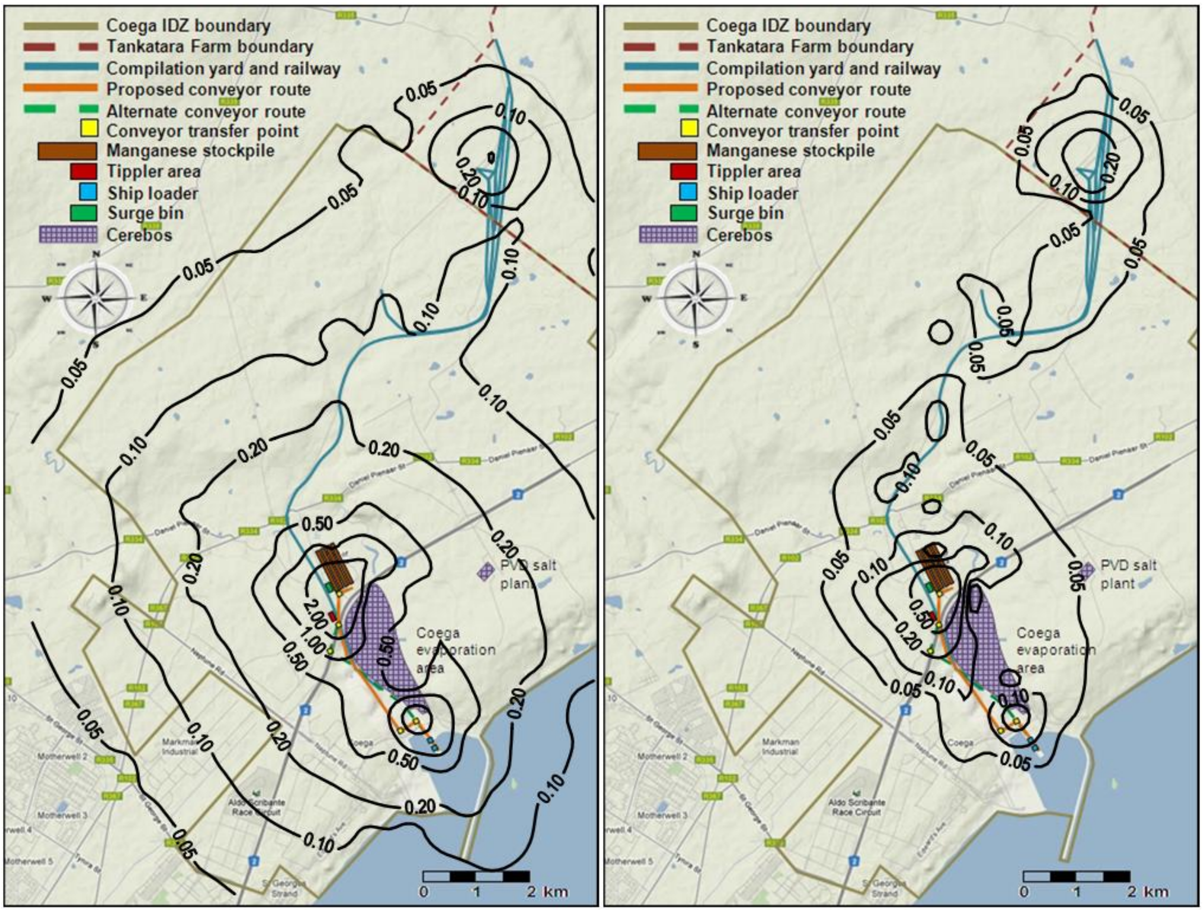


Figure 5-11: Predicted annual average $PM_{2.5}$ concentrations ($\mu g/m^3$) for the proposed Manganese Ore Export Facility operating under standard conditions (left) and with full mitigation measures (right)

5.6.6 Predicted NO_X concentrations

Predicted annual and 1-hour maximum ambient NO_x concentrations resulting from the diesel combustion in the compilation yard and on the line to the tippler are shown in Figure 5-12 with the number of exceedances. The predicted annual NO_x concentrations are shown in Figure 5-13.

There is no ambient standard for NO_x, but only for NO_2 (see discussion in Section 5.2.3.3). The highest 1-hour maximum concentration occur at the compilation yard where concentrations in excess of 600 $\mu g/m^3$ are predicted with a maximum of 1 140 $\mu g/m^3$ The limit value of the national ambient standard for NO_2 is therefore exceeded over a relatively large area of the IDZ and the Tankatara Farm. A total of 88 exceedances of the hourly standard is however permitted. This is equivalent to 264 exceedances of the three year modelling period. The area where more than 264 exceedances are predicted to occur is limited to the immediate compilation yard area. Therefore, the 1-hour NO_2 ambient air quality standard is predicted to be exceeded only in the compilation yard.

The annual ambient standard for NO$_2$ is not exceeded. Impacts relating to ambient NO$_X$ concentrations will endure for the life time of the proposed Manganese Ore Export Facility. They will be limited to the compilation yard.

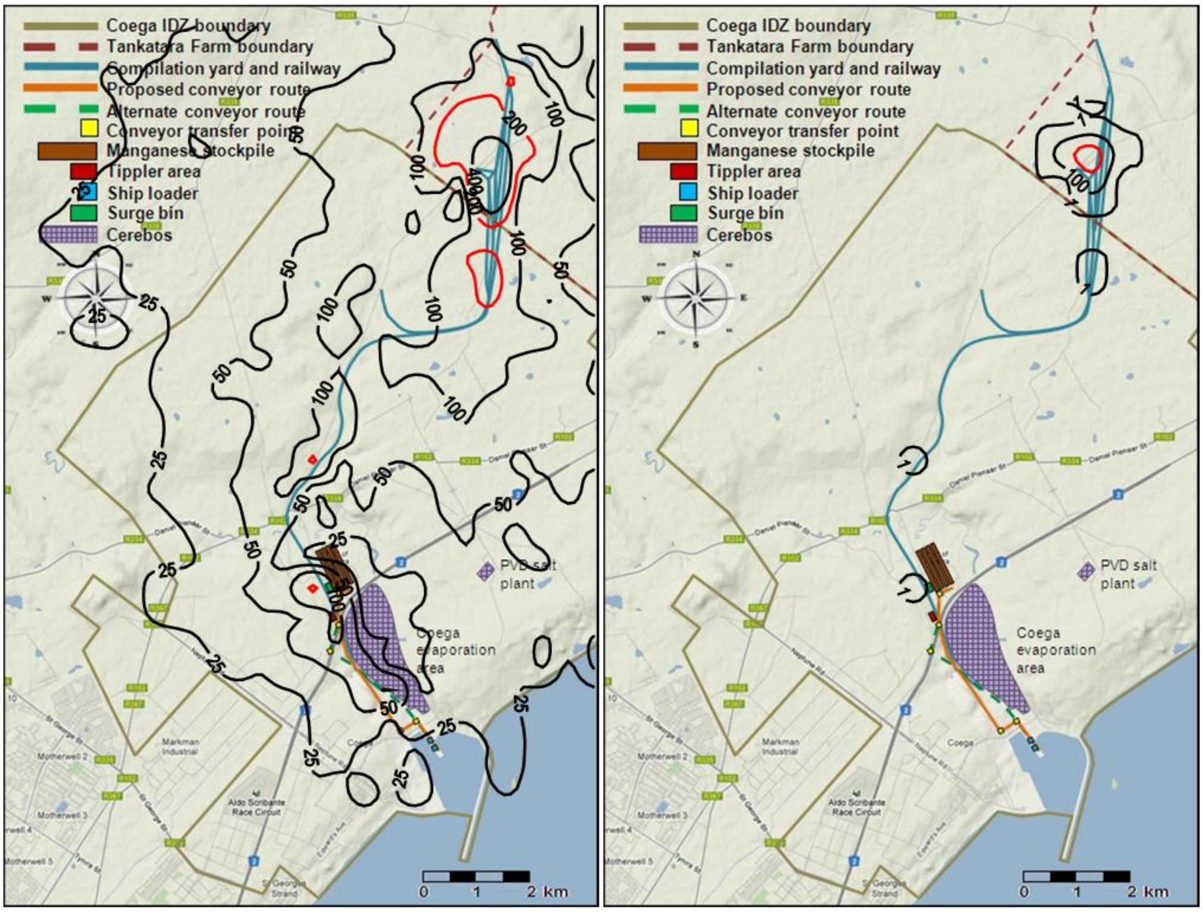


Figure 5-12: Predicted 1-hour NO$_X$ concentrations (µg/m^3) for the proposed Manganese Ore Export Facility operating under standard conditions (left) and number of exceedances of the South African Standard over a 3-year period (right)

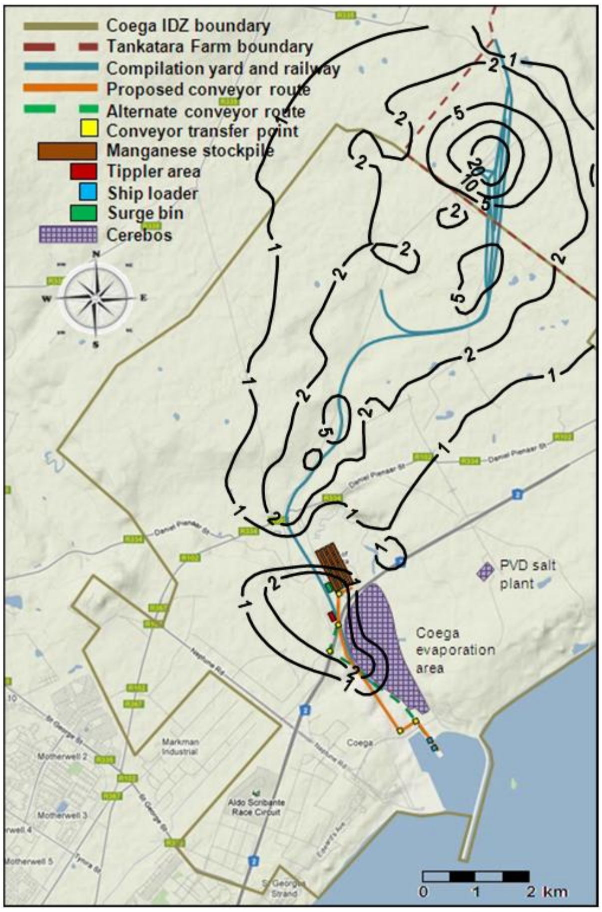


Figure 5-13: Predicted annual average NO_X concentrations (µg/m^3) for the proposed Manganese Ore Export Facility operating under standard conditions

5.6.7 Predicted benzene concentrations

Predicted annual concentrations of benzene resulting from the diesel combustion in the compilation yard and on the line to the tippler are shown in Figures 5-14.

The highest concentrations are predicted to occur in the compilation yard. The predicted concentrations are very low and the respective ambient guideline values for the compounds are not exceeded anywhere in the study area.

Impacts relating to ambient benzene concentrations will endure for the life time of the proposed Manganese Ore Export Facility. They will be limited to the compilation yard.

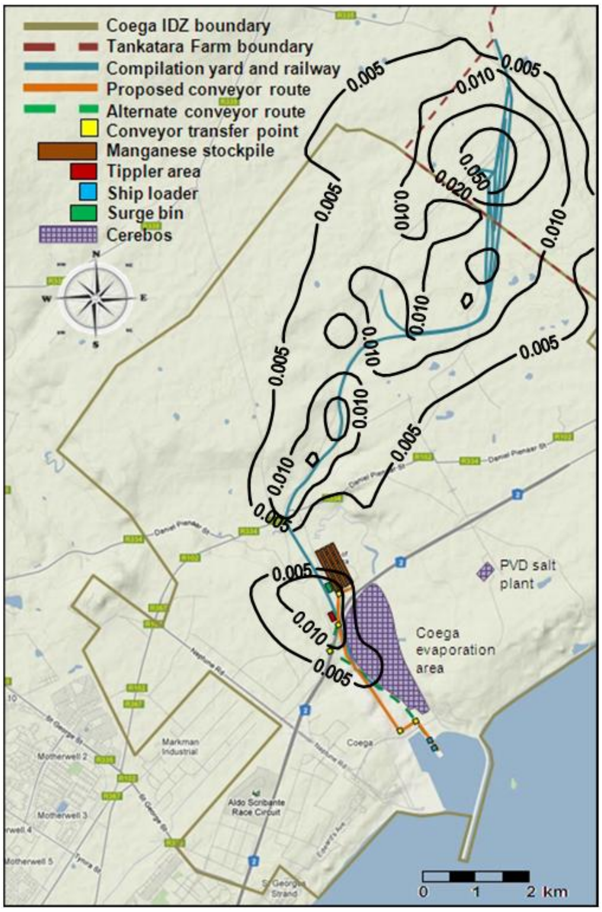


Figure 5-14: Predicted annual average benzene concentrations (µg/m³) for the proposed Manganese Ore Export Facility operating under standard conditions

5.6.8 Predicted toluene, ethylbenzene and xylene concentrations

Predicted concentrations of toluene, ethylbenzene and xylene resulting from the diesel combustion in the compilation yard and on the line to the tippler are shown in Figures 5-15 to Figure 5-17.

The highest concentrations are predicted to occur in the compilation yard. The predicted concentrations are very low and the respective ambient guideline values for the compounds are not exceeded anywhere in the study area.

Impacts relating to ambient toluene, ethylbenzene and xylene concentrations will endure for the life time of the proposed Manganese Ore Export Facility. They will be limited to the compilation yard.

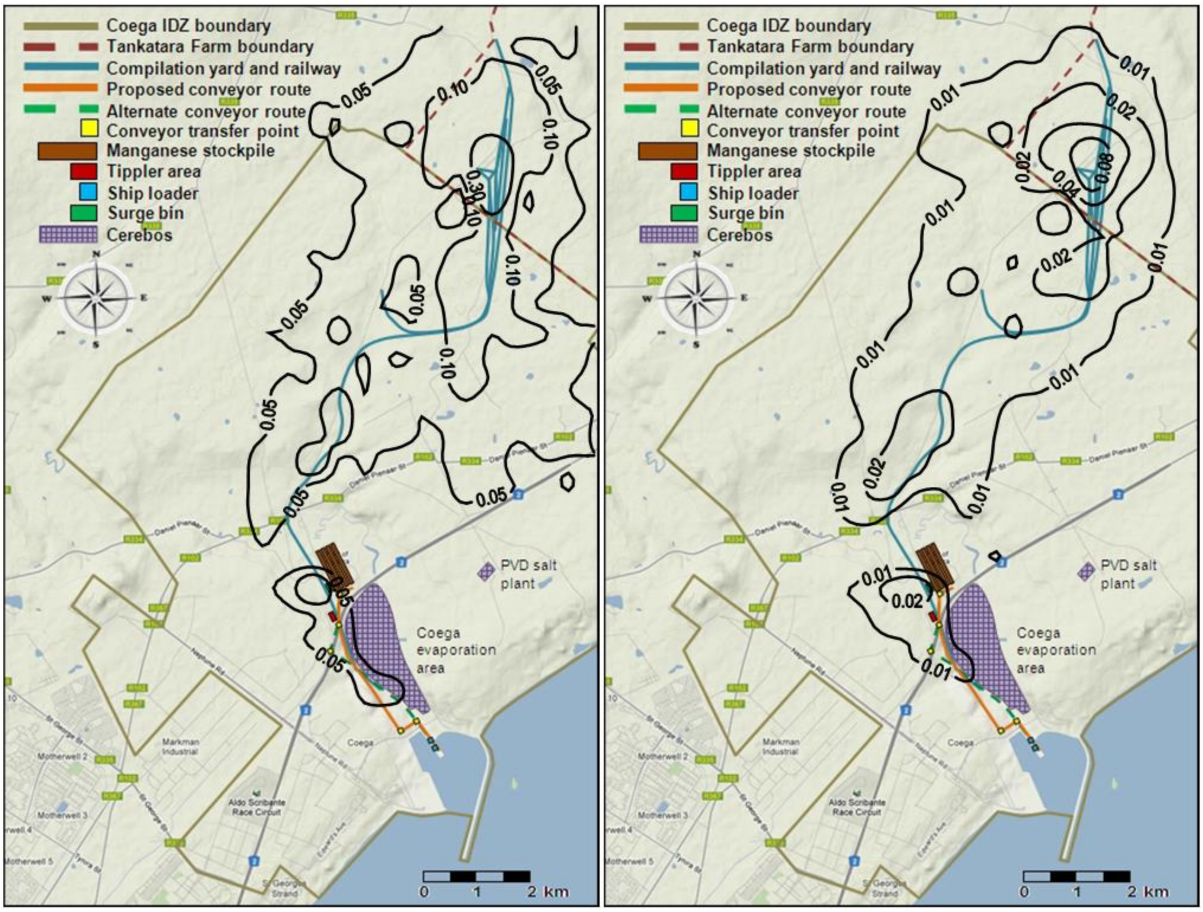


Figure 5-15 Predicted 1-hour toluene concentrations ($\mu g/m^3$) (left) and 24-hour toluene concentrations ($\mu g/m^3$) (right) for the proposed Manganese Ore Export Facility operating under standard conditions

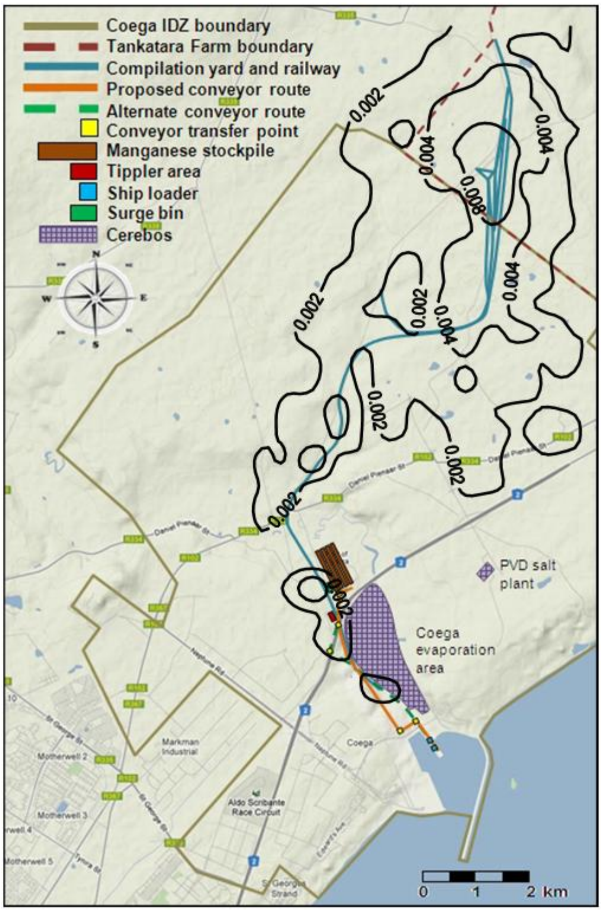


***Figure 5-16:* Predicted 1-hour ethylbenzene concentrations (µg/m³) for the proposed Manganese Ore Export Facility operating under standard conditions**

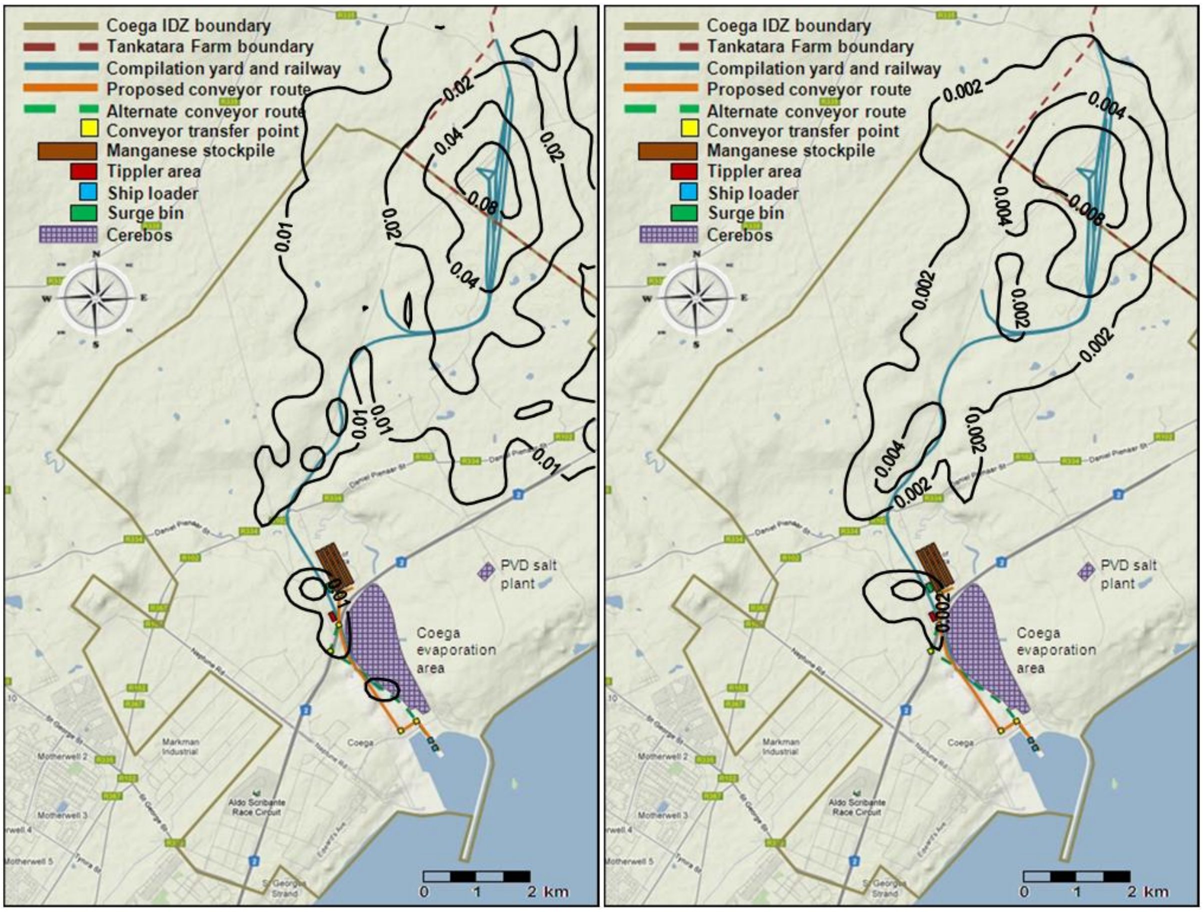


Figure 5-17: Predicted 1-hour xylene concentrations (µg/m^3) (left) and 24-hour xylene concentrations (µg/m^3) (right) for the proposed Manganese Ore Export Facility operating under standard conditions

5.6.9 Air quality impact assessment

The potential impacts on air quality are assessed for the construction and operational phases on the Manganese Ore Export Facility using the criteria described in the EIA report. The assessment is based on the maximum anticipate throughput of 16 Mt of manganese ore per annum

Construction phase

Potential impact 1: Increased dust and other pollutants during construction

Most civil construction activities generate dust and the emission of particulates into the atmosphere is through vehicle dust entrainment, demolition, excavation, ground levelling, etc. In most cases the dust is relatively coarse, but may include fine particles (PM_{10}). These emissions are released close to ground level and have no buoyancy. As a result the coarse particulates generally settle relatively close to the emission source. Finer particulates may be transported further from the point of release, as they are easily carried by wind. Exhaust emissions from construction vehicles and equipment typically include particulates (including PM_{10} and $PM_{2.5}$), carbon monoxide (CO), nitrogen oxides (NO_X), and volatile organic compounds (VOCs) including benzene. The construction activities are typically short lived and the pollutants are released close to ground level which limits their dispersion to the site. The significance of the potential air quality impacts on human health from construction is expected to be very low. The impact scores are shown in Table 5-18.

Operation phase

Potential impact 2: Dust deposition from the Manganese Ore Export Facility in the neighbouring environment

Design consideration in all aspects of the proposed Manganese Ore Export Facility and the proposed dust suppression ensures that the national dust deposition limit value for residential areas of 600 $mg/m^2/day$ is not predicted to be exceeded anywhere in the modelling domain from the emission of dust from the proposed Manganese Ore Export Facility.

Despite the relatively low predicted dust deposition rates, the generically black dust from the Mn ore may result in nuisance impacts and at neighbouring facilities such as the Cerebos salt pans in the IDZ if dust is not adequately controlled. At the Sunday's River, PDV and Swartkops evaporation pans the deposition rates of more than 10 $mg/m^2/day$ for the standard mitigation decrease to between 1.5 $mg/m^2/day$ and less than 0.25 $mg/m^2/day$ for full mitigation.

Impacts relating to deposition of dust from the Manganese Ore Export Facility will endure for the life time of the proposed Manganese Ore Export Facility. Although relatively low, dust deposition potentially affects the whole of the IDZ, mostly immediately adjacent to the stockyard. The significance of the potential dust deposition impacts on human health from dust deposition is expected to be low with full mitigation. The impact scores for dust deposition are shown in Table 5-18.

Potential impact 3: Ambient PM_{10} concentrations exceed ambient standards

The predicted average annual ambient PM_{10} concentrations resulting from all sources are below the current and future national ambient standard when the proposed mitigation measures are fully implemented. Exceedances of the 24-hour ambient standard are predicted at the stockyard and the immediate surrounding environment if dust suppression with water and chemical surfactants does not take place.

Impacts relating to ambient PM_{10} concentrations will endure for the life time of the proposed Manganese Ore Export Facility. They will be limited to the stockyard and the area immediately surrounding it. The intensity of the impact is expected to be low for the standard mitigation scenario and very low for the full mitigation scenario. The significance of the potential impacts of exposure to PM_{10} on human health is expected to be low. The impact scores for PM_{10} are shown in Table 5-18.

Potential impact 4: Ambient $PM_{2.5}$ concentrations exceed ambient standards

The predicted average annual ambient $PM_{2.5}$ concentrations are not exceeded anywhere in the study area for either the standard mitigation or the full mitigation scenarios. The predicted 24-hour $PM_{2.5}$ concentrations are exceeded in a small area in the stockyard.

Impacts relating to ambient $PM_{2.5}$ concentrations will endure for the life time of the proposed Manganese Ore Export Facility. They will be limited to the immediate stockyard area. The intensity of the impact is expected to be very low for the standard mitigation scenario as well as the full mitigation scenario. The significance of the potential impacts of exposure to $PM_{2.5}$ on human health is expected to be low. The impact scores for $PM_{2.5}$ are shown in Table 5-18.

Potential impact 5: Ambient NO_x concentrations exceed ambient standards

The highest 1-hour maximum concentration occur at the compilation yard where concentrations in excess of 600 µg/m^3 are predicted with a maximum of 1 140 µg/m^3. While the limit value of the national ambient standard for NO_2 is exceeded over a relatively large area of the IDZ and the Tankatara Farm, the area where more than 264 exceedances are predicted to occur is limited to the immediate compilation yard area. Therefore, the 1-hour NO_2 ambient air quality standard is predicted to be exceeded only in the compilation yard.

Impacts relating to ambient NO_x concentrations will endure for the life time of the proposed Manganese Ore Export Facility. They will be limited to the compilation yard. The intensity of the impact is expected to be low. The significance of the potential impacts of exposure to NO_x on human health is expected to be low. The impact scores for NO_x are shown in Table 5-18.

Potential impact 6: Ambient BTEX concentrations exceed ambient standards

Predicted ambient concentrations for the BTEX compounds are not predicted to exceed ambient standards and guidelines anywhere in the study area. Impacts relating to ambient BTEX concentrations will endure for the life time of the proposed Manganese Ore Export Facility. The intensity of the impact is expected to be very low. The significance of the potential BTEX impacts on human health is expected to be very low. The impact scores for the BTEX compounds are shown in Table 5-18.

Potential impact 7: Cumulative impacts

There are no other bulk ore terminals in the Coega IDZ. As a result the assessment of cumulative effects with respect to manganese ore dust is irrelevant. There is however, other combustion sources of NO_x and BTEX such as port side equipment, trucks and shipping that contribute to the existing atmospheric load. Ambient monitoring has shown that existing ambient concentrations for these compounds is well below the ambient standards. The dispersion modelling in this study has shown that the spatial distribution of these pollutants from diesel locomotives is limited to the compilation yard and rail track to the tippler. Beyond these areas the predicted ambient concentrations are very low. It is therefore unlikely that they will add significantly to the current ambient concentrations beyond the immediate project site. The significance of the potential cumulative impacts on human health is expected to be low.

5.6.10 Air quality impact summary

The potential impacts assessed and described above are summarised in the Tables below according to the defined assessment criteria. Tables 5-18 and 5-19 distinguish between impacts resulting from *operations* and *operational activities* at the Manganese Ore Export Facility. *Operations* consider the potential impacts on ambient air quality in the surrounding environment that may result from the handling and storage of manganese ore at the terminal. *Operational activities* relate these impacts to each of the phases of handling and storage of manganese ore, providing input to management of the different sources.

Table 5-18: Air quality impact scores for construction, operations and operational activities

Impact description	Status	Extent	Duration	Reversibility	Irreplaceability	Intensity/ Magnitude	Probability	Significance (standard mitigation)	Mitigation	Significance (full mitigation)	Confidence level
CONSTRUCTION											
Increased dust and other pollutants during construction	Negative	Site specific	Short	Reversible	N/A	Low	Probable	Low	Refer to Table 5-24	Very low	Med
IMPACTS FROM OPERATIONS											
Dust deposition from the Manganese Ore Export Facility in the neighbouring environment	Negative	Local	Long	Reversible	N/A	Low	Highly probable	Medium	Refer to Table 5-24	Low	High
Ambient PM_{10} concentrations exceed ambient standards	Negative	Local	Long	Reversible	N/A	Low	Highly probable	Low		Very low	High
Ambient $PM_{2.5}$ concentrations exceed ambient standards	Negative	Site specific	Long	Reversible	N/A	Low	Probable	Low		Very low	High
Ambient NO_x concentrations exceed ambient standards	Negative	Site specific	Long	Reversible	N/A	Low	Probable	Low	No mitigation	Low	High
Ambient BTEX concentrations	Negative	Site specific	Long	Reversible	N/A	Low	Improbable	Very low	No mitigation	Very low	High

Impact description	Status	Extent	Duration	Reversibility	Irreplaceability	Intensity/ Magnitude	Probability	Significance (standard mitigation)	Mitigation	Significance (full mitigation)	Confidence level
exceed ambient standards											
Cumulative impacts of dust, PM_{10}, $PM_{2.5}$, NO_x and BTEX	Negative	Local	Long	Reversible	N/A	Low	Probable	Low	No mitigation	Low	Med

Table 5-19: Air quality impact scores for construction, operations and operational activities

IMPACTS FROM OPERATIONAL ACTIVITIES									
Activity description	**Mitigation scenario**	**Comment**	**Status**	**Extent**	**Duration**	**Intensity**	**Probability**	**Significance**	**Confidence level**
Tippler	Standard mitigation	Enclosed	Negative	Local	Long	Low	Highly probable	Medium	High
	Full mitigation	Enclosed with dust suppression/water sprays	Negative	Site only	Long	Very low	Probable	Low	High
Stockpiles	Standard mitigation	Low position	Negative	Regional	Long	Medium	Highly probable	Medium	High
	Full mitigation	Chemical sprays	Negative	Local	Long	Medium/low	Highly probable	Low	High
Stacking and reclaiming	Standard mitigation	Low drop heights	Negative	Local	Long	Low	Highly probable	Low	High
	Full mitigation	Water sprays and stockpile dampened prior to reclaiming	Negative	Site only	Long	Very low	Probable	Very low	High
Conveyor system incl. transfer points[1]	Standard mitigation: Proposed route	Enclosed conveyor and transfer points	Negative	Site only	Long	Very low	Probable	Low	High
	Full mitigation: Proposed route	Enclosed with transfer point water sprays	Negative	Site only	Long	Very low	Probable	Very low	High
	Standard mitigation: Alternative route	Enclosed conveyor and transfer points	Negative	Site only	Long	Very low	Probable	Low	High
	Full mitigation: Alternative route	Enclosed with transfer point water sprays	Negative	Site only	Long	Very low	Probable	Very low	High
Surge bins	Standard mitigation	Enclosed	Negative	Local	Long	Low	Highly probable	Low	High
	Full mitigation	Enclosed with water sprays	Negative	Site only	Long	Very low	Probable	Very low	High
Ship Loader	Standard mitigation	Low drop heights	Negative	Site only	Long	Low	Probable	Low	High
	Full mitigation	Low drop heights and water sprays	Negative	Site only	Long	Very low	Probable	Very low	High
Compilation	Standard mitigation	No mitigation	Negative	Site only	Long	Very low	Improbable	Very low	

IMPACTS FROM OPERATIONAL ACTIVITIES

Activity description	Mitigation scenario	Comment	Status	Extent	Duration	Intensity	Probability	Significance	Confidence level
Yard[2]	(Preferred layout)								High
	Standard mitigation (Alternative layout)	No mitigation	Negative	Site only	Long	Very low	Improbable	Very low	High
Retention and attenuation ponds	Standard mitigation	No mitigation	Negative	Site only	Long	Very low	Improbable	Very low	Medium

1 The preferred and alternative conveyor routes have the same number of transfer points and the same emissions. The predicted impact significance is the same for both options.

2 The preferred and alternative layout of the compilation yard result in the same emissions and the predicted impact significance is the same for both options.

5.7 APPLICATION OF THE HUMAN HEALTH RISK ASSESSMENT FRAMEWORK

5.7.1 Hazard Identification

The air pollutants of concern in this risk assessment were decided upon by the health specialist and the air quality specialist, based on the pollutants expected to be created during construction, operational en decommissioning phases of the project as follows:

- For the construction phase: Mainly particulate matter (PM) but also NO_2 and BTEX from vehicles.
- For the operational phase: Particulate matter from manganese ore and $NO_{2,}$ and BTEX from diesel trains and other vehicles as well as storage ponds and tanks.
- For the decommissioning phase, the pollutants are expected to be the same as for the construction phase: Mainly particulate matter but also NO_2 and BTEX from vehicles

Reliable databases, including those of the US-EPA were used to determine whether the pollutants of concern could be detrimental to human health and to obtain relevant target limits, guidelines and / or standards. The results of the literature review on manganese are presented in Appendix 5.A, while the effects of NO_2 and PM are discussed in section 5.2.3. Known effects of exposure to BTEX, include acute neurological effects such as headache when exposed to relatively high concentrations. Some Volatile Organic Compounds may also cause cancer, for example benzene.

5.7.2 Exposure assumptions applicable to this risk assessment

The populations of concern

The populations of concern are those living within the 40 X 40 km area for which modelling was done with the focus on the identified sensitive receptor areas. All 18 receptor sites fall within the Nelson Mandela Metro Municipality (NMMM). The demographics and factors that can make the people in the areas under consideration more vulnerable to air pollution are discussed in Appendix 5.B.

The sensitive receptor areas identified in this project are illustrated in Table 5-20 and Figure 5-18.

Table 5-20: Air quality impact scores for construction, operations and operational activities

HHRA Receptor Point	Distance (km) from centre of Manganese Terminal Stockyard	Direction (degrees) from centre of Manganese Terminal Stockyard
Motherwell	5.15	West-southwest
Wells Estate	6.5	South-southwest
Bluewater Bay	9.1	South-southwest
Colchester	15.8	Northeast
Sundays River	13.8	Northeast
Ibhayi	13.2	Southwest
North End	20	South-southwest
Tankatara Farm (southern border)	7.6	North-northeast
Tankatare Farm (centre)	10.6	North-northeast
Addo Elephant National Park (south)	14.4	North-northeast
Cerebos - Coega evaporation area (north)	0.82	Southeast
Cerebos - Coega evaporation area (centre)	2.1	South-southeast
Cerebos - PVD Salt Plant	2.85	East
Cerebos - Sundays River evaporation area	9.7	Northeast
Cerebos - Swartkops evaporation area	11.35	West
Jahleel Island	5.4	Southeast
St Crois Island	10	East-southeast
Brenton Island	10.1	East-southeast

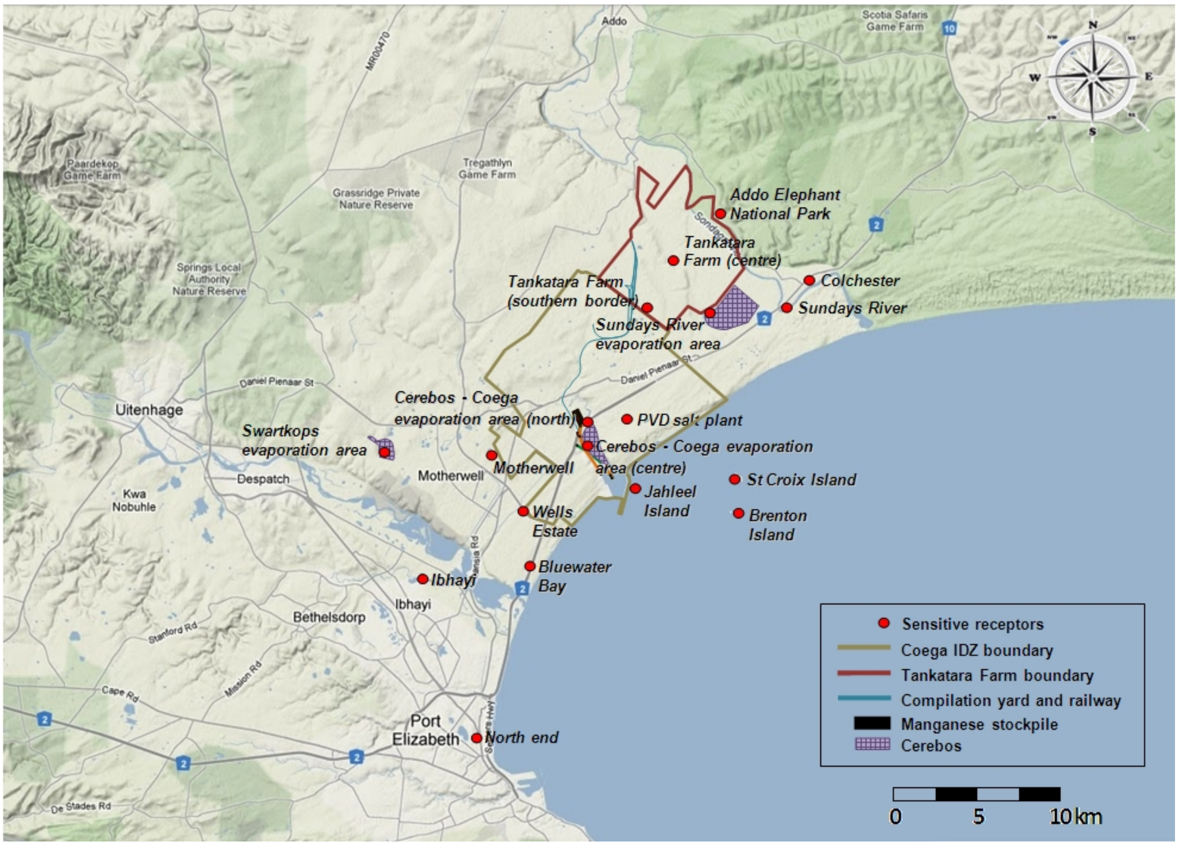


Figure 5-18: Location of sensitive receptors relative to the Manganese Ore Export Facility

- **The exposure concentrations**

It is assumed that people will be exposed to the 99th percentile of modelled concentrations of pollutants. For Mn and silica, the respireable fractions of fine particulate matter ($PM_{2.5}$) were used in the risk assessment.

- **The magnitude, frequency and duration of exposure**

As behavioural patterns of the specific communities are not known, it is assumed that individuals will be exposed for 24 hours per day to the modelled concentrations as the emissions are based on a total ore throughput of 16 Mtpa with the facility operating continuously.

5.7.3 Dose-response Assessment

In this study, numeric benchmark values obtained from reliable databases are used to describe the dose-response relationships. The preferred benchmark values (guidelines or standards) used, are those based on health effects in human beings and not those incorporating economic or social factors.

The benchmark values used in this study were those from the WHO, the EPA and the Centre for Disease Control (CDC), as tabulated in Tables 5.1 and 5.2. For Mn, all benchmark values were derived from occupational studies with similar adverse effect levels and with neurological symptoms as health outcome. The WHO benchmark value had the lowest uncertainty factor (200) compared to the other values. However, the CDC benchmark value is the most recent (2012) of the values.

The benchmark values used for BTEX were as follows:

- Benzene (chronic) SA national standard 5 µg/m^3
- Toluene (acute) CDC guideline 3 760 µg/m^3
- Ethylbenzene (acute) CDC guideline 22 000 µg/m^3
- Xylene (acute) CDC guideline 8 720 µg/m^3

Dust fall-out is an indication of the amount of dust generated at a site but cannot, however, be used in a Human Health Risk Assessment as the results are not presented in weight-per-volume (µg/m^3) but in weight-per-surface area per day (mg/m^2/day). Fall-out dust also normally consists of larger particles that “fall-out” close to the source. Fall-out dust is however, an indication of the nuisance effect.

5.7.4 Risk Characterization

Acute non-cancer risks which are associated with short-term exposure (1-hr or 24-hr) were quantitatively assessed by determining a hazard quotient (HQ). An HQ > 1 indicates that the likelihood of adverse effects is enhanced while an HQ value <1 indicates that the potential for adverse health effects is minimal. *Acute effects* were assessed for PM (PM_{10} and $PM_{2.5}$), NO_2, and TEX.

No acute risk from exposure to manganese could be determined as no acute (short-term) benchmark values could be found for inhalation of manganese in the databases searched. The reason is that people are normally not exposed to metals in the air, unless exposed in their working environment or if they live in areas where manganese is emitted. The main route of exposure of the general public to metals is ingestion of food and water that contain these metals.

Chronic (long-term) non-cancer risks were quantitatively assessed for PM (PM_{10} and $PM_{2.5}$.) and NO_2, using the 99th percentile of the modelled annual average concentrations. Cancer risks were assessed for benzene, a known human carcinogen.

Refer to Tables 5-21 and 5-22 for the modelled concentrations (99 percentile) at the various receptor areas, used in the acute and chronic human health risk assessments.

5.7.5 Results of the Human Health Risk Assessment

***Acute risks from exposure to PM** (*PM_{10} *and* $PM_{2.5}$*)*

Where fall-out dust consists mainly of larger particles that are not inhalable or respireable, and deposited relatively close to source, PM_{10} and $PM_{2.5}$ consist of small particles that may pass the defence mechanisms of the body and enter the respiratory system as deep as the alveolar region of the lung. These particles, because they are so small, may also stay in the air much longer and may be transported much further from the source.

Modelled PM_{10} ***data***

The highest acute risk from exposure to PM_{10} at any of the 18 sensitive receptor areas was an HQ of 0.83 predicted for Cerebos - Coega evaporation area (northern boundary) under the standard mitigation scenario, which means no water and or chemical mitigation procedures, only standard operating procedure. The second highest risk (HQ 0.20) is predicted for Cerebos’ Coega evaporation area (centre of site), also under the standard mitigation scenario. Both these HQs are however below

1, indicating that acute effects, such as respiratory effects will be unlikely to be experienced by any individual at any of the 18 sensitive receptor points.

Under the full mitigation scenario, the risks are lower, with the maximum risk at 0.12 (HQ), again at the Cerebos' Coega evaporation area (northern boundary) site with the second highest risk calculated for all 18 sensitive receptor sites, being at Cerebos' Coega evaporation area (centre of site), where the risk is predicted to be 0.02. These HQs indicate that adverse effects from PM_{10} under the mitigation scenario will be unlikely. Even sensitive individuals are not expected to experience any adverse health effects.

For the cumulative effect of PM_{10}, the background concentration of PM_{10} at the Cerebos' Coega evaporation area (northern boundary) is not known, but if the 24-h mean background concentration monitored at Saltworks (62.7 $\mu g/m^3$) in 2010 is added to the predicted 24-h PM_{10} then the risk at the Coega evaporation area (northern boundary) may be above 1 (HQ 1.35) for the standard mitigation scenario (i.e. upset condition). However, under mitigation, the cumulative risk is still below 1 (HQ 0.64) indicating that it would be unlikely for individuals to experience adverse effects.

PM_{10} was also monitored at Motherwell. If the monitored 24-h mean for 2010 (67.7 $\mu g/m^3$) is added to the predicted 24-h concentration of 3.42 $\mu g/m^3$ under the standard mitigation scenario, then the risk is 0.59 (HQ), thus below 1. Under the full mitigation scenario, the cumulative HQ is lower (0.57).

Modelled $PM_{2.5}$ data

The highest acute risk for exposure to $PM_{2.5}$ (HQ of 0.38) is predicted for "Cerebos - Coega evaporation area (northern boundary)" for the standard mitigation scenario, which can be considered as an upset condition. The second highest risk (HQ 0.07) is predicted for Cerebos - Coega evaporation area (centre of site), also for the standard mitigation scenario. Both these HQs are well below 1, indicating that acute effects, such as respiratory effects will be unlikely to be experienced by any individual at any of the 18 sensitive receptor points.

Under the full mitigation scenario, the risks are even lower, with the maximum risk (HQ of 0.08) being located again at the northern boundary of Cerebos' Coega evaporation area. The area exposed to the second highest risk, amongst the identified sensitive receptor sites is located at the centre of the Cerebos' Coega evaporation area, where the risk is predicted to be 0.01 (HQ). These HQs indicate that adverse effects from $PM_{2.5}$ under this scenario will be unlikely.

The cumulative effects for $PM_{2.5}$ could not be determined, as no background data were available for $PM_{2.5}$.

Chronic risk for PM

The HQs determined for chronic exposure to PM_{10} at the 18 sites, ranged from 0.001 at the North End to 0.34 at the Cerebos - Coega evaporation area (northern boundary) for the standard mitigation scenario and between < 0.001 and 0.07 at the same sites under the full mitigation scenario. These HQs indicate that chronic effects from exposure to the modelled PM_{10} concentrations are unlikely. Cumulative effects were not assessed, as no annual background PM_{10} concentrations were available.

HQs for chronic risks for $PM_{2.5}$ ranged from 0.0001 at the North End to an HQ of 0.19 at the northern boundary of the Cerebos' Coega evaporation area for the standard mitigation scenario and between <0.0001 and 0.02 at the same sites under the full mitigation scenario. These HQs indicate that chronic effects from exposure to the modelled $PM_{2.5}$ concentrations are unlikely. Cumulative effects were not assessed, as no annual background $PM_{2.5}$ concentrations were available.

Conclusions for risk from exposures to PM

In summary, no adverse effects from exposure to modelled 24-hour or annual PM concentrations (PM_{10} and $PM_{2.5}$) are expected at any of the sensitive receptor areas under 'standard mitigation" conditions (i.e. which equals to an upset condition). There is a possibility that 24-h cumulative PM_{10} concentrations could pose a risk of respiratory effects at Cerebos' Coega evaporation area (northern boundary) but only under standard mitigation.

Acute risks from exposure to TEX (toluene, ethylbenzene, xylene)

When considering the 24-h modelled concentrations for TEX, the highest risk is predicted for the western border of Tankatara Farm. The HQ values determined for all three pollutants (toluene, ethylbenzene and xylene) at all 18 sensitive receptor areas are all well below 1 (highest HQ 0.002), indicating that no acute adverse health effects as a result of exposure to the predicted TEX concentrations are expected in any individual, even sensitive individuals, at any of the identified sensitive receptor areas. The human health risk for TEX was calculated under "standard" operating conditions.

No background concentrations for TEX were available to predict a cumulative risk.

In summary, the acute risks for predicted concentrations of TEX are negligible even under upset conditions (i.e. standard mitigation).

Cancer risk from exposure to benzene

The incremental cancer risk from exposure to benzene under standard operating conditions, was determined using the annual modelled concentrations for the 18 sensitive receptor areas. The WHO inhalation unit risk of between 4.4 and 7.5 x 10^{-6} per µg/m^3 was used to calculate the cancer risk. The risk was below the acceptable risk of 1 in a million at all 18 of these sites. Tankatara Farm (western border) had the highest risk, ranging between 0.54 and 0.92 in ten million.

No cumulative cancer risk assessment could be calculated for benzene, as ambient background concentrations for benzene were not available.

Acute and chronic risks from exposure to NO_2

For the purpose of this assessment, the modelled NO_x concentrations (NO and NO_2) were assumed to be equal to NO_2 as NO is rapidly converted to NO_2 in the atmosphere. The receptor site (out of the 18 sites assessed) that showed the highest modelled (predicted) NO_2 concentration under the "standard" operating scenario, was the western border of the Tankatara Farm. The HQ calculated for acute risks at this site was 0.17, indicating a low risk. The second highest concentration was predicted for Cerebos' Coega evaporation area (northern boundary), where the HQ was calculated to be 0.15, while the third highest HQ (at the centre of the Cerebos - Coega evaporation area) was 0.13. All of these HQs are below 1, indicating a low risk.

Cumulative risk
NO_2 concentrations monitored in 2010 showed a mean 24-h concentration of 8.0 µg/m^3 at Motherwell and 11.4 µg/m^3 at Saltworks. When the concentration monitored at Saltworks is added to the highest concentration modelled (i.e. at the western border of Tankatara Farm , then the predicted HQ is 0.22, which is well below 1 and an indication of a low risk for the "standard" operating scenario.

The chronic risk for NO_2 was calculated from the highest annual concentration modelled for a sensitive site, which was the Tankatara Farm (western border). The HQ for the "standard" operating scenario was 0.08, indicating a low risk and that it would be unlikely for any individual exposed to develop chronic adverse effects (such as an increased susceptibility for respiratory infections) as a result of the predicted exposure.

In summary, the HQs calculated for acute, chronic and cumulative risks from exposure to NO_2 showed that it would be unlikely for any individual to develop adverse health effects as a result of exposure to the modelled and monitored concentrations.

Risk of exposure to silica

When the manganese ore was analysed by the laboratory, it was found that the silicon (Si) contend was higher than 1% and from a risk assessment perspective it was then decided to assess the risk for exposure to Si in the modelled respireable fraction ($PM_{2.5}$) of the particulate matter (dust). The highest 24-h concentration modelled (standard mitigation) in the respirable fraction of the dust was 0.68 µg/m^3. Neither South Africa, nor the WHO, US-EPA or the CDC has any ambient air guideline or standard for Si, but the South African occupational standard for exposure to respireable Si is 5 mg/m^3 (5 000 µg/m^3). It is clear that the modelled concentration is orders lower.

Chronic risk from exposure to manganese (Mn)

Concentrations of manganese were modelled in the respireable fraction of particulate matter ($PM_{2.5}$) predicted for the 18 sensitive receptor sites. Modelling was undertaken for the annual average concentration and the 99th percentile of the daily or hourly maximum concentrations for standard mitigation and full mitigation.

Under the "standard mitigation" scenario and taking into account the conversion factor (Mn vs MnO), three sites were found where predicted concentrations were elevated. These were Cerebos' Coega evaporation area (centre of site) (0.30 µg/m^3), Cerebos' Coega evaporation area (northern boundary) (1.98 µg/m^3) and Cerebos PVD Salt Plant (0.11 µg/m^3). HQs calculated for these sites using the WHO manganese guideline, were 2.0 (moderate risk), 13.1 (high risk) and 0.73 (low risk) respectively. This standard mitigation scenario, with no additional water or chemical mitigation, show a moderate to high risk of adverse effects (neurological effects) developing in people chronically exposed to the modelled concentrations.

Under the full mitigation scenario, the HQ for Cerebos' Coega evaporation area (centre of site) decreased from 2.0 to 0.3 (thus from moderate to low). At Cerebos' Coega evaporation area (northern boundary), the HQ decreased from 13.1 (high risk) to 2.8 (moderate) and at Cerebos PVD Salt Plant, although low, the HQ decreased further (from 0.73 to 0.12), indicating a low risk.

The HQs calculated for the rest of the 18 sensitive receptor areas were all below 0.45, without mitigation, and below 0.05 with mitigation, indicating that it would be unlikely for any individual chronically exposed at these sites to develop neurological effects due to manganese exposure.

In summary, the risk estimates calculated for manganese in this study suggest a moderate to high risk at certain receptor points within the industrial area for neurological effects. However, with mitigation, the risk will be low within the neighbouring environment and IDZ, except at one area within the IDZ where it will be moderate (Cerebos' Coega evaporation area (northern boundary).

Uncertainty analyses

Methods and models used in this assessment are supported by the EPA. Guidelines and standards used are from reliable databases and based on health effects. There is uncertainty in the activity patterns and vulnerability of the individuals at the specific sites assessed, as vulnerability factors are only known at municipal level.

Table 5-21: Modelled concentrations (99th percentile) at receptor areas used in acute human health risk assessment

Pollutant	[1]PM_{10} (µg/m^3)		[1]$PM_{2.5}$ (µg/m^3)		[1]Toluene (µg/m^3)	[2]Ethylbenzene (µg/m^3)	[1]Xylene (µg/m^3)	[2]NO_2 (µg/m^3)	[1]Si (µg/m^3)
Receptor points	**Standard**	**Mitigation**	**Standard**	**Mitigation**	**Standard**	**Standard**	**Standard**	**Standard**	**Standard**
North end	0.62	0.03	0.04	0.01	0.0001	0.000008	0.00002	0.28	0.001
Ibhayi	0.93	0.07	0.13	0.02	0.0003	0.00002	0.00005	0.64	0.003
Bluewater Bay	3.25	0.19	0.27	0.04	0.0004	0.00003	0.00007	1.12	0.007
Wells Estate	11.00	0.51	0.48	0.07	0.0007	0.00005	0.0001	1.87	0.013
Brenton Island	3.03	0.15	0.16	0.03	0.0006	0.00005	0.0001	1.67	0.004
Jahleel Island	7.05	0.35	0.79	0.09	0.0008	0.00008	0.0001	2.85	0.021
St Croix Island	3.60	0.16	0.19	0.03	0.0007	0.00006	0.0001	1.96	0.005
Cerebos - Swartkops evaporation area	3.03	0.14	0.14	0.02	0.0003	0.00003	0.00007	1.17	0.004
Motherwell	3.42	0.27	0.57	0.09	0.0009	0.00008	0.0002	3.06	0.016
Cerebos - Coega evaporation area (centre of site)	24.20	1.80	4.68	0.63	0.008	0.0007	0.001	25.7	0.128
Cerebos - Coega evaporation area (Northern boundary)	100.00	13.90	24.90	5.00	0.009	0.0008	0.001	29.2	0.679
Cerebos PVD salt plant	25.10	1.20	1.78	0.29	0.002	0.0002	0.0004	7.29	0.049
Cerebos Sundays River evaporation area	7.59	0.32	0.25	0.04	0.001	0.0001	0.0002	4.33	0.007
Tankatara Farm (Western border)	8.83	0.42	0.41	0.12	0.01	0.001	0.003	33.30	0.011
Sundays River	4.79	0.22	0.17	0.04	0.0008	0.00008	0.0002	2.90	0.005
Colchester	4.30	0.19	0.13	0.02	0.0006	0.00006	0.0001	2.01	0.004
Tankatara Farm (centre)	5.66	0.25	0.24	0.05	0.001	0.0001	0.0002	4.72	0.007
Addo Elephant Park	4.78	0.21	0.13	0.04	0.002	0.0002	0.0003	6.34	0.004

1: 99th percentile of 24-hour concentration
2: 99th percentile of 1-hour concentration

Table 5-22: Annual average modelled concentrations at receptor areas used in chronic human health risk assessment

Pollutant	PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)		Benzene (µg/m³)	NO_2 (µg/m³)	Mn (µg/m³)	
Scenario	**Standard**	**Mitigation**	**Standard**	**Mitigation**	**Standard**	**Standard**	**Standard**	**Mitigation**
North end	0.04	0.002	0.003	0.0005	0.00004	0.01	0.001	0.0002
Ibhayi	0.06	0.005	0.01	0.001	0.0001	0.03	0.004	0.001
Bluewater Bay	0.20	0.01	0.03	0.004	0.0002	0.05	0.011	0.002
Wells Estate	0.45	0.03	0.05	0.008	0.0004	0.09	0.021	0.003
Brenton Island	0.24	0.02	0.03	0.005	0.0004	0.10	0.013	0.002
Jahleel Island	0.71	0.05	0.16	0.02	0.0006	0.16	0.066	0.007
St Croix Island	0.26	0.02	0.03	0.005	0.0004	0.12	0.013	0.002
Cerebos - Swartkops evaporation area	0.17	0.01	0.02	0.003	0.0002	0.05	0.007	0.001
Motherwell	0.31	0.03	0.06	0.01	0.0005	0.14	0.024	0.004
Cerebos - Coega evaporation area (centre of site)	2.93	0.31	0.71	0.12	0.0099	2.65	0.298	0.052
Cerebos - Coega evaporation area (Northern boundary)	17.40	2.81	4.75	1.04	0.011	3.04	1.979	0.432
Cerebos PVD salt plant	2.43	0.17	0.26	0.05	0.0021	0.56	0.107	0.019
Cerebos Sundays River evaporation area	0.69	0.04	0.03	0.009	0.0013	0.33	0.014	0.004
Tankatara Farm (Western border)	0.74	0.08	0.08	0.05	0.0123	3.30	0.035	0.022
Sundays River	0.44	0.02	0.02	0.005	0.0006	0.17	0.009	0.002
Colchester	0.37	0.02	0.02	0.003	0.0004	0.11	0.006	0.001
Tankatara Farm (centre)	0.44	0.03	0.03	0.008	0.0014	0.37	0.012	0.004
Addo Elephant Park	0.33	0.02	0.02	0.007	0.0011	0.31	0.008	0.003

5.7.6 Health risk summary at sensitive receptors

The potential health risks are summarised in Table 5-23 according to the defined assessment criteria.

Table 5-23: Health impacts at sensitive receptor areas

Impact description	Status	Extent	Duration	Reversibility	Irreplace-able	Intensity/ Magnitude	Probability	Significance (standard mitigation)	Mitigation	Significance (full mitigation)	Confidence level
Increase in respiratory effects due to increased exposure to dust and other pollutants during construction	Negative	Local	Short	Reversible	N/A	Low	Probable	Low	Refer to Table 5-24	Very low	Med
Neurological symptoms from exposure to Mn dust in the neighbouring environment	Negative	Local	Long	Irreversible when affected	N/A	Low	Probable	Medium to high within the industrial area and low in the neighbouring environment	Refer to Table 5-24	Low to medium within the industrial area and low in the neighbouring environment	High
Respiratory symptoms from exposure to PM_{10} concentrations exceeding ambient standards	Negative	Regional	Long	Reversible	N/A	Low	Probable	Low		Low	High
Respiratory symptoms from exposure to ambient $PM_{2.5}$	Negative	Regional	Long	Reversible	N/A	Low	Probable	Low		Low	High

Impact description	Status	Extent	Duration	Reversibility	Irreplaceable	Intensity/ Magnitude	Probability	Significance (standard mitigation)	Mitigation	Significance (full mitigation)	Confidence level
concentrations exceeding ambient standards											
Respiratory symptoms from exposure to ambient NO_x concentrations exceeding ambient standards	Negative	Local	Long	Reversible	N/A	Low	Probable	Low	No mitigation	Low	High
Neurological symptoms from exposure to ambient BTEX concentrations exceeding ambient standards	Negative	Local	Long	Reversible	N/A	Low	Improbable	Very low	No mitigation	Very low	High
Cumulative impacts of dust, PM_{10}, $PM_{2.5}$, NO_x and BTEX	Negative	Regional	Long	Reversible to Irreversible	N/A	Low	Probable	Low	No mitigation	Low	Med

5.7.7 Effects of manganese on ruminants

A literature search on the database "ScienceDirect" with the key words ruminants or livestock or wild life and manganese, delivered more than a thousand articles per set of key words. However, these articles were not on inhalation toxicity, but focussed on trace metals in the diet of these animals and the subsequent effects deficiencies of trace metals may have on the animals. The focus was generally on reproductive performance and meat quality.

Short and medium-term studies on the inhalation of manganese are restricted to controlled experimental studies involving animals such as rats, mice and monkeys, while chronic (long-term) inhalation studies of manganese are based on exposure in humans (mainly in the working environment) (CDC, 2012).

Results of the animal studies showed that in rats the lowest levels at which effects could be detected, were 43 mg/m^3 (of MnO_2) for respiratory effects (inflammation of the lung) and 0.01 mg/m^3 (of $MnSO_4$) for neurological effects and 0.05 mg/m^3 (of $MnSO_4$) for reproductive effects (CDC, 2012). In monkeys, cardiovascular effects and effects on the blood and nervous system (neurological) were found at 1.5 mg/m^3 (of $MnSO_4$) (CDC, 2012). Effects on the blood were found in pigeons exposed to 0.17 mg/m^3 (of Mn_3O_4) (CDC, 2012).

5.8 MITIGATION AND MONITORING

The proposed ore handling and storage approaches at the Manganese Ore Export Facility are described in Section 5.3 including the proposed dust control measures. The dust control measures are summarised here, with comment on the efficacy of these measures at controlling dust and limiting the resultant impact in the surrounding environment.

Construction

Dust entrained by vehicles and equipment on the construction site depends mostly on the amount of dust on the surface, the size and speed of the vehicles and the moisture content of the surface. Dust entrained from exposed areas by the wind depends largely on the surface moisture content. Diesel emissions from construction vehicles depend largely on the fuel quality, the engine technology, driving practices and the service history of the vehicle.

Sound on-site management practices on the construction site can reduce dust entrainment significantly. These include traffic management, such as vehicle speed, and surface wetting. Traffic management and routine vehicle servicing can reduce exhaust emissions from the construction fleet. Detail input for the management of dust and other pollutants is included in Table 5-24.

Tippler

Little or no dust is expected to be blown from the ore wagons as any fine material will have been displaced in transit. Similarly, no dust will result from falling through the wagons as they are closed bins. Dust will however be generated when the wagons are tipped. The amount of dust that is generated and emitted to the atmosphere depends on the dust control measures at the tippler and the moisture content of the ore.

The proposed dust control measures at the tippler are consistent with accepted best practice methods. The tippler will be fully enclosed in a sheeted building. The building will have open gable walls on the entry and exit sides. The partition walls will have an aperture the size of the Transnet Freight Rail “moving structure gauge.” Dust will be suppressed within the tippler building including a high pressure water fog system at the tippler hopper vibrating feeder chutes.

The dispersion modelling has shown that the design of the tippler and the proposed dust suppression measures are effective at controlling dust. The control of dust is however not only dependent on the design and technologies, but is also dependant on optimum operations and management at the facility. It is therefore critically important that operators are appropriately trained and are aware of the dust control requirements; that Standard Operating Procedures (SOPs) for the tippler consider the control of dust and that the dust suppression is implemented according to the design specifications. Detail input for the management of dust and other pollutants is included in Table 5-24.

Stockyard

Dust may be generated during stacking and reclaiming ore as well as by wind entraining dust from the stockpiles and the stockyard in general. The amount of dust that is generated and emitted to the atmosphere from the stockyard and the related activities depends on the dust control measures that are employed and the effectiveness of these measures.

The stockyard has been shown to be the largest potential source of dust from the Manganese Ore Export Facility. The proposed dust control measures in the stockyard include the location in a relatively low lying area to reduce the effects of wind and the use of cannons to spray water or chemical suppressant to damp down the stockpile surface. Additional dust control measures should include automation of the cannon spray system and the investigation into the added effectiveness of a berm or fixed porous wind barriers.

The stackers will spray water onto the manganese ore as it falls onto the stockpile. The control system will be designed to limit the free fall of manganese ore from the end of the stacker onto the stockpile to a maximum drop of 1.5m, as the primary dust mitigation action. The stacker transfer will incorporate a dynamic chute which reduces noise, ore degradation and dust generation. The reclaimers will be equipped with water sprays onto the reclaimed Mn ore at the bucket wheel and onto the receiving conveyor at the point of contact. They will also incorporate a dynamic chute. These control measures compare favourably with dust abatement practices described in dust management plans elsewhere in the world (e.g. Fortescue Metal Group, 2009; OPT, 2010).

It is not feasible or practical to cover the entire stockyard. It is however critically important that operators are appropriately trained and are aware of the dust control requirement and that Standard Operating Procedures (SOPs) in the stockyard and for stacking and reclaiming consider the control of dust. Detail input for the management of dust and other pollutants is included in Table 5-24.

Conveyor system

Dust can result from wind blowing across the loaded ore conveyors. The overland conveyor system will however be covered to reduce windblown dust being emitted from the conveyor. The tippler reclaim conveyors run in a tunnel. The stockpile conveyors all run at ground level except for a short section at the feed and discharge ends. As such, these conveyors are partially shielded by the stockpiles and run roughly parallel to the prevailing wind direction. The elevated sections will be equipped with wind boards to limit windborne dust generation. The transfer points and surge bins will be enclosed and equipped with atomising sprays.

The conveyor system meets best design principles with respect to dust control and the dispersion modelling has shown that the proposed dust control measures on the conveyor system are effective in controlling dust. The control of dust is however not only dependent on the design and technologies, but is also dependant on their optimum operations and management. It is therefore critically important that operators are appropriately trained and are aware of the dust control requirement; that Standard Operating Procedures (SOPs) for the conveyor and transfer points consider the control of dust and that all equipment is operated and maintained according to the design specifications. Detail input for the management of dust and other pollutants is included in Table 5-24.

Ship loader

Dust may be generated during ship loading, both from the loaders and from dust escaping from the ship holds as a result of air displacement. The amount of dust that is generated and emitted to the atmosphere depends on the dust control measures that are employed and on the loading activity.

The ship-loader meets best design principles with respect to dust control and the dispersion modelling has shown that the proposed dust control measures adequately control dust. It is critically important however that operators are appropriately trained and are aware of the dust control requirement; that Standard Operating Procedures (SOPs) for the ship-loader consider the control of dust and that all equipment is operated and maintained according to the design specifications. Detail input for the management of dust and other pollutants is included in Table 5-24.

Spill management

Ore spillages and the accumulation of ore dust may occur at conveyor transfer points. These points of accumulation may be sources of windblown dust. Similarly, the accumulation of ore dust on roads and open areas may be a source of dust by wind entrainment and vehicle movement.

These can result in significant dust entrainment from the Manganese Ore Export Facility in general and a spillage management programme is proposed with wetting of unpaved roads and sweeping of paved roads. Such programs can be very effective in reducing the dust generated at such sites if they are appropriately designed and implemented. Standard Operating Procedures (SOPs) for spill management and site maintenance are required. Detail input for the management of dust and other pollutants is included in Table 5-24.

Compilation yard and transport of Mn ore from the compilation yard to the tippler

Little or no dust is expected to be blown from the ore wagons as any fine material will have been displaced in transit. Similarly, no dust will result from falling through the wagons as they are closed bins. It is therefore unnecessary to cover the wagons en route and in the compilation yard.

Upset conditions

The standard mitigation scenario refers to dust control measures such as the enclosed tippler and conveyor, while the full mitigation scenario refers to additional dust control measures using water or chemical suppressant. A situation of drought or water rationing could therefore restrict the effectiveness of the full mitigation scenario depending on the availability of water in the retention pond. The main source of concern is a situation with no water for dust control on the stockpiles (Tables 5-18 and 5-19) where the intensity of the impact is medium/low for the standard mitigation and low with the addition of water or chemical suppressant. In the case of water restriction, the recommended management action is to only supress dust on the stockpiles using only chemical suppressant. Chemical suppressant is more effective that water alone and less water is required. In a severe drought with no available water in the retention pond, the appropriate management action is to cease operations at the Manganese Ore Export Facility when the wind speed exceeds a predetermined threshold at which dust is visibly entrained.

Table 5-24: Air quality mitigation/management action summary table, includes mitigation in design, operations and site management

Aspect	Impact	Recommended Mitigation/Management actions
Construction	Increased dust and other pollutants during construction	Where possible, loading and unloading bulk construction should be in areas protected from the wind and if possible, should be avoided in strong wind conditions Limit access to construction site to construction vehicles only Impose vehicle speed restrictions on the construction site Maintain high moisture content on exposed surface and roads by spraying with water Maintenance programme for construction vehicles to ensure optimum performance reduced emissions
Tippler	Dust deposition and ambient PM_{10} and $PM_{2.5}$ concentrations in the neighbouring environment	Fully enclose the tippler Open gable walls on the entry and exit sides. The partition walls will have an aperture the size of the Transnet Freight Rail “moving structure gauge.” Install high pressure water fog system at hopper feeder chutes
		Operate and maintain high pressure water fog system at hopper feeder chutes Train tippler operators with respect to dust management and enhance awareness
Stockyard	Dust deposition and ambient PM_{10} and $PM_{2.5}$ concentrations in the neighbouring environment	Install automated water cannons at the stockpiles Equip stackers with water sprayers and dynamic chute Equip reclaimers with water sprayers and dynamic chute Investigate the effectiveness of porous wind barriers to further reduce dust emission from stockpiles
		Maintain stockpile moisture content to avoid dust generation using chemical surfactant Ensure maximum stacker drop height of 1.5 m Operate and maintain spraying during stacking

Aspect	Impact	Recommended Mitigation/Management actions
		• Operate and maintain spraying during reclaiming • Train operators with respect to minimising dust and increase awareness regarding dust • Implement traffic control measures on the stockyard and limit access
Conveyor system	Dust deposition and ambient PM_{10} and $PM_{2.5}$ concentrations in the neighbouring environment	• Cover overland conveyor • Install wind board on stockyard conveyor • Enclose transfer points • Enclose surge bins • Install water sprayers at transfer points and surge bins
		• Operate and maintain sprayer at transfer points and surge bins
Ship-loader	Dust deposition and ambient PM_{10} and $PM_{2.5}$ concentrations in the neighbouring environment	• Equip ship-loader with loading spouts
		• Ensure ore is as wet as possible • Minimise drop heights
Ore spill management	Dust deposition and ambient PM_{10} and $PM_{2.5}$ concentrations in the neighbouring environment	• Design and implement spill management programme to effectively and effectively clean spilt ore • Implement programme to vacuum spilt ore on paved surfaces and to avoid ore and dust accumulation • Implement wetting programme for unpaved roads and open areas • Vegetate open unused areas with suitable ground cover

5.9 REFERENCES

Alberta Environment (AE) (2004). Review of Approaches for Setting an Objective for Mixtures in Ambient Air [Online] Available: http://www.environment.gov.ab.ca/info/posting.asp?assetid=8051&categoryid=1 (accessed 18 July 2011).

ATSDR (1997).. Public health statement for fluorides, hydrogen fluoride and fluorine. ATSDR CD Rom issue 97-2.

Briggs D, Corvalan C and Nurminen M. (1996). Linkage methods for environmental health analysis: general guidelines. World Health Organization, Geneva.

Brock-Neely W. (1994). Introduction to Chemical Exposure and Risk Assessment. Lewis Publishers.

Cal-EPA (2008). [Online] Available:

http://www.oehha.org/air/hot_spots/2008/AppendixD1_final.pdf#page=170

C&M Consulting Engineering (2011). Nelson Mandela Bay Municipality (NMBM) Air Quality Management Plan, Progress Report Number 321/09 PR.5, Final Report January 2011.

CCINFO. (1998). The Canadian Centre for Occupational Health and Safety database at http://ccinfoweb.ccohs.ca

Centre for Disease Control (CDC) 2008 [Online] Available: http://www.atsdr.cdc.gov/mrls/index.html, (accessed September 2010).

CDC Centre for Disease Control. (2012). Manganese. [Online] Available:

http://www.atsdr.cdc.gov/toxprofiles/tp151-c3.pdf (accessed January 2013)

CSIR (2012). Scoping and Environmental Impact Assessment for the proposed Manganese Export Facility and Associated Infrastructure in the Coega Industrial Development Zone, Port of Ngqura and Tankatara area: DRAFT SCOPING REPORT. CSIR Report Number: CSIR/CAS/EMS/ER/2012/0013/B

DEA, (2009). National Ambient Air Quality Standards, Government Gazette, 32861, Vol. 1210, 24 December 2009.

DEA, (2010). Listed Activities and Associated Minimum Emission Standards indentified in terms of Section 21 of the Air Quality Act, Act No. 39 of 2004, Government Gazette, 33064.

DEA, (2011). Guideline to air dispersion modelling for South Africa air quality regulations, Version 1.0.

EAE, (2006). Encyclopaedia of the Atmospheric Environment, 2006, Nitrogen [Online], http://www.ace.mmu.ac.uk/eae/Air_Quality/Older/Nitrogen_Dioxide.html

Government of Alberta (2011): http://environment.gov.ab.ca/info/library/5726.pdf,1 Jun 2012.

Graham, J.D., 1993. The legacy of one in a million, in Risk in Perspective, Vol. 1, No. 1, Harvard Centre for Risk Analysis in March 1993.

Hurley, P. (2000). Verification of TAPM meteorological predictions in the Melbourne region for a winter and summer month. Australian Meteorological Magazine, 49, 97-107.

Hurley, P.J., Blockley, A. and Rayner, K. (2001). Verification of a prognostic meteorological and air pollution model for year-long predictions in the Kwinana industrial region of Western Australia. Atmospheric Environment, 35(10), 1871-1880.

Hurley, P.J., Physick, W.L. and Ashok, K.L. (2002). The Air Pollution Model (TAPM) Version 2, Part 21: summary of some verification studies, CSIRO Atmospheric Research Technical Paper No. 57, 46 p.

Institute of Environmental Health (IEH-UK). (2007). Overview of Research into the Health

Effects of Manganese (2002-2007). [Online] Available: http://www.silsoe.cranfield.ac.uk/ieh/

Integrated Risk Information System (IRIS) (EPA) (2006): [Online] Available:

http://cfpub.epa.gov/iris/quickview.cfm?substance_nmbr=0276 (September 2010)

Kelly R E (1994). "The myth of 10^{-6} as a definition of acceptable risk." EPA Watch, Vol. 3 No. 17. . [Online] Available http://www.heartland.org/custom/semod_policybot/pdf/17603.pdf, (Accessed 18 July 2011)

Lemly AD. (1996). Evaluation of the Hazard Quotient Method for Risk Assessment of Selenium. *Ecotoxicology and Environmental Safety* **35**, 156–162 (

National Pollutant Inventory (NPI),(2001). Emission Estimation Technique Manual for Mining.

Version 2.3.

National Pollutant Inventory (NPI), (1999a). Emissions Estimation Technique Manual for Aggregated emissions from Railways, Version 1.0, November 1999, Environment Australia.

National Pollutant Inventory (NPI), (1999b). Emission Estimation Technique Manual for Railway Yard Operations, Version 2.0, June 2008, Australian Government - Department of the Environment, Water, Heritage and the Arts.

National Research Council (NRC) (1994). *Science and Judgment in Risk Assessment*. National Academic Press.

NERDDC (1988), Air Pollution from Surface Coal Mining: Volume 2 Emission Factors and Model Refinement, National Energy Research and Demonstration Council, Project 921.

Occupational Safety and Health Association (OSHA) (2000). [Online] available

http://www,osha-slc.gov/FedReg_osha_data/FED19960124.html (21 June 2003).

Roels *et al* 1992. British Journal of Industrial Medicine 49:25-34

South African Weather Services (SAWS), (1992). Climate of South Africa - Climate Statistics up to 1992, WB42.

South African Weather Service (SAWS), (1998). Climate of South Africa, WB42, Climate Statistics 1961-1990, South African Service, Department of Environment Affairs.

Toxicology Excellence for Risk Assessment (TERA) (2000): [Online] available:

http://www.tera.org/iter/RiskMethods.html (accessed 18 July 2011)

Transnet, (2012). Scoping and impact assessment report for the proposed manganese export facility and proposed infrastructure in the Coega Industrial Development Zone, Port of Ngqura and Tankatara area, Draft Scoping Report.

US EPA (1985). Compilation of Air Pollutant Emission Factors, AP-42, Fourth Edition United States Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, 27711.

US EPA, (1995). SCREEN3 Model User's Guide. EPA-454/B-95-004.U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards Emissions, Monitoring, and Analysis Division, Research Triangle Park, North Carolina.

US EPA (1998). Compilation of Air Pollutant Emission Factors, AP-42, Fourth Edition, United States Environmental Protection Agency, Office of Air and Radiation Office of Air US EPA,(2005): Compilation of Air Pollutant Emission Factor, AP-42, Fifth Edition, Volume I: Stationery Point and Area Sources, 2005. Quality Planning and Standards, Research Triangle Park, North Carolina, 27711.

US EPA, (2006a). Compilation of air pollution emission factors, Vol. 1 – Stationary point and area sources, AP-42, 5th Ed, Chapter 13, http://www.epa.gov/ttn/chief/ap42.

US EPA (2006b).*Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, AP-42, Chapter 7.1, Organic Liquid Storage Tanks*, United States Environmental Protection Agency, Office of Air Quality Planning and Standards.

US EPA (2009c): Emissions Factors & AP 42. http://www.epa.gov/ttn/chief/ap42/index.html. Visited 1 May 2009.

US-EPA (2012). Reference Concentration,

http://nlquery.epa.gov/epasearch/epasearch?querytext=rfc&fld=nceawww1&areaname=IRIS&areacontacts=http%3A%2F%2Fwww.epa.gov%2Firis%2Fcomments.htm&areasearchurl=www.epa.gov%2Firis&typeofsearch=epa&result_template=epafiles_default.xsl&filter=sample4filt.hts

U.S. EPA. (1986). *Guidelines for Carcinogen Risk Assessment*. Federal Register 51(185):33992-43003.

US EPA, (1999). User guide to Storage Tank Emissions Calculation Software, Version 4.0, http://www.epa.gov/ttnchie1/software/tanks/index.html.

WHO, (1997). Guidance for setting air quality standards. Report on a Working Group. Barcelona, Spain 12-14.

World Bank Group, (1998). Pollution Prevention and Abatement Handbook, General Environmental Conditions and Summary of Air Emissions and Effluent Discharge Requirements, July 1998.

WHO, (2000). [Online] Available: http://www.who.int/peh/air/Airqualitygd.htm

WHO (2005). WHO Air Quality Guidelines Global Update 2005.

http://www.who.int/phe/air/aqg2006execsum.pdf

5.10 APPENDICES

APPENDIX 5.A Background information on Manganese and implications for human health

APPENDIX 5.B Description of communities at risk

APPENDIX 5.A

Background information on Manganese and implications for human health

Manganese is the fifth most abundant metal in the earth's crust. However, in nature manganese does not exist in the elemental form but most commonly as manganese dioxide (MnO_2) (CDC, 2008). Manganese is an essential nutrient in the human body and acts as a catalyst in some enzyme systems, is needed in the formation of cartilage and bone and plays a role in the production of glucose as well as in the healing of wounds (CDC, 2008). Therefore, manganese is often added to natural food supplements.

The inorganic form of manganese is used in steel, glass, paint, cosmetics, dry-cell batteries, as a fertiliser and in the leather and textile industry, while the organic forms are used in fungicides and as an additive (MMT) in fuel to act as an anti-knock agent in the engine (CDC, 2008). There are thus many natural and man-made sources of manganese in the environment. In the US, concentrations in air of manganese of between 0.02 and 0.3 µg/m^3 have been measured (CDC, 2008).

The public is mostly exposed to manganese through ingestion, while dermal contact is not a recognised route of exposure and inhalation is only of concern if individuals work in an environment where there are elevated concentrations of manganese in the air or live close to a source of manganese (CDC, 2008)

Although low levels of manganese are essential for normal body functions, high levels may be toxic (CDC, 2008). Adverse health effects through inhalation, are not only limited to occupational environments, but the same effects, for example neurological effects found in an occupational environment, have also been seen in individuals from environmental exposure (CDC, 2008). Manganese, once absorbed in the body, usually accumulated in the basal ganglia region of the brain (CDC, 2008). The absorption and elimination route of manganese in the human body is influenced by the concentration of manganese in the diet (Slikker *et al.* 2004), as well as by dietary iron intake, since the two metals compete for the same binding protein in serum (Roth and Garrick, 2003). Individuals with an iron deficiency will absorb more manganese (Montes, *et al.,* 2008).

Neurological effects and manganese

Toxicity from exposure to elevated levels of manganese is known as "manganism". Manganism is a chronic neurologic disease that cannot be reversed (CDC, 2008, Haynes, 2010). The symptoms of manganism are tremors, a mask-like face and spasms of the facial muscles, speech disturbance and a difficulty in walking. Concentrations at which exposure was found to cause manganism, were in the order of about 2 mg/m^3 to 22 mg/m^3 (CDC, 2008). Before these serious symptoms develop, less serious symptoms may be experienced, such as irritability, aggressiveness, poor performance on neurobehavioral tests and poor eye-hand coordination. Concentrations of manganese in air that caused these effects in chronically exposed workers ranged from about 0.07 mg/m^3 to 0.97 mg/m^3 (CDC, 2008). Environmental exposure to elevated levels of manganese may also lead to pre-clinical symptoms including poor performance on neurobehavioral tests and increased neuropsychiatric disturbances. The individuals most affected, were those above 50 years of age and with an elevated level of manganese in the blood (CDC, 2008).

Chia *et al*., (1993) studied neurological effects of exposure to levels of manganese of 1.59 mg/m^3 (mean concentration of dust) for an average of about 36 and a half years in the workplace, and found significant differences between exposed and non-exposed groups. Visuomotor coordination and the prevalence of insomnia and perspiration were significantly higher among the exposed group

A study was undertaken amongst workers at a manganese smelter in South Africa, during which personal monitoring as well as several other neurobehavioral, clinical and biological tests had been conducted. Inhalation exposure concentrations ranged from below 0.1 mg/m^3 to 2 mg/m^3. The study was inconclusive; in the words of the author, the study did not provide any "convincing evidence for exposure effects in general, or for the notion of a continuum of effects" (Myers *et. al*. 2003).

<u>Parkinson's disease and exposure to manganese</u>.
There are similarities between the clinical symptoms of manganism and Parkinson's disease but also differences. For example those with manganism have hypokinesia (decreased body movement) and less frequent resting tremor (tremor while hands are resting) and more frequent dystonia (prolonged muscle contractions) than Parkinson's patients and those with manganism also sometimes have psychiatric disturbances early in the disease. Those with manganism also have a tendency to fall backwards when pushed, have a "cock-walk" and a failure to respond to dopaminomimetics (drug used in treatment of Parkinson's disease).

The lesion sites in the brain of Parkinson's and manganism patients are different. Parkinson's disease primarily affects the nigra (a section in the mid brain that plays a role in movement)-striatum pathway. Neurotoxicity due to manganese is associated with loss of neurons in the globus pallidus section of the brain. This area then show elevated manganese and iron levels. Iron may thus be a contributing factor in the loss of neuron cells during manganese toxicity. It is also important to note that iron deposition occurs in brain areas where there are lesions associated with diseases such as Alzheimer's and Parkinson's, especially in light of the fact that iron can generate reactive oxygen species which may eventually lead to cell death (Roth and Garrick, 2003). Individuals with an iron deficiency accumulate more manganese when exposed to the element (Montes, *et al.,* 2008, Kim, 2011).

Rama Rao *et al*., (2007) found that manganese may accumulate in astrocytes (the largest and most numerous neurological cells in the brain and spinal cord), where it then causes dose-dependent swelling. This phenomenon may play a role in swelling of the brain. They further noticed that manganese may cause oxidative stress and histopathological changes in these astrocytes. These changes resemble Alzheimer type II changes. It was also found that antioxidants could prevent astrocyte swelling, which indicates that oxidative stress is involved in the mechanism of action whereby manganese causes swelling of the astrocytes.

Normally only individuals above 50 years of age, develop Parkinson's disease. However, in about 5% to 10% of cases it may occur in people as young as in their 20s and is then called "early-onset Parkinson's" (US-NIH, 2011). Mutations of Parkin (a protein) have found to be present in as many as 37% of this early-onset Parkinson's cases. However, laboratory mice with defective Parkin did not have obvious symptoms of Parkinson's disease, indicating that defective Parkin may indirectly contribute to the development of early-onset Parkinson's by changing the amount and types of fat in people's bodies (US-NIH, 2011).

<u>Epilepsy and exposure to manganese</u>
Limited information was found on manganese exposure and epilepsy in the literature surveyed. A manganese deficiency was found in inpatients with epilepsy compared to those without epilepsy, while patients who developed epilepsy due to trauma, had higher concentrations of manganese than those without a history of trauma (Grant, 2004). A review article published in Brain Research Reviews, reported on publications between 1966 and 2006 and found only six articles related to humans on this topic. Five of these articles reported on the association between a manganese deficiency and epilepsy, while one article reported that no significant difference could be found between cases (with epilepsy) and controls (those without epilepsy) and a manganese deficiency (Gonzales-Reyes, 2007).

Respiratory effects and manganese
Inhalation exposure to high concentrations of MnO_2 (manganese ore dust) may cause inflammatory reactions in the lung. Long term inflammation of the lungs may result in a decrease in lung function and an increase in susceptibility to infections of the lungs including bronchitis and pneumonia (CDC, 2008). However, studies have found that pneumonia may develop from particulate matter containing metals other than manganese as well, thus it is possible that the pneumonia develops from exposure to inhalable particles and not from the manganese as such (CDC, 2008).

It had been proposed that the lung serves as a reservoir for manganese, from where it is transported to the blood. Some studies with manganese chloride and manganese phosphate (soluble forms of manganese) suggest another route of exposure, namely transport via the olfactory nerve directly to the brain (Fechter *et. al*. 2002).

Reproductive effects and manganese
Individuals with manganism are normally also impotent (CDC, 2008). Studies have not found any direct effects of manganese on the fertility of women, while the fertility of male workers exposed to manganese at 0.97 mg/m^3 for one to 19 years, were adversely affected although they did not have manganism (CDC, 2008).

Developmental effects and manganese
Studies on children exposed to high levels of manganese over months or years, indicated that they may develop attention deficit disorder, their memory may be affected, and they may become aggressive and/or hyperactive. However, these studies did not control for environmental or genetic factors (CDC, 2008).

General
Studies involving the inhalation of MMT are lacking (CDC, 2008). However, a study done in South Africa involved 814 children in Cape Town and Johannesburg. The concentrations of manganese in the blood of the children as well as in water, soil and classroom dust were determined. The results showed higher concentrations of manganese in classroom dust, school soil and children's blood in Johannesburg compared with Cape Town. This phenomenon was attributed to the introduction of MMT in petrol in the Johannesburg area two years prior to the study. Twelve percent of the children in Johannesburg and 4% of children in Cape Town had higher concentrations of manganese in their blood than the upper normal reference value of 14 μg/l specified by the CDC in the US (Röllin, *et al*, 2005).

Batterman *et al*., (2011) investigated the environmental exposure of manganese and lead in Durban. They monitored manganese and lead in air and in blood of school children and found manganese in air (in PM_{10}) to be about 0.05 $\mu g/m^3$ and the average in blood about 10 μg/L, with 8% of the children monitored (mainly those in the industrialised area) above the guideline of 15 μg/L. A population study over three years in Korea, showed that an iron deficiency leads to increased levels of manganese in the general population (Kim, 2011).

Two publications by Roels *et al* in the nineties, informed the benchmark values for manganese, specifically the RfC of 0.05 $\mu g/m^3$ set by the US-EPA. These publications were on follow-up occupational studies (Winder *et al*., 2010). No observed adverse effect levels (NOAEL) or Lowest observed adverse effect levels (LOAEL) are determined from observations in epidemiological and or toxicological studies. Uncertainty factors are then applied to these adverse effect levels to set a benchmark value. In addition to the approach of applying uncertainty factors to NOAELs and LOAELs, there are also the "no statistical significance of trend" (NOSTASOT) approach, the benchmark concentration analysis (BMCL) approach and the Bayesian analysis approach. When these approaches were applied to the data from the Roels studies, the applicability of the NOSTASOT method to epidemiology data was questioned, while a proposed RfC of between 0.09 and 0.10 µg/m^3 were derived using the other methods (Winder *et al.*, 2010).

In an article by Verma, *et al*, (2002) the authors describe the procedure followed to determine benchmark values, with special reference to occupational exposure limit values. They mention that these values are based on toxicological and epidemiological studies and medical surveillance in the working environment. They are of the opinion that the answer to whether a chemical may cause adverse health effects is "rarely characterised by scientific certainty". This uncertainty was illustrated in the 1980s when the WHO and the EPA had different opinions on the scientific evidence of the effects of manganese, despite the fact that the adverse effects of manganese exposure (to pyrolusite ore or MnO2) had already been demonstrated in 1837 (Verma *et al.*, 2002) Verma *et al.*, (2002) state that the specific health effect caused by a chemical is driving the limit value and control mechanisms put in place for that chemical. In this regard they believe that if a chemical is causing cancer or a neurological disease it is usually regarded as more important to control than a chemical causing respiratory irritation for example. The setting of limit values and control mechanisms are therefore a compromise between "scientific evidence of varying degree of certainty, interest group lobbying, and feasibility considerations".

References in Appendix 5.A

Batterman S, Su FC, Jia C, Naidoo RN, Robins T and Naik I. 2011. Manganese and lead in children's blood and airborne particulate matter in Durban, South Africa. *Science of the Total Environment*, **409:** 1058-1068.

CDC Centre for Disease Control. 2008. Manganese. [Online] Available: http://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=101&tid=23

CDC Centre for Disease Control. 2012. Manganese. [Online] Available: http://www.atsdr.cdc.gov/toxprofiles/tp151-c3.pdf

Chia SE, Foo SC, Gan SL, Jeyaratnam J, Tian CS. 1993. Neurobehavioral functions among workers exposed to manganese ore. *Scand J Work Environ Health*, **19**(4): 264-270.

Fechter LD, Johnson DL and Lynch RA. 2002. The relationship of Particle Size to Olfactory Nerve Uptake of a Non-Soluble Form of Manganese into the Brain. *NeuroToxicology*, **23** (2): 177-183.

Fortescue Metal Group. 2009: Ppilbara iron ore and infrastructure project Chichester operations, Dust environmental management plan, 23 October 2009, CB-PL-EN-0009, http://reports.fmgl.com.au/CCWMS/2/L.%20Chichester%20Operations%20Dust%20Environmental%20Management%20Plan.pdf.

Gonzales-Reyes RE, Gutierres-Alvarez AM and Moreno CB. 2007. Manganese and Epilepsy: A Systematic Review of the Literature. *Brain Research Reviews*, **53**: 332-336.

Grant ECG. 2004. Epilepsy and manganese. *The Lancet*, **363**: 572.

Haynes EN, Heckel P, Ryan P, Roda S, Leung Y, Sebastian K and Succop P. 2010. Environmental Manganese Exposure in Residents Living near a Ferromanganese Refinery in Southeast Ohio: A Pilot study. *NeuroToxicology*, **31**: 468-474.

Kim Y and Lee BK. 2011. Iron Deficiency Increases Blood Manganese Level in the Korean General Population According to KNHANES 2008. *NeuroToxicology*, **32**: 247-254.

Myers JE, Thompson ML, Ramushu S, Young T, Jeebhay MF, London L, Esswein E, Renton K, Spies A, Boulle A, Naik I, Iregren A, Rees DJ. 2003. The Nervous System Effects of Occupational Exposure on Workers in a South African Manganese Smelter. *NeuroToxicology*, **24** (6): 885-94.

Montes S, Riojas-Rodriquez H, Sabido-Pedraza E and Rios C. 2008. Biomarkers of manganese exposure in a population living close to a mine and mineral processing plant in Mexico. *Environmental Research*, **106** (1): 89 -95.

OPT. 2010: Okajee Port and Rail, Terrestrial Port DRAFT Operations Environmental Management Plan Air Quality & Dust Management, Doc No : 301012-01054-1200-EN-PLN-0016,Http://www.opandr.com/images/PER/Appendices/APP%20N_Draft%20EMPs/Operation%20EMP%20PORT%20Air%20Quality.pdf.

Rama Rao KV, Reddy PVB, Hazell AS and Norenberg, MD. 2007. Manganese induces swelling in cultured astrocytes. *NeuroToxicology,* **28**(4): 807-812

Röllin, H., Mathee, A., Levin, J., Theodorou, P. and Wewers, F. 2005.
Blood Manganese concentrations among first-grade school children in South African cities. *Environmental Research* 91(1): 93-99.

Roth, J.A. and Garrick, M.D., 2003.
Iron interactions and other biological reactions mediating the physiological and toxic actions of manganese. *Biochemical Pharmacology*. 66(1):1-13.

Slikker, W (jnr), Andersen, M.E., Bogdanffy, M.S., Bus, J.S., Cohen, S.D., Conolly, R.B., David, R.M., Doerrer, N.G., Dorman, D.C., Gaylor, D.W., Hattis, D., Rogers, J.M., Woodrow-Setzer, R., Swenberg, J.A. and Wallace, K. 2004. Dose-dependent transitions in mechanisms of toxicity: case studies. *Toxicology and Applied Pharmacology,* **201**(3): 203-25…..

US NIH United States National Institute of Health. [Online] Available: http://www.nih.gov/news/health/aug2011/nhlbi-25.htm (accessed August 2011).

Verma DK, Purdham JT and Roels HA. 2002. Translating Evidence about Occupational Conditions into Strategies for Prevention. *Occup Environ Med*, **59**: 205–214

Winder BS, Salmon AG and Marty MA. 2010. Inhalation of an Essential Metal: Development of Reference Exposure Levels for Manganese. *Regulatory Toxicology and Pharmacology***,** **57**: 195-199.

APPENDIX 5.B

Description of communities at risk

Background

In any development the protection of not only the workers, but also the public from ill health is of importance. Air pollution created by the proposed facility is a major concern, not only to the health of the workers but also to the public. Although there are no residential areas within the Coega Industrial Zone, some surrounding residential areas outside the IDZ may be affected by pollutants created at the facility, depending on the wind direction. The wind direction in the area tends to follow the coast line and could therefore blow from a west or south-westerly direction or from an east or north-easterly direction. The existing residential area west of the facility may therefore be affected.

From experience of similar studies done, it can be stated that where manganese dust is known to be emitted, the public is concerned about diseases associated with exposure to manganese, such as manganism. The risks to potential health effects may be increased if there are other sources in the area emitting the same pollutants.

Communities of concern

The Nelson Mandela Metropolitan Municipality (NMMM) had a population of 1.15 million in 2011. More rapid growth in total PCE has taken place in the NMMM since 2008/09, with an average annual growth rate of 27.6% in Nelson Mandela Bay Metro (DHB, 2010-11).

The biggest contribution to the economy in the NMMM is from community, social and personal services (27.3%) followed by manufacturing (25.8%) and trade and accommodation (16.3%). Communities in the NMMM range from relatively affluent to highly deprived. The deprivation index of the area was 1.55 in 2007, which was the lowest (best) in the Eastern Cape. Deprivation is influenced by factors such as unemployment rate and access to goods and services.

Public health challenges include:

The NMMM has the following public health challenges (IDP, 12-13):
(a) Non-existence of a single health authority, with three gazetted sub-district areas.
(b) Environmental challenges and climate change.
(c) Illegal dumping

Environmental health focus areas include:

- Compliance to water quality and availability and protection of water sources.
- Promoting environmental health and hygiene awareness and education campaigns.
- Monitoring food safety and hygiene.
- Monitoring waste management, waste disposal and general hygiene, and advocating for sanitary practices.
- Ensure the Control and monitoring of vectors and stray animals
- Monitoring of environmental pollution, including air pollution and noise
- Monitoring and ensuring the control of the disposal of the dead.
- Monitoring and ensuring adherence to all health standards during traditional circumcision practices.
- Monitoring and control of communicable diseases and those related to environmental health.

Education levels

When individuals are better qualified they are at a lower risk of being unemployed and may be able to cope better also with environmental pollution. In 2007, 40.1% of South Africans 20 years and older had at least some form of secondary education, while only 9.1% had a tertiary education (SAHR, 2008). The 2010 General Household Survey indicated that the percentage of persons with a tertiary qualification increased from 9.2% in 2002 to 11.2% in 2010 (StatsSA, 2011). The percentage of persons with no formal education decreased significantly from 10.8% (2002) to 7% (2010). In 2010, 7% of the population 20 years and older in South Africa had no schooling

Socio-economic status

Employment status and types of employment

When people are employed they can cope better under stress as they have the means to provide for themselves (StatsSA, 2007).

Data from Statistics South Africa show a decrease in unemployment of 4% between 2001 and 2007 in South Africa.. There has been an increase in the unemployment rate in South Africa since 2009 when it was 23.6% to the current (2011) 25.0% (SAHR, 2011).

Housing: access and conditions

In order to have “healthy housing” it is assumed that the following elements are adequately addressed: shelter, water supply, sanitation, solid waste, wastewater, overcrowding, indoor air pollution, food safety, vectors of disease, as well as aspects related to transport, and shopping facilities (WHO 1997). The lack of any of these factors may result in inadequate housing, marked by among others, overcrowding, home accidents, home fires and stress. Such conditions become fertile breeding grounds for many health ailments including communicable diseases (such as TB), stress and related mental disorders, burns, and poisonings. In 2010, 25% of households in SA lived in dwellings that could be classified as informal (StatsSA, 2011).

The percentage of households living in formal and informal dwellings in the NMMM, according to Census 2001 and CS 2007 were (StatsSA, 2007):

Formal	increased from 75% (Census 2001) to 85% (StatsSA, 2007)
Informal	decreased from 23% (Census 2001) to 14% (StatsSA,2007)

The percentage of households living in informal dwellings in the NMMM was higher than the provincial average of 8% (13.7%) (StatsSA, 2007).

Health outcomes related to inadequate housing conditions

Overcrowding, which is a common occurrence in communities of poor socioeconomic status, is often associated with emotional problems, social tension and irritability (DH, 2008). In addition, accidents and fires in the home are particularly common in young children and older persons in low income households (DH, 2008). Accidents may include fatal falls, burns, scalds and swallowing of hazardous objects or substances such as paraffin (DH, 2008). Fires which may result from burning candles and stoves, are often accidental, and may result in smoke inhalation potentially leading to asphyxiation and death if no help is available (DH, 2008).

Comparative mortality ratios for all cause mortality showed that Nelson Mandela Bay had the highest all cause mortality rate at 2.11 which is almost 1.5 times the mortality experienced in Cape Town after standardising for age (DHB, 2010-11). Non-communicable diseases as well as injury mortality were also the highest in Nelson Mandela Bay (1.14 and 1.25 respectively relative to Cape Town).

South African children evidently have a higher prevalence of respiratory diseases than the global average. Between 2000 and 2008, 64.8% of children in South Africa below the age of 5 years were taken to a health care facility for acute respiratory illness (ARI) (WHO, 2010).

Although TB may be declining globally (WHO, 2010), South Africa has the highest incidence (new cases) and prevalence (existing cases) as well as the highest mortality rate per capita of TB in the world (Cooke, 2009). Compared to the global incidence of TB of 140/100 000 people in 2008, the incidence for South Africa increased from 580 to 960/100 000 between 2000 and 2008 (WHO, 2010). During the same time period, the prevalence of TB in South Africa increased from 470 to 610/100 000, compared to a global prevalence of 170/100 000 in 2008 (WHO, 2010). These figures are of concern when considering that Millennium Development Goal (MDG) number 6 aims to combat HIV/AIDS, malaria and other diseases. Another concern is the increase in multi-drug resistant and extremely drug resistant TB (Cooke, 2009). In addition, in 2007, 64% of TB patients in South Africa also tested positive for HIV (WHO, 2009).

In 2010 there were 4689 new cases of TB identified in the NMMM and there were 1156 TB cases per 100 000 of the population. Seventeen percent of women who visited ante natal clinics in the municipality in 2010, tested positive for HIV. About 3% of children under the age of 5 years in the municipality had severe malnutrition in 2010 (DHB, 2010-11).

Waste infrastructure and management
The percentage of households that had refuse removed by the local authority did not change much between 2001 and 2008 (90% vs 88%), and was much higher than that of the Eastern Cape (39 vs 40%) (StatsSA, 2007).

Water and sanitation infrastructure and management
The percentage of households in the NMMM having access to piped water inside the dwelling (Census 2001 vs CS 2007) was 47% in 2001 and increased 71% in 2007, in comparison to the provincial levels that increased from 18%-30% during the same period (StatsSA, 2007).

The percentage of households that did not have access to a toilet decreased from 4-2% in NMMM, in comparison to the provincial levels that decreased from 31% - 24% (StatsSA, 2007).

Water- and sanitation-related health outcomes

Water
Between 2000 and 2008, 63% of children in South Africa below the age of 5 years were taken to a health care facility for oral rehydration treatment for diarrhoea. The global median for this indicator is 47% (WHO, 2010). It thus seems as if South African children have a higher prevalence of diarrhoea than the global average. Although many factors may influence the prevalence of diarrhoeal diseases, the quality of water that the children are exposed to, also plays a role. Infectious diseases may be reduced through measures such as infection control, but these measures often rely on basic standards of hygiene, including the provision of safe drinking water. Twelve percent of children below 5 years of age in South Africa died from diarrhoeal diseases in 2008 (DoH, 2011).

The drinking water quality as per the Blue Drop score for NMMM was 90.4% for 2012, which is regarded as excellent (ewisa, 2012).

Sanitation
The calculated years of life lost (YLL) due to premature death from diarrhoea (which may be regarded as an indicator of sanitation-related health impacts), were 4.2 for South Africa in 2010. The 2010/11 incidence of diarrhoea in children below 5 years of age in the.NMMM was below the South African average. The Green Drop score (an indication of water management practises) of the NMMM was 80% in 2010-11 (ewisa, 2012).

Energy
The NMMM recorded proportions of households using electricity for heating that were higher than the provincial average (75%) (StatsSA, 2007).

The percentage of households using electricity for cooking in the NMMM increased from 65% - 85% between 2001 and 2007, in comparison to the provincial levels which increased from 28% - 45% (GHS, 2007).

Immunisation

The immunisation coverage in South Africa among one-year old children has decreased between 1990 and 2008 (WHO, 2010). For diphtheria, tetanus and pertussis (DTP) this decrease was from 72% to 67% and for measles from 79 to 62%. Immunisation coverage decreased from 71% to 67% for hepatitis B between 2000 and 2008 (WHO, 2010).

The NMMM has recorded coverage above 90% for the past four years, but achieved 78.3% coverage in 2010/11. It is suggested that any well-resourced health district should show performance above the national average and therefore Nelson Mandela Bay Metro needs to investigate and address these deficiencies in order to improve its immunisation coverage (DHB, 2010-11).

References used in Appendix B

Stats SA. 2007. Community Survey. Basic Results, Municipalities.

DHB, 2010-11. District Health Barometer.

EWISA 2012. http://www.ewisa.co.za/ewisawaterworks/misc/municipalcontacts/defaultECNMBayContacts.htm