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AIR QUALITY IMPACT ASSESSMENT FOR THE PROPOSED MODIFICATION OF THE WELGEDACHT WATER CARE WORKS, GAUTENG

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uMoya-NILU Consulting (Pty) Ltd
P O Box 20622
Durban North 4016

BENTON PILLAY
MARK ZUNCKEL

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EXECUTIVE SUMMARY

The East Rand Water Care Company (ERWAT) owns and operates the Welgedacht Water Care Works (WCW) in Springs in the Ekurhuleni Metropolitan Municipality in Gauteng Province. The facility is situated in the midst of a gold mine, numerous tailings dams, and formal and informal settlements. The residential settlements include Welgedacht (1.4 km, south-east), Bakerton (2.6 km, south), Everest Informal Settlement (2 km, south-west), Dersley (4.7 km, east) and Modder East (3.5 km, north-east).

The WCW has a design capacity of 35 000 m^3/day (35 ml/d), but is under increasing pressure as a result of increasing wastewater volumes draining towards the plant. In order to adequately treat increased wastewater volumes, ERWAT is proposing to expand the Welgedacht WCW by approximately 100 000 m^3/day over the next 30 years. The first phase of the expansion of 50 000 m^3/day is proposed to be commissioned as soon as possible, followed by a further 50 000 m^3/day by 2021. The expansion will consist of the installation of a modular plant (Module 1), which will be located adjacent to the existing WCW. Construction of the additional infrastructure is planned to begin as soon as possible.

uMoya-NULU Consulting was appointed by Savannah Environmental to undertake the specialist air quality assessment for the proposed expansion of the WCW. ERWAT requires authorisation from the Gauteng Department of Agriculture and Rural Development (GDARD) (formally referred to as Gauteng Department of Agriculture, Conservation and Environmental (GDACE)) to undertake the proposed project.

The key aspects of the air quality assessment are the:
(1) development of emissions inventories for baseline and future scenarios,
(2) description of climatology in the vicinity of the WCW,
(3) determination of air quality using dispersion modelling,
(4) comparison of air quality with relevant guidelines and standards,
(5) undertaking of an air quality impact assessment, and
(6) if required, development of mitigation measures.

Emissions inventory:

The USEPA's (United States Environmental Protection Agency's) Water9 model was used to estimate emissions from the Welgedacht WCW for both the baseline and future scenarios. The estimated emission rates of pollutants for the two scenarios are presented in Table A.

Table A: Emissions rates for current and future scenarios	**BASELINE EMISSION RATE**		**FUTURE EMISSION RATE**	
	(kg/year)	**(g/s)**	**(kg/year)**	**(g/s)**
Hydrogen sulphide	128	4.05 x 10^{-3}	310	9.84 x 10^{-3}
Benzene	117	3.72 x 10^{-3}	285	9.06 x 10^{-3}
Toluene	111	3.51 x 10^{-3}	293	8.55 x 10^{-3}
Ethyl benzene	112	3.54 x 10^{-3}	271	8.59 x 10^{-3}
Xylene	99	3.15 x 10^{-3}	243	7.89 x 10^{-3}

It is evident from the table that the emissions of all pollutants will increase with the expansion of the WCW. The average increase in emissions from baseline to future scenarios is 143%, due primarily to the increase in influent throughput and the increase in the number of possible emission sources.

Climatology:

The area is characterised by winds of all directions, with easterly and north-westerly winds being slightly more dominant in the summer months and south-easterly winds dominating slightly more in winter months. Wind speeds drop markedly from the summer to winter months and from day to night. Wind speeds during summer are mostly light (1.8 to 3.34 m/s) to moderate (3.34 to 8.49 m/s). However, strong winds (>8.49 m/s) occur at a low frequency in the easterly and north-westerly directions during summer days. Winds at night are mostly calm. The Welgedacht WCW is located in the summer rainfall region of South Africa and therefore receives most of its rainfall during this period.

Ambient air quality and comparison with guidelines:

Ground-level pollutant concentrations were determined by using the USEPA's Screen3 air dispersion model. Predicted ambient concentrations were compared with health and odour-based standards and guidelines to identify the probable negative effects of exposure to the pollutants. Maximum ambient concentrations of the pollutants are predicted to occur at a distance of 200 m to 250 m from the fenceline of the WCW. These maximum concentrations, which are expected to occur during worst-case meteorological conditions, are as follows:

- H_2S - 8.5 µg/m^3 (30-minute average)
- Benzene - 1.1 µg/m^3 (annual average)
- Toluene - 12.0 µg/m^3 (30-minute average)
- Ethyl benzene - 12.1 µg/m^3 (1-hour average)
- Xylene - 10.6 µg/m^3 (1-hour average)

The only pollutant expected to exceed its standard or guideline is H_2S. The maximum predicted concentration of H_2S of 8.5 µg/m^3 is greater than the WHO odour threshold of 7 µg/m^3. However, this is expected to occur 200 m away from the WCW, where there is currently no exposure to the general public. The predicted maximum H_2S concentration at the nearby Welgedacht residential settlement is 1 µg/m^3, substantially below the odour threshold of 7 µg/m^3. The predicted maximum ambient concentration of benzene, reported as an annual average of 1.1 µg/m^3, is safely below the South African ambient air quality standard of 10 µg/m^3. This implies that no health impacts are expected from exposure to benzene emitted from the proposed WCW expansion. The predicted maximum ambient concentration of toluene of 7.4 µg/m^3 is substantially less than its odour threshold of 1 000 µg/m^3. The predicted maximum concentration of ethyl benzene, also reported as an hourly average, is 6.5 µg/m^3. The predicted maximum concentration of xylene of 6.0 µg/m^3 is also substantially below its health-based guideline value of 2 300 µg/m^3. Exposure to these pollutants will therefore not be detrimental to the health of people working and living in the vicinity of the Welgedacht WCW.

Impact assessment:

The expansion of the Welgedacht WCW was assessed in terms of direct, indirect and cumulative impacts for the construction and decommissioning, and operational phases of the WCW. Direct impacts result from exposure to dust emitted during construction and decommissioning. The impact of dust is cumulative as the Modderfontein East Gold Mine and numerous tailings dams are also sources of dust. However, these cumulative dust impacts will only apply to the construction and decommissioning phases, which are relatively short in duration.

Direct impacts will also result from the inhalation of hazardous (benzene, toluene, ethyl benzene and xylene) and odorous (hydrogen sulphide) pollutants emitted during the operational life of the WCW. The impacts resulting from these pollutants are not cumulative in nature. No indirect impacts from the operation, commissioning and decommissioning of the WCW are envisaged. The summaries of air quality impacts during operation and construction and decommissioning are presented in the tables below.

Table B: Summary of air quality impacts during operation of the WCW

Nature: Air quality impacts are caused by exposure to benzene, toluene, ethyl benzene, xylene (BTEX) and hydrogen sulphide, which are contained in trace amounts in the influent to the WCW. The inhalation of the benzene, toluene, ethyl benzene and xylene at concentrations exceeding health-based air quality standards, will result in negative health impacts. The inhalation of hydrogen sulphide and toluene at concentrations exceeding odour-based air quality thresholds, will result in negative quality of life or nuisance impacts.		
	Without mitigation	**With mitigation**
Extent	Limited to site and immediate surroundings (1)	N/A
Duration	Long-term (4)	N/A
Magnitude	Minor (2)	N/A
Probability	Low (2)	N/A
Significance (positive or negative)	**Low (14) and negative**	N/A
Reversibility	No	N/A
Irreplaceable loss of resources?	No	N/A
Can impacts be mitigated?	Not	N/A
Mitigation: None		
Cumulative Impacts: None		
Residual Impacts: None		

Table C: Summary of air quality impacts during construction and decommissioning of the WCW*Nature:* Cumulative air quality impacts are caused by exposure to dust generated during construction and decommissioning and by other existing sources in the vicinity of the WCW. Dust has a nuisance impact and negatively affects quality of life by

causing soiling, contamination, structural corrosion and damage to precision equipment, machinery and computers.		
	Without mitigation	**With mitigation**
Extent	Limited to site and immediate surroundings (1)	Limited to site and immediate surroundings (1)
Duration	Immediate (1)	Immediate (1)
Magnitude	Moderate (6)	Moderate (2)
Probability	High (4)	High (4)
Significance (positive or negative)	**Medium (32) and negative**	**Low (16) and negative**
Reversibility	No	No
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes	Yes
Mitigation: Dust management plan.		
Cumulative Impacts: None		
Residual Impacts: None		

From the scoring above, it is evident that the significance of all impacts during the operational phase is low, while the significance of cumulative impacts during construction and decommissioning is medium. Implementation of basic dust control measures during construction and decommissioning could reduce the significance of impacts from medium to low.

Mitigation:

A basic dust management plan is considered adequate to mitigate for dust impacts during construction and decommissioning. The plan should entail the following measures:

- Removal of vegetation limited to only what is necessary to accommodate construction activities.
- Traffic control measures to limit vehicle-entrained dust from unpaved roads e.g. by limiting vehicle speeds and by restricting traffic volumes.
- Re-vegetation of the construction terraces once all the construction is completed, and when the laydown area is vacated.
- Spray unpaved site roads with water routinely throughout construction to contain dust. Water can be used as a wetting or binding agent on the unpaved roads and terraces.

GLOSSARY OF ACRONYMS, TERMS AND UNITS

ADWF	Average dry weather flow
ADF	Average daily flow
COD	Chemical oxygen demand
DEA	Department of Environmental Affairs
DWA	Department of Water Affairs
EIA	Environmental Impact Assessment
Emission	The direct or indirect release of substances, vibrations, heat or noise from individual or diffuse sources in an installation into the air, water or land.
ERWAT	East Rand Water Care Company
Hazard	A property of a substance or a situation in which particular circumstances could lead to harm.
m^3/day	Cubic meters per day
Odorants	Odorous substances emitted from a site.
$\mu g/m^3$	Micrograms of gaseous substance in one cubic metre of total gas
Screen3	US-EPA screening model for dispersion modelling
USEPA	United States Environmental Protection Agency
Water9	US-EPA emission estimation model for wastewater treatment plants
WHO	World Health Organization

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1. INTRODUCTION AND BACKGROUND INFORMATION

1.1 Background to Study

The East Rand Water Care Company (ERWAT) owns and operates the Welgedacht Water Care Works (WCW) in Springs in the Ekurhuleni Metropolitan Municipality in Gauteng Province. The WCW has a design capacity of 35 000 m^3/day (35 ml/d), but is under increasing pressure as a result of increasing wastewater volumes draining towards the plant. In order to adequately treat the increased wastewater volumes, ERWAT is proposing to expand the Welgedacht WCW by approximately 100 000 m^3/day over the next 30 years. The first expansion of 50 000 m^3/day is proposed to be commissioned as soon as possible, followed by a further 50 000 m^3/day by 2021. The expansion of the plant is proposed to be undertaken adjacent to the existing WCW. The footprint of the proposed expansion will be approximately 50 072 m^2 in extent, and will be located to the south-west, adjacent to the existing WCW, within the Farm Welgedacht 74IR Portion 82, which is owned by ERWAT. Due to the urgent need for the initial 50 000 m^3/day expansion due to the increasing demand on the WCW, construction of this additional infrastructure is planned to begin as soon as possible.

The expansion of the existing plant will ensure that the increasing wastewater volumes can be adequately treated while maintaining the quality of effluent to the required effluent standards (as stipulated by the Department of Water Affairs (DWA)), DWA intend to institute stricter measures to regulate the amount of chemical oxygen demand, nitrates and suspended solids found in treated water. A number of options were considered for the discharge of the additional effluent from the WCW. These included:

- Discharge to the Blesbokspruit, as is currently the case, and the option selected.
- Discharge to the Blesbokspruit at a point below the RAMSAR site.
- Transfer of the effluent to the Olifants or Crocodile catchment.
- Sale and re-use of this effluent by other users within the catchment.

The facility is situated in the midst of a gold mine, numerous tailings dams, and formal and informal settlements. The residential settlements include Welgedacht (1.4 km, south-east), Bakerton (2.6 km, south), Everest Informal Settlement (2 km, south-west), Dersley (4.7 km, east) and Modder East (3.5 km, north-east).

Figure 1.1: Locality map of the study area showing the relative position of the site

uMoya-NULU Consulting was appointed by Savannah Environmental to undertake an air quality impact assessment for the proposed expansion. The main objective of the study is to provide an air quality impact assessment of the potential impacts of the proposed expansion on the surrounding ambient air quality.

In terms of the Environmental Impact Assessment (EIA) Regulations published in terms of Section 24(5) of the National Environmental Management Act (NEMA, No 107 of 1998), ERWAT requires authorisation from the Gauteng Department of Agriculture and Rural Development (GDARD) (formally referred to as Gauteng Department of Agriculture, Conservation and Environmental (GDACE)) for undertaking the proposed project. As part of this process, a specialist air quality investigation is required.

1.2 General Description of Current Operation and Proposed Modifications

The Welgedacht WCW has been in operation since 2003. The existing plant has a design capacity of 35 000 m^3/day with the following basic process flow scheme:

- Three sets of Archimedean screw pumps lift the raw water into the inlet works in two stages.
- Two coarse screens followed by two automatic fine screens and screw compactor, are used to remove rags from the influent.
- Grit is removed in two automatic Pista degritters.

- The reactor utilises a 5-stage Phoredox process configuration, with the following zones: anaerobic anoxic, aerobic, second anoxic followed by re-aeration.
- Aeration is by 16 surface mounted aerators and mixing by 13 submersible mixers.
- Effluent from the reactor flows into three parallel biological clarifiers from which the underflow is recycled back to the anaerobic zone of the reactor.
- Excess sludge is wasted from the underflow.
- The clarifiers overflow to three chemical clarifiers where ferric chloride or polymers can be used for additional phosphate removal. Chlorine is used to disinfect the water, and excess chlorine is removed by automated sulphonation.
- Sludge handling includes the use of three linear gravity screens followed by three belt presses, after which the sludge is dried on sludge drying beds.

The addition of two new modules, Modules 1 and 2, each of 50 000 m^3/day design capacity, will constitute the expansion of the WCW. The expansion will commence with the installation of Module 1, followed later by the installation of Module 2. Module 1 will comprise the following key components:

- Three new dual stage screws lift trains of 75 000 m^3/day duty capacity.
- Two new screening channels equipped with a duty/standby configuration, each capable of handling peak design flow of 3.0 x 50 000 m^3/day ADWF.
- Screw-type screening press.
- Three parallel vortex degritters for treating 50 000 m^3/day ADWF.
- Balancing tank of 10 500 m^3 volume.
- Two 34 m diameter primary settling tanks.
- Two biological nutrient removal (BNR) reactors.
- Four 36 m diameter clarifiers.
- Two ferric chloride holding tanks.
- Dual medium gravity filters for precipitate removal.
- Two chlorine contact tanks of 1 350 m^3 capacity.
- Four digesters for treating sludge.

1.3 Description of Environmental Issues

The description of environmental issues will relate solely to air quality impacts associated with the construction (and decommissioning) and operation of the Welgedacht WCW.

Construction and Decommissioning:

Direct impacts during construction and decommissioning will result primarily from exposure to dust. Dust emissions during construction result mainly from earth moving activities (scraping, compacting, excavation, grading), construction of the settling tanks, movement of construction vehicles and back-fill operations. Dust emissions during decommissioning result from the demolition of concrete tanks, earth moving activities (scraping, compacting, excavation, grading), movement of construction vehicles and back-fill operations. During windy conditions, this dust could potentially have negative impacts beyond the construction site. Contractors and site agents may be required to adopt dust control measures to reduce dust emissions to an acceptable level while carrying out construction works.

The quantity of dust emitted is not expected to add significantly to dust emissions from other existing sources in the area. The other sources identified, which are substantially larger than the WCW, are the gold mine and mine tailings dams. Dust emission from the WCW will thus be insignificant and assessed qualitatively.

Operation:

The key sources of hazardous air pollutants emitted from wastewater treatment processes include:

- Aeration during primary treatment,
- Aerobic digestion,
- Mechanical thickening of sludge,
- Anaerobic digestion,
- Sludge drying.

The specific type of air emissions arising from operations is highly dependent on the composition of the influent streams. The USEPA identifies the key hazardous air pollutants emitted from wastewater treatment plants as benzene, toluene, xylenes, methylene chloride, ethyl benzene, chloroform, tetrachloroethylene and naphthalene. Of these, benzene, a carcinogen, has been identified by the Department of Environmental Affairs (DEA) as a crucial pollutant in the South African context with an annual standard of 10 $\mu g/m^3$, to be reduced to 5 $\mu g/m^3$ in 2014 (DEA, 2009). The pollutants listed above are formed by the volatilization of organic compounds in the treatment process. Industrial processes are often the source of organic compounds present in wastewater. Many of these compounds are associated with health effects, and also cause safety problems due to common characteristics such as flammability.

Wastewater treatment plants are also associated with the emission of odorous compounds, the most notable of which is hydrogen sulphide (H_2S). H_2S is formed through the anaerobic bacterial reduction of sulphates and sulphur-containing organic compounds. Sulphur is available in wastewater treatment plants as either organic sulphur from faeces or inorganic sulphur from the sulphate ion, which is prevalent in nearly all water. H_2S causes an offensive rotten egg smell, which is detected at very low concentrations. It can also be toxic and even fatal at higher concentrations, although more common symptoms include dizziness, headaches, and nausea. H_2S can also corrode pipes, causing expensive maintenance fixes. The World Health Organisation (WHO, 2000), recommends a 30-min average ambient air concentration not exceeding 7 $\mu g/m^3$ as the odour threshold limit for H_2S.

No dust emissions are anticipated from the operational site. This study will therefore consist of a quantitative assessment of the following air pollutants:

- Benzene
- Toluene
- Ethyl benzene
- Xylene
- H_2S

The emission rates of these compounds will be estimated, their ambient concentrations modelled and their concentrations compared with health-based standards or guidelines.

2. TERMS OF REFERENCE

The terms of reference for the air quality specialist study relate to assessing the air quality impacts due to the proposed modifications to the Welgedacht WCW. The study intends to:

- Develop emissions inventories for both the baseline scenario using current data and the future scenario using data post the modifications to the WCW.
- Estimate the baseline ambient air quality using baseline emissions.
- Estimate future ambient air quality using future emissions.
- Compare the ambient concentrations of any identified pollutants with health or odour-based standards or guidelines.
- Assess direct, indirect and cumulative impacts of the modifications to the WCW. This will entail an assessment of the nature, extent, duration, magnitude, probability and subsequently the significance of air quality impacts during the construction and operational phases of the project.

3. APPROACH TO STUDY

3.1 Development of Emissions Inventories

The estimation of emissions was undertaken for baseline and future scenarios. Emissions from current operations represent the baseline emissions inventory, whereas emissions from future operations represent the future emissions inventory. Furthermore, the estimation of future emissions is sub-divided into construction and decommissioning phase emissions, and operational phase emissions. During the construction and decommissioning phase of the project, dust is produced from the movement of construction vehicles and general construction activities (excavating, demolishing, laying concrete, etc.). But these are considered to be insignificant as there will not be a significant increase in vehicular movement to the facility. General construction activities like excavation during the construction and installation of Module 1 are also expected to be limited, thus producing low dust emissions.

The USEPA has developed a model to estimate emissions from wastewater treatment plants called Water9. The Water9 model is highly credible and was selected for this study to estimate emissions of H_2S, benzene, toluene, ethyl benzene and xylene from the Welgedacht WCW for both the baseline and future scenarios. The model uses a graphical interface that corresponds to engineering flow diagrams. The model contains a preloaded database listing of many of the common organic pollutants and their properties and allows separate emission estimates to be made for each individual pollutant identified as a constituent of the waste. The emission calculations are based on the properties of the pollutant, its concentration in the waste, and the path of the waste through the collection and treatment system.

Input data for the Water9 model was provided by ERWAT. The types of data required as input to the model relate primarily to the configuration and operation of the treatment plant and include:

- Influent data - flow rate, solids content, oil content, temperature, content of pollutant compounds, etc.
- Process equipment data – dimensions, operating temperature, area of agitation, power of agitator, etc.

3.2 Estimation of Baseline Ambient Air Quality

Baseline air quality represents the current status of air quality in the region. The measurement of pollutant concentrations in the ambient environment provides the most accurate determination of baseline air quality. The Ekurhuleni District Municipality continuously measures air quality using its ambient air quality monitoring network, which consists of six monitoring stations located throughout the municipality. The Etwata and Springs monitoring stations are located approximately 8.5 km to the north and 10.5 km to the south-west of the Welgedacht WCW, respectively. These distances are considered excessive to adequately represent the air quality in the vicinity of the Welgedacht WCW. The modelling of baseline air quality is thus necessary as no representative measurement data is available.

Baseline air quality was thus determined by using the USEPA's Screen3 air dispersion model. The Screen3 model is the USEPA's current regulatory screening model for new installations and other air permitting applications. The Screen3 model is based on steady-state Gaussian plume algorithms. It is applicable for estimating ambient impacts from point, area, and volume sources out to a distance of about 50 kilometers.

The model is used to determine ground level concentrations of benzene, toluene, ethyl benzene, xylene and H_2S downwind of the WCW. The inputs to the model are baseline emission rates, estimated by using the method described in 3.1 above. Wind data, which was acquired from the South African Weather Service for the OR Tambo International Airport weather station was then used to determine the areas of maximum impact.

3.3 Estimation of Future Ambient Air Quality

Future ambient air quality is predicted by also using the USEPA's Screen3 air dispersion model. The model is used to determine ground level concentrations of benzene, toluene, ethyl benzene, xylene and H_2S downwind of the WCW. The inputs to the model are future emission rates estimated by the method described in 3.1 above. Wind data from the Springs weather station of SAWS (South African Weather Service) are used to determine the areas of maximum impact.

Ground-level concentrations resulting from the estimated emission rates are modelled for two scenarios, namely, a summer scenario and a winter scenario, using worst-case meteorological conditions in both cases. Ground level concentrations are plotted as a function of distance from the source and estimated concentrations tabulated for 1, 2, 3, 4 and 5 km distances away from the source for the baseline and future scenarios.

Emissions from wastewater treatment plants are classified as area sources and will be inputted as such in the Screen3 model. The model is also prompted to consider all meteorological conditions and reports the highest possible hourly-average ambient concentrations.

3.4 Comparison of Air Quality with Health and Odour-Based Guidelines

Air quality guidelines and limits are fundamental to effective air quality management, providing the link between the potential source of atmospheric emissions and the user of that air at the downwind receptor site. Ambient air quality standards indicate generally safe exposure levels for the majority of the population, including the very young and the elderly, throughout an individual's lifetime. Air quality standards are typically set for common air pollutants which cause widespread exposures. Particulate matter, sulphur dioxide, nitrogen dioxide, carbon monoxide, lead and ozone are classified by most countries as 'criteria pollutants', for which air quality standards are set.

The aim of the comparison is to identify the probable negative effects of exposure to a hazardous substance. The nature of the environment surrounding the WCW, the concentrations of the hazardous pollutants and the effects of the pollutants on human health forms the basis of the assessment of the risk posed to human health.

Future ambient air quality determined through dispersion modelling is compared to the relevant South African ambient air quality standards and World Health Organisation (WHO) guidelines (Table 3.1) contained in the World Bank/International Finance Corporation (IFC) environmental health & safety guideline values (WB/IFC, 2007).

Table 3.1: Ambient air quality guidelines

POLLUTANT	AVERAGING PERIOD	GUIDELINE VALUE (µg/m^3)	SOURCE
Benzene	Calendar year	5	SANS 1929
Toluene	24-hour 30-min	7 500 (CNS effect) 1 000 (odour detection)	WHO
Xylene	1-hour 24-hour	2 300 700	Alberta, Canada
Ethyl benzene	1-hour	2 000	Alberta, Canada
Hydrogen sulphide	30-min 24-hours	7 (odour threshold) 150	WHO

3.5 Assessment of Air Quality Impacts

An assessment is conducted of the significance of direct, indirect and cumulative air quality impacts from the proposed modifications. The assessment considers the nature, extent, duration, probability and severity of air quality impacts, which leads to the determination of the significance of the impacts.

A look at the nature of impacts examines what causes the effect, what is affected and how it is affected. The extent of impacts involves determining whether the impacts are local or regional and scoring the impacts accordingly from 1 to 5. The duration of impacts considers the lifetime of the impacts, be they very short (0 - 1 years), short (2 – 5 years), medium-term (5 – 15 years), long-term (> 15 years) and permanent. Scores of 1 to 5 are also allocated. The magnitude of impacts, quantified on a scale of 0 to 10, examines the magnitude of the impacts as no effect, minor effect, low effect, moderate effect, high effect and very high effect. The probability of occurrence examines the likelihood of the impact actually occurring. Probability is also be estimated on a scale of 1 to 5, where 1 is very improbable, 2 is improbable, 3 is probable, 4 is highly probable, and 5 is definite.

The significance of impacts is derived from an assessment of all of the above and is categorised as low, medium or high.

4. CLIMATOLOGY OF STUDY REGION

The dispersion of pollutants released into the atmosphere is dependent on wind characteristics like wind speed and wind direction in the near-surface layer, and atmospheric stability. The wind rose is a diagram that illustrates the frequency of wind speed and direction measurements in the 16 cardinal wind directions for a given period. Wind direction is indicated as from where the wind blows (e.g. easterly winds blow from the east); the dashed circles indicate the frequency of occurrence of hourly wind in bands of 4%; the coloured bars indicate the wind speed classes. The general wind patterns in the region of the Welgedacht WCW are illustrated in Figures 4.1 and 4.2 with the aid of wind roses for summer (January, February and December) and winter (June, July and August). A distinction is also made between day and night wind behaviour. The wind roses are based on meteorological data from the SAWS (South African Weather Service) weather station at Springs for 2004, 2005 and 2006.

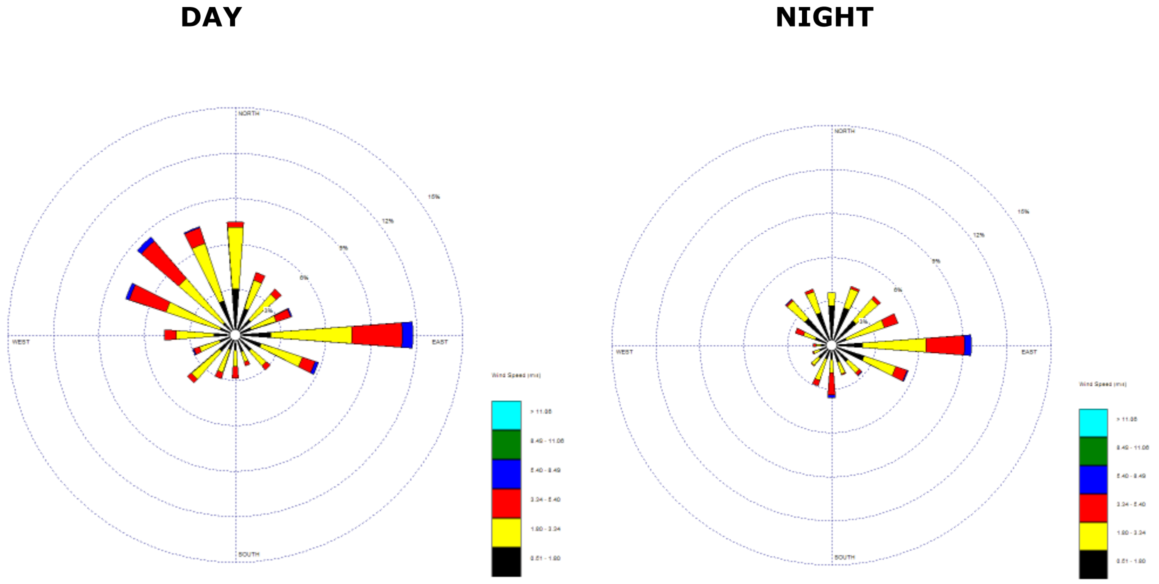

Figure 4.1 – Wind roses for summer

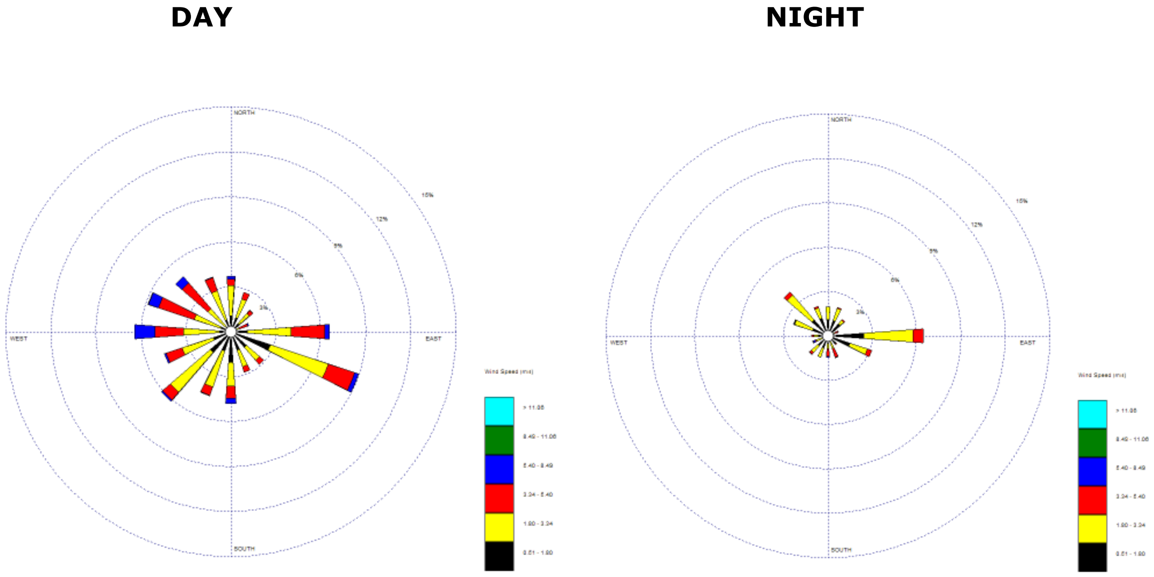

Figure 4.2 – Wind roses for winter

The area is characterised by winds of all directions with easterly and north-westerly winds being slightly more dominant in the summer months and south-easterly winds dominating slightly more in winter months. Easterly winds occur both during summer days at an overall frequency of 12% and summer nights at an overall frequency of 9%. The north-westerly winds however occur primarily during the day, with no distinct dominance at night. The winds from the various directions appear to be more evenly spread at night.

The pattern of wind directions during winter also shows a tendency of winds in all directions to be present. However, in the case of winter days, south-easterly dominate slightly at a frequency of 9%. This differs slightly from the summer months when easterly winds exhibit greater dominance. The day-time dominance of south-easterly winds subsides at night and is replaced by easterly winds.

Wind speeds drop markedly from the summer to winter months and from day to night. Wind speeds during summer are mostly light (1.8 to 3.34 m/s) to moderate (3.34 to 8.49 m/s). However, strong winds (>8.49 m/s) occur at a low frequency in the easterly and north-westerly directions during summer days. As expected, wind speeds exhibit a tendency of being lower at night during summer. During the days in winter, a higher frequency of strong winds occur than during the days in summer. However, these winds also subside quite notable a night. The winds at night are mostly calm.

Table 4.1 presents the frequency distribution for the various wind directions and wind speeds.

Table 4.1: Frequency distribution for winds at Springs (South African Weather Service: 2004, 2005, 2006).

DIRECTION	SPEED (m/s)						
	0.51 - 1.8	**1.8 - 3.34**	**3.34 - 5.4**	**5.4 - 8.49**	**8.49 - 11.06**	**>11.06**	**Total**
N	3.06%	3.07%	0.41%	0.05%	0.00%	0.00%	**6.59%**
NNE	2.38%	2.14%	0.53%	0.01%	0.00%	0.00%	**5.06%**
NE	1.89%	1.98%	0.41%	0.01%	0.00%	0.00%	**4.28%**
ENE	0.86%	1.77%	1.25%	0.17%	0.00%	0.00%	**4.04%**
E	3.13%	6.22%	3.58%	1.07%	0.03%	0.00%	**14.04%**
ESE	3.55%	4.65%	1.46%	0.23%	0.00%	0.00%	**9.90%**
SE	1.98%	1.18%	0.28%	0.02%	0.00%	0.00%	**3.46%**
SSE	1.59%	1.31%	0.54%	0.02%	0.00%	0.00%	**3.46%**
S	1.65%	1.90%	1.53%	0.25%	0.00%	0.00%	**5.34%**
SSW	1.79%	2.33%	0.43%	0.03%	0.00%	0.00%	**4.58%**
SW	2.41%	3.12%	0.61%	0.03%	0.00%	0.00%	**6.17%**
WSW	1.43%	1.89%	0.72%	0.11%	0.01%	0.00%	**4.16%**
W	1.54%	2.49%	1.27%	0.52%	0.01%	0.00%	**5.84%**
WNW	1.66%	3.42%	2.49%	0.52%	0.02%	0.00%	**8.11%**
NW	1.99%	3.87%	2.11%	0.47%	0.00%	0.00%	**8.44%**
NNW	2.42%	3.00%	1.08%	0.04%	0.00%	0.00%	**6.54%**

DIRECTION	SPEED (m/s)						
	0.51 - 1.8	1.8 - 3.34	3.34 - 5.4	5.4 - 8.49	8.49 - 11.06	>11.06	Total
Totals	**33.34%**	**44.35%**	**18.70%**	**3.55%**	**0.07%**	**0.00%**	**100.00%**

Table 4.1 provides further evidence of the relatively even spread of wind directions (see right-most column) based on the three years of data, with the slightly higher frequency of easterly and north-westerly wind directions. Also evident is the domination of calm and light winds (bottom row) which occur at a total frequency of 77.69%. Strong winds occur at a frequency of only 0.07%.

The summer climate is mild and neither too hot nor humid. The area is located in the summer rainfall region of SA and therefore receives most of its rainfall during this period. The winter months are characterised by intermittent cold spells, especially during July and August, and occasionally during September. The highest monthly rainfall occurs in November and January while the months of May to August experience little rainfall. December and January are the hottest times of the year.

Climatic conditions and implications for air quality:

The diffusion of pollutants into the atmosphere is dependent on climatic conditions and local atmospheric stability, which may vary on a daily and seasonal basis. During winter, the Highveld is dominated by a high-pressure system, which is characterised by subsidence that results in clear skies, light winds, and temperature inversions. These conditions are unfavourable for pollution dispersion and diffusion. During summer, moist unstable conditions dominate, resulting in conditions that are conducive to rapid pollution dispersion and air mixing. The Highveld, and more specifically the Ekhuruleni Metropolitan Municipality, are slightly dominated by easterly and north-westerly winds in summer and south-easterly winds in winter. This is primarily due to the southerly migration of the high pressure cell, which also results in winds becoming more north-easterly and more north-westerly in spring and autumn respectively.

Temperature inversions:

Temperature inversions on flat terrain usually occur under clear skies, and calm and dry conditions through radiational loss of heat. Surface temperature inversions occur at night and frequently during winter. Temperature inversions result in stable air conditions below the temperature inversion and limit mixing of air between air above and below the inversion layer. This results in a build-up of pollutants below the inversion boundary layer that may exceed acceptable pollution levels. Tosen and Pearse (1987) showed that surface inversions occur on between 80 and 90% of winter nights when early morning inversions vary between 3 to 11 in strength and from 100 to 400 m from ground level[9]. In the summer the surface inversions are not as frequent and they are not as intense or as deep as in the winter.

5. ASSUMPTIONS AND LIMITATIONS

The following limitations are associated with this study:

- Screen3 only calculates hourly ambient concentrations at ground level. Therefore, modelled concentrations for other averaging periods were calculated using an empirical formulae developed by the USEPA.
- Concentrations of 0.01 ppm in the influent were used in the emissions estimation model for benzene, toluene, ethyl benzene, xylene and H_2S, although their actual concentration are <0.01 ppm.
- A concentration of 1 ppm in the influent was used in the emissions estimation model for oil, although its actual concentration was <1 ppm.
- A concentration of 1 000 ppm in influent was used in the emissions estimation model for dissolved solids, although its actual concentration was <1000 ppm.
- The impact assessment was based on worst-case meteorological conditions. It is therefore logical that predicted ambient concentrations are higher than would actually be expected.

6. EMISSIONS INVENTORY

The emission rates of H_2S, benzene, toluene, ethyl benzene and xylene are dependent on the concentrations of these pollutants in the influent processed by the treatment works, and the configuration of the process.

The concentrations of pollutants in the influent to Welgedacht WCW are below the detection limit of 0.01 ppm. However, in the estimation of emission rates, the value of 0.01 ppm is used to provide a conservative estimate. Emission rates are determined for the baseline and future scenarios. A feed rate of 35 000 m^3/day is used for the baseline scenario, whereas a feed rate of 85 000 m^3/day is used for the future scenario.

The determination of baseline emissions considered the existing plant configuration, consisting of a course screen, a mechanical screen, a grit separator, a reactor, six clarifiers, a mixer and a sump. The design and operational details relating to these process units were inputted in the Water9 model. The determination of future emissions considered the existing plant configuration, in addition to the proposed Module 1 configuration, consisting of two screening channels, three vortex degritters, a balancing tank, two primary settling tanks, two BNR reactors, four clarifiers and four digesters.

The emission rates of H_2S, benzene, toluene, ethyl benzene and xylene, estimated by using the WATER9 model, are presented in Table 5.1.

Table 5.1: Emissions rates for current and future scenarios

	BASELINE EMISSION RATE		**FUTURE EMISSION RATE**	
	(kg/year)	**(g/s)**	**(kg/year)**	**(g/s)**
Hydrogen sulphide	128	4.05×10^{-3}	310	9.84×10^{-3}
Benzene	117	3.72×10^{-3}	285	9.06×10^{-3}
Toluene	111	3.51×10^{-3}	293	8.55×10^{-3}
Ethyl benzene	112	3.54×10^{-3}	271	8.59×10^{-3}
Xylene	99	3.15×10^{-3}	243	7.89×10^{-3}

From Table 5.1, it is clear that emission rates are higher for the future scenario than for the baseline scenario. This is primarily attributable to two main reasons:

- The increase in plant throughput from 35 000 m^3/day for the baseline scenario with the addition of 50 000 m^3/day for phase one, making the plant an 85 000 m^3/day for the future scenario means that more pollutants will enter the WCW in the influent after the proposed expansion.
- The introduction of new equipment with the proposed installation of Module 1 means that there will be an increase in the number of possible emission sources. Equipment such as the degritters, settling tanks, reactors, clarifiers and digesters will form part of Module 1.

The average increase in emission rates from baseline to future scenarios is 143%.

7. AMBIENT AIR QUALITY

The modelled ambient concentrations for the baseline and future scenarios for all the pollutants considered in this study are graphically presented in the graphs below as concentration curves and concentric circles. The concentration curves are presented in Figures 7.1, 7.3, 7.5, 7.7 and 7.9, up to a distance of 5 km around the plant for baseline and future scenarios. Pollutant concentrations are plotted against the distance from the fenceline of the WCW. The black and blue curves represent the baseline and future scenarios, respectively. Screen3 reports pollutant concentrations as hourly averages for worst-case meteorological conditions. However, in order to make meaningful comparisons with ambient standards and guidelines, it is necessary to convert the modelled hourly concentrations to time averages in which the standards and guidelines are set. The USEPA has developed an empirical formula (see footer) for this very purpose. This formula is used to convert the modelled hourly averages of benzene to annual averages, and the modelled hourly averages of H_2S and toluene to 30-minute averages.

The concentric curves are presented in Figures 7.2, 7.4, 7.6, 7.8 and 7.10 and represent concentration plots at 1 km intervals up to a distance of 5 km from the Welgedacht WCW for worse-case meteorological conditions only for the future scenario, when the highest ambient concentrations are expected. Each circle represents the maximum potential concentration at 1 km intervals from the WCW. Screen3 does not take wind direction and actual topography into account; hence these concentrations are given for a specified distance, but may occur in any direction from the source. The prevailing wind directions are then used to obtain an indication of the general direction in which the pollution plumes would travel.

The Duffee, O'Brien and Ostojic stability dependent formula (Duffee *et al.*, 1991) is used to convert modelled values to alternative averaging times according the following equation:

$C_1 = C_0 \times (t_0/t_1)^n$

Where:
C_1 = concentration for the longer time-averaging period;
C_0 = concentration for the shorter time-averaging period;
t_1 = the longer averaging time
t_0 = the shorter averaging time
n = stability class coefficient (0.2)

Hydrogen sulphide:

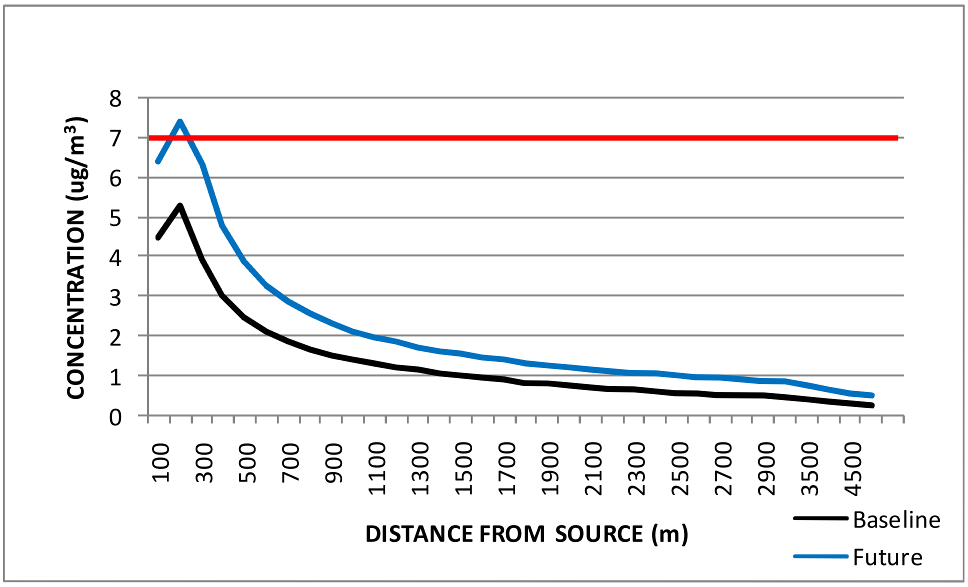

Figure 7.1: Maximum 30-min ambient concentrations of H_2S for baseline and future scenarios as a function of distance away from the WCW

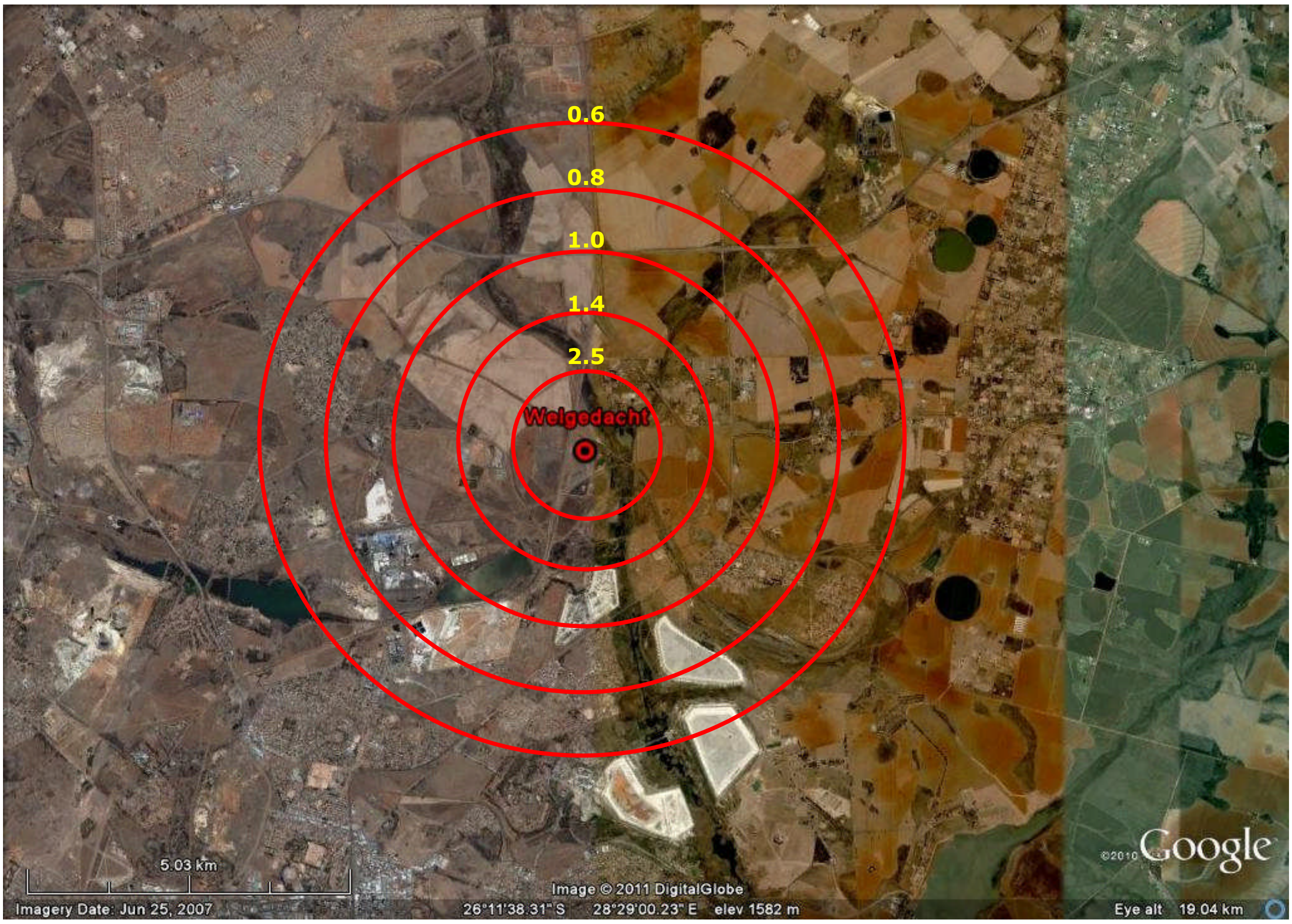

Figure 7.2: Predicted maximum 30-min ambient concentrations of H_2S within a 5 km radius of the WCW for the future scenario

Benzene:

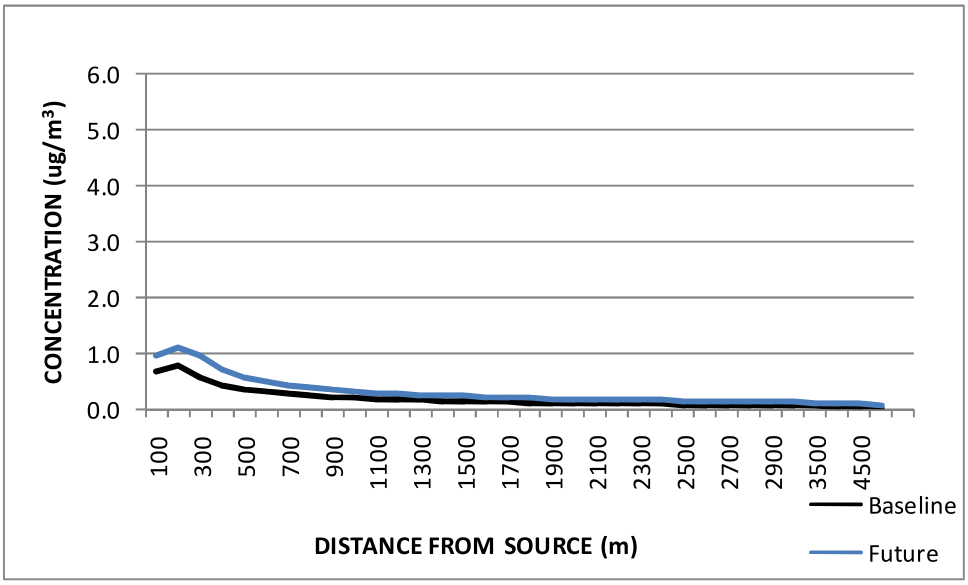

Figure 7.3: Maximum annual ambient concentrations of benzene for baseline and future scenarios as a function of distance away from the WCW

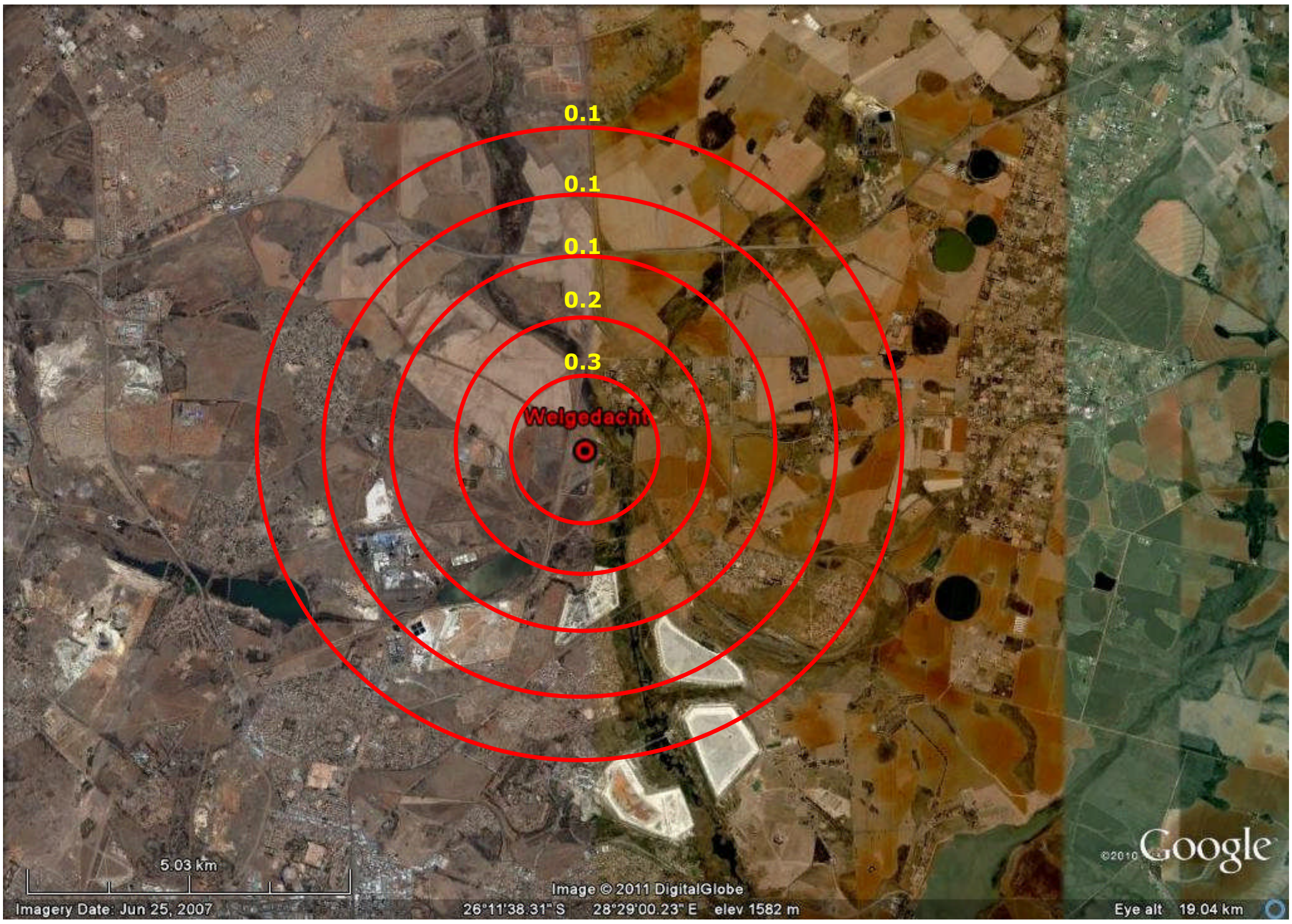

Figure 7.4: Predicted maximum annual concentrations of benzene within a 5 km radius of the WCW for the future scenario

Toluene:

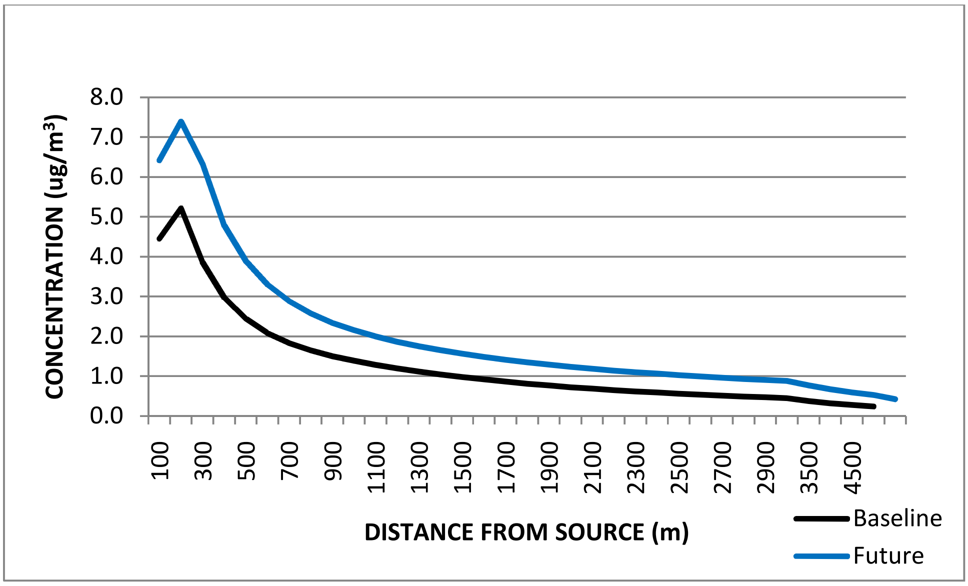

Figure 7.5: Maximum 30-min ambient concentrations of toluene for baseline and future scenarios as a function of distance away from the WCW

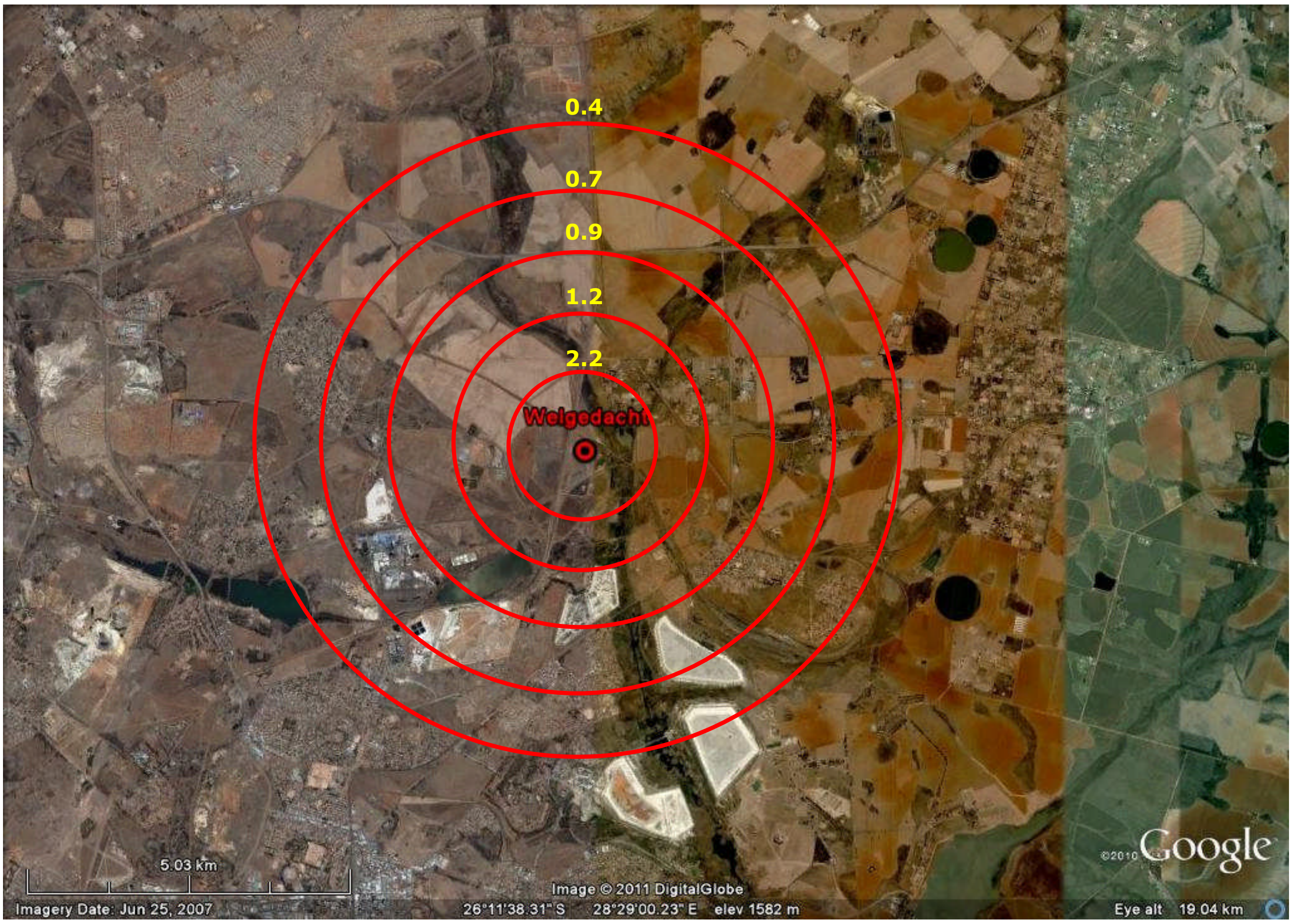

Figure 7.6: Predicted maximum 30-min concentrations of toluene within a 5 km radius of the WCW for the future scenario

Ethyl benzene:

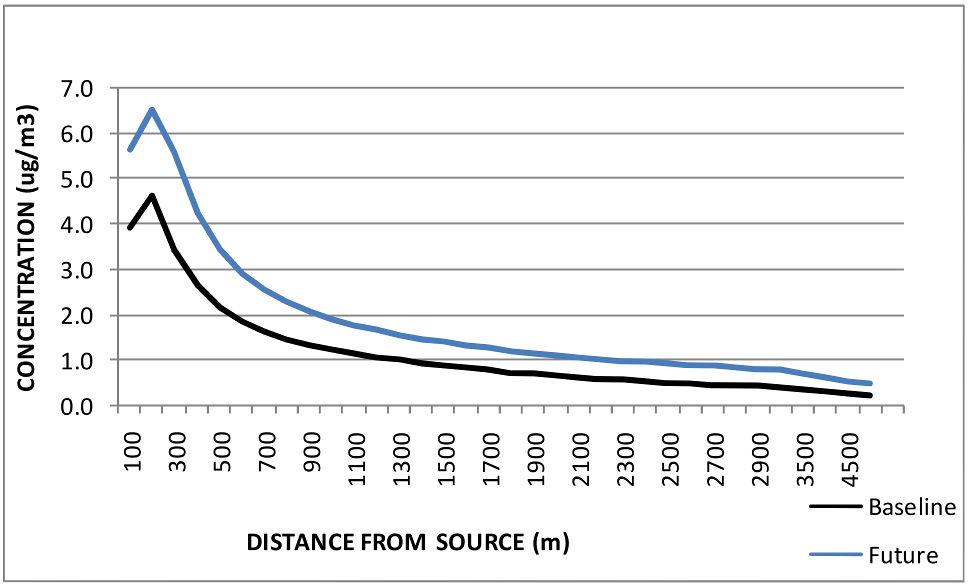

Figure 7.7: Maximum hourly ambient concentrations of ethyl benzene for baseline and future scenarios as a function of distance away from the WCW

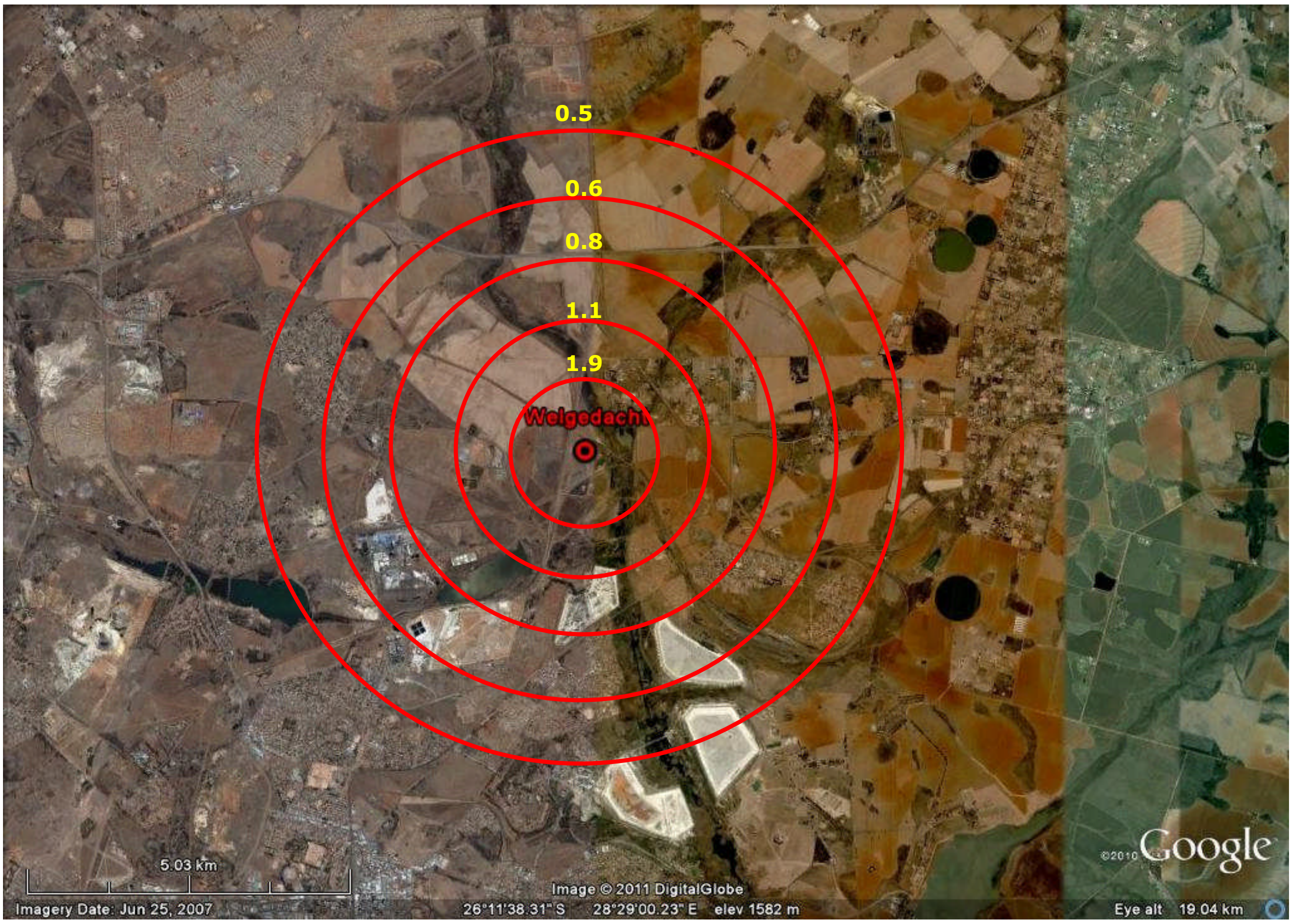

Figure 7.8: Predicted hourly maximum concentrations of ethyl benzene within a 5 km radius of the WCW for the future scenario

Xylene:

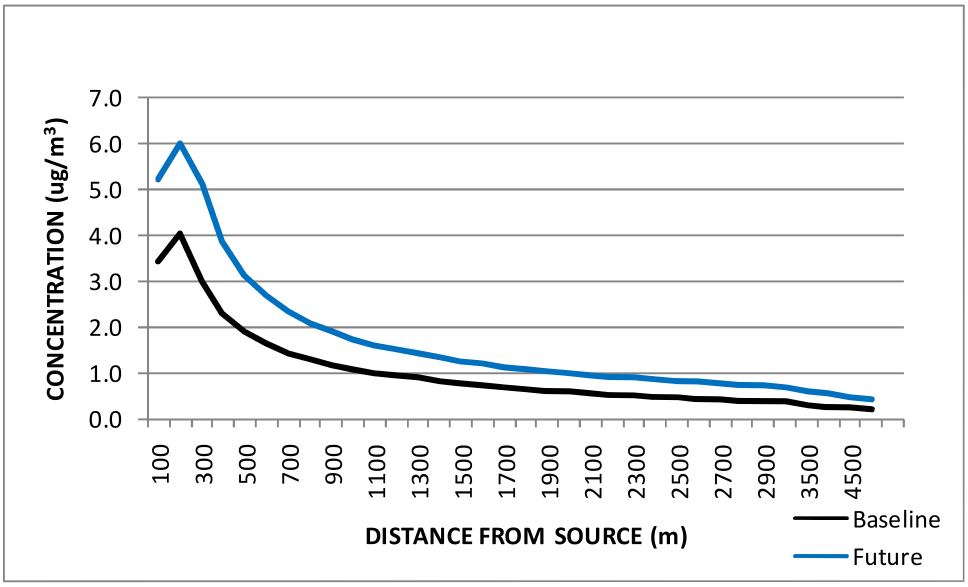

Figure 7.9: Maximum hourly ambient concentrations of xylene for current and future scenarios as a function of distance away from the WCW

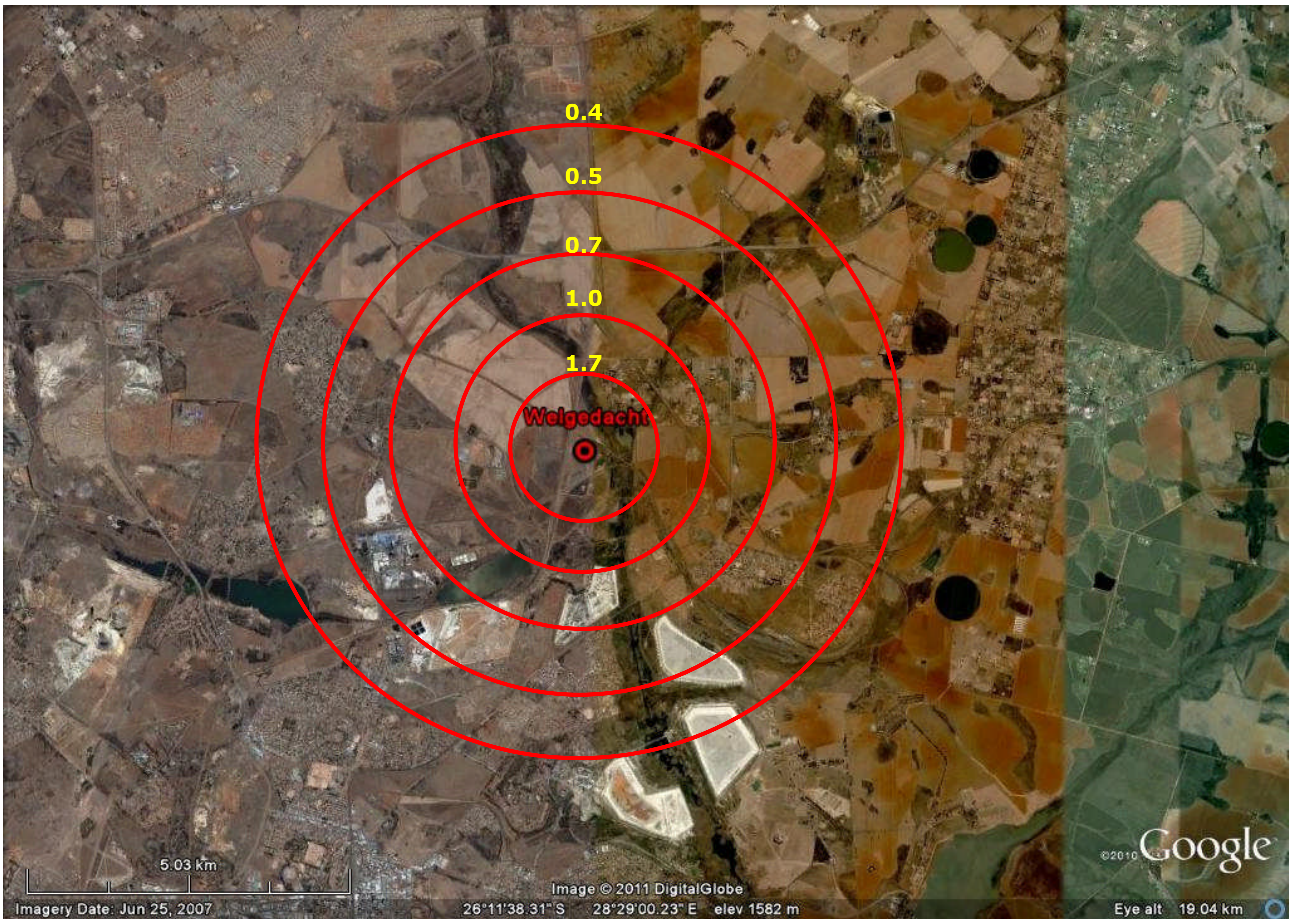

Figure 7.10: Predicted hourly maximum concentrations of xylene within a 5 km radius of the WCW for the future scenario

The concentration curves represent the highest possible ambient concentrations, which are based on worst-case meteorological conditions. It is thus imperative to view the concentrations in these graphs with respect to the prevailing wind directions, as discussed in

Section 4. The graphs show an increase in estimated ground-level pollutant concentrations from the point of release until a maximum concentration is reached very close to the WCW; thereafter the pollutant concentrations decrease steadily. The maximum ground-level concentrations for all pollutants are observed approximately 50 to 100 m from the boundary of the WCW. At a distance of 5 km from the WCW, ground-level concentrations approach 0 $\mu g/m^3$ for all pollutants. For benzene, ground-level concentrations reach 0 $\mu g/m^3$ a mere 1 km from the WCW. In line with expectations, higher concentrations were modelled for the future scenarios (blue curves), when emission rates are estimated to be higher. The maximum modelled concentrations for the various pollutants are:

- H_2S - 8.5 $\mu g/m^3$ (30-minute average)
- Benzene - 1.1 $\mu g/m^3$ (annual average)
- Toluene - 12.0 $\mu g/m^3$ (30-minute average)
- Ethyl benzene - 12.1 $\mu g/m^3$ (1-hour average)
- Xylene - 10.6 $\mu g/m^3$ (1-hour average)

The graphs for the concentric concentration circles are based on 30-minute averages for H_2S and toluene, 1-hour averages for ethyl benzene and xylene and annual averages for benzene. This reporting format ensures consistency with the time averaging periods of the South African ambient air quality standards and other guidelines. The concentric concentration circles also clearly show that concentrations are highest close to the WCW and reduce with distance away.

Of all the maximum modelled concentrations, the only pollutant that is expected to exceed its standard or guideline is H_2S. The maximum predicted ground-level concentration of H_2S of 8.5 $\mu g/m^3$ is greater than the WHO odour threshold of 7 $\mu g/m^3$. However, this is only expected to occur 200 m away from the WCW, where there is currently no exposure to the general public. The closest residential settlement is Welgedacht, which is located approximately 1.4 km south-east of the WCW, and thus outside the potentially negative odour impact zone. The predicted maximum 30-minute H_2S concentration at the Welgedacht residential settlement is 1 $\mu g/m^3$, substantially below the odour threshold of 7 $\mu g/m^3$.

As discussed in Section 4, the distribution of winds is relatively uniform in all directions around the WCW, with a slightly higher frequency in the easterly direction. This implies that air quality impacts occur in all directions around the WCW, but are slightly greater in the areas located to the west of the WCW, where the effects of the easterly winds are more prominent. The two settlements located to the west of the WCW are Modder East and Dersley, located approximately 3.7 km and 4.8 km to the west of the WCW, respectively. However, the concentration graphs show that ground-level concentrations are very low at these residential settlements. The maximum expected 30-minute H_2S concentration for the future scenario at Dersley of 0.9 $\mu g/m^3$ is substantially less than the H_2S odour threshold of 7 $\mu g/m^3$. This implies there is not likely to be any negative odour impacts resulting from the Welgedacht WCW at Dersley. Predicted concentrations of all other pollutants at Dersley are similarly very low and well below South African ambient air quality standards.

8. COMPARISON OF AIR QUALITY WITH STANDARDS AND GUIDELINES

Table 8.1 lists the ambient air quality standards or guidelines for the pollutants considered in this study, beyond which negative health or odour impacts will occur. Also listed are the maximum predicted pollutant concentrations for the proposed expansion of the WCW, determined through the use of the Screen3 model.

Table 8.1 – Ambient air quality standards / guidelines versus predicted maximum concentrations

POLLUTANT	AVERAGING PERIOD	STANDARD/ GUIDELINE VALUE (µg/m^3)	PREDICTED MAX. AMBIENT CONCENTRATION (µg/m^3)
Hydrogen sulphide	30-min	7 (odour threshold)	8.5
Benzene	Calendar year	10	1.1
Toluene	30-min	1 000 (odour detection)	7.4
Xylene	1-hour	2 300	6.0
Ethyl benzene	1-hour	2 000	6.5

Hydrogen sulphide:

Exposure to low concentrations of H_2S may cause irritation to the eyes, nose, or throat. It may also cause difficulty in breathing for some asthmatics. Brief exposures to high concentrations of H_2S (greater than 500 ppm) can cause a loss of consciousness and possibly death. There may be permanent or long-term effects such as headaches, poor attention span, poor memory, and poor motor function. No health effects have been found in humans exposed to typical environmental concentrations of H_2S (0.11–0.33 ppb). H_2S has not been shown to cause cancer in humans[8].

However, typical ambient concentrations of H_2S in South Africa present more of an odour problem than a health problem. The WHO odour threshold value for H_2S is a 30-minute average of 7 µg/m^3. This is exceeded by the predicted maximum ambient concentration of H_2S of 8.5 µg/m^3. However, this concentration is predicted to occur only at a distance of 200 m away from the Welgedacht WCW and during worst-case meteorological conditions. At the boundary of the closest residential settlement, namely, Welgedacht, located to the south-east of the WCW, the predicted maximum H_2S concentration drops to approximately 1 µg/m^3, thus not posing a serious odour threat to the population.

Benzene:

Chronic inhalation of benzene has caused disorders in the blood, such as aplastic anaemia (not found at concentrations found in the general environment). Excessive bleeding, and damage to the immune system (by changes in blood levels of antibodies and loss of white blood cells) may develop. This condition can make individuals more susceptible to infections. Benzene can cause leukaemia (cancer of the blood-forming organs), especially acute myeloid leukaemia (AML) (ATSDR; 2007). The South African ambient air quality standard for benzene is currently set at 10 µg/m^3, but due for reduction to 5 µg/m^3 in 2012 (DEAT; 2009).

The predicted maximum ambient concentration of benzene, reported as an annual average of 1.1 µg/m^3, is safely below the South African air quality standards of 10 µg/m^3. This implies that no health impacts are expected from exposure to benzene emitted from the proposed WCW expansion.

Toluene:

Chronic inhalation exposure in an occupational environment causes central nervous system symptoms and hearing effects. Spontaneous abortions occurred among women occupationally exposed to toluene (ATSDR; 2007). Toluene is not listed in the South African ambient air quality standards, but nevertheless considered in this study due to its known health effects. The WHO cites both health-based guideline and odour threshold values for toluene. The health-based guideline of 7 500 µg/m^3 is extremely high and only likely to be exceeded in an occupational environment, where toluene is manufactured or stored.

The odour threshold value of 1 000 µg/m^3 provides a practical point of reference for comparison and is reported as a 30-minute average. The predicted maximum ambient concentration of toluene of 7.4 µg/m^3 is substantially less than the odour threshold of 1 000 µg/m^3. Toluene emissions from the proposed expansion of the WCW are therefore not expected to cause negative odour or health impacts in the surrounding communities.

Ethyl benzene:

Ethyl benzene has low acute and chronic toxicity for both animals and humans. Prolonged skin contact with the liquid may cause dermatitis due to the de-fatting action of ethyl benzene (CCINFO; 2 000). As with toluene, ethyl benzene is not listed in SANS 1929, but nevertheless considered in this study due to its known effect health effects. The health-based guideline for ethyl benzene of 2 000 µg/m^3, an hourly average, was sourced from Alberta, Canada.

The predicted maximum concentration of ethyl benzene, also reported as an hourly average, is 6.5 µg/m^3. Ethyl benzene emissions from the WCW are therefore not expected to negatively impact on the health of the public living in the vicinity.

Xylene:

Long-term exposure to concentrations found in an occupational environment may cause upper respiratory irritation and central nervous system effects such as headaches, dizziness and tremors (ATSDR; 2007). The WHO does not provide health-based guidelines for xylene. The guideline value of 2 300 µg/m^3, reported as an hourly average, was sourced from Alberta, Canada.

The predicted maximum ambient concentration of 6.0 µg/m^3 is also substantially below the health-based guideline value of 2 300 µg/m^3. Xylene is therefore not expected to pose a serious threat to the health of the public living in the vicinity of the Welgedacht WCW.

9. IMPACT ASSESSMENT

Impacts can generally be categorised as direct, indirect or cumulative. Direct impacts are impacts that are caused directly by the activity and generally occur at the same time and place of the activity. Indirect impacts are indirect or induced changes that may occur as a result of the activity. These types of impacts include all the potential impacts that do not manifest immediately when the activity is undertaken or which occur at a different place as a result of the activity.

Cumulative impacts are impacts that result from the incremental impact of the proposed activity on a common resource when added to the impacts of other past, present or reasonably foreseeable future activities.

For this study, direct impacts will result from the inhalation of H_2S, benzene, toluene, ethyl benzene and xylene emitted during the operational life of the WCW. Direct impacts will also result from exposure to dust generated by construction and decommissioning activities. No indirect impacts from the operation, commissioning and decommissioning of the WCW are envisaged.

With respect to cumulative impacts, the gold mine, tailings dams and domestic fuel burning are identified as sources of dust. There will thus be a cumulative impact with dust generated during construction and decommissioning of the WCW. The Welegedacht WCW is located in an area where there are no notable sources of H_2S, benzene, toluene, ethyl benzene and xylene. There will thus be no compounding of effects and hence no cumulative impacts during operation of the WCW.

Extent of Impacts:

The extent of impacts are assessed in accordance with the following scoring criteria:
1 - Limited to the site and its immediate surroundings
2 - Local/municipal extending only as far as the local community or urban area
3 - Provincial/regional
4 - National i.e. South Africa
5 - Across international borders

PHASE	**EXTENT OF IMPACTS**		
	DIRECT	**INDIRECT**	**CUMULATIVE**
Construction and decommissioning	1	1	1
Operation	1	1	1

Construction and decommissioning activities will result in the emission of low quantities of dust, not expected to pose a health or nuisance risk. Furthermore, dust emissions will not travel over vast distances, but will settler within 100 m to 1 km of the WCW. The extent of direct and cumulative dust impacts are thus considered to be limited to the site and its immediate surroundings.

From the concentration curves of Section 7, it is clear that some elevated concentrations of H_2S, benzene, toluene, ethyl benzene and xylene are expected close to the fenceline of the WCW, but not in the neighbouring communities. The extent of direct impacts from these pollutants are thus limited to the site and its immediate surroundings.

Duration of Impacts:

The duration of impacts are assessed in accordance with the following scoring criteria:
1 - Immediate (less than 1 year)
2 - Short term (1-5 years)
3 - Medium term (6-15 years)
4 - Long term (the impact will cease after the operational life span of the project)
5 - Permanent (no mitigation measures of natural process will reduce the impact after construction)

PHASE	**DURATION OF IMPACTS**		
	DIRECT	**INDIRECT**	**CUMULATIVE**
Construction and decommissioning	1	1	1
Operation	4	1	1

Construction and decommissioning impacts will last for a short period as these activities occur over short periods, typically a few months. Direct and cumulative impacts from construction are therefore expected to be immediate.

Impacts from operation will however last for the full period of operation of the WCW, which is typically greater than 15 years. The duration of direct impacts from operation are therefore expected to be long-term. There are no cumulative impacts from operation.

Probability of Impacts:

The probability of impacts are assessed in accordance with the following scoring criteria:
0 - None (impact will not occur)
1 - Improbable (the possibility of the impact materialising is very low as a result of design, historic experience or implementation of adequate mitigation measures)
2 - Low probability (there is a possibility that the impact will occur)
3 - Medium probability (the impact may occur)
4 - High probability (it is most likely that the impact will occur)
5 - Definite / do not know (the impact will occur regardless of the implementation of any prevention or corrective actions or it the specialist does not know what the probability will be based on too little published information)

PHASE	**PROBABILITY OF IMPACTS**		
	DIRECT	**INDIRECT**	**CUMULATIVE**
Construction and decommissioning	2	0	4
Operation	2	0	0

The probability of direct impacts are considered to be low for all phases of the project. Dust emissions from construction and decommissioning are not likely to reach the Welgedacht residential settlement located 1.4 km south-east of the WCW. Dust normally settles within 100 m to 1 km from the point of generation. There is therefore a low probability of direct dust impacts from construction and decommissioning activities. However, there is a high probability of cumulative dust impacts due to the existing of other dust sources in the vicinity of the WCW.

The probability of direct and cumulative impacts of other pollutants, such as H_2S and benzene, emitted during normal operation of the WCW, are also considered to be low. Predictive modelling using the Screen3 air dispersion model provides maximum expected ambient concentrations of the relevant pollutants based on a worst-case meteorological scenario. The results of modelling show that the maximum expected concentrations are significantly less than any air quality standards or guidelines. There is therefore a low probability of air quality direct and cumulative impacts during the operation of the WCW.

Magnitude of Impacts:

The magnitude of impacts may be assessed in accordance with the following scoring criteria:
0 - None (where the aspect will have no impact on the environment)
2 - Minor (where the impact affects the environment in such a way that natural, cultural and social functions and processes are not affected),
4 - Low (where the impact affects the environment in such a way that natural, cultural and social functions and processes are slightly affected),
6 - Moderate (where the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way),
8 - High (where natural, cultural or social functions or processes are altered to the extent that it will temporarily cease), or
10 - Very high / don't know (where natural, cultural or social functions or processes are altered to the extent that it will permanently cease).

PHASE	**MAGNITUDE OF IMPACTS**		
	DIRECT	**INDIRECT**	**CUMULATIVE**
Construction and decommissioning	2	0	6
Operation	2	0	0

The magnitude of impacts provides an indication of how serious the impacts are. From an air quality perspective, seriousness relates to the potential health impacts to humans that could result from the inhalation of polluted air. Seriousness could also relate to quality of life being compromised by offensive odours.

No serious direct impacts are expected from dust generated during construction and decommissioning of the WCW. However, cumulative impacts may result from the dust combining with dust from other sources such as the gold mine and tailings dams. Air quality studies have highlighted the elevated levels of dust (or particulate matter) in the Ekurhuleni

Metropolitan Municipality. The cumulative impact of dust emissions is therefore considered to be moderate.

The predicted ambient concentrations for all pollutants emitted during operation of the WCW are expected to be substantially below health or odour-based air quality standards and guidelines. The predicted ambient concentration for H_2S will exceed its odour threshold on the immediate boundary of the WCW. The overall magnitude of direct impacts during operation is therefore rated as minor.

Significance of Impacts:

The significance of impacts is determined through the following equation:

Significance = (Extent + Duration + Magnitude) x Probability

A score of less than 30 implies that impacts are of a low significance, a score of between 30 and 60 implies a medium significance, whereas a score of greater than 60 implies a high significance.

For the proposed modifications to the Welgedacht WCW, the significance is:

PHASE	**SIGNIFICANCE OF IMPACTS**		
	DIRECT	**INDIRECT**	**CUMULATIVE**
Construction and decommissioning	(1+1+2)x2=8	(1+1+1)x0=0	(1+1+6)x4=32
Operation	(1+4+2)x2=14	(1+1+1)x0=0	(1+1+1)x0=0

From the scoring above, it is evident that the significance of all impacts during the operational phase is low, while the significance of cumulative impacts during construction and decommissioning is medium.

Summary of Impacts:

In summarising the impacts, the highest score in each category described above is selected.

Table 9.1: Summary of air quality impacts during operation of the WCW*Nature:* Air quality impacts are caused by the inhalation of benzene, toluene, ethyl benzene, xylene (BTEX) and hydrogen sulphide, which are contained in trace amounts in the influent to the WCW. The inhalation of the benzene, toluene, ethyl benzene and xylene at concentrations exceeding health-based air quality standards, will result in negative health impacts. The inhalation of hydrogen sulphide and toluene at concentrations exceeding odour-based air quality thresholds, will result in negative quality of life or nuisance impacts.

	Without mitigation	**With mitigation**
Extent	Limited to site and immediate surroundings (1)	N/A
Duration	Long-term (4)	N/A

Magnitude	Minor (2)	N/A
Probability	Low (2)	N/A
Significance (positive or negative)	**Low (14) and negative**	N/A
Reversibility	No	N/A
Irreplaceable loss of resources?	No	N/A
Can impacts be mitigated?	Not	N/A
Mitigation: None		
Cumulative Impacts: None		
Residual Impacts: None		

Since the significance of impacts during the operational phase is low, mitigation is not considered necessary.

Table 9.2: Summary of air quality impacts during construction and decommissioning of the WCW

Nature: Cumulative air quality impacts are caused by exposure to dust generated during construction and decommissioning of the WCW and by other existing sources in the vicinity of the WCW. Dust has a nuisance impact and negatively affects quality of life by causing soiling, contamination, structural corrosion and damage to precision equipment, machinery and computers.		
	Without mitigation	**With mitigation**
Extent	Limited to site and immediate surroundings (1)	Limited to site and immediate surroundings (1)
Duration	Immediate (1)	Immediate (1)
Magnitude	Moderate (6)	Moderate (2)
Probability	High (4)	High (4)
Significance (positive or negative)	**Medium (32) and negative**	**Low (16) and negative**
Reversibility	No	No
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes	Yes
Mitigation: Dust management plan.		
Cumulative Impacts: None		
Residual Impacts: None		

Since the significance of impacts during construction and decommissioning is medium, a very basic dust management plan is considered adequate.

10. MITIGATION

Due to the low significance of direct, indirect and cumulative impacts during operation, mitigation measures are not considered necessary for the operational phase of the project. However, it is recommended that a dust management plan be implemented to mitigate against cumulative dust impacts during construction and decommissioning. The plan is presented below in Table 10.1.

Table 10.1 – Dust mitigation plan to be included in EMP

OBJECTIVE: The reduction of dust levels during the construction and decommissioning phases of the project.	
Project component/s	Installation of Module 1 to increase capacity of the Welgedacht WCW from 35 000 m^3/day to 85 000 m^3/day.
Potential Impact	Dust consists of particles that are large enough to settle down and not remain suspended indefinitely in the atmosphere. Dust negatively affects quality of life by causing soiling, contamination, structural corrosion and damage to precision equipment, machinery and computers.
Activity/risk source	Construction and decommissioning
Mitigation: Target/Objective	To reduce dust levels in the project area resulting from construction and decommissioning activities at the WCW.

Mitigation: Action/control	Responsibility	Timeframe
Removal of vegetation limited to only what is necessary to accommodate construction activities.	Construction Project Manager	Before and during construction phase
Traffic control measures to limit vehicle-entrained dust from unpaved roads e.g. by limiting vehicle speeds and by restricting traffic volumes.	Construction Project Manager	During construction and decommissioning phases
Re-vegetation of the construction terraces once all the construction is completed, and when the laydown area is vacated.	Construction Project Manager	After construction phase
During construction and decommissioning phases	During construction and decommissioning phases	During construction and decommissioning phases

Performance Indicator	» No complaints received from neighbouring communities regarding dust
Monitoring	» An incidents/complaints register must be maintained, in which any complaints from the community must be logged. The date, time, nature of complaint, name of complainant and corrective actions must be logged for all complaints. Complaints must be investigated and, if

	appropriate, acted upon

11. CONCLUSIONS

The following key conclusions are drawn from the study:

- The key pollutants emitted during the operational phase of the Welgedacht WCW, currently and once expanded, are benzene, toluene, ethyl benzene, xylene and H_2S.
- The pollutant emitted during the construction and decommissioning phases of the Welgedacht WCW is dust.
- Emission rates of all pollutants will increase on average by 143 % from the baseline to future scenarios as a result of the increased influent load and increase in the number of emission sources .
- The area is characterised by winds of all directions with easterly and north-westerly winds being slightly more dominant in the summer months and south-easterly winds dominating slightly more in winter months.
- Wind speeds during summer are mostly light (1.8 to 3.34 m/s) to moderate (3.34 to 8.49 m/s). Winds at night are mostly calm.
- The Welgedacht WCW is located in the summer rainfall region of SA and therefore receives most of its rainfall during this period.
- Predicted maximum ambient concentrations of the pollutants occur at a distance of 200 m to 250 m from the fenceline of the WCW, during worst-case meteorological conditions.
- The only pollutant expected to exceed its standard or guideline is H_2S. The maximum predicted concentration of H_2S of 8.5 $\mu g/m^3$ is greater than the WHO odour threshold of 7 $\mu g/m^3$. However, this is only expected to occur 200 m away from the WCW, where there is currently no exposure to the general public.
- No indirect impacts are expected from the operational or construction and decommissioning phases of the WCW.
- The significance of all impacts during the operational phase is low, while the significance of cumulative impacts during construction and decommissioning is medium.
- A basic dust management plan is considered adequate to mitigate for dust impacts during construction and decommissioning.

11. EXPERIENCE AND QUALIFICATIONS OF CONSULTANTS

This air quality assessment was performed by uMoya-NILU Consulting (Pty) Ltd, an independent consultancy that specializes in air quality management. The team members involved in the assessment were Dr. Mark Zunckel and Benton Pillay.

Dr. Mark Zunckel has a PhD from the University of the Witwatersrand. He is a Meteorologist with 13 years of operational meteorology and research experience at the South African Weather Service before he joined the air pollution group at CSIR. There he developed his career further by leading the research group and many small and large research and consultancy projects over a 15 year period in a number of southern African countries and in South America. These included air quality specialist studies for industrial developments, the Dynamic Air Pollution Prediction System, and leading the development of the National Framework for Air Quality Management. Dr Zunckel has conducted courses in Air Quality Management and dispersion modelling, and is an Honorary Professor at the University of Kwa-Zulu Natal. Mark is currently the Managing Director of uMoya-NILU Consulting (Pty) Ltd, a Durban-based air quality management consultancy company.

Benton Pillay is a Chemical Engineer. He has 10 years of working experience in the chemical and petrochemical industries, having most recently worked as Environmental Manager at the SAPREF refinery in Durban. In air quality management, he has 5 years of experience, during which time he worked for government to help establish the South Durban Basin Multi Point Plan. This initiative still serves as the benchmark for establishing air quality management systems in South Africa. He also served on a team that developed and rolled out the new Scheduled Trade Permit for industries in Durban. Benton received his training in air quality management from NILU (Norwegian Institute for Air Research). He is currently a Director at uMoya-NILU, where he is involved in conducting air quality projects.

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