Air Quality Impact Assessment

Prepared for the Southern Waste Water Treatment Works

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Glossary

Ambient air	The air of the surrounding environment.
Baseline	The current and existing condition before any development or action.
Boundary layer	In terms of the earth's planetary boundary layer is the air layer near the ground affected by diurnal heat, moisture or momentum to or from the surface.
Concentration	When a pollutant is measured in ambient air it is referred to as the concentration of that pollutant in air. Pollutant concentrations are measured in ambient air for various reasons, i.e. to determine whether concentrations are exceeding available health risk thresholds (air quality standards); to determine how different sources of pollution contribute to ambient air concentrations in an area; to validate dispersion modelling conducted for an area; to determine how pollutant concentrations fluctuate over time in an area; and to determine the areas with the highest pollution concentrations.
Condensation	The change in the physical state of matter from a gaseous into liquid phase.
Dispersion potential	The potential a pollutant has of being transported from the source of emission by wind or upward diffusion. Dispersion potential is determined by wind velocity, wind direction, height of the mixing layer, atmospheric stability, presence of inversion layers and various other meteorological conditions.
Emission	The rate at which a pollutant is emitted from a source of pollution.
Emission Factor	A representative value, relating the quantity of a pollutant to a specific activity resulting in the release of the pollutant to atmosphere.
Evaporation	The opposite of condensation
Inversion	An increase of atmospheric temperature with an increase in height.
Meteorological	The atmospheric phenomena and weather of a region.
Mixing layer	The layer of air within which pollutants are mixed by turbulence. Mixing depth is the height of this layer from the earth's surface
Oxides of Nitrogen	Refers to NO and NO_2. The gas is produced during combustion especially at high temperatures.
Particulate matter (PM)	The collective name for fine solid or liquid particles added to the atmosphere by processes at the earth's surface and includes dust, smoke, soot, pollen and soil particles. Particulate matter is classified as a criteria pollutant, thus national air quality standards have been developed in order to protect the public from exposure to the inhalable fractions. PM can be principally characterised as discrete particles spanning several orders of magnitude in size, with inhalable particles falling into the following general size fractions: * PM10 (generally defined as all particles equal to and less than 10 microns in aerodynamic diameter; particles larger than this are not generally deposited in the lung); * PM2.5, also known as fine fraction particles (generally defined as those particles with an aerodynamic diameter of 2.5 microns or less) ;

- PM10-2.5, also known as coarse fraction particles (generally defined as those particles with an aerodynamic diameter greater than 2.5 microns, but equal to or less than a nominal 10 microns); and
- Ultra fine particles generally defined as those less than 0.1 microns.

Precipitation	Ice particles or water droplets large enough to fall at least 100 m below the cloud base before evaporating.
Relative Humidity	The vapour content of the air as a percentage of the vapour content needed to saturate air at the same temperature
Wastewater treatment plant	An industrial structure designed to remove biological or chemical waste products from water, thereby permitting treated water to be used for other purposes.

1 INTRODUCTION

Royal HaskoningDHV was appointed by AECOM to conduct an Air Quality Impact Assessment for the proposed upgrades at the Southern Waste Water Treatment Works (SWWTW) and Solids Removal Facility located in the Durban South Basin, Kwa-Zulu Natal (Figure 1-1). The SWWTW is located in Merewent on the eastern bank of the Umlass Canal. The SWWTW is surrounded by residential and industrial developments. The aim of the proposed upgrades is to reduce the quantity of industrial raw sludge being disposed of through the sea outfall by developing new sludge treatment infrastructure.

This study forms part of a scoping study for the site and aims to determine the potential air quality impacts associated with the proposed upgrades. As part of the scoping report, a baseline assessment was undertaken which included a review of the prevailing meteorological conditions and the baseline air quality situation in the area, Meteorological data was obtained from the South African Weather Services for the period Jan 2009 - Dec 2013. Ambient air quality monitoring data was obtained from the EThekwini Metropolitan Municipality which commissioned 10 monitoring stations in 2009 within the Durban South Basin as part of their air quality monitoring programme and management plan. Priority pollutants such as sulphur dioxide, nitrogen dioxide and particulate matter are assessed at these monitoring stations.

During the Impact Assessment phase, the potential odourous impacts from the proposed project on the surrounding environment will be evaluated through the compilation of an emissions inventory and subsequent dispersion modelling simulations using the AERMOD dispersion model. Passive monitoring will also be undertaken during this phase in order to compare the results to monitored data.

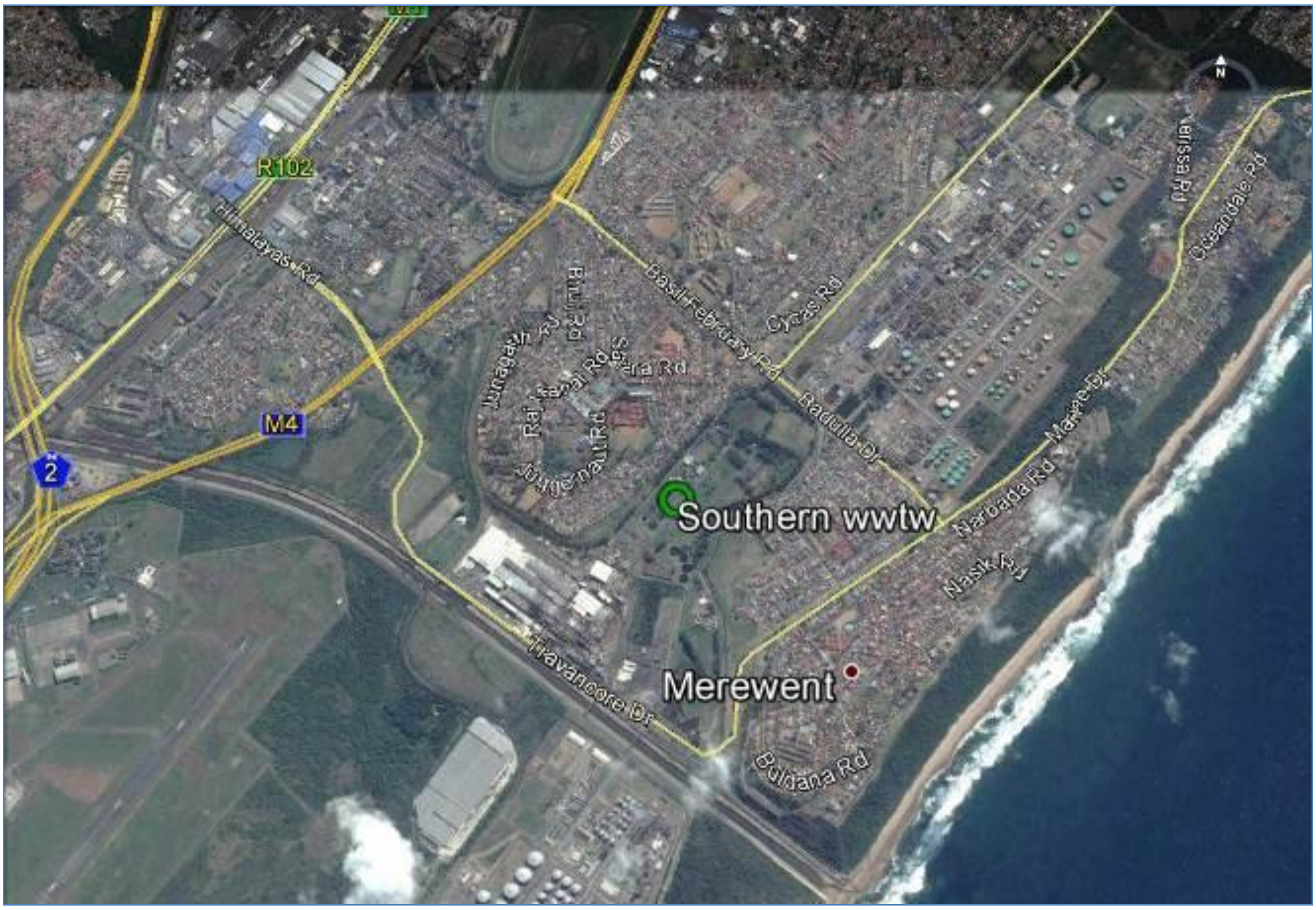


Figure 1-1: Location of the Southern Waste Water Treatment Works

1.1 Process Description

The Southern Waste Water Treatment Works receives the majority of its raw sewage effluent through three large (1500 mm diameter) trunk sewers, i.e. the Main Southern Trunk Sewer (referred to as the Jacobs Trunk Sewer), the Wentworth Valley Trunk Sewer and the Umlaas Trunk Sewer. Other smaller diameter pipelines coming to this Works includes those from Mondi and SAPREF (each separately discharging at the inlet of this Works) and Illovo (discharging closer to the outlet of this Works). The total average daily flow to this works is in the region of 130 Mega (million) litres per day and all the treated flows leaving this works is discharged directly to sea (by gravity and by pumping) through a 1500 mm diameter, 4,2 km long sea outfall.

The Umlaas Trunk Sewer which serves the areas of Chatsworth and Umlazi discharges effluent to this Works is predominantly domestic in origin. The discharged flow [currently in the region of 35 Mega (million) litres per day] is immediately directed to a separate treatment facility where it undergoes preliminary, primary, secondary and tertiary treatment. The secondary and tertiary treatment processes are managed by a private entity (Veolia Water) who stores and sells the tertiary treated (or reclaimed) effluent to industry. All sludge generated from the treatment of this effluent is discharged to sea.

The Jacobs Trunk Sewer which serves the residential areas of Yellow Wood Park and Woodlands and the industrial areas of Jacobs and Mobeni, discharges sewage effluent that is a combination of domestic and industrial in origin. The Wentworth Valley Trunk Sewer which serves the areas of the Bluff, Wentworth, Clairwood, Bayhead and Island View discharges sewage effluent that is also a combination of domestic and industrial in origin. The flows conveyed by these two trunk sewers [currently in the region of 95 Mega (million) litres per day] combine at the main inlet works and undergo preliminary treatment only (i.e. removal of screenings and grit) before being discharged to sea.

In addition to the pipeline discharge of sewage effluent to this works, smaller volumes of effluent are also discharged by various road tankers. The effluent discharged by these road tankers also undergoes preliminary treatment before being discharged to sea.

1.2 Terms of Reference

The terms of reference for the Air Quality Impact Assessment for the proposed project can be summarised as follows:

- **Baseline Assessment**
    - Provide an overview of the prevailing meteorological conditions in the area;
    - Review applicable legislation and policies related to air quality management which are applicable to the treatment works;
    - Review potential health effects associated with emissions released from the proposed upgrades;
    - Identification of existing sources of emission and sensitive receptors, such as local communities, surrounding the treatment works;
    - Assess the baseline air quality using available ambient air quality monitored data.

- **Impact Assessment**
    - Compilation of an emissions inventory for the proposed air quality sources identified on site;
    - Undertake dispersion modelling simulations using AERMOD to determine the potential air quality impacts of the proposed activities on the surrounding area;
    - Comparison of the modelled results to the National ambient air quality standards to determine compliance;
    - Provide recommendations for the implementation of appropriate mitigation measures;
    - Compilation of an Air Quality Impact Assessment Report.

1.3 Methodology

An overview of the methodological approach to be followed during the development of the Air Quality Impact Assessment is outlined in the section which follows.

1.3.1 Baseline Assessment

During the baseline assessment, a qualitative approach was used to assess the baseline conditions in the project area. Meteorological data was obtained from the South Weather Services weather station located in the Durban South Basin (Latitude: -29.9650; Longitude: 30.9460) for the period January 2009 to December 2013. Applicable air quality legislation was reviewed and criteria pollutants relevant to the project and their potential human health effects were also discussed. The existing sources of air pollution surrounding the treatment plant will be qualitatively assessed in section 3 of the report. The sensitive receptors, such as local communities in close proximity to the treatment works will be identified through satellite imagery and a site visit.

Ambient data from ten monitoring stations located in the Southern basin was obtained from the South African Air Quality Information System (SAAQIS) in order to assess the baseline air quality conditions.

1.3.2 Impact Assessment

During this phase, an emissions inventory will be compiled to estimate emissions from the identified emission sources associated with the proposed upgrades and activities on site. Dispersion modelling simulations will be undertaken using the AERMOD dispersion model and will be presented graphically as isopleth plots. Comparison with the National and international ambient air quality standards (GN263; 2009) will be made to determine compliance. Based on the predicted results, recommendations for appropriate mitigation measures will also be provided

1.3.2.1 *Overview of the Aermod Dispersion Model*

Dispersion modelling will be undertaken using the US EPA approved AERMOD Model. Aermod is based on the Gaussian plume equation and is capable of providing ground level concentration estimates of various averaging times, for a number of meteorological and emission source configuration (point, area, volume sources for gaseous and particle emissions). Input data into AERMOD includes: source and receptor data, meteorological parameters and terrain data. The meteorological data includes: wind velocity and direction, ambient temperature, mixing heights, stability class, barometric pressure, average precipitation and relative humidity.

1.3.2.2 *Overview of the WATER9 (Waste water treatment) Model*

WATER9 is a Windows based program and consists of analytical expressions for estimating air emissions of individual waste constituents in waste water collection, storage, and treatment and disposal facilities; a data base listing many of the organic compounds and procedures for obtaining reports of constituent fates, including air emissions and treatment effectiveness. WATER9 is used to estimate air emissions from site specific water treatment plants (including the prediction of biodegradation and sludge sorption or organics) for common waste water treatment units.

Once the WATER9 emission estimates have been made and the AERMOD model has been run, an output of potential impacts will be provided. The assessment of the potential air quality impacts will then be undertaken by comparing AERMOD results, with local and international standards for the pollutants identified.

1.4 Report Structure

Section 1 of the report provides the background to the project. **Section 2** includes a meteorological overview of the region. A review of applicable air quality legislation, pollutants and their potential health effects and the existing baseline air quality situation are presented in **Section 3**. **Section 4** gives a summary of the general impacts associated with the proposed upgrade at the SWWTW. **Section 5** provides a literature review of odour management.

2 BASELINE DESCRIPTION OF THE AREA

2.1 Meso-Scale Meteorology

The nature of the local climate will determine what will happen to particulates when released into the atmosphere (Tyson and Preston-Whyte, 2000). Concentration levels fluctuate daily and hourly, in response to changes in atmospheric stability and variations in mixing depth. Similarly, atmospheric circulation patterns will have an effect on the rate of transport and dispersion.

The release of atmospheric pollutants into a large volume of air results in the dilution of those pollutants. This is best achieved during conditions of free convection and when the mixing layer is deep (unstable atmospheric conditions). These conditions occur most frequently in summer during the daytime. This dilution effect can however be inhibited under stable atmospheric conditions in the boundary layer (shallow mixing layer). Most surface pollution is thus trapped under a surface inversion (Tyson and Preston-Whyte, 2000).

Inversion occurs under conditions of stability when a layer of warm air lies directly above a layer of cool air. This layer prevents a pollutant from diffusing freely upward, resulting in an increased pollutant concentration at or close to the earth’s surface. Surface inversions develop under conditions of clear, calm and dry conditions and often occur at night and during winter (Tyson and Preston-Whyte, 2000). Radiative loss during the night results in the development of a cold layer of air close to the earth’s surface. These surface inversions are however, usually destroyed as soon as the sun rises and warm the earth’s surface. With the absence of surface inversions, the pollutants are able to diffuse freely upward; this upward motion may however be prevented by the presence of an elevated inversion (Tyson and Preston-Whyte, 2000).

The climatic profile of the coastal regions of South Africa is typical of a humid subtropical climate, with hot and humid summers and warm dry winters. The coastal region is occasionally affected by tropical storms and cyclones during the cyclone season (November – April). Generally cold, dry conditions prevail during the winter, with strong winds and cold air drainage off the Drakensburg Mountains exacerbating the drying effect, particularly in the southern part of the province where the high mountains lie closer to the coast. Summer months are usually marked by strong, high pressure easterly winds.

2.1.1 Wind

Wind roses comprise of 16 spokes which represents the direction from which the winds blew during the period under review. The colours reflect the different categories of wind speeds. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories.

Based on an evaluation of the site specific meteorological data obtained from the Durban South monitoring station, Kwa-Zulu Natal, the following deductions regarding the prevailing wind direction and wind frequency can be presented. The parameters such as wind direction, wind speed, temperature, relative humidity, barometric pressure and precipitation.

Based on the available meteorological data (Figure 2-1), winds occur predominantly from the north-north-east (13% of the time), south-west (10% of the time) and south-south-west (10% of the time).

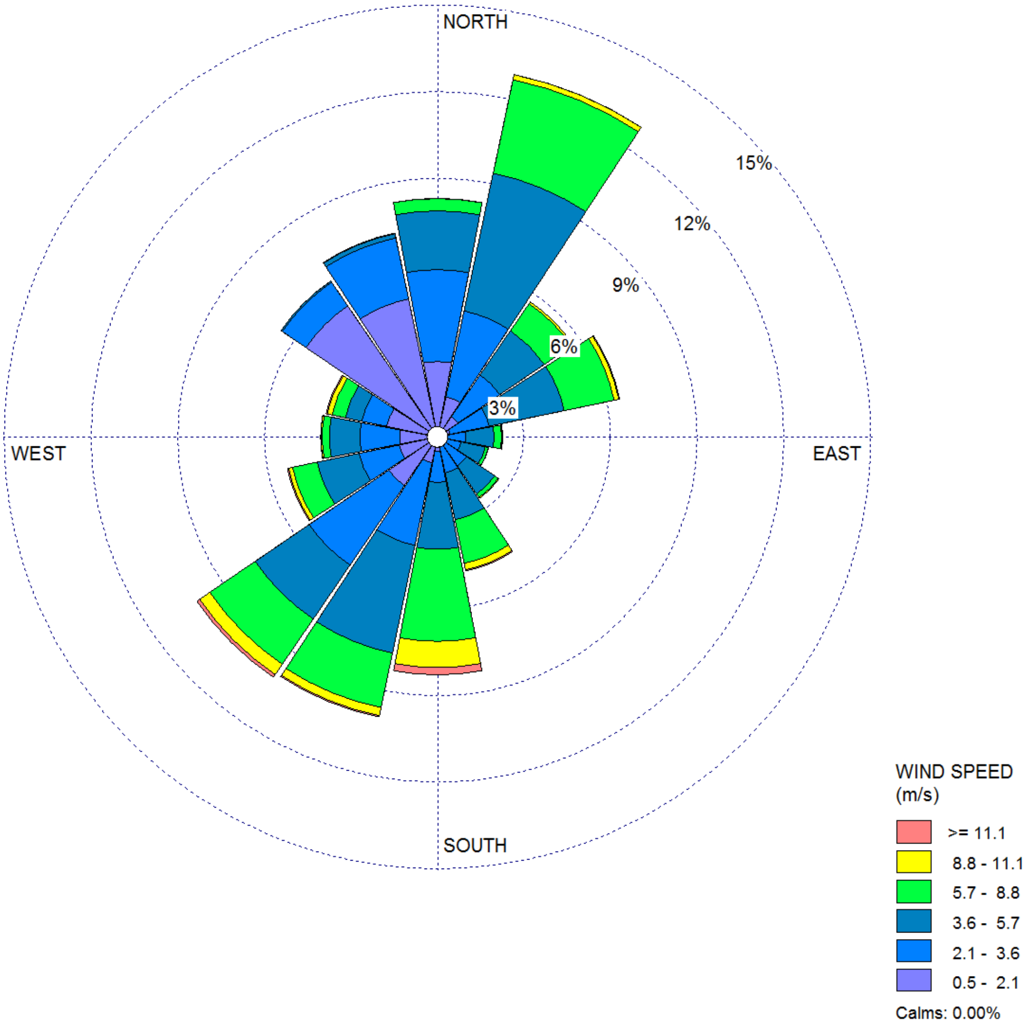


Figure 2-1: Period Wind Rose for the period Jan 2009 – Dec 2013

Figure 2-7 below illustrates the wind class frequency distribution for the period Jan 2009 – Dec 2013. 27.8% of the total wind speeds experienced fell within the 3.6 - 5.7 m/s wind class, while 26.7 % of the total wind speeds fell within the 2.1 – 3.6 m/s wind class. The site is characteristic of moderate to low winds.

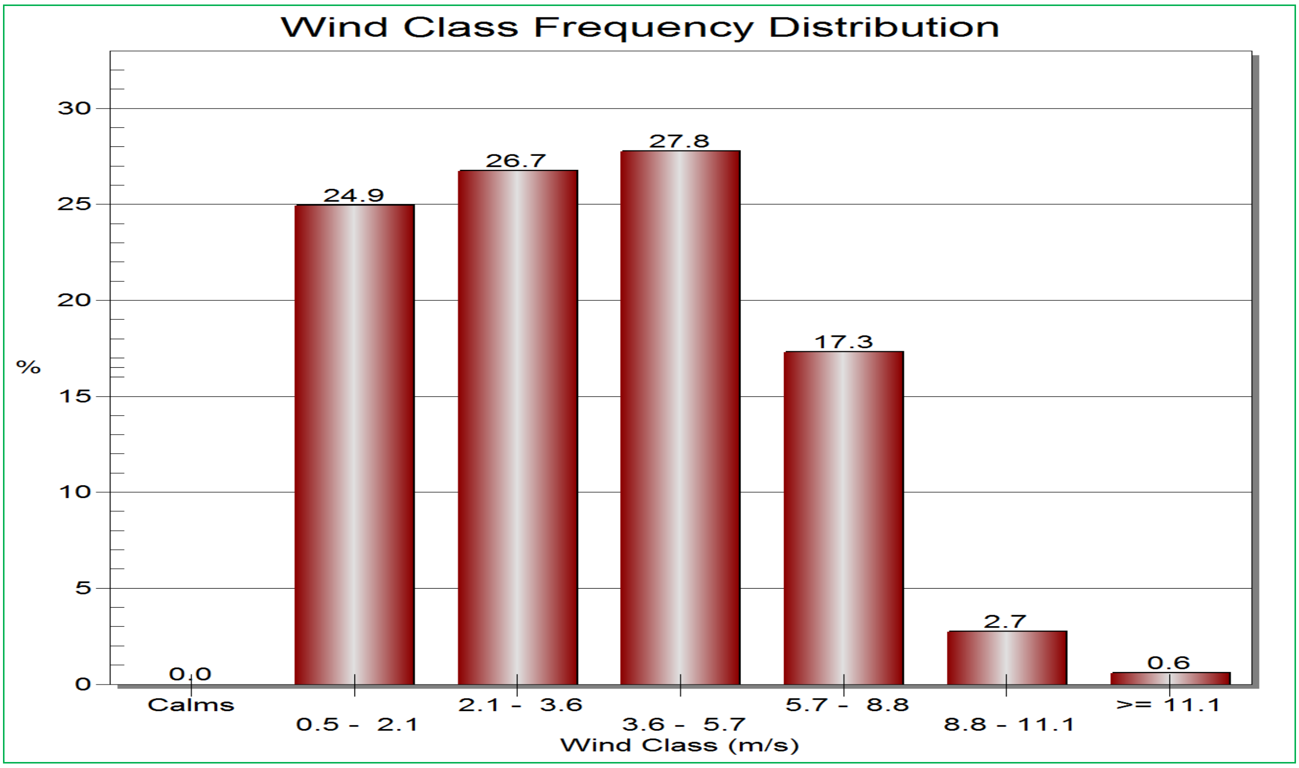


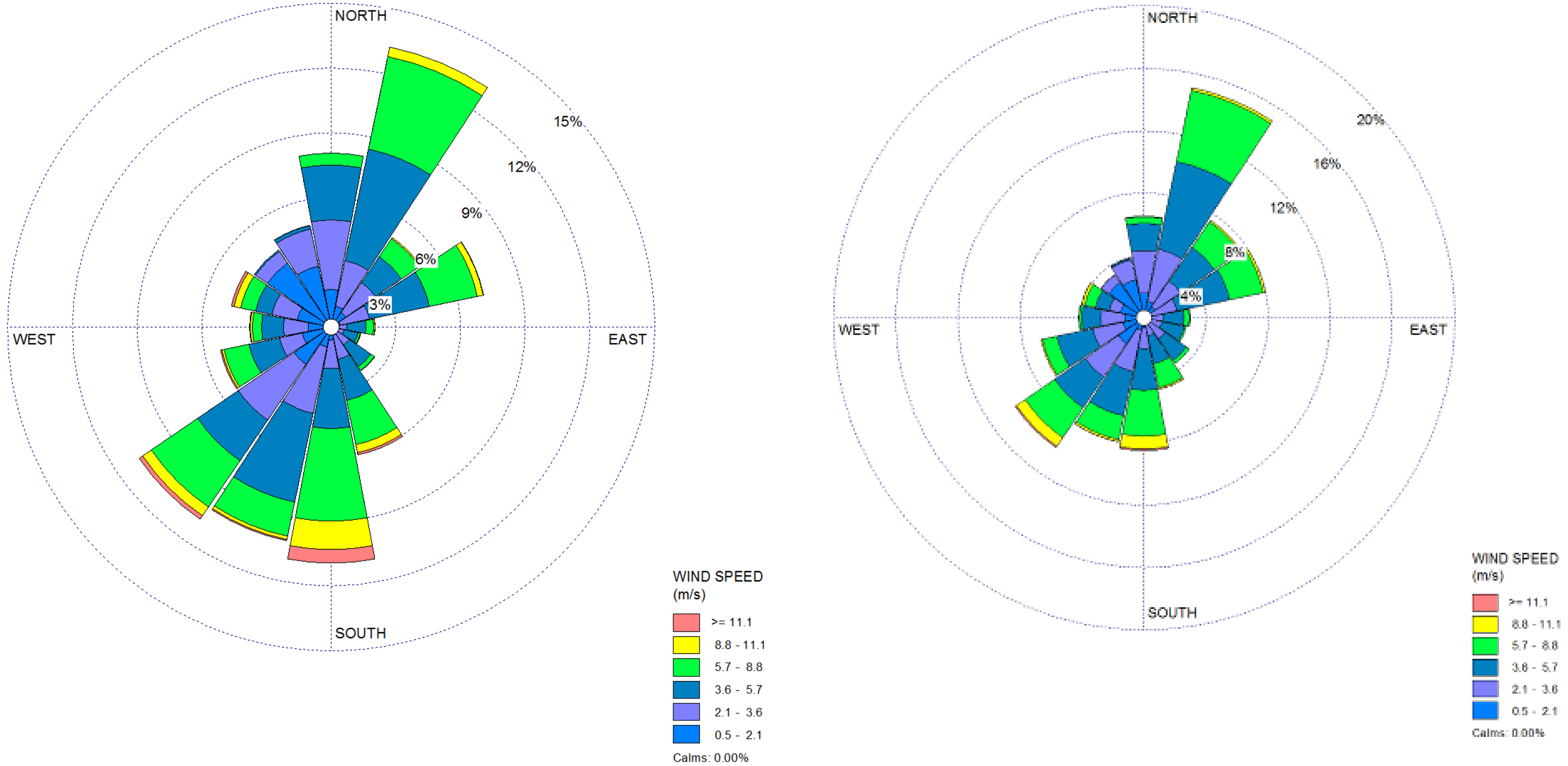
Figure 2-2: Wind class frequency distribution.

Seasonal variability in the wind field at the SWWTW is shown in Figure 2-3 and Figure 2-4 below. The spring months (September, October and November) experienced a predominant wind direction from the north east and south west region. The spring months were characteristic of moderate to slow wind condition of 3.6 -5.7 m/s which occurred 30% of the time. High winds occurred 21.7% of the time with a wind speed class of 5.7 – 8.8 m/s.

The summer months (December, January and February) experienced a predominant wind direction from the north east and south west region. Secondary winds were observed mainly from the south. High wind speeds of 8.8 – 11.1 m/s were experienced for 26% of the time. Majority of the wind speeds were low calm conditions of 3.6 – 5.7 m/s which was experienced for 32.3 % of the time.

The autumn (March, April and May) and winter (June, July and August) months experienced a similar wind profile which was characteristic of low and stable wind conditions. The predominant wind direction experienced at the site was mainly from the north, north west, south and south west regions.

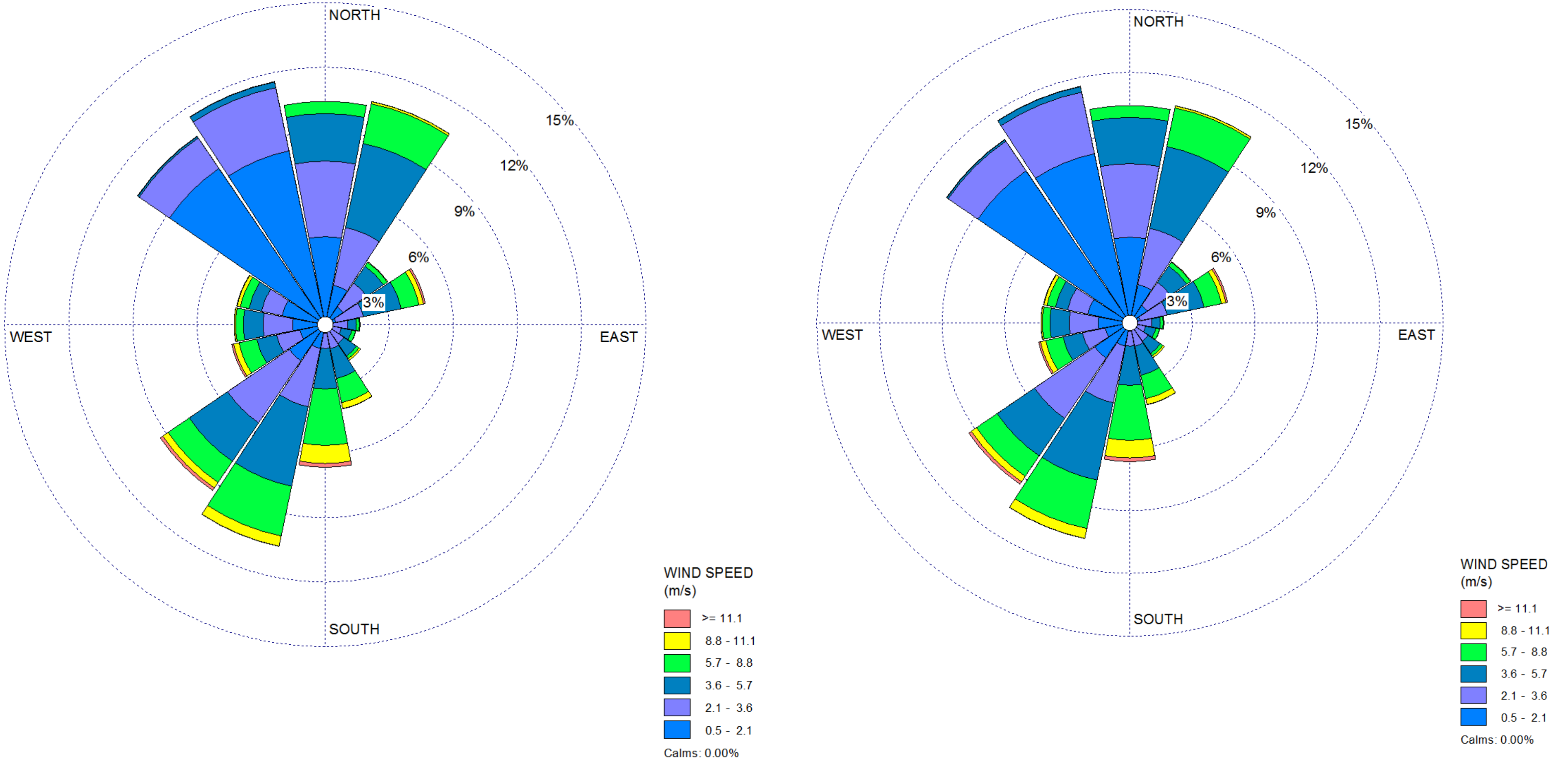
The diurnal trends in the wind field for the proposed project is presented in Figure 2-5 and Figure 2-6 below. Between the 00:00 - 12:00 morning hours, the winds originate predominately from the north west and south west direction with secondary winds originating from the western region. A shift in the wind profile is seen during the afternoon (12:00 – 18:00) and evening (18:00 – 00:00) conditions with a predominant wind direction originating from the north east and south region with secondary winds seen from the south east region.



Spring

Summer

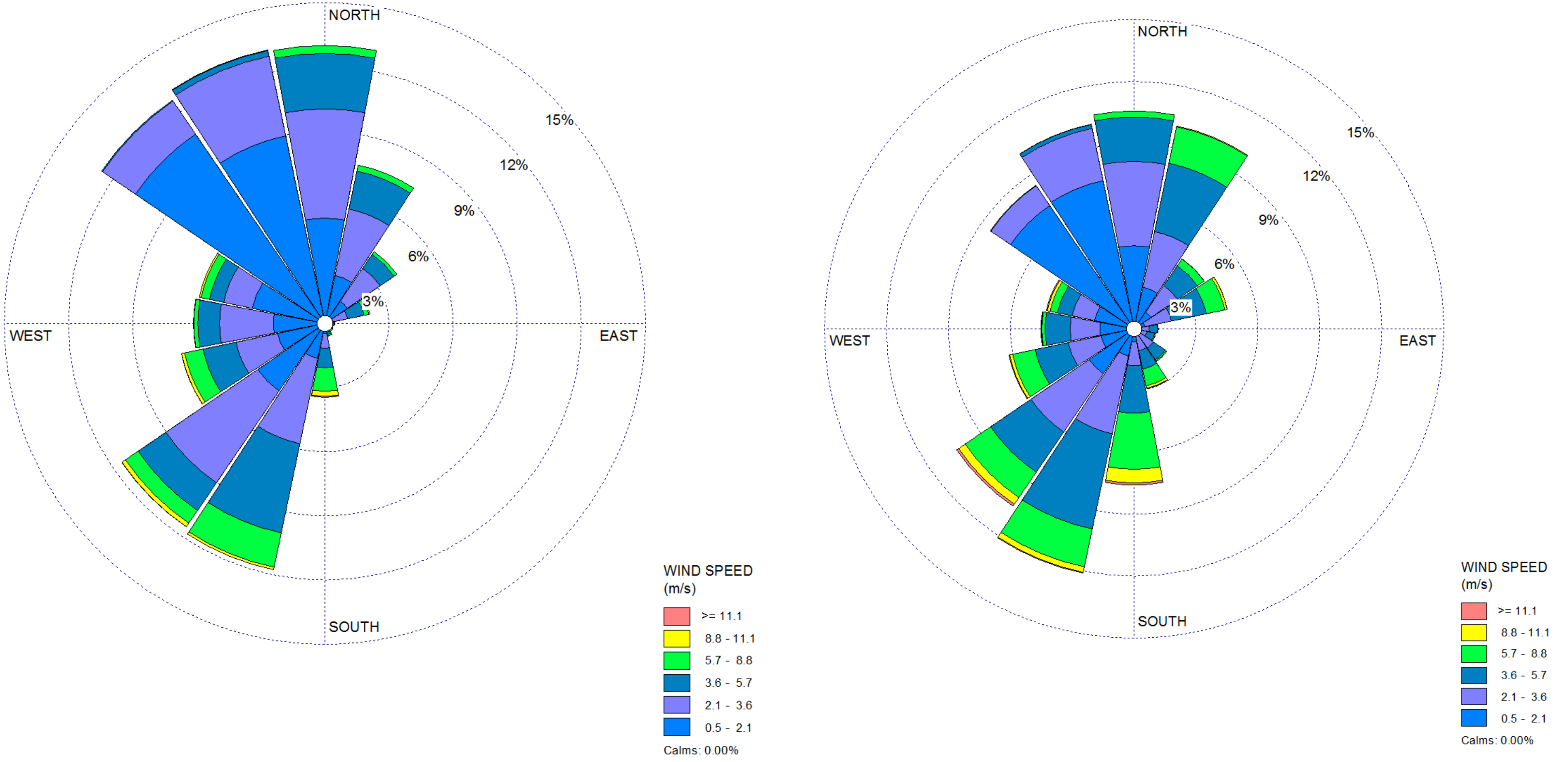
Figure 2-3: Seasonal wind rose (Spring and summer) for the Jan 2009 – Dec 2013 monitoring period.



Autumn

Winter

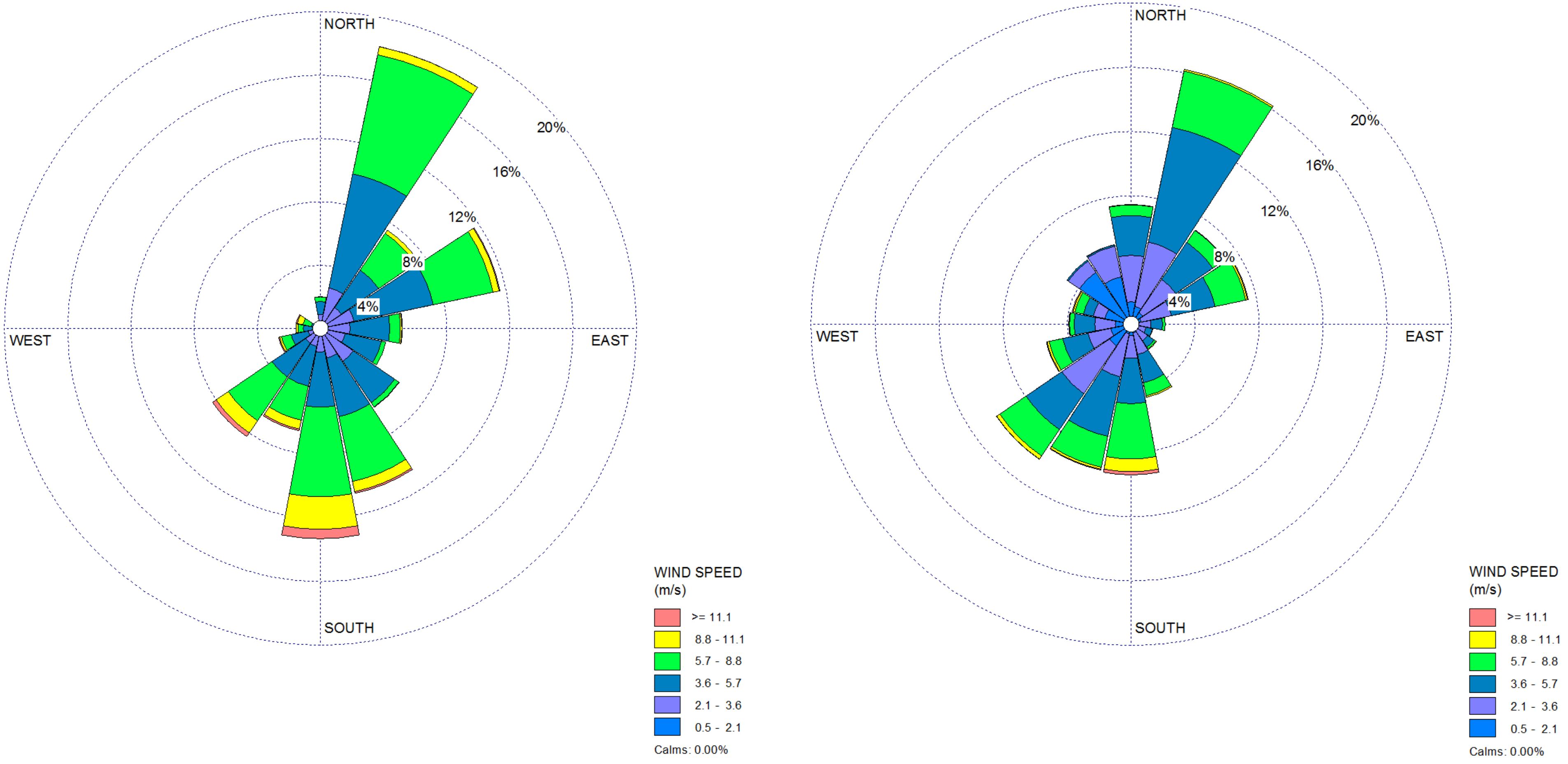
Figure 2-4: Seasonal wind roses (Autumn and winter) for the Jan 2009 – Dec 2013 monitoring period.



00:00 – 06:00

06:00 – 12:00

Figure 2-5: Diurnal wind roses (00:00 – 12:00) for the Jan 2009 – Dec 2013 monitoring period.



12:00 -18:00

18:00 -00:00

Figure 2-6: Diurnal wind roses (12:00 – 00:00) for the Jan 2009 – Dec 2013 monitoring period.

2.1.2 Atmospheric stability

Atmospheric stability is commonly categorised into one of seven stability classes. These are briefly described in Table 2-1 below. The atmospheric boundary layer is usually unstable during the day due to turbulence caused by the sun's heating effect on the earth's surface. The depth of this mixing layer depends mainly on the amount of solar radiation, increasing in size gradually from sunrise to reach a maximum at about 5-6 hours after sunrise. The degree of thermal turbulence is increased on clear warm days with light winds. During the night a stable layer, with limited vertical mixing, exists. During windy and/or cloudy conditions, the atmosphere is normally neutral. A neutral atmospheric potential neither enhances nor inhibits mechanical turbulences. An unstable atmospheric condition enhances turbulence, whereas a stable atmospheric condition inhibits mechanical turbulence.

Table 2-1: Atmospheric Stability Class

A	Very unstable	calm wind, clear skies, hot daytime conditions
B	Moderately unstable	clear skies, daytime conditions
C	Slightly Unstable	moderate wind, slightly overcast daytime conditions
D	Neutral	high winds or cloudy days and nights
E	Slightly Stable	moderate wind, slightly overcast night-time conditions
F	Moderately stable	low winds, clear skies, cold night-time conditions
G	Very stable	Calm winds, clear skies, cold clear night-time conditions

Figure 2-7 below indicates the stability class frequency distribution for the area under review. Majority of the wind class fell within class F with 23.9%, which is characteristic of moderately stable conditions with low winds, clear skies and cold night time conditions. Slightly unstable conditions were noted for 17.8% of the time which is indicative of slightly unstable climatic conditions with moderate winds and slightly overcast daytime conditions.

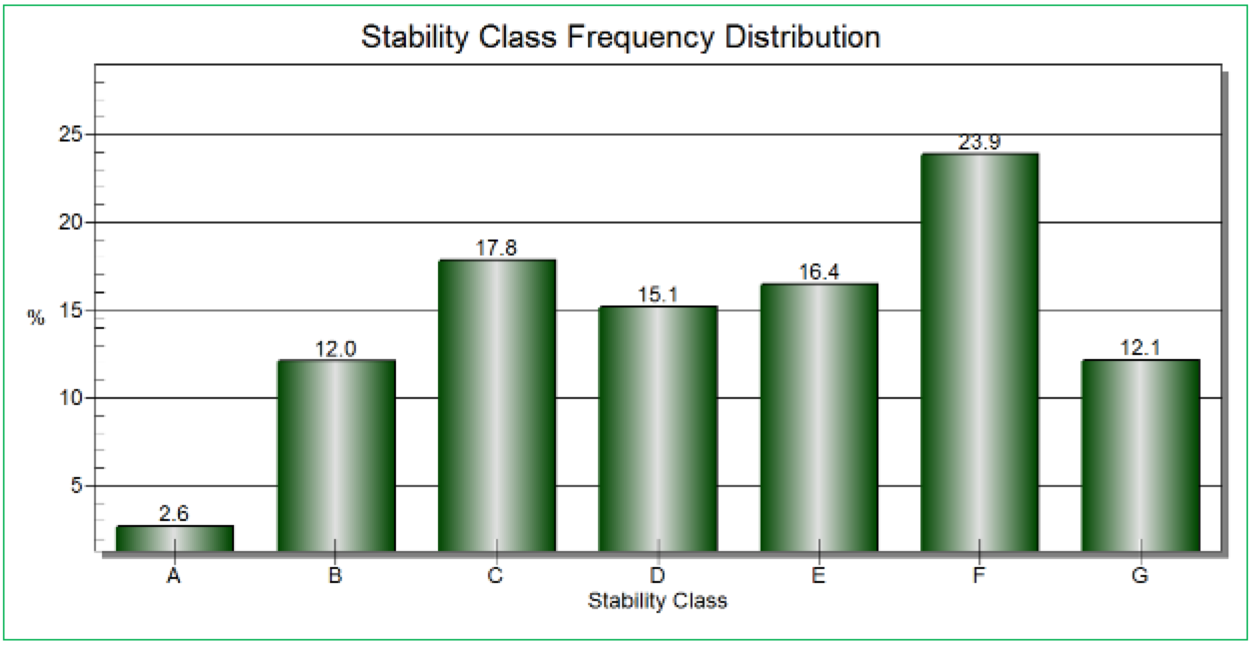


Figure 2-7: Wind Class Frequency Distribution

2.1.3 Temperature and Humidity

Temperature affects the formation, action, and interactions of pollutants in various ways (Kupchella and Hyland, 1993). Chemical reaction rates tend to increase with temperature and the warmer the air, the more water it can hold and hence the higher the humidity. Temperature also provides an indication of the rate of development and dissipation of the mixing layer as well as determining the effect of plume buoyancy; the larger the temperature difference between the plume and ambient air, the higher the plume is able to rise.

Higher plume buoyancy will result in an increased lag time between the pollutant leaving the source, and reaching the ground. This additional time will allow for greater dilution and ultimately a decrease in the pollutant concentrations when reaching ground level.

Humidity is the mass of water vapour per unit volume of natural air. When temperatures are at their highest the humidity is also high, the moisture is trapped inside the droplets of the water vapour. This makes the moisture content of the air high. When relative humidity exceeds 70%, light scattering by suspended particles begins to increase, as a function of increased water uptake by the particles (CEPA/FPAC Working Group, 1999). This results in decreased visibility due to the resultant haze. Many pollutants may also dissolve in water to form acids, as well as secondary pollutants within the atmosphere.

The average monthly temperature and relative humidity for the period Jan 2009 - Dec 2013 is presented in Figure 2-8 below with the average humidity indicated with a blue line. Daily average summer temperatures ranged between 22.5 ºC – 25.1 ºC, while the average winter temperatures ranged between 16.8 ºC – 20.0 ºC. Relative humidity for the period Jan 2009 – Dec 2013 was highest during the summer months and lowest during the winter months.

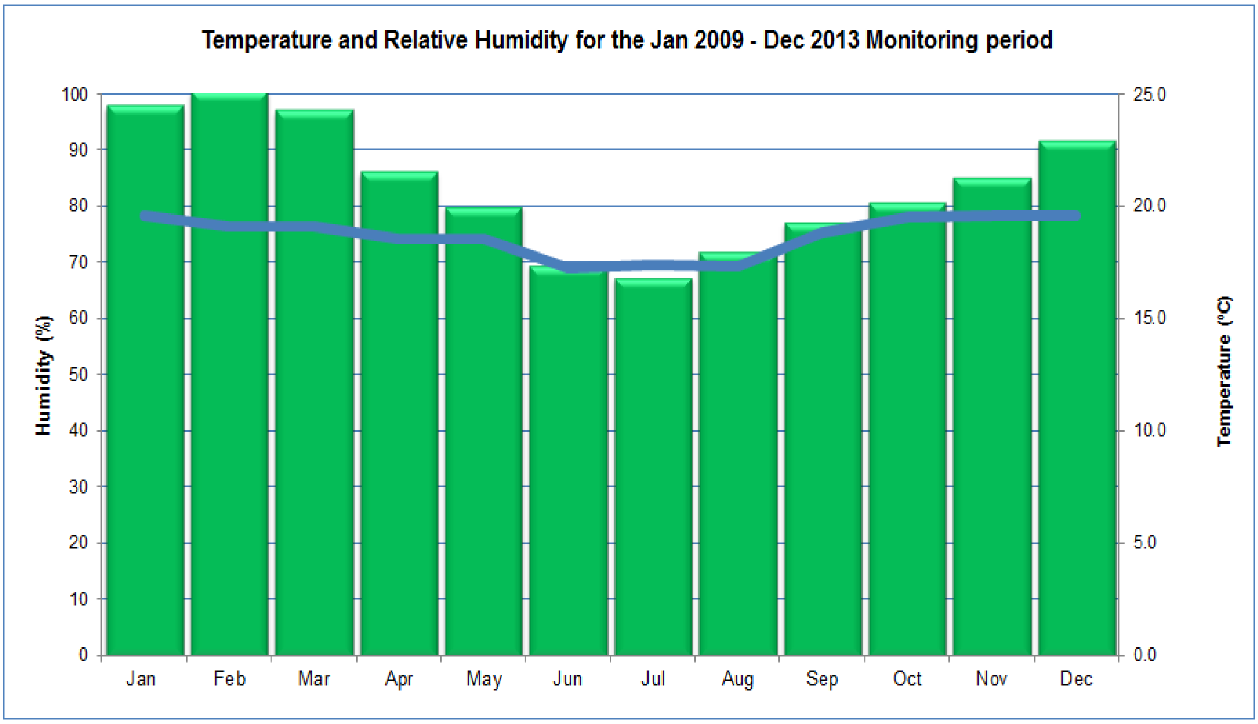


Figure 2-8: Average Temperature (°C) and Relative Humidity (%) for the period Jan 2009 – Dec 2013

2.1.4 Precipitation

Precipitation cleanses the air by washing out particles suspended in the atmosphere (Kupchella and Hyland, 1993). It is calculated that precipitation accounts for about 80-90% of the mass of particles removed from the atmosphere (CEPA/FPAC Working Group, 1999).

The total rainfall profile for the period Jan 2009 – Dec 2013 is illustrated in Figure 2-9 below. The spring and summer months recorded the highest rainfall with 242.26 mm and 250.7 6mm recorded respectively while the winter months recorded the lowest precipitation with 92.24 mm.

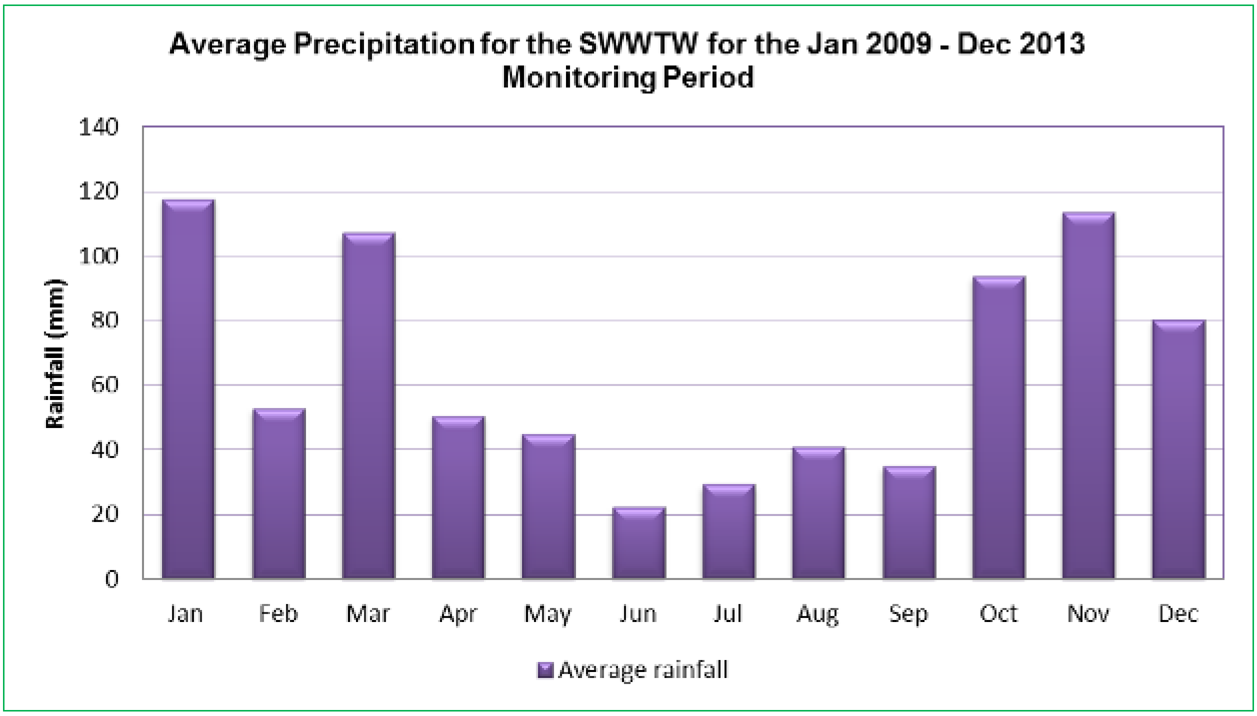


Figure 2-9: Average Precipitation (mm) for the period Jan 2009 – Dec 2013

3 APPLICABLE LEGISLATION

3.1 National Environmental Management: Air Quality Act 39 of 2004

The National Environmental Management: Air Quality Act 39 of 2004 has shifted the approach of air quality management from source-based control to receptor-based control. The main objectives of the Act are to:

- Give effect to everyone's right 'to an environment that is not harmful to their health and well-being'
- Protect the environment by providing reasonable legislative and other measures that (i) prevent pollution and ecological degradation, (ii) promote conservation and (iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development

The Act makes provision for the setting and formulation of National ambient air quality standards for 'substances or mixtures of substances which present a threat to health, well-being or the environment'. More stringent standards can be established at the provincial and local levels.

The control and management of emissions in AQA relates to the listing of activities that are sources of emission and the issuing of emission licences. Listed activities are defined as activities which 'result in atmospheric emissions and are regarded to have a significant detrimental effect on the environment, including human health'. Listed activities have been identified by the minister of the Department of Environmental Affairs and atmospheric emission standards have been established for each of these activities. These listed activities now require an atmospheric emission licence to operate. The issuing of emission licences for Listed Activities is the responsibility of the metropolitan and district municipalities.

In addition, the minister may declare any substance contributing to air pollution as a priority pollutant. Any industries or industrial sectors that emit these priority pollutants will be required to implement a Pollution Prevention Plan. Municipalities are required to 'designate an air quality officer to be responsible for co-ordinating matters pertaining to air quality management in the Municipality'. The appointed Air Quality Officer is responsible for the issuing of atmospheric emission licences.

3.2 National Ambient Air Quality Standards

Air quality guidelines and standards are fundamental to effective air quality management, providing the link between the source of atmospheric emissions and the user of that air at the downstream receptor site. The ambient air quality guideline values indicate safe daily exposure levels for the majority of the population, including the very young and the elderly, throughout an individual's lifetime. Air quality guidelines and standards are normally given for specific averaging periods. These averaging periods refer to the time-span over which the air concentration of the pollutant was monitored at a location. Generally, five averaging periods are applicable, namely an instantaneous peak, 1-hour average, 24-hour average, 1-month average, and annual average.

The Department of Environmental Affairs (DEA) has issued ambient air quality standards to support receiving environment management practices. Ambient air quality standards are only available for criteria pollutants which are commonly emitted, such as particulates, sulphur dioxide (SO_2), lead (Pb), nitrogen oxides (NO_x), benzene (C_6H_6) and carbon monoxide (CO). Local and international guidelines applicable to the project are provided in the sections below.

3.2.1 Particulate matter

Particulate matter is the collective name for fine solid or liquid particles added to the atmosphere by processes at the earth's surface. Particulate matter includes dust, smoke, soot, pollen and soil particles (Kemp, 1998). Particulate matter has been linked to a range of serious respiratory and cardiovascular health problems. The key effects associated with exposure to ambient particulate matter include: premature mortality, aggravation of respiratory and cardiovascular disease, aggravated asthma, acute respiratory symptoms, chronic bronchitis, decreased lung function, and an increased risk of myocardial infarction (USEPA, 1996).

Particulate matter represents a broad class of chemically and physically diverse substances. Particles can be described by size, formation mechanism, origin, chemical composition, atmospheric behaviour and method of measurement. The concentration of particles in the air varies across space and time, and is related to the source of the particles and the transformations that occur in the atmosphere (USEPA, 1996).

Particulate Matter can be principally characterised as discrete particles spanning several orders of magnitude in size, with inhalable particles falling into the following general size fractions (USEPA, 1996):

- PM10 (generally defined as all particles equal to and less than 10 microns in aerodynamic diameter; particles larger than this are not generally deposited in the lung);
- PM2.5, also known as fine fraction particles (generally defined as those particles with an aerodynamic diameter of 2.5 microns or less)
- PM10-2.5, also known as coarse fraction particles (generally defined as those particles with an aerodynamic diameter greater than 2.5 microns, but equal to or less than a nominal 10 microns); and
- Ultra fine particles generally defined as those less than 0.1 microns.

Fine and coarse particles are distinct in terms of the emission sources, formation processes, chemical composition, atmospheric residence times, transport distances and other parameters. Fine particles are directly emitted from combustion sources and are also formed secondarily from gaseous precursors such as sulphur dioxide, nitrogen oxides, or organic compounds. Fine particles are generally composed of sulphate, nitrate, chloride and ammonium compounds, organic and elemental carbon, and metals.

Table 3-1: Ambient air quality standards and guidelines for particulate matter.

Pollutant	Averaging period (µg/m^3)	Guideline (µg/m^3)	Number of Exceedance Allowed Per Year
PM10	Daily average	75	4 4
	Annual average	40	0 0
PM2.5	Daily average	65 (3) 40 (4) 25 (5)	4 4 4
	Annual average	25 (3) 20 (4) 15 (5)	0 0 0

3.2.2 Nitrogen dioxide

Air quality guidelines and standards issued by most other countries and organisations tend to be given exclusively for NO_2 concentrations as NO_2 is the most important species from a human health point of view. International and South African standards for NO_2 are presented in Table 3-2.

Table 3-2: ambient air quality guidelines and standards for oxides of nitrogen

Averaging Period	South Africa		WHO		EC		Australia	
	µg/m^3	ppm	µg/m^3	ppm	µg/m^3	ppm	µg/m^3	Ppm
Annual Ave	40	0.021	40	0.021	40	0.021	57	0.03
Max. 1-hr	200	0.10	200	0.10	200	0.10	240	0.12

NO_2 is an irritating gas that is absorbed into the mucous membrane of the respiratory tract. The most adverse health effect occurs at the junction of the conducting airway and the gas exchange region of the lungs. The upper airways are less affected because NO_2 is not very soluble in aqueous surfaces. Exposure to NO_2 is linked with increased susceptibility to respiratory infection, increased airway resistance in asthmatics and decreased pulmonary function.

Available data from animal toxicology experiments indicate that acute exposure to NO_2 concentrations of less than 1 880 µg/m^3 (1 ppm) rarely produces observable effects (WHO 2000). Normal healthy humans, exposed at rest or with light exercise for less than two hours to concentrations above 4 700 µg/m^3 (2.5 ppm), experience pronounced decreases in pulmonary function; generally, normal subjects are not affected by concentrations less than 1 880 µg/m^3 (1.0 ppm). One study showed that the lung function of subjects with chronic obstructive pulmonary disease is slightly affected by a 3.75-hour exposure to 560 µg/m^3 (0.3 ppm) (WHO 2000).

Asthmatics are likely to be the most sensitive subjects, although uncertainties exist in the health database. The lowest concentration causing effects on pulmonary function was reported from two laboratories that exposed mild asthmatics for 30 to 110 minutes to 565 µg/m^3 (0.3 ppm) NO_2 during intermittent exercise. However, neither of these laboratories was able to replicate these responses with a larger group of asthmatic subjects. NO_2 increases bronchial reactivity, as measured by the response of normal and asthmatic subjects following exposure to pharmacological bronchoconstrictor agents, even at levels that do not affect pulmonary function directly in the absence of a bronchoconstrictor. Some, but not all, studies show increased responsiveness to bronchoconstrictors at NO_2 levels as low as 376-565 µg/m^3 (0.2 to 0.3 ppm); in other studies, higher levels had no such effect. Because the actual mechanisms of effect are not fully defined and NO_2 studies with allergen challenges showed no effects at the lowest concentration tested (188 µg/m^3; 0.1 ppm), full evaluation of the health consequences of the increased responsiveness to bronchoconstrictors is not yet possible.

Studies with animals have clearly shown that several weeks to months of exposure to NO_2 concentrations of less than 1 880 µg/ m^3 (1ppm) causes a range of effects, primarily in the lung, but also in other organs such as the spleen and liver, and in blood. Both reversible and irreversible lung effects have been observed. Structural changes range from a change in cell type in the tracheobronchial and pulmonary regions (at a lowest reported level of 640 µg/m^3), to emphysema-like effects. Biochemical changes often reflect cellular alterations, with the lowest effective NO_2 concentrations in several studies ranging from 380-750µg/m^3. NO_2 levels of about 940 µg/m^3 (0.5ppm) also increase susceptibility to bacterial and viral infection of the lung. Children of between 5-12 years old are estimated to have a 20% increased risk for respiratory symptoms and disease for each increase of 28 µg/m^3 NO_2 (2-week average), where the weekly average concentrations are in the range of 15-128 µg/m^3 or possibly higher. However, the observed effects cannot clearly be attributed to either the repeated short-term high-level peak, or to long-term exposures in the range of the stated weekly averages (or possibly both). The results of outdoor studies consistently indicate that children with long-term ambient NO_2 exposures exhibit increased respiratory symptoms that are of longer duration, and show a decrease in lung function.

3.2.3 Sulphur dioxide

SO_2 is an irritant that is absorbed in the nose and aqueous surfaces of the upper respiratory tract, and is associated with reduced lung function and increased risk of mortality and morbidity. Adverse health effects of SO_2 include coughing, phlegm, chest discomfort and bronchitis.

Short-period exposures (less than 24 hours)

Most information on the acute effects of SO_2 comes from controlled chamber experiments on volunteers exposed to SO_2 for periods ranging from a few minutes up to one hour (WHO 2000). Acute responses occur within the first few minutes after commencement of inhalation. Further exposure does not increase effects. Effects include reductions in the mean forced expiratory volume over one second (FEV_1), increases in specific airway resistance, and symptoms such as wheezing or shortness of breath. These effects are enhanced by exercise that increases the volume of air inspired, as it allows SO_2 to penetrate further into the respiratory tract. A wide range of sensitivity has been demonstrated, both among normal subjects and among those with asthma. People with asthma are the most sensitive group in the community. Continuous exposure-response relationships, without any clearly defined threshold, are evident.

Sub-chronic exposure over a 24-hour period

Information on the effects of exposure averaged over a 24-hour period is derived mainly from epidemiological studies in which the effects of SO_2, suspended particulate matter and other associated pollutants are considered. Exacerbation of symptoms among panels of selected sensitive patients seems to arise in a consistent manner when the concentration of SO_2 exceeds 250 $\mu g/m^3$ in the presence of suspended particulate matter. Several more recent studies in Europe have involved mixed industrial and vehicular emissions now common in ambient air. At low levels of exposure (mean annual levels below 50 $\mu g/m^3$; daily levels usually not exceeding 125 $\mu g/m^3$) effects on mortality (total, cardiovascular and respiratory) and on hospital emergency admissions for total respiratory causes and chronic obstructive pulmonary disease (COPD), have been consistently demonstrated. These results have been shown, in some instances, to persist when black smoke and suspended particulate matter levels were controlled for, while in others no attempts have been made to separate the pollutant effects. In these studies no obvious threshold levels for SO_2 has been identified.

Long-term exposure

Earlier assessments, using data from the coal-burning era in Europe judged the lowest-observed-adverse-effect level of SO_2 to be at an annual average of 100 $\mu g/m^3$, when present with suspended particulate matter. More recent studies related to industrial sources of SO_2, or to the changed urban mixture of air pollutants, have shown adverse effects below this level. There is, however, some difficulty in finding this value.

Based upon controlled studies with asthmatics exposed to SO_2 for short periods, the WHO (WHO 2000) recommends that a value of 500 $\mu g/m^3$ (0.175 ppm) should not be exceeded over averaging periods of 10 minutes. Because exposure to sharp peaks depends on the nature of local sources, no single factor can be applied to estimate corresponding guideline values over longer periods, such as an hour. Day-to-day changes in mortality, morbidity, or lung function related to 24-hour average concentrations of SO_2 are necessarily based on epidemiological studies, in which people are in general exposed to a mixture of pollutants; and guideline values for SO_2 have previously been linked with corresponding values for suspended particulate matter. This approach led to a previous guideline 24-hour average value of 125 $\mu g/m^3$ (0.04 ppm) for SO_2, after applying an uncertainty factor of two to the lowest-observed-adverse-effect level. In more recent studies, adverse effects with significant public health importance have been observed at much lower levels of exposure. However, there is still a large uncertainty with this and hence no concrete basis for numerical changes of the 1987-guideline values for SO_2.

Table 3-3: Ambient Air quality Standards and guidelines for Sulphur dioxide

Origin	Annual Average Maximum (µg/m^3)	24-Hour Maximum (µg/m^3)	1-Hour Maximum (µg/m^3)	<1-Hour Maximum (µg/m^3)
RSA	50	125	350	500 (10 min average)
WHO	50 10-30	125	-	500 (10 min average)
EC	20	125	350	
UK	20	125	350	266 (15 min mean)
World Bank	50	125	-	-
US-EPA	80	365	-	-
Australia	53	209	520	-

3.2.4 Volatile Organic Compounds

Volatile Organic Compounds (VOCs) are compounds that have a high vapour pressure at ordinary, room-temperature conditions. It is noted that some organic compounds have little or no known direct human health effects, while others are extremely toxic and/or carcinogenic. The USEPA has classified benzene as a Group A, known human carcinogen. Increased incidence of leukemia (cancer of the tissues that form white blood cells) has been observed in humans occupationally exposed to benzene. The USEPA has derived a range of inhalation cancer unit risk estimates for benzene. The value at the high end of the range was used in this assessment. Chronic (long-term) inhalation exposure has caused various disorders in the blood, including reduced numbers of red blood cells and aplastic anemia, in occupationally exposed humans. Reproductive effects have been reported in women exposed by inhalation to high levels of benzene, and adverse effects on the developing foetus have been observed in animal tests (USEPA, 2001).

The USEPA calculated a range of 2.2×10^{-5} to 7.8×10^{-6} as the increase in the lifetime cancer risk to an individual who is continuously exposed to 1 µg/m^3 of benzene in the air over his or her lifetime. EPA estimates that, if an individual were to continuously breathe air containing benzene at an average of 0.13 to 0.45 µg/m^3 over his or her entire lifetime, that person would have no more than a 1 in a million increased chance of developing cancer as a direct result (USEPA, 2001).

Chronic inhalation of certain levels of benzene causes disorders in the blood of humans. Benzene specifically affects bone marrow (the tissues that produce blood cells). Aplastic anemia, excessive bleeding, and damage to the immune system (by changes in blood levels of antibodies and loss of white blood cells) may develop. In animals, chronic inhalation and oral exposure to benzene produce the same effects as seen in humans. Reproductive effects have been reported for women exposed by inhalation to high levels, and adverse effects on the developing foetus have been observed in animal tests (USEPA, 2001).

Benzene is the only VOC for which a National ambient air quality standard has been established. An annual average standard of 10 µg/m^3 and 5 µg/m^3, respectively, has been established for current and future compliance (1 Jan 2015). Although standards for exposure to VOCs in non-industrial settings do not exist, a number of exposure limits have been recommended. The European Collaborative Action (ECA) Report No. 11 titled *Guidelines for Ventilation Requirements in Buildings* (CEC, 1992) lists the following Total Volatile Organic Compound (TVOC) concentration ranges as measured with a flame ionisation detector calibrated to toluene. These recommendations are based on Mølhave's toxicological work on mucous membrane irritation (Mølhave, 1990).

Comfort range: <200 µg/m^3
Multi-factoral exposure range: 200 to 3 000 µg/m^3
Discomfort range: 3 000 to 25 000 µg/m^3
Toxic range: >25 000 µg/m^3

The same European report also lists a second method based on Seifert's work (Seifert, 1990). This method established TVOC guidelines based on the ten most prevalent compounds in each of seven chemical classes. The concentrations in each of these classes should be below the maximums listed below.

Alkanes: 100 µg/m^3
Aromatic hydrocarbons: 50 µg/m^3
Terpenes: 30 µg/m^3
Halocarbons: 30 µg/m^3
Esters: 20 µg/m^3
Aldehydes and ketones (excl. formaldehyde): 20 µg/m^3
Other: 50 µg/m^3

The TVOC concentration is calculated by adding the totals from each class. Seifert gives a target TVOC concentration of 300 µg/m^3 which is the sum of the above listed target concentrations. The author also states that no individual compound concentration should exceed 50 percent of the guideline for its class or 10 percent of the TVOC guideline concentration. However, Seifert states that "…the proposed target value is not based on toxicological considerations but – to the author's best judgement."

3.2.4.1 *Health and Nuisance Evaluation Criteria*

Table 3-7 below summarises the US EPA and California guidelines for the pollutants applicable in this study.

Table 3-4: Ambient Air Quality Guidelines applicable to the study

Pollutant	Averaging period	US –EPA (µg/m^3) (µg/m^3)	California (µg/m^3)
Ammonia	Hourly average		
	Annual average	100	
Hydrogen Sulphide	30 minute average	7	
	Hourly average		10
	Daily average	150	
	Annual average		42
Acetone	Hourly average		
	Annual average		
Benzene	Hourly average	30	60
	Annual average		1300
Chloroform	Hourly average		300

	Annual average		150
Methanol	Hourly average		28000
	Annual average		4000
Phenol	Hourly average		5800
	Annual average		200
Toulene	Hourly average		37000
	Annual average	5000	300

3.2.5 Cancer Risk Assessment

Unit risk factors are applied in the calculation of carcinogenic risks. These factors are defined as the estimated probability of a person (60-70 kg) contracting cancer as a result of constant exposure to an ambient concentration of 1 µg/m^3 over a 70-year lifetime. In the generic health risk assessment undertaken as part of the current study, maximum possible exposures (24-hours a day over a 70-year lifetime) are assumed for all areas beyond the boundary of the proposed development site. Unit risk factors were obtained from the WHO (2000) and from the US-EPA IRIS database (accessed May 2005). Unit Risk Factors for compounds of interest in the current study are given in Table 3-5.

The definition of what is deemed to be an acceptable risk remains one of the most controversial aspects of risk characterization studies. An important point to be borne in mind is the crucial distinction between voluntary and involuntary risks. The risk to which a member of the public is exposed from an industrial activity is an involuntary one. In general, people are prepared to tolerate higher levels of risk for hazards to which they exposure themselves voluntarily. There appears to be a measure of uncertainty as to what level of risk would be acceptable to the public. Pollutants are often excluded from further assessment when they contribute an individual risk of less than 1 x 10^{-7}. (A carcinogenic risk of 1 x 10^{-7} corresponds to a one-in ten- million chance of an individual developing cancer during their lifetime.) The US-EPA adopts a 1 in a million chance for cancer risks (i.e. 1 x 10^{-6}), applied to a person being in contact with the chemical for 70 years, 24-hours per day. Although a risk of 10^{-7} (1 in 10 million) would be desirable, and a risk of less than 10^{-6} (1 in 1 million) acceptable in terms of US regulations, some authors (Kletz, 1976; Lees, 1980; Travis *et al*., 1987) suggest that a risk level of between 10^{-5} and 10^{-6} per year (i.e. 1:100 000 and 1: 1000 000) could still be acceptable. Further work by Travis *et al*. (1987) indicated that for small populations, risks of less than 10^{-4} (1 in 10 000) may also potentially be acceptable, whereas risks greater than 10^{-4} are likely to prompt action. Locally the Department of Environmental Affairs (DEA) has only been noted to give an indication of cancer risk acceptability in the case of dioxin and furan exposures. According to the DEA, emissions of dioxins and furans from a hazardous waste incinerator may not result in an excess cancer risk of greater than 1: 100 000 on the basis of annual average exposure (DEAT, 1994). Excess cancer risks of less than 1:100 000 appear therefore to be viewed as acceptable to the DEA.

Table 3-5: Cancer risk factors for compounds investigated at the waste water treatment works.

Compound	US EPA Cancer Risk factor
Benzene	$2.2E^{6}$ – $7.8 E^{-6}$
Chloroform	$2.3 E^{-5}$

3.2.5.1 *Odour Impact Evaluation*

Odour thresholds are defined in several ways including absolute perception thresholds, recognition thresholds and objectionability thresholds. At the perception threshold one is barely certain that an odour is detected but it is too faint to identify further. Recognition thresholds are normally given for 50% and 100% recognition by an odour panel. The acute WHO guideline values given for odourants most frequently represent odour limits rather than health risk thresholds as was indicated in Table 3-6.

Table 3-6: Odour Threshold values for odour compounds

Pollutant	Odour Recognition thresholds		Other odour thresholds	WHO
	100% Recognition	50% Recognition		
	µg/m^3	µg/m^3	µg/m^3	µg/m^3
Ammonia			500 (a)	
Hydrogen sulphide	1430	11.2	4.29 (a)	7
Acetone			1100 (a)	
Benzene			3000 (b)	
Chloroform			20000 (c)	
Methanol			2660 (b)	
Phenol			184	
Toluene			700	1000

a) South African guideline (personnel communication, M Lloyd, 8/10/98).

b) Odour threshold concentration (Verschueren, 1996).

c) Absolute perception threshold (Verschueren, 1996).

- **Evaluation Odour Impact Accessibility**

Due to the absence of detailed local guidance, reference was made to the international literature in identifying a suitable method to use in assessing the potential acceptability of odour impacts associated with the waste water treatment works. Reference was primarily made to approaches adopted in the US and in Australia due to the availability of literature on the approaches adopted in these countries.

There are two main steps in odour assessment, viz.: (i) calculation of odour units based on predicted or measured ground level air pollution concentrations, and (ii) evaluation of odour unit acceptability based on defined odour performance criteria. The manners in which these steps are carried out are discussed in subsequent subsections and a method recommended for adoption in the current study.

- **Odour unit calculation**

The detectability of an odour is a sensory property that refers to the theoretical minimum concentration that produces an olfactory response or sensation. This point is called the odour thresholds and defines one odour unit per cubic metre (OU/m^3). I.e. The odour unit is the concentration of a substance divided by the odour threshold for that substance or the number of dilutions required for the sample to reach the threshold. This threshold is typically the numerical value equivalent to when 50% of a testing panel correctly detect an odour.

Therefore, an odour criterion of less than 1 OU/m³ would theoretically result in no odour impact being experienced.

Different states in the US and Australia apply varying methodologies in the calculation of odour units and also differ in their selection of suitable detection limits. Examples of such differences include the following:

- ➢ *Averaging periods* - the New South Wales (NSW) EPA (2001b) and Victoria EPA recommend the use of 3-minute average air pollution concentrations in OU calculation, whereas the Draft Queensland EPA (1999) guideline refers to 1-hour averages.
- ➢ *Percentiles* - the NSW EPA (2001b) specify the use of the 99.9th percentile when selecting 3-minute averaging air pollutant concentrations to be used in OU calculation given a "level 3"[1] assessment. The Queensland and Victoria EPAs both recommend that the 99.5th percentile be used.
- ➢ *Detection Limits (Refer to detection by human olfactory system)* - the NSW EPA includes odour detection levels in a Technical Note as the basis for the calculation of odour units. These detection levels were found to be very low in certain instances representing the lower bounds of the detection range. The California Air Resources Board (CARB) refers to a detection range and specifies the use of the geometric mean for use as a detection threshold for use in odour unit estimation. E.g. For hydrogen sulphide the NSW EPA detection limit is given as 0.14 µg/m³, whereas the CARB recognise a detection range of 0.098 µg/m³ to 1960 µg/m³ but specify the use of the geometric mean which is 11.2 µg/m³ (0.008 ppm).

• Odour Performance Criteria

In practice, the character of a particular odour can only be judged by the receiver's reaction to it, and preferably only compared to another odour under similar social and regional conditions. The NWS EPA, having referred to the literature in its determining the level at which an odour is perceived to be of nuisance, gives this level as ranging from 2 OU/m³ to 10 OU/m³ depending on a combination of the following factors:

- ➢ *Odour Quality* – whether the odour results from a pure compound or from a mixture of compounds (Pure compounds tend to have higher threshold, lower offensiveness than a mixed compound)
- ➢ *Population Sensitivity* - any given population contains individuals with a range of sensitivities to odour. The larger the population, generally the greater the number of sensitive individuals contained.
- ➢ *Background Level* - refers to the likelihood of cumulative odour impacts due to the co-location of sources emitting odours
- ➢ *Public expectation* - whether a given community is tolerant of a particular type of odour and does not find it offensive. Background agricultural odours may, for example, not be considered offensive until a higher threshold is reached whereas odours from a waste disposal site or chemical facility may be considered offensive at lower thresholds.
- ➢ *Source Characteristics* – emissions from a point source are more easily controlled than those that are diffused, e.g.: waste disposal sites

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[1] A level 3 assessment requires that comprehensive atmospheric dispersion modelling be done, as opposed to screening dispersion modelling acceptable in a level 2 odour impact assessments.

- *Health Effects* – whether a particular odour is likely to be associated with adverse health effects. In general, odour from an agricultural operation is less likely to present a health risk than emissions from a waste disposal or chemical facility.

Experience gained in NSW through odour assessments for proposed and existing facilities has indicated that an odour performance criterion of 7 OU/m³ is likely to represent the level below which "offensive" odours should not occur for an individual with a "standard sensitivity"[2] to odours.

The NSW EPA policy therefore recommends that, as design criteria, no individual be exposed to ambient odour levels of greater than 7 OU/m^3. Where a number of the factors listed above simultaneously contribute to making an odour 'offensive', odour criteria of 2 OU/m^3 at the nearest sensitive receptor (existing or any likely future receptor) is appropriate. This is given as generally occurring for affected populations equal to or above 2000 people. A summary of the NSW EPA's odour performance criteria for various population densities is shown in the Table 3-7 below.

Table 3-7: NSW EPA odour performance criteria defined based on population density (NSW EPS, 2001a).

Population of Affected Community	Odour performance criteria (odour units/m³) (a)
Urban area (>2000)	2.0
500 – 2000	3.0
125 – 500	4.0
30 – 125	5.0
10 – 30	6.0
Single residences (≤2)	7.0

a) The NSW EPA indicates that these should be regarded as interim criteria to be refined over time through experience and case studies. The EPA makes provision for the future updating of the odour performance criteria as new industry-specific research is completed, with the acceptable procedure for developing future criteria being outlined in a Technical Note.

The odour performance criteria specified by the NSW EPA is compared to that used in other jurisdictions is presented in Table 3-8 below. It is evident that the odour performance criteria range specified by the NSW EPA includes the criteria stipulated in various other jurisdictions. The exception being the South Coast Air Quality Management District in the US which permits odour units of up to 10 OU in certain instances.

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[2] "Standard Sensitivity" is defined by the Draft Australia and European CEN Standards, which require that the geometric mean of individual odour thresholds estimates must fall between 20 ppb and 80 ppb for n-butanol (the reference compound).

Table 3-8: Odour performance criteria used in various jurisdiction in the US and Australia (after NSW EPA, 2001b).

Jurisdiction	Odour Performance Criteria (given for application to odour units) (OU)
New South Wales EPA (NSW EPA, 2001a, 2001b)	2 to 7
California Air Resources Board (Amoore, 1999)	5
South Coast Air Quality Management District (SCAQMD) (CEQA, 1993)	5 to 10
Massachusetts (Leonardos, 1995)	5
Connecticut (Warren Spring Laboratory, 1990)	7
Queensland (Queensland Department of Environment and Heritage, 1994)	5

- **Recommended approach for use in current study**

It is recommended that the NSW EPA draft approach (NSW EPA, 2001a and 2001b) be largely adopted for use in the current study given that it has been recently drafted and is comprehensively documented. Reference will, however, be made to the CARB method of selecting detection limits for use in the odour unit calculation. The approach recommended may be summarised as follows:

(i) 3-minute average air pollutant concentrations will be calculated based on predicted 1-hourly average concentrations (since most dispersion models, including the Australian regulatory model Ausplume and the US-EPA regulatory model used in this study, do not allow for the prediction of averages over a shorter time interval than 1 hour);

The equation for calculating concentrations for different averaging periods than the period over which they were monitored can be seen below. Although this is a function of both source configuration and atmospheric turbulence, it can be generally shown that concentrations obtained over different averaging times are related as follows:

$$C1/C2 = (T2/T1)^p$$

Where

C1 and C2 are concentrations for averaging times T1 and T2, respectively;

T1 and T2 are any two averaging times;

P is a parameter ranging from 0.16 to 0.68, depending on the atmospheric stability. Most widely used values range between 0.16 and 0.25. Until locally derived values become available, it is recommended to use 0.2. For the purpose of the current study a value of 0.68 was applied to provide for a conservative assessment of the potential for short term peaks in ambient concentrations.

(ii) recognition of the detection range for a substance and calculation of the geometric mean detection limit within the range;

(iii) calculation of odour units by calculating ratios between the 99.9th percentile 3-minute average air pollutant concentrations and the respective geometric mean detection limits; and

(iv) application of the odour performance criteria set out by the NSW EPA in Table 3-4

It is recognised that the NSW EPA odour assessment procedure is still a draft procedure and that the odour performance criteria are given as being interim criteria to be tested in the field and modified as necessary (NSW EPA, 2001b). The above approach is similarly recommended as a test method, with experience gained locally in the field to be used to inform and tailor this approach.

- **Application of odour performance criteria**

It is interesting to note how odour assessment and management is carried out in countries in which the regulators have documented approaches. The procedure outlined, for example, by the NSW EPA for the assessment of odour impacts for existing facilities is depicted in Figure 3-1 below. It is notable that the NSW EPA’s odour performance criteria are not used as environment protection licence conditions. Compliance with these criteria is considered difficult to measure and therefore meaningless as licence conditions.

The NSW EPA policy identifies the potential for using negotiation between stakeholder to deal with cases where feasible and reasonable avoidance and mitigation strategies would not curb all potentially offensive odour impacts. Such negotiation processes are generally only regarded to be relevant to odour management for existing facilities. It is recommended that any negotiated solution between a facility operator and a neighbour be formalised (e.g. though a contract) so the agreement is clearly documented and understood.

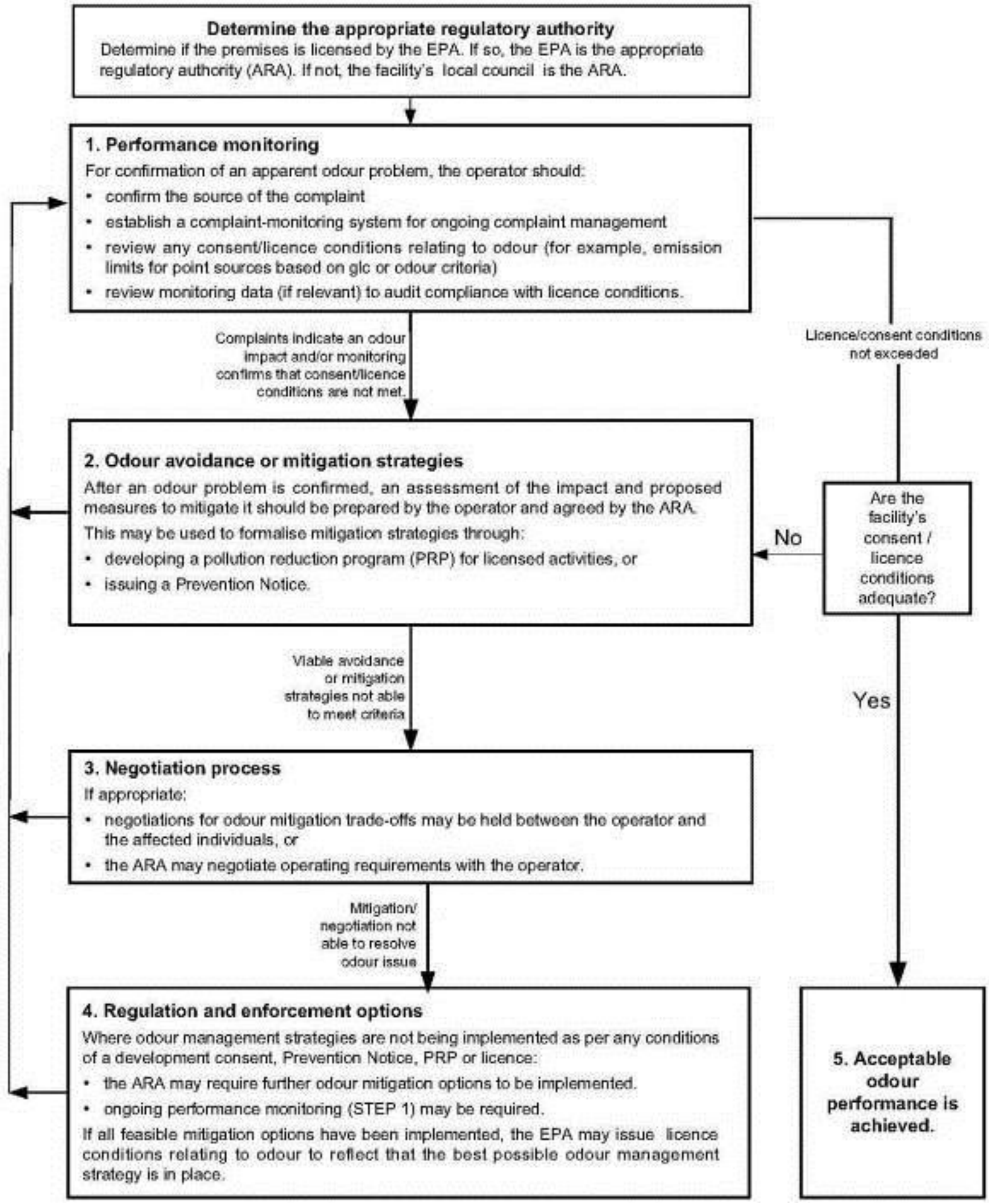


Figure 3-1: Odour impact assessment procedure stipulated by the New South Wales Environmental Protection Agency for existing facilities (NSW EPA, 2001)

3.3 Other Polluting Sources in the Area

Based on satellite imagery and a site visit; the following surrounding sources of air pollution were identified in the area:

- Vehicle tailpipe emissions;
- Industrial emissions;
- Landfill site

3.3.1 Vehicle emissions

Traffic volume is high within the Merebank and Jacob's Commercial area. Vehicle exhaust emissions play a significant role in the contribution to air pollution within the area**.** Vehicles are a major source of criteria and hazardous air pollutants such as NOx, CO, carbon dioxide (CO_2), HCs, SO_2, particulate matter, VOCs and Pb. Light petrol motor vehicles not equipped with pollution control devices have the highest exhaust emissions during acceleration, followed by deceleration and idling cycles. Frequent cycle changes characteristic of congested urban traffic patterns thus tend to increase pollutant emissions. At higher cruise speeds HC and CO emissions decrease, while NO_x and CO_2 emissions increase. Emissions from diesel-fuelled vehicles include particulate matter, NO_x, SO_2, CO and HC, the majority of which occurs from the exhaust. Operating at higher air-fuel ratios (about 30:1 as opposed to 15:1 characteristic of petrol-fuelled vehicles with electronic fuel injection engines), diesel-powered vehicles tend to have low HC and CO emissions, despite having considerably higher particulate emissions.

Particulate emissions from petrol-driven vehicles are usually negligible. Such emissions when they do occur would result from unburned lubricating oil, and ash-forming fuel and oil additives. Higher particulate emissions are associated with diesel-powered vehicles. Particulates emitted from diesel vehicles consist of soot formed during combustion, heavy HC condensed or adsorbed on the soot and sulphates. In older diesel-fuelled vehicles the contribution of soot to particulate emissions is between 40% and 80%. The black smoke observed to emanate from poorly maintained diesel-fuelled vehicles is caused by oxygen deficiency during the fuel combustion or expansion phase.

3.3.2 Industries

Mondi paper mill is located adjacent to the southern waste water treatment works. The production of paper has a number of adverse effects on the environment causing pollution of the atmosphere, water and land. Air emissions of hydrogen sulphide, methyl mercaptan, dimethyl disulphide and other volatile organic compounds are the source of the odorous characteristics of pulp mills utilizing the Kraft process. Other chemicals released into the atmosphere and water are as follows:

- Ammonia
- Carbon monoxide
- Nitrogen dioxide
- Mercury
- Nitrates
- Methanol
- Benzene
- Volatile organic compounds, chloroform

Emissions released from refinery industrial processes such as Engen and Sapref include SO_2, CO, NO_X and PM_{10}. Through the combustion of various fuels such as coal, paraffin and diesel, various levels of volatile organic compounds or heavy metals are also expected to be released to the atmosphere.

3.3.3 Landfill site

Landfill poses a risk to air, land and groundwater. Landfill gas emissions and fugitive dust are the main concerns arising from landfill operations. Fugitive dust emissions arise from vehicle entrainment on paved and unpaved roads, material handling activities, wind erosion from exposed surfaces and earth moving activities.

Landfill gas is produced by the chemical reactions and microbes acting on the waste and as biodegradable wastes decomposes. Landfill gas is composed of 60% methane and the remainder of carbon dioxide. Varying amounts of nitrogen, oxygen, water vapour, hydrogen sulphide and other contaminants are present in landfill gas. Contaminants are known as “non methane organic compounds” and include toxic chemicals such as benzene, toluene, chloroform, vinyl chloride and carbon tetrachloride. The US-EPA has identified 41 halogenated compounds present in landfill gases such as chlorine, bromine, and fluorine.

The major environmental concern is the influence of landfill gas on climate change as the major components are the greenhouse gases; methane and carbon dioxide.

3.4 Sensitive receptors

A sensitive receptor for the purpose of this report is identified as a place or activity which could involuntarily be exposed to odour and air emissions generated from the proposed abattoir operations. Based on this definition the residential, educational and recreational land uses in the area are considered to be sensitive receptors.

For this study, the position of houses/dwellings was taken off 1:50 000 topographical cadastral maps and verified as far as possible using Google Earth and a site visit. Even though the latest editions were used, maps may be out of date and there may be new dwellings and/or some of the existing shown buildings may be derelict.

The area surrounding the waste water treatment work is surrounded by residential communities. Several schools and communities are situated in close proximity to the treatment works as shown in Table 3-9 below.

Other sensitive receptors within the area would be the local fauna and flora. It has been identified that dust settling on the leaves of plants can result in damage to plants and inhalation of dust may result in sickness and associated lung diseases for wildlife and humans which will be present in the vicinity of the treatment works. A more detailed inventory of settlements and sensitive receptors will be obtained on a site visit and with assistance of the public participation specialists working on the project.

Table 3-9: Sensitive receptors with approximate distance and direction from the southern waste water treatment works.

Sensitive receptor	Direction	Distance
Settlers Primary School	NE	~ 1 km
PRP Secondary school	SE	~ 1.5 km
Merebank Secondary school	N	~1
Nizam Primary school	SE	~ 1.2 km
Religious centre	E	~800m

3.5 Baseline Air Quality

In response to the air quality issues within the southern basin, the eThekwini Metropolitan Municipality commissioned ten monitoring stations. The southern basin is located on the eastern seaboard of Kwa- Zulu Natal and has a mixture of heavy industrial activity and residential settlements in close proximity. The objective of the monitoring stations is to target and provide a quantitative measure on the two main sources of air pollution namely; industrial and traffic emissions.

The established monitoring network, whilst primarily focused on the southern basin, also extends into the city centre and has background sites (Alverstone, Ferndale and Prospecton). The pollutants measured include SO_2, NO_2, PM_{10}, Total Reduced Sulphur (TRS) and CO. Table 3-10 below provides a list of all the monitoring stations and the measured parameters.

Table 3-10: Location of Monitoring stations and parameters measured.

Monitoring station	Meteorology	SO_2	NO_2	PM_{10}	TRS	CO
Prospecton		x				
Southern Works	x	x	x	x	x	
Settlers School		x			x	
Ganges School		x	x	x		
Grosvenor		x				
Wentworth	x	x	x	x		
Jacobs	x	x	x			
Ferndale		x	x	x		
Warwick			x			x
City Hall			x	x		

Figure 3-2: Map indicating the location of the monitoring stations

3.5.1 Sulphur dioxide

Figure 3-3 below illustrates the annual trends of SO_2 from 2004 – 2013. There is gradual decrease in the annual concentrations of SO_2 since 2004. The monitoring stations, with the exception of the 2004 exceedance at the Southern Works, all fell below the annual SO_2 standard of 50 $\mu g/m^3$.

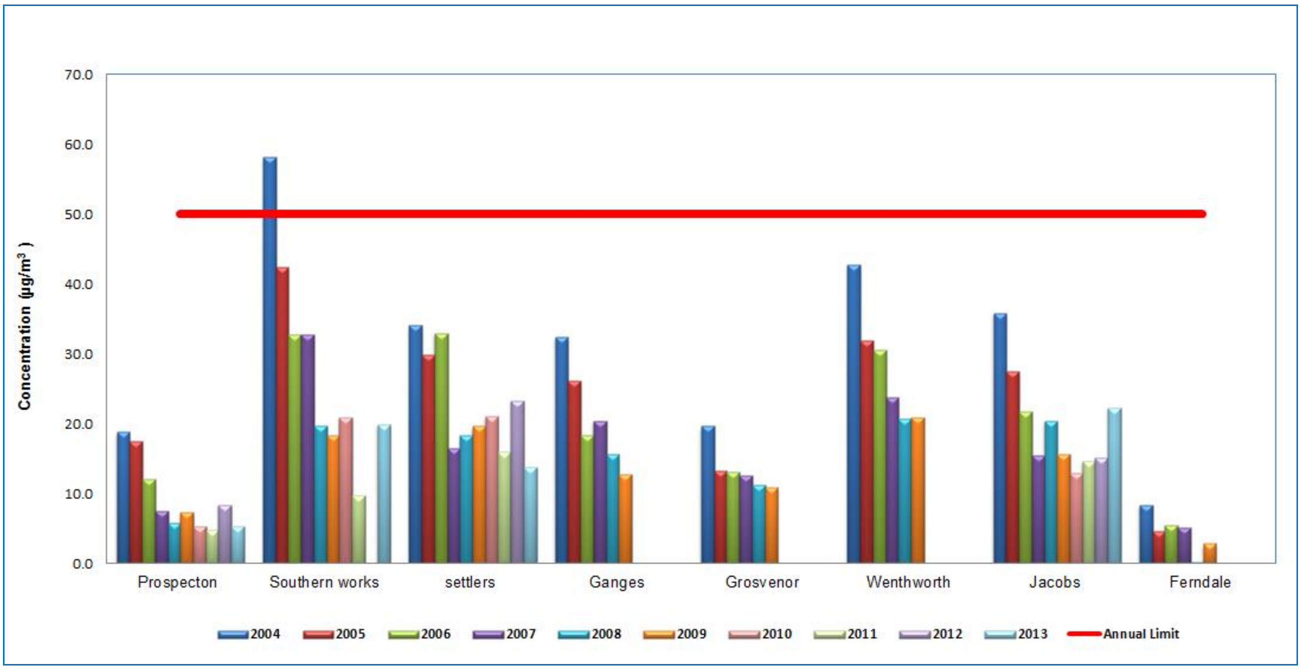


Figure 3-3: Annual trends in sulphur dioxide concentrations (µg/m^3) from 2004 – 2013.

3.5.2 Nitrogen dioxide

Figure 3-4 below illustrates the annual trends of NO_2 from 2004 – 2013. The monitoring station located at the Ganges School exceeded the annual limit of 40 µg/m^3 for NO_2 on 4 occasions in 2004, 2005, 2006 and 2009. The Warwick monitoring station exceeded the annual standard of NO_2 during the 2004 and 2008 monitoring period, while the City Hall exceeded the annual standard in 2006 and Jacobs Monitoring station in 2007 and 2011 respectively.

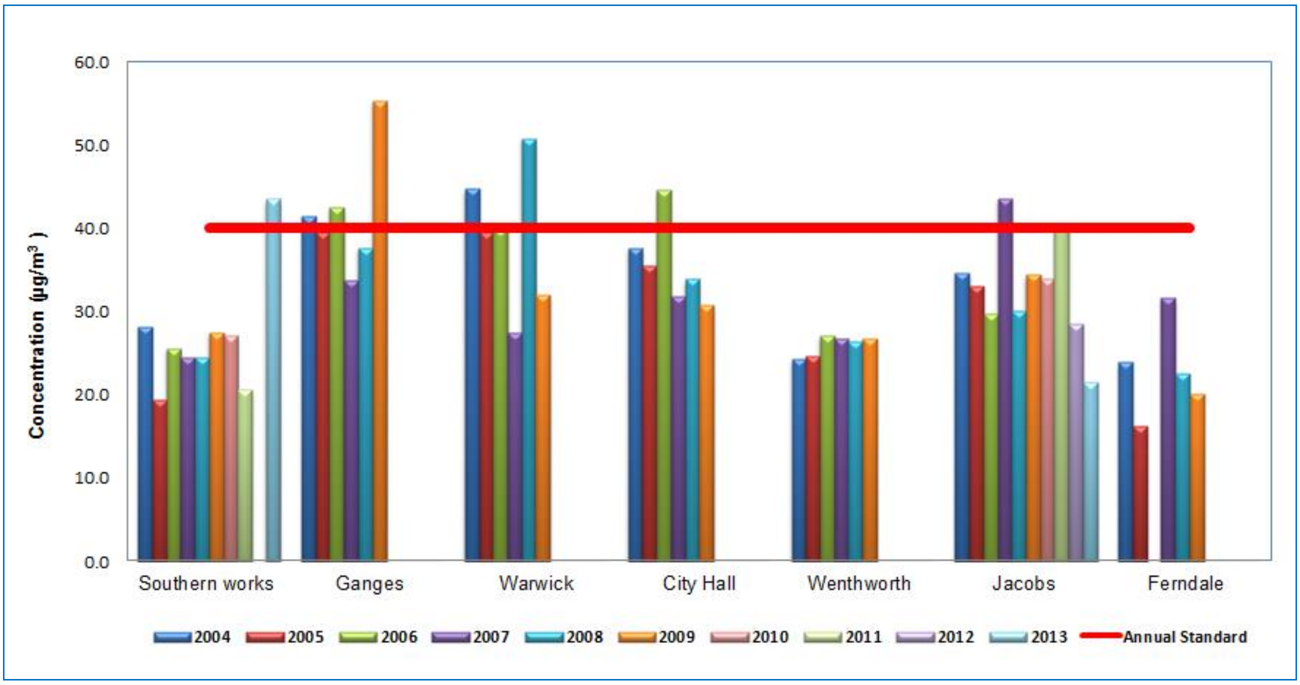


Figure 3-4: Annual trends in nitrogen dioxide concentrations (µg/m^3) from 2004 – 2013.

3.5.3 Particulate Matter

Particulate matter represents a broad class of chemically and physically diverse substances. Particles can be described by size, formation mechanism, origin, chemical composition, atmospheric behaviour and method of measurement. The concentration of particles in the air varies across space and time, and is related to the source of the particles and the transformations that occur in the atmosphere (USEPA, 1996).

Figure 3-5 below illustrates the annual trends for particulate matter at the various monitoring stations. As seen from the trends illustrated in the graph below, PM10 concentrations at all stations fell below the annual standard of 50 µg/m^3. The highest PM10 concentrations were experienced at the Ganges monitoring station.

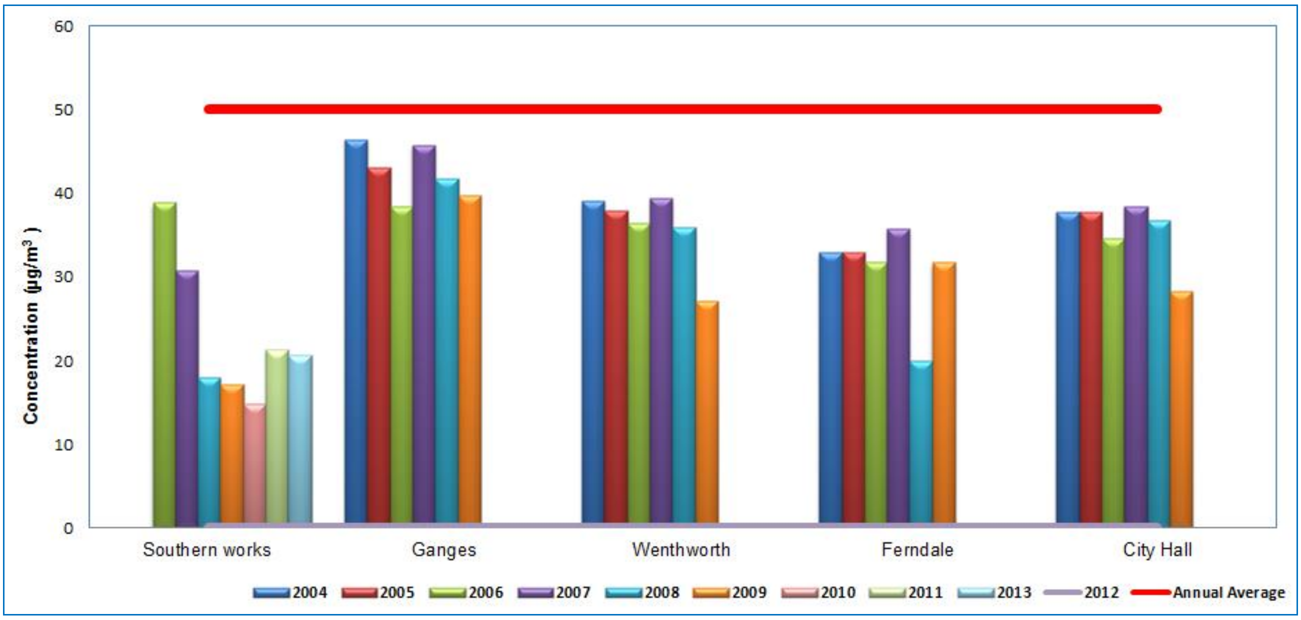


Figure 3-5: Annual trends in particulate matter concentrations (µg/m^3) from 2004 – 2013.

3.5.4 TRS (Total Reduced Sulphur)

Total reduced sulphur is not classified as a priority pollutant as thus has no prescribed South African Ambient Air Quality Standards. Use is therefore made of the European Union standards for hydrogen sulphide which comprises of 60% of TRS.

Figure 3-6 below illustrates the TRS concentrations measured during 2008 - 2013. Both monitoring stations recorded an annual average below the annual H_2S standard of 7.8 ppb.

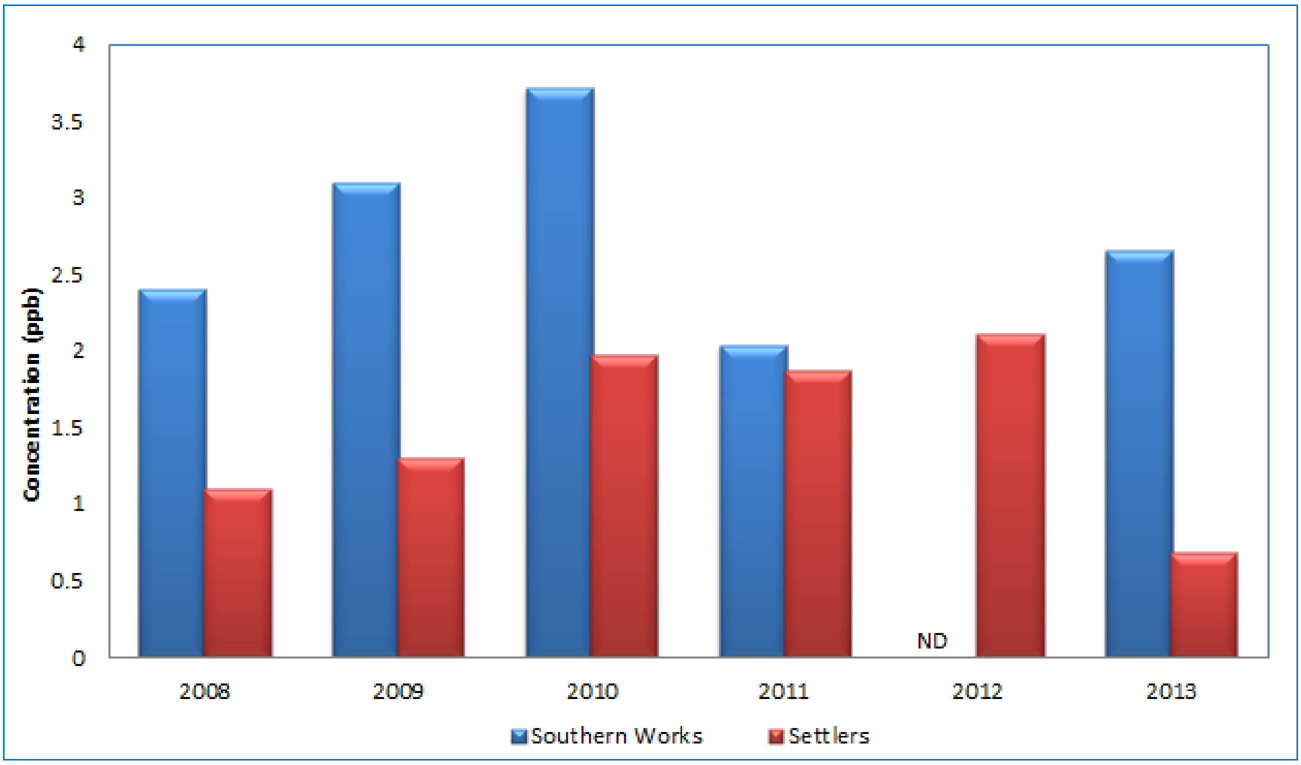


Figure 3-6: Annual TRS concentrations (ppb) from 2008-2009

4 IMPACT ASSESSMENT

This section of the report outlines the potential impacts associated with the upgrades at the Waste Water Treatment Works. To clearly detail the potential impacts in ambient ground level concentration, operational emissions will be discussed quantitatively. The construction and decommissioning impacts will be discussed qualitatively due to the variability and unpredictable nature of the construction operations on site, and initial details are provided in the subsections to follow.

4.1 Methodology

4.1.1 Model overview

AERMOD, a state-of-the-art Planetary Boundary Layer (PBL) air dispersion model, was developed by the American Meteorological Society and USEPA Regulatory Model Improvement Committee (AERMIC). AERMOD utilizes a similar input and output structure to ISCST3 and shares many of the same features, as well as offering additional features. AERMOD fully incorporates the PRIME building downwash algorithms, advanced depositional parameters, local terrain effects, and advanced meteorological turbulence calculations.

The AERMOD atmospheric dispersion modelling system is an integrated system that includes three modules:

- A steady-state dispersion model designed for short-range (up to 50 km) dispersion of air pollutant emissions from stationary industrial sources.
- A meteorological data pre-processor (AERMET) for surface meteorological data, upper air soundings, and optionally, data from on-site instrument towers. It then calculates atmospheric parameters needed by the dispersion model, such as atmospheric turbulence characteristics, mixing heights, friction velocity, Monin-Obukov length and surface heat flux.
- A terrain pre-processor (AERMAP) which provides a physical relationship between terrain features and the behaviour of air pollution plumes. It generates location and height data for each receptor location. It also provides information that allows the dispersion model to simulate the effects of air flowing over hills or splitting to flow around hills.

4.1.2 Model requirements

Input data requirements for Aermod include meteorological and emissions source data. Meteorological data which includes wind speed, wind direction, relative humidity, pressure, temperature, precipitation, cloud cover and ceiling height was obtained from the South African weather services for the Jan 2009 – Dec 2013 monitoring period. Source and emission parameters for the model are detailed in the section below.

The emissions inventory will need to be developed to determine the emissions generated from each source. This is likely to be undertaken using the US-EPA waste water treatments emission model – Water9. The inventory will be developed based on the processes carried out on site such as source specifications and characteristics.

4.2 Emissions inventory

The US EPA Water9 model is a windows based computer programme that is used for estimating air emissions of individual waste constituents in the wastewater collection, storage, and treatment and disposal facilities. It is a data base listing many of the organic compounds and procedures for obtaining reports of constituent's fates, including air emissions and treatment effectiveness. The emissions that are released during operation of a waste water treatment works (WWTW) are namely; odour and aerosols.

Table 4-1 below lists the specifications of each tank currently in operation at the treatment works. Table 4-2 below lists the emission rates for the pollutants anticipated to be released from the treatment works.

Table 4-1: Source specifications

Tank	Height (m)	Diameter (m)	Throughput (Ml/d)	Volume (m^3)	Temperature (°C)
Primary sedimentation tanks	4.8	35.9	30	4858.7	25
Tanker bay facility	4	-	120	77	25
Thickeners	6.03	18.9	187.2	47.205	25
Primary Digesters	25.040	20.015	755000	4587	35
Secondary digesters	18.285	20.012	755000	3978	25
Sludge silos	4.1	6	113	150	25

Table 4-2: Pollutants of concern anticipated to be released from the Waste water treatment works and their calculated emission rates.

Pollutants	g/s
Ammonia	1.62E- 03
Hydrogen sulphide	7.35E - 05
Acetone	7.76E - 05
Benzene	6.43E-05
Chloroform	6.72E-05
Methanol	3.96E-05
Phenol	1.18E-05
Toluene	6.04E-05

4.2.1 Assumptions and Knowledge gaps

- It is assumed that all source characteristics and volumes provided for by the client are correct;
- The low lying sump was incorporated within the Water9 model in order to calculate emissions,
- Emission from other surrounding industries were taken into consideration.

4.3 Impact assessment

4.3.1 Construction/ Upgrade Impacts

Construction is a source of dust emission which has a temporary impact on the local air quality. Infrastructure and road construction are the two types of construction activity with high emission potentials.

The temporary nature of construction activities is what distinguishes it from other fugitive sources present within the locality. Emissions from construction activities are expected to have a definitive start and end period and will vary depending on the various construction phases. In contrast to other fugitive sources, here the emissions occur in a steady state or follow a discernible pattern. The quantity of dust emissions from construction activities is proportional to the area of land under construction (USEPA, 1996).

The impact on air quality and air pollution of fugitive dust is dependent on the quantity and drift potential of the dust particles (USEPA, 1996). Large particles settle out near the source causing a local nuisance problem. Fine particles can be dispersed over much greater distances. Fugitive dust may have significant adverse impacts such as reduced visibility, soiling of buildings and materials, reduced growth and production in vegetation and may affect sensitive areas and aesthetics. Fugitive dust can also adversely affect human health.

The following component of the environment which may be impacted upon during the upgrades at the Southern Waste Water Treatment Works includes:

- The ambient air quality
- Local residents and neighbouring communities
- The surrounding environment and possible the fauna and flora.

Because construction is of a temporary nature, it is recommended that mitigation control measures be put in place to limit the impacts on the local air quality. Wet suppression and wind speed reduction are common methods used to control open dust sources at construction sites.

The aim of the proposed SWWTW upgrades is to reduce the quantity of suspended solids being disposed of to sea by affording primary treatment to the combined effluent discharges from the Jacobs and Wentworth Valley Trunk Sewers. This physical treatment process (through primary settling) will result in the organic load to sea being drastically reduced. The settled solids (referred to as primary (or raw) sludge) will then be removed and stabilised through a process of anaerobic digestion, before being dewatered. The options proposed for the disposal of the dewatered sludge are as follows:

- Removal off-site to agriculture and/or landfill;
- Thermal drying and then removal off-site to agriculture;
- Manufacture of fertilizer through a separate sludge pelletizing process to be established on site by a private entity (unconfirmed at this stage) and then removal off-site. This option may be investigated under a separate study and does not form part of this study nor the scope of work described hereunder.

The work will be undertaken in 2 phases, with Phase 1 being the immediate upgrade and Phase 2 being the future upgrade. The Phase 1 upgrade will result in the primary treatment of approximately 60 Mega (million) litres (or 63.5 %) of the present combined flow (i.e. 95 Mega [million] litres) being discharged from the Jacobs and Wentworth Valley Trunk Sewers. The solids (or sludge) to be removed will then be combined with that currently being removed from the treatment of the sewage effluent being discharged from the Umlaas Trunk Sewer, before being pumped to the anaerobic digesters. The biogas (which is made up of approximately 60 %

methane and 40 % carbon dioxide) and emanating from the anaerobic digestion process will be stored in gas holders. The options proposed for the use of the biogas are as follows:

- Consumption of at least one third of the stored volume for heating of the sludge (as part of the digestion process) and flaring (or burning) of the remainder;
- Utilising most of the stored gas to dry the sludge through a mechanical thermal drying process and then using the waste heat from the drying process to heat the sludge. It is important to note that the drying of sludge would greatly reduce the road transportation requirements for removal of sludge off site.

The work to be completed under each phase is proposed as follows:

Phase 1:

a) Refurbish and bring back on line two out of six existing primary settling tanks;

b) Refurbish and bring back on line existing two anaerobic primary digesters and secondary digester and construct two new primary digesters and one secondary digester, all of same capacity as existing;

c) Refurbish and bring back on line existing raw sludge gravity thickener and construct a new gravity thickener of the same capacity;

d) Refurbish and bring back on line existing gas holder and construct a new gas holder of the same capacity.

e) Refurbish and bring back on line various existing (unused) electrical substation buildings and small pumping stations;

f) Establishing a new mechanical sludge dewatering facility on site and 2 x 150 000 litres fully enclosed steel sludge storage silos;

g) Establishment a new mechanical sludge thermal drying facility on site.

h) Provide additional effluent storage capacity of 23 000 000 litres at existing low level pumping station and install two new 350 kilowatt pumps;

i) Replace the last 70 m of the landline section of the sea outfall pipeline with new 2x 1000 m diameter pipe;

j) Construct new road tanker effluent discharge bays in close proximity to the entrance of the Works;

k) Install new medium voltage and low voltage electrical cables and equipment;

l) Minor road works and new tanker bay facility access designs;

m) The installation of a standby generator.

Phase 2:

a) Refurbish and bring back on line remaining four of the existing six primary settling tanks and construct two new primary settling tanks of the same capacity as existing;

b) Construct four new anaerobic primary digesters and two new secondary digesters, all of the same capacity as existing;

c) Construct a new raw sludge gravity thickener, of the same capacity as existing;

d) Construct a new gas holder;

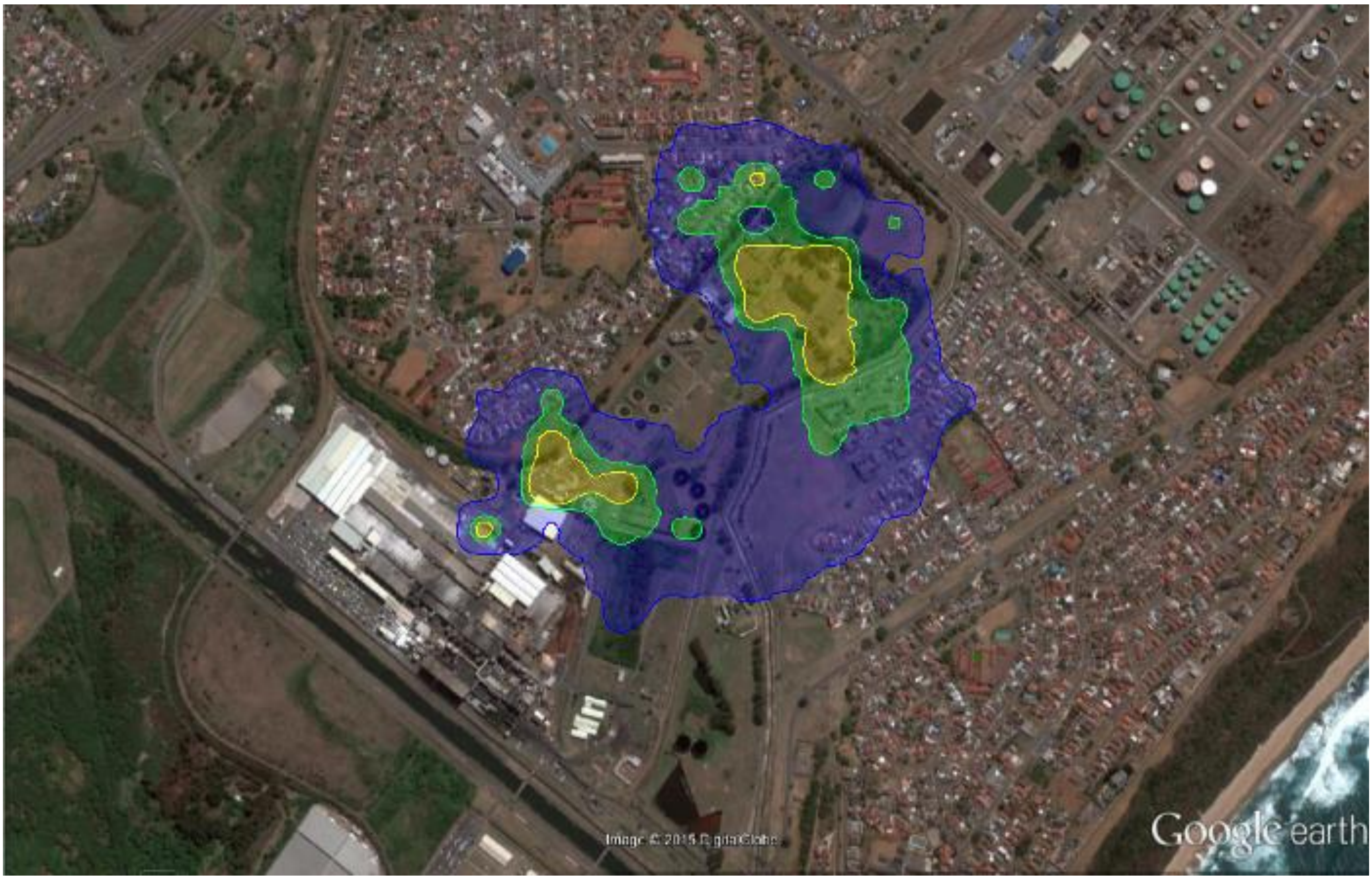
e) Install additional mechanical sludge dewatering equipment.

4.3.2 Operational Impacts

Dispersion modelling simulations were undertaken to determine the potential air quality impacts associated with the proposed operational phases of the waste water treatment works. These impacts are reflected as Isopleths plots. The isopleths plots reflect the gridded contours of zones of impact at various distances from the contributing sources. The patterns generated by the contours are representative of the maximum predicted ground level concentrations for the period being represented. Where applicable hourly, daily and annual ground level concentrations are represented in **Error! Reference source not found.**- Figure 4-3 respectively. The Maximum extents of impacts associated with the Southern Waste Water Treatment works are further represented in Table 4-3 below.

	🟦	🟩	🟨
Ammonia	1.62	2.43	2.92
Hydrogen sulphide	0.07	0.11	0.13
Acetone	0.08	0.12	0.14
Benzene	0.06	0.10	0.12
Chloroform	0.07	0.10	0.12
Methanol	0.04	0.06	0.07
Phenol	0.01	0.02	0.02
Toulene	0.06	0.09	0.11

Phase 1



	🟦	🟩	🟨
Ammonia	56.70	64.80	68.04
Hydrogen sulphide	2.57	2.94	3.09
Acetone	2.72	3.10	3.26
Benzene	2.25	2.57	2.70
Chloroform	2.35	2.69	2.82
Methanol	1.39	1.58	1.66
Phenol	0.41	0.47	0.50
Toulene	2.11	2.42	2.54

Figure 4-1: Phase 1- hourly average predicted ground level concentration (µg/m^3) for the Southern Waste Water Treatment Works.

	🟦	🟩	🟨
Ammonia	8.10	12.96	16.20
Hydrogen sulphide	0.37	0.59	0.74
Acetone	0.39	0.62	0.78
Benzene	0.32	0.51	0.64
Chloroform	0.34	0.54	0.67
Methanol	0.20	0.32	0.40
Phenol	0.06	0.09	0.12
Toulene	0.30	0.48	0.60

Figure 4-2: Phase 1 - daily average predicted ground level concentration (µg/m^3) for the Southern Waste Water Treatment Works.

	🟦	🟩	🟨
Ammonia	1.62	2.43	2.92
Hydrogen sulphide	0.07	0.11	0.13
Acetone	0.08	0.12	0.14
Benzene	0.06	0.10	0.12
Chloroform	0.07	0.10	0.12
Methanol	0.04	0.06	0.07
Phenol	0.01	0.02	0.02
Toulene	0.06	0.09	0.11

Figure 4-3: Phase 1 - annual average ground level concentration (µg/m^3) for the Southern Waste Water Treatment Works

Table 4-3: Phase1 - Maximum predicted ground level concentration (µg/m^3).

Pollutants	Maximum Predicted Concentrations			Guidelines			Fraction of the Guidelines (%)		
	Hourly	Daily	Annual	Hourly	Daily	Annual	Hourly	Daily	Annual
Ammonia	81.00	16.20	4.05			100			0.4
Hydrogen sulphide	3.68	0.74	0.18	10	150	42	0.3	<0.1	<0.1
Acetone	3.88	0.78	0.19						
Benzene	3.22	0.64	0.16	1300		30	<0.1		<0.1
Chloroform	3.36	0.67	0.17	300		150	<0.1		<0.1
Methanol	1.98	0.40	0.10	28000		4000	<0.1		<0.1
Phenol	0.59	0.12	0.03	5800		200	<0.1		<0.1
Toluene	3.02	0.60	0.15	37000		300	<0.1		<0.1

Table 4-3 above compares the maximum ground level concentration as a fraction of the standards. There were no exceedances of the hourly, daily and annual standards for the pollutants anticipated to be released as a result of the treatment works. All concentrations during phase 1 of the upgrades were less than 1 % of the respective guidelines.

The Cancer risk due to exposure from certain pollutants is presented in Table 4-4 below. The table evaluated the various cancer risk factors on the US EPA unit risk factor. The Total cancer risk assessment indicated benzene with a cancer risk of 3.5 individuals in a population of 10 million, while Chloroform had an estimated cancer risk of 3.86 individuals in a population of 1 million.

Usually a cancer risk of 1 individual in a population of hundred thousand is deemed to be an acceptable risk level. Based on these factors, the cancer risk associated with these pollutants are not significant.

Table 4-4: Phase 1 - Predicted cancer Risk

Pollutant	Annual average concentration (µg/m^3)	US-EPA Cancer Risk Factor	Estimated Cancer Risk
Benzene	3.54E-07	2.2E-06	3.5 in 10 million
Chloroform	3.86E-06	2.3E-05	3.86 in 1 million

Table 4-5 below lists the predicted odour impacts. Odour thresholds are defined in several ways including absolute perception thresholds, recognition thresholds and objectionability thresholds. At the perception threshold one is barely certain that an odour is detected but it is too faint to identify further. Recognition thresholds are normally given for 50% and 100% recognition by an odour panel. Ammonia had an odour detection of 0.16 % of the standard, while Hydrogen sulphide was estimated at 0.8% of the standard. The odour detection threshold for the remainder of the assessed pollutants was <0.1 % of a fraction of the standard.

Table 4-5: Phase 1 - Predicted Odour nuisance impacts

Pollutant	1hr Average concentration (µg/m^3)	Odour detection limit (µg/m^3)	Fraction of the standard (%)
Ammonia	81.00	500	0.16
Hydrogen sulphide	3.68	4.29	0.8
Acetone	3.88	1100	<0.1
Benzene	3.22	3000	<0.1
Chloroform	3.36	20000	<0.1
Methanol	1.98	2660	<0.1
Phenol	0.59	184	<0.1
Toluene	3.02	700	<0.1

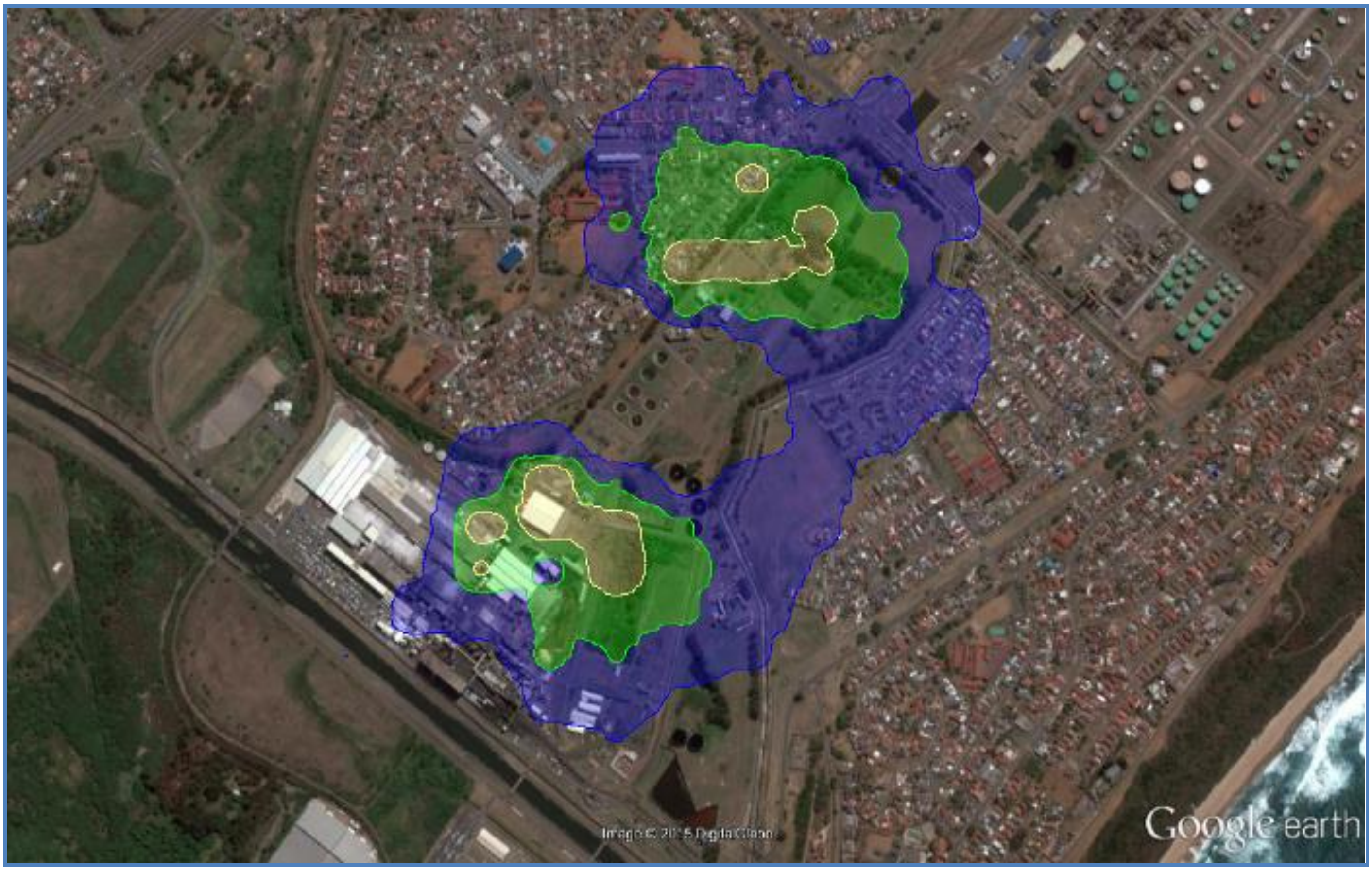
Table 4-6 below lists the 1 hour average odour concentration recorded at the sensitive receptors. There were no exceedance of the odour detection limit during phase 2 of the assessment.

Table 4-6: Odour concentration at each sensitive receptor.

Pollutants	Merebank Secondary	Settlers Primary School	Nizam Road Primary School
Ammonia	4.71	4.15	3.27
Hydrogen sulphide	0.21	0.19	0.15
Acetone	0.23	0.20	0.16
Benzene	0.19	0.16	0.13
Chloroform	0.20	0.17	0.14
Methanol	0.12	0.10	0.08
Phenol	0.03	0.03	0.02
Toluene	0.18	0.15	0.12

Phase 2

Phase 2 dispersion simulations involves the refurbishing the existing four primary settling tanks as well as the construction of two additional settling tanks with the same new capacity as the existing tanks. The construction of four anaerobic primary digesters and two secondary digesters were also included in the model runs.



	🟦	🟩	🟨
Ammonia	121.50	145.80	16.20
Hydrogen sulphide	5.51	6.62	0.74
Acetone	5.82	6.98	0.78
Benzene	4.82	5.79	0.64
Chloroform	5.04	6.05	0.67
Methanol	2.97	3.56	0.40
Phenol	0.89	1.06	0.12
Toulene	4.53	5.44	0.60

Figure 4-4: Phase 2 – hourly average predicted ground level concentration (µg/m^3) for the Southern Waste Water Treatment Works.

	🟦	🟩	🟨
Ammonia	14.58	19.44	19.44
Hydrogen sulphide	0.66	0.88	0.88
Acetone	0.70	0.93	0.93
Benzene	0.58	0.77	0.77
Chloroform	0.60	0.81	0.81
Methanol	0.36	0.48	0.48
Phenol	0.11	0.14	0.14
Toulene	0.54	0.72	0.72

Figure 4-5: Phase 2 - daily average predicted ground level concentration (μg/m^3) for the Southern Waste Water Treatment Works.

	🟦	🟩	🟨
Ammonia	3.24	4.05	4.86
Hydrogen sulphide	0.15	0.18	0.22
Acetone	0.16	0.19	0.23
Benzene	0.13	0.16	0.19
Chloroform	0.13	0.17	0.20
Methanol	0.08	0.10	0.12
Phenol	0.02	0.03	0.04
Toulene	0.12	0.15	0.18

Figure 4-6: Phase 2 - annual average ground level concentration (µg/m^3) for the Southern Waste Water Treatment Works.

Table 4-7 below compares the maximum ground level concentration as a fraction of the standards. There were no exceedances of the hourly, daily and annual standards for the pollutants anticipated to be released as a result of the treatment works. All concentrations of pollutants complied with the respective hourly, daily and annual standard. The highest emission assessed was ammonia and hydrogen sulphide.

Table 4-7:Phase 2 – Maximum predicted ground level concentration (µg/m^3)

Pollutants	Maximum Predicted Concentrations (µg/m^3)			Guidelines			Fraction of the Guidelines (%)		
	Hourly	Daily	Annual	Hourly	Daily	Annual	Hourly	Daily	Annual
Ammonia	178.20	40.50	9.72			100			0.1
Hydrogen sulphide	8.09	1.84	0.44	10	150	42	0.8	<0.1	<0.1
Acetone	8.54	1.94	0.47						
Benzene	7.07	1.61	0.39	1300		30	<0.1		<0.1
Chloroform	7.39	1.68	0.40	300		150	<0.1		<0.1
Methanol	4.36	0.99	0.24	28000		4000	<0.1		<0.1
Phenol	1.30	0.30	0.07	5800		200	<0.1		<0.1
Toluene	6.64	1.51	0.36	37000		300	<0.1		<0.1

Table 4-8 below show the cancer risk assessment for phase 2 model runs. Benzene had an estimated cancer risk of 1.02 in 10 million which is significantly lower than the cancer risk factor. Chloroform had an estimated cancer risk of 8.87 in 10 million which is lower than the US –EPA cancer risk factor. The cancer risk factor arising from the treatment works is not significant.

Table 4-8: Phase 2 – Cancer risk assessment

Pollutant	Annual average concentration (µg/m^3)	US-EPA Cancer Risk Factor	Estimated Cancer Risk
Benzene	4.66E-01	2.2E-06	1.02 in 10 million
Chloroform	3.86E-01	2.3E-05	8.87 in 10 million

Table 4-9 below lists the predicted odour impact. Odour thresholds are defined in several ways including absolute perception thresholds, recognition thresholds and objectionability thresholds. At the perception threshold one is barely certain that an odour is detected but it is too faint to identify further. Recognition thresholds are normally given for 50% and 100% recognition by an odour panel. The only pollutant noted to exceed the odour detection limit is hydrogen sulphide during phase 2 of the upgrades.

Table 4-9: Phase 2 - Predicted Odour nuisance impacts

Pollutant	1hr Average concentration (µg/m^3)	Odour detection limit (µg/m^3)	Fraction of the standard (%)
Ammonia	121.50	500	0.2
Hydrogen sulphide	5.51	4.29	1.2
Acetone	5.82	1100	<0.1
Benzene	4.82	3000	<0.1
Chloroform	5.04	20000	<0.1
Methanol	2.97	2660	<0.1
Phenol	0.89	184	<0.1
Toluene	4.53	700	<0.1

Table 4-10: Odour concentration at each sensitive receptor (Exceedance highlighted in Bold)

Pollutants	Merebank Secondary	Settlers Primary School	Nizam Road Primary School
Ammonia	91.76	108.33	112.53
Hydrogen sulphide	4.16	**4.91**	**5.11**
Acetone	4.40	5.19	5.39
Benzene	3.64	4.30	4.47
Chloroform	3.81	4.49	4.67
Methanol	2.24	2.65	2.75
Phenol	0.67	0.79	0.82
Toluene	3.42	4.04	4.20

Table 4-10 above lists the 1 hour average odour concentration recorded at the sensitive receptors. Hydrogen sulphide odour emission was exceeded at Settlers Primary and Nizam Road Primary school during phase 2 of the upgrades.

4.4 Decommissioning impacts

The decommissioning phase is associated with activities related to the demolition of infrastructure and the rehabilitation of disturbed areas. The total rehabilitation will ensure that the total area will be a free draining covered with topsoil and grassed. The following activities are associated with the decommissioning phase (US-EPA, 1996):

- Existing buildings and structures demolished, rubble removed and the area levelled;
- Land and permanent waste piles prepared for re-vegetation.

Possible sources of fugitive dust emission during the closure and post-closure phase include:

- Grading of sites;
- Infrastructure demolition;
- Infrastructure rubble piles;
- Transport and dumping of building rubble;
- Preparation of soil for re-vegetation – ploughing and addition of fertiliser, compost etc.

Exposed soil is often prone to erosion by water. The erodability of soil depends on the amount of rainfall and its intensity, soil type and structure, slope of the terrain and the amount of vegetation cover (Brady, 1974). Re-vegetation of exposed areas for long-term dust and water erosion control is commonly used and is the most cost-effective option. Plant roots bind the soil, and vegetation cover breaks the impact of falling raindrops, thus preventing wind and water erosion. Plants used for revegetation should be indigenous to the area, hardy, fast-growing, nitrogen-fixing, provide high plant cover, be adapted to growing on exposed and disturbed soil (pioneer plants) and should easily be propagated by seed or cuttings.

5 ODOUR MANAGEMENT

The purpose of an odour management plan is to ensure that the waste water treatment works is managed in such a way that the risk of odour nuisance is minimised as far as practical.

Sewage is produced as a by-product of human existence and numerous industrial processes and is odorous by nature. Even though the constituents of sewage are primarily water, it also contains various other biological and chemical materials which if released in an uncontrolled manner to the environment, are capable of causing pollution.

5.1.1 Good housekeeping practices

The general means of odour management at a treatment works includes the following:

- Good housekeeping and raw material handlings practices;
- Control and minimization of odours from residual material and waste which includes imported sludge or septic tank waste;
- Maintaining the effluent aeration for aerobic processes;
- Avoiding anaerobic conditions and minimizing septicity;
- Selecting process steps that presents the least risk of odour generation;
- Minimization of sludge retention time in primary settlement;
- Application of extended aeration to avoid primary settlements;
- The build-up of scum and foam on tank surfaces can at times contribute and lead to odour. The draining of tanks for cleaning has been implicated as a prominent source of odour complaints. Practical measures such as use of appropriate chemicals can be used to minimize and mitigate odour impacts.
- Storage of sludge and products on site needs to be minimized;
- The cleaning of screens and grit should be done regularly, so as to reduce the odour potential;

5.1.2 Plant performance and maintenance

Research has shown that some odour problems which occur at waste water treatment works had been due to plant maintenance and proper operations of odour abatement equipment. These problems were said to be due partly to difficulties in operations and lack of training. Plant performance, maintenance, inspection and operator training are therefore crucial in maintaining the effectiveness of odour control measures. The following should be kept in mind for an efficient operation of a treatment works;

- Sufficient supply of reagents and consumables should be kept on site;
- A record of maintenance should be available for inspection;
- The operator should maintain a record of training requirements for each operational post as well as a record of training received by each personnel whose actions have an impact on the environment;
- Minimisation of emissions on start up and shut down;

5.1.3 Plant design and upgrades

Odour problems can occur at almost any stage of the WWTW depending upon the influent, plant location, operation and design. The areas most commonly responsible for potentially offensive odour releases are the inlet works, primary sedimentation, high rate storage. However the areas most commonly responsible for potentially offensive odour releases are the inlet works, primary sedimentation tank, high rate secondary treatment processes and all stages of un-stabilised sludge handling and storage.

However there exists opportunities for the minimization of odour emissions at certain stages of the process for instance during the primary settlement stage as the tanks are usually large; there is a significant surface area with which to emit pollutants. An effective method may be to use a low rate biological treatment step such as extended aeration of sewage or a high rate process within a building to avoid primary treatment. However there is cost implications and is dependant upon the size of the plant.

5.1.4 Transport of sewage to the works

Measures which can be put in place to reduce the septicity and minimize the retention time of sewage in transport under anaerobic conditions includes the following;

- Improve ventilation;
- If septic conditions develop, chemical dosing will assist in reducing the concentration of odorous emissions;
- Minimize intermediate storage;
- Regular cleaning to remove accumulations;
- Also ensure that the slope of gravity prevents sedimentation and accumulation.

5.1.5 Inlet works

Screening and pre-treatment of raw sewage is required to remove grit and other compounds prior to primary treatment. Procedures that should be considered to minimize emissions released during this stage of treatment involve the following:

- Lowering discharge points to minimise emissions;
- Balancing the flow of sludge liquors to even the load over the day;
- Regular cleaning and flushing of screens and influent channels.

5.1.6 Primary and secondary treatment

During the primary treatment, sewage flows through large tanks known as the primary sedimentation tanks. The tanks are used to settle sludge, while oil and grease rises to the surface and is skimmed. The minimization of the sludge retention time in the primary tanks can reduce odour emissions. The appropriate steps taken to reduce odorous emissions during primary treatment are as follows;

- Use of covers to reduce the impact of odour emissions;
- A reduction in the hydraulic retention time;
- Improving the efficiency of the de-sludge process and ensure regular cleaning of the tanks, sumps, scum and grease removal equipment.

The conditions during secondary aerobic treatment should ensure that aerobic conditions are maintained at all times for activated sludge plants. Increasing the aeration can minimize the generation of aerosols.

5.1.7 Sludge handling, storage and thickening

Sludge and bio-solid handling is usually the most significant source of odour release and good sludge management is essential. All raw sludge and bio solids will release odour largely dependent upon age. In general, sludge handling, storage and processing should be enclosed or covered and provided with ventilation to odour abatement equipment.

- Sludge which has been lime treated can generate odour, particularly ammonia, and should be stored under cover to prevent odour generation;
- Sludge should be processed as soon as possible after generation as retention will lead to anaerobic conditions. It is good practice to minimise the potential storage of sludge before treatment and storage for un-stabilised sludge should be limited to a maximum capacity of 24-hours production.

5.1.8 Anaerobic digestion

- The gas produced in an anaerobic digester will be odorous;
- Routinely drain condensate traps to remove water ad avoid back pressure;
- Secondary digesters are often not covered and they can lose up to 10% of methane generated and odorous pollutants.
- The primary digester should reduce the risk of odour generation at the secondary stage. In instances where the operation of the primary digester leads to emissions in the secondary stage, the secondary digester may require covering and venting to an odour and methane treatment facility.

5.1.9 Odour abatement

There is a wide range of odour abatement equipment that can be used to treat emissions of contained air from the SWWTW. There are many factors which will affect the choice of equipment including odour removal efficiency, flow rate and inlet odour concentration, type of chemical species in the odour, variability in flow and load, space requirements and infrastructure.

Any odour abatement equipment installed on contained emissions should have an odour removal efficiency of not less than 95%. However abatement measure has severe cost implications.

6 CONCLUSION

The Air Quality Impact Assessment undertaken for the Southern Waste Water Treatment Works includes a meteorological overview of the area. Meteorological data was obtained from the South African Weather services in Amersfoort for the Jan 2009 – Dec 2013 monitoring period.

An emissions inventory was undertaken with the aim of quantifying emissions associated with the operational processes of the treatment works. Use was made of the Water9 model in order to quantify the emission anticipated to be released.

Dispersion modelling simulations were undertaken using AERMOD. Hourly, daily and annual average concentrations were evaluated and compared to best available standards and guidelines.

Based on the dispersion modelling simulations, the main conclusions can be summarised are as follows;

Phase 1;

- All hourly, daily and annual maximum average concentrations of pollutants were below the respective standards. There were no exceedances of any guidelines.
- The odour perception threshold was below the 50% recognition for a given population size
- The concentrations were highest during the primary treatment particularly from the Primary sedimentation tanks.

Phase 2;

- All hourly, daily and annual average concentrations of pollutants for phase 2 were below the respective standards. There were no exceedances of any guidelines.
- The odour perception threshold was below the 50% recognition for a given population size, with the exception of Hydrogen sulphide which exceeded the detection limit.
- The concentrations were highest at the Primary sedimentation tanks;

There are expected to be nuisance impacts associated with the phased upgrades at the Southern Waste Water Treatment Works. It is primarily the result of the release of hydrogen sulphide into the atmosphere during phase 2. These impacts are noted to extend beyond the site boundary for hydrogen sulphide. All other pollutants evaluated during the assessment were compliant with their guidelines and thresholds.

In conclusion there alternative scenario will have any effect on the air quality situation and emissions will remain the same.

7 REFERENCES

CEPA/FPAC WORKING GROUP, 1998. National Ambient Air Quality Objectives for Particulate Matter. Part 1. Science Assessment Document, A Report by the Canadian Environmental Protection Agency (CEPA) Federal-Provincial Advisory Committee (FPAC)on Air Quality Objectives and Guidelines.

EPA (1996). Users Guide for the Industrial Source Complex (ISC3) Dispersion Models., EPA-454/B-95-003a, *US-Environmental Protection Agency, Research Triangle Park, North Carolina*

EPA (1996). Compilation of Air Pollution Emission Factors (AP-42), 6th Edition, Volume 1, as contained in the AirCHIEF (AIR Clearinghouse for Inventories and Emission Factors) CD-ROM (compact disk read only memory), *US Environmental Protection Agency, Research Triangle Park, North Carolina.*

IRIS (1998). *US-EPA's Integrated Risk Information Data Base*, available from www.epa.gov/iris (last updated 20 February 1998).

Tyson P. D., Preston-Whyte R.A. (2002). The weather and climate of southern Africa. *International journal of climatology, 22, pp 883-884.*

WHO (2000). Guidelines for Air Quality*, World Health Organisation, Geneva.*