AIR QUALITY IMPACT ASSESSMENT

Prepared for

SPARTA HOLDING (PTY) LTD WELKOM OPERATIONS

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AIR QUALITY IMPACT ASSESSMENT

1 INTRODUCTION

Sparta Holding (Pty) Ltd (Sparta) operates a network of production and marketing of a wide range of beef-related products. One of their operations is located in the industrial area to the east of Welkom in the Free State and entails, inter alia, an abattoir and related activities. The nearest residential area is located approximately 1.2 km west to north-west of Sparta's operations.

These operations are included in the List of Activities that Result in Atmospheric Emissions as published in Government Notice 893 of 22 November 2013 (GN893). The list categorises industries according to its activities and those applied by Sparta's Welkom operations are covered in Category 10, "*Animal matter processing*" with the description "*Processes for the rendering, cooking, drying, dehydrating, digesting, evaporating or protein concentrating of any animal matter not intended for human consumption*". The threshold production capacity is 1 ton of raw materials per day.

Cape Environmental Assessment Practitioners (Cape EAPrac) wishes to assist Sparta's Welkom operations to obtain the environmental authorisation required by current environmental management legislation in South Africa. As Sparta's operations are included GN893 an atmospheric emissions license (AEL) is required which, in turn, requires a specialist air quality impact assessment.

Cape EAPrac subsequently invited Lethabo Air Quality Specialists CC (LAQS) to assist in the project, notably to deal with all the issues that relate to air emissions licensing and air quality impacts. This proposal describes the steps that LAQS will carry out in order to provide the necessary information to meet these goals. It is understood that Cape EAPrac will deal with all environmental impact and regulatory issues that may arise.

This report discusses the dispersion modelling work and air quality impact assessment outcome in detail.

2 SPARTA OPERATIONS

Waste products from the abattoir are treated in two processes on site, i.e. a waste rendering plant and a blood drying plant.

2.1 RENDERING PLANT

Meat rendering plants process animal by-product materials for the production of inedible tallow, grease, and high-protein meat and bone meal in a dry rendering batch process where raw material is dehydrated in order to release fat in cookers where melted fat and protein solids are separated.

In the batch process raw material from the receiving bin is screw conveyed to a crusher where it is reduced to smaller size to improve cooking efficiency. Cooking normally requires 1.5 to 2.5 hours to complete. To begin the cooking process the cooker is charged with 1.5 tons raw material and the material is heated to a final temperature ranging from 120° to 135°C. Following the cooking cycle, the contents are discharged to the percolator drain pan. Vapour emissions from the cooker pass through a condenser where the water vapour is condensed and non-condensable vapours are emitted to atmosphere as VOC emissions through a stack.

The percolator drain pan contains a screen that separates the liquid fat from the protein solids.

From the percolator drain pan, the protein solids, which still contain about 25 percent fat, are conveyed to the screw press. The screw press completes the separation of fat from solids, and yields protein solids that have a residual fat content of about 10 percent.

These solids are then ground and screened to produce protein meal. The fat from both the screw press and the percolator drain pan is pumped to the crude animal fat tank, centrifuged or filtered to remove any remaining protein solids, and stored in the animal fat storage tank.

Although currently processing approximately 9 tons of waste product per day, Sparta's rendering plant has the capacity to treat approximately 18 tons of abattoir waste products per day. Based on an uninterrupted operating cycle of 274 days per year, a total of approximately 4 930 tons of abattoir waste can be produced per annum.

2.2 BLOOD PROCESSING AND DRYING

Whole blood from the abattoir contains approximately 18% to 20% total protein solids which are processed and dried to recover protein as blood meal. The blood meal is a valuable ingredient in animal feed because it has a high lysine content.

A continuous cooking cooker is used into which whole blood is introduced into a steam-injected, inclined tubular vessel in which the blood solids coagulate. The coagulated blood solids and liquid (serum water) are then separated in a centrifuge, and the blood solids dried in either a continuous gas-fired, direct-contact ring dryer or a steam tube, rotary dryer.

Although currently processing 1.96 tons of dry blood meal per day, Sparta's process has the capacity to produce approximately 2.75 tons of dried blood meal per day.

2.3 COAL-FIRED BOILER

Sparta operates a small coal-fired boiler to produce steam for use in various sections of their operations. At the current level of operations approximately 8.5 tons of coal is burned per day. It is estimated that the consumption of coal would increase to 12 tons per day should all of Sparta's operations operate at full capacity.

A consumption rate 12 tons per day equate to 500 kg per hour. At a heating value of 26.12 MJ/kg this level of consumption implies a net input energy of 3.63 MW which is well below the threshold limit of 10 MW set for small boiler inclusion in atmospheric emission licenses.

3 EMISSIONS

3.1 BOILER

Emissions from coal-fired boilers consist essentially of products of combustion, i.e. particulate matter, carbon monoxide carbon dioxide, sulphur dioxide and nitrogen oxides.

For the purpose of this project the emissions of carbon dioxide are excluded as no ambient air quality standard exists against which the estimated ground-level concentrations can be compared.

3.2 RENDERING PLANT

Emissions from the rendering process consist mainly of volatile organic compounds (VOCs). The major constituents that have been qualitatively identified as potential emissions include organic sulfides, disulfides, C-4 to C-7 aldehydes, trimethylamine, C-4 amines, quinoline, dimethyl pyrazine, other pyrazines, and C-3 to C-6 organic acids. In addition, lesser amounts of C-4 to C-7 alcohols, ketones, aliphatic hydrocarbons, and aromatic compounds are potentially emitted.

Historically, the VOCs are considered an odour nuisance in residential areas in close proximity to rendering plants, and emission controls are directed toward odour elimination. However, Sparta's process does not include any specific odour reduction steps. The odour detection threshold for many of these compounds is low; some as low as 1 part per billion (ppb)

For the purpose of this project the emissions of all odorous compounds were grouped together to estimate the odour footprint resulting from emissions from the rendering plant.

3.3 BLOOD DRYING

Emissions from the blood drying plant consist mainly of particulate matter, hydrogen sulphide and ammonia.

For the purpose of this project the emissions of hydrogen sulphide were combined with the odorous emissions from the rendering plant to show the potential odour footprint of Sparta's operations. In addition, the emissions of ammonia are excluded as no ambient air quality standard exists against which the estimated ground-level concentrations can be compared.

4 DISPERSION MODELLING STUDY

4.1 DISPERSION MODEL

The dispersion modelling study was carried out with EnviMan, a GIS-based emissions management software suite produced by Opsis AB in Sweden. The dispersion modelling component of the suite consists of the following four modules:

Mapper: A map manipulation tool
Emissioner: An extensive, relational emissions data base
Envimet: A meteorological data management program
Planner: The actual dispersion model

4.1.1 MAPPER

Mapper is a digital map compiler. It is used to define GIS data sets and map sets to be used by all EnviMan GIS modules. It can import a variety of digital maps and structure the data in suitable forms, e.g. sheets, objects, etc.

It is the basis of the EnviMan GIS suite as it defines all co-ordinates for subsequent use by the various EnviMan modules.

4.1.2 EMISSIONER

Emissioner is a comprehensive, relational emissions data base that locates emission sources at fixed co-ordinates on the map compiled with Mapper. Sources are placed on the map by the user and the co-ordinates are automatically generated by Mapper.

Emissioner can handle particulate and gaseous emissions from the following sources:

- Point sources, e.g. industrial stacks
- Area sources, e.g. landfill sites
- Grid sources, e.g. complete informal settlement areas
- Line sources, e.g. motor vehicle emissions

Of these, only point sources are of interest in this study.

When multiple sources are investigated, it is possible to add keywords to each source to uniquely identify it and to investigate plume dispersion from a single, or group of sources.

4.1.3 ENVIMET

Envimet uses meteorological data collected at ground level to calculate boundary scaling data sets used in dispersion modelling studies. Of primary importance are those parameters that define scaling of the boundary air layer. These are:

- Wind speed
- Wind direction
- Standard deviation of wind direction
- Temperature
- Solar radiation

These parameters are used by Envimet to calculate all of the parameters, e.g. stability of the air boundary layer, mixing heights, climate sets, etc., which are required by Planner in calculating the dispersion of pollutants from a source.

4.1.4 PLANNER

Planner is the dispersion module of the EnviMan suite and links with Mapper, Emissioner and Envimet to carry out dispersion modelling activities. It is designed to run simulations of air quality based on emission data created in Emissioner for the following scenarios:

-- Hypothetical weather definitions, i.e. user-supplied information about temperature, wind speed, wind direction, cloud cover, etc.

-- True weather period, i.e. using recorded data from a weather monitoring station to simulate plume dispersion hour-by-hour over a defined period

-- Statistical weather period, i.e. using a pre-calculated sample of various weather conditions that typically occur during a year. This allows the creation of annual air quality maps for comparison against national guidelines and limit values.

Of these scenarios, the statistical period is applicable to the study of plume dispersion from Sparta's operations.

Planner makes use of three different dispersion models, two of which are aimed at motor vehicle emissions. Use is made of the Aermod dispersion model for the purposes of calculating the dispersion of plumes from point, area and grid sources. Aermod is an USEPA-approved Gaussian plume dispersion model and is capable of simulating dispersion of pollutants over a distance up to approximately 50 km from the source. Aermod is also accepted as a suitable model for the purpose of this project by the South African Department of Environmental Affairs, as discussed in Government Notice R.533 of 11 July 2014 (GN R533).

4.2 INPUT DATA

4.2.1 MAPPER

Two digital maps of the area in the form of a bitmap was copied from Google Earth® and imported into Mapper. The first map covers an area of approximately 5000 metres x 3000 metres and was used in the dispersion modelling of all pollutants except odorous compounds. The second map covered an area of approximately 9200 metres x 5700 metres and was used to show the potential odour footprint of Sparta's operations.

The maps are shown in Figures 1 and 1a below. The emissions data base (Emissioner) links with the map and places emission sources on specific locations, as defined by the user.

Figure 1: Map of 5000 x 3000 k area

Figure 1a: Map of 9200 x 5700 k area

4.2.2 EMISSIONER

Compulsory information required for point source emissions are:

- Stack height
- Height of adjacent structures that could influence plume behaviour
- Stack internal and external diameters
- Stack gas velocity or flow rate
- Stack gas temperature
- Definition of pollutants
- Emission rates of pollutants

Three point emission sources are used in Sparta's operations, i.e. boiler stack, the rendering plant stack and the blood drying plant stack. Pertinent details of the three stacks are given in Table 1 below.

Parameter	**Boiler stack**	**Rendering**	**Blood**
Stack height, m	17.5	16.5	16.5
Stack OD, m	1.02	0.47	0.37
Stack ID, m	1.0	0.45	0.35
Flue gas velocity, m/s	10	12 (*)	12 (*)
Flue gas temperature, °C	180	50	50

(*): Estimated

Table 1: Stack and flue gas physical properties

Height of adjacent buildings:

The heights of the boiler stack and blood drying stack extends sufficiently far above adjacent rooftops so that structures adjacent to the stack will not affect the dispersion of pollutants from these stacks.

The heights of rooftops adjacent to the rendering plant stack are only about 1 - 1.5 metres below the stack height and could, therefore, affect the dispersion of pollutants from this stack. The dimensions of the surrounding structures were entered into the dispersion model.

Pollutant emission rates:

No emission measurements have been carried out on any of the stacks to date. As a result LAQS estimated the emissions from emission factors published by the Unites States of America's Environmental Protection Agency (USEPA) and information published in research documentation.

USEPA emission factors were used together with production rates to estimate emissions from the boiler stack and blood drying stack and the following annual emissions were calculated:

Boiler stack:

PM10 particulates (PM10)	8.9 tons per annum
Carbon monoxide (CO)	8.9 tons per annum
Sulphur dioxide (SO_2)	33.8 tons per annum
Nitrogen dioxide (NO_2)	8.88 tons per annum

Blood drying stack:

PM10 particulates	1.14 tons per annum
Hydrogen sulphide (H_2S)	0.12 tons per annum
Ammonia (NH_3)	0.9 tons per annum

Internationally published literature was consulted to estimate the emissions from the rendering plant as no emission factors was such operations were published by the USEPA. In August 1999 *Meat and Livestock Australia Limited* published an informative document "*Investigation of odourous gas emissions from meat and remaining plants*". This publication gave the results of quantitative emission measurements of several VOCs, including the concentrations of various odorous compounds. Based on this publication LAQS estimated the following odorous emissions from Sparta's rendering plant:

Carbon disulphide	0.0054 tons per annum
Carbonyl sulphide	0.0330 tons per annum
Dimethyl sulphide	0.0087 tons per annum
Dimethyl disulphide	0.0187 tons per annum
Methyl mercaptans	0.0764 tons per annum
Ethyl mercaptans	0.0009 tons per annum

The total emissions of odorous compounds are, therefore, estimated to be 0.1431 tons per annum.

Output units:

Given an input of tons per annum, the output of Planner is in units of micrograms per cubic meter ($\mu g/m^3$). Inputs of kilograms per annum would yield results in units of nanograms per cubic metre.

4.2.3 ENVIMET

An extensive set of meteorological data was procured from the South African Weather Service (SAWS) and this data set was used as input data for Envimet. The data set covered a period of three years and is regarded as reliable and of sufficient quality for calculating a boundary layer scaling set. Parameters covered are:

- Wind speed
- Wind direction
- Temperature
- Solar radiation

4.2.4 PLANNER

Planner does not require any user input as it extracts data from Mapper, Emissioner and Envimet.

5 RESULTS

The approach to the project was to determine both the annual average ground-level concentrations and 99-percentile concentrations (the concentrations that may occur for 1% of the time) of the pollutants in the vicinity of the plant, i.e. where the concentrations are expected to be the highest.

All simulations were carried out for a receptor height of 2 metres above ground level and a plume dispersion period of 120 minutes. This simulation period ensured that very low winds, e.g. below 1 m/s, would carry pollutants some distance from the plant.

Graphic presentation of the dispersion of pollutants is shown in Figures 2 to 11 below.

Figures 2 and 3 show the estimated annual average and 99-percentile concentrations of PM10 particulate matter.

Figures 4 and 5 show the estimated annual average and 99-percentile concentrations of sulphur dioxide.

Figures 6 and 7 show the estimated annual average and 99-percentile concentrations of nitrogen dioxide.

Figures 8 and 9 show the estimated annual average and 99-percentile concentrations of carbon monoxide.

Figures 10 and 11 show the estimated annual average and 99-percentile odour footprints of VOC emissions.

Figure 2: Annual Average PM10 Concentrations

Figure 3: 99-percentile daily average PM10 Concentrations

Figure 4: Annual Average SO_2 Concentrations

Figure 5: 99-percentile SO_2 Concentrations

Figure 6: Annual Average NO_2 Concentrations

Figure 7: 99-percentile NO_2 Concentrations

Figure 8: 8-hour Average CO Concentrations

Figure 9: 99-percentile 8-hour CO Concentrations

Figure 10: Annual Average Odour Footprint

Figure 11: 95-percentile Odour Footprint

6 DISCUSSION

6.1 MODEL RELIABILITY

The results of any computer model are only as reliable as the quality of the input data.

6.1.1 Emissioner

The concentrations of the individual pollutants emitted were obtained either from USEPA emission factors or calculated from mass balance data.

Boiler Stack:

It was assumed that the emission factors provided by the USEPA are a true reflection of Sparta's boiler operations. The estimated emissions are based on SPARTA's daily coal combustion rate and an assumption was made that an increase in daily production would result in a similar increase in coal usage. As a worst-case scenario the maximum estimated coal consumption was used to estimate annual emissions instead of current daily consumption.

As the actual emissions have never been measured, this assumption places a degree of uncertainty on the actual emissions.

Rendering Plant Stack:

Four major assumptions were made in estimating the emissions of odorous components from the rendering plant. Firstly, it was assumed that emissions occur continuously throughout the day instead of in batches as the pressure in the cooker is released after each cooking cycle. Secondly, it was assumed that the gas velocity was constant at 12 m/s. Thirdly, it was assumed that the concentrations of the listed odorous compounds are similar to those reported in literature. Finally, it was assumed that Sparta operates on a daily maximum rendering rate of 18 tons instead of the current level of 9 tons per day. This was done in order to show a worst-case condition.

These assumptions impose a substantial degree of uncertainty on actual emissions and, therefore, the impact that it will have on air quality.

6.1.2 Envimet

The meteorological data provided by SAWS is comprehensive and only a few minor gaps exist in the data set. It is, therefore, regarded as a reliable meteorological data set.

The distribution of winds in the Welkom area is shown graphically in Figure 12 below.

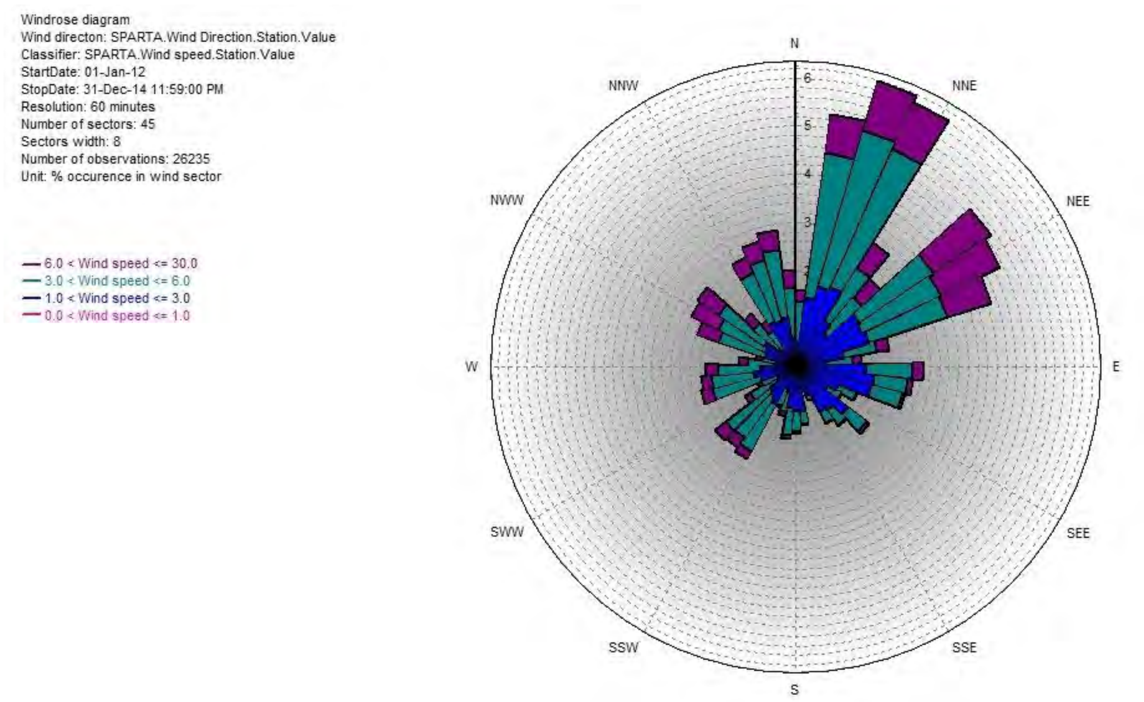

Figure 12: Frequency of Wind Direction

Figure 12 shows that the predominant wind direction is from a north-easterly direction which implies that pollutants will disperse mainly in a south-westerly direction from Sparta's operations.

6.1.3 Planner

As was stated previously, the user provides no direct data input to Planner. It uses Aermod, the latest USEPA approved Gaussian plume dispersion model, and there is no reason to doubt the reliability of the dispersion calculations.

7 IMPACT ON OVERALL AIR QUALITY

7.1 AMBIENT AIR QUALITY

Air quality standards for some pollutants are defined by the Standards South Africa (SSA) in their publication SANS 1929:2005, South African National Standard, “Ambient Air Quality – Limits for Common Pollutants”.

Of the pollutants included in this study ambient air quality standards exist for PM10 particles, SO_2, NO_2 and CO and these are:

PM10

Annual average:	40 µg/m^3, no exceedences
Maximum daily concentration:	75 µg/m^3, 4 exceedences

SO_2

Annual average limit	50 µg/m^3, no exceedences
1-hour maximum	350 µg/m^3, 88 exceedences

NOx (as NO_2)

Annual average limit	40 µg/m^3, no exceedences
1-hour maximum	200 µg/m^3, 88 exceedences

CO

8-hour running average	10 mg/m^3, 11 exceedences
1-hour maximum	30 mg/m^3, 88 exceedences

7.2 PM10 PARTICULATE MATTER

The highest annual average concentration of PM10 particulates was estimated to be 0.35 µg/m^3 and is well below the ambient air quality standard. The maximum concentration is estimated to occur in the vicinity of Sparta's southern fence-line.

The highest annual average concentration at the residential area is less than 0.1 µg/m^3 and is well below the air quality standard.

The highest 99-percentile daily concentration of PM10 particulate matter was estimated to be 3.4 $\mu g/m^3$ and is well below the ambient air quality standard. The maximum concentration is estimated to occur approximately 290 metres south of south-west of the centre of Sparta's operations.

The highest 99-percentile concentration at the residential area is 1.3 $\mu g/m^3$ and is well below the air quality standard.

7.3 SULPHUR DIOXIDE

The highest annual average concentration of SO_2 was estimated to be 1.03 $\mu g/m^3$ and is well below the ambient air quality standard. The maximum concentration is estimated to occur in the vicinity of Sparta's southern fence-line.

The highest annual average concentration at the residential area is estimated to be 0.13 $\mu g/m^3$ and is well below the air quality standard.

The highest 99-percentile daily concentration of SO_2 was estimated to be 16.1 $\mu g/m^3$ and is well below the ambient air quality standard. The maximum concentration is estimated to occur approximately 290 metres south of south-west of the centre of Sparta's operations.

The highest 99-percentile concentration at the residential area is 4.6 $\mu g/m^3$ and is well below the air quality standard.

7.4 NITROGEN DIOXIDE

The highest annual average concentration of NO_2 was estimated to be 0.33 $\mu g/m^3$ and is well below the ambient air quality standard. The maximum concentration is estimated to occur in the vicinity of Sparta's southern fence-line.

The highest annual average concentration at the residential area is less than 0.1 $\mu g/m^3$ and is well below the air quality standard.

The highest 99-percentile daily concentration of NO_2 was estimated to be 4.2 $\mu g/m^3$ and is well below the ambient air quality standard. The maximum concentration is estimated to occur approximately 290 metres south of south-west of the centre of Sparta's operations.

The highest 99-percentile concentration at the residential area is 1.2 µg/m^3 and is well below the air quality standard.

7.5 CARBON MONOXIDE

The highest 8-hour average concentration of CO was estimated to be 3.6 µg/m^3 and is well below the ambient air quality standard. The maximum concentration is estimated to occur in the vicinity of Sparta's southern fence-line.

The highest annual average concentration at the residential area is less than 1 µg/m^3 and is well below the air quality standard.

The highest 99-percentile daily concentration of CO was estimated to be 4.4 µg/m^3 and is well below the ambient air quality standard. The maximum concentration is estimated to occur approximately 290 metres south of south-west of the centre of Sparta's operations.

The highest 99-percentile concentration at the residential area is 1.2 µg/m^3 and is well below the air quality standard.

7.6 ODOURS

As odours are subjective and perceived differently by different people, no clear odour detection limit can be defined for any gas. However, according to literature the odorous compounds listed in Section 4.2.2 above have the following odour threshold values (the concentrations at which their odours can generally be detected):

Carbon disulphide	80 µg/m^3
Carbonyl sulphide	250 µg/m^3
Dimethyl sulphide	24 µg/m^3
Dimethyl disulphide	6.2 µg/m^3
Methyl mercaptans	0.4 µg/m^3

Ethyl mercaptans	0.1 $\mu g/m^3$
Hydrogen sulphide	0.7 $\mu g/m^3$

From the list is can be seen that the odour threshold limits of the first three compounds are substantially higher than the rest. The odour thresholds are also well in excess of the estimated ground-level concentrations of any of the other pollutants discussed in Sections 7.2 to 7.5 above. As their estimated annual emissions are significantly lower than that for, e.g., SO_2 or NO_2, their individual concentrations will be significantly lower than their odour thresholds. They can, therefore, be ignored as odour contributors.

The last four compounds, however, have very low odour threshold values. To demonstrate the potential spread of odours from Sparta's operations, LAQS assumed is general odour threshold level of 3 $\mu g/m^3$ as an arbitrary level approximately midway between the lowest and highest odour threshold limits of the remaining four compounds.

Figure 10 shows that odours will generally be detected over a large area essentially south-west of the plant and that some odours may be detected on the fringes of the eastern boundaries of the residential areas closet to the industrial area where Sparta is located.

Figure 11 shows the 95-percentile spread of odours, i.e. those areas where odours may be detected for 5% of the time. It shows that odours mat extend as far as the centre of the town and, in some cases, beyond that point. As the stability in the air during winter months imply the worst pollutant dispersion scenario, it is expected that the 95-percentiel values will occur mainly during this period.

It should be pointed out that none of the estimated ground-level concentrations of odorous emissions pose any risk to health in the area, but may be a nuisance in general.

8 CONCLUSIONS

As described in Section 6.1 above some assumptions were necessary in order to compile an emissions database for Sparta's operations in the Welkom Industrial area. The assumptions made were aimed at over-estimating the mass emissions of the various pollutants in order to create a worst-case scenario.

The results of the dispersion modelling study show that the estimated maximum ground-level concentrations are very low and that none exceed ambient air quality standards.

The results also show that odours from the plant's operations would generally not be detected much beyond the eastern boundary of the residential areas closets to Sparta's operations, but that odours could extend to the centre of town and beyond under certain circumstances.

LAQS concludes, therefore, that the impact of Sparta's emissions on air quality in the general Welkom Industrial area is low, but that some nuisance due to odorous emissions can be caused.

9 RECOMMENDATIONS

9.1 EMISSIONS VERIFICATION

As no representative data on stack emissions exist, LAQS recommends that Sparta commissions a suitably qualified and experienced contractor to measure the concentration of the odorous pollutants and pertinent gas parameters in the rendering plant and blood drying plant stacks. This data will allow LAQS to compare it with the assumptions made and revise the outcome of the report if necessary.

It must be pointed out that measurement of the compounds listed in Section 7.6 above is extremely difficult, especially at the estimated low concentrations in the stack gases.

There may be some difficulty in identifying a contractor that is actually capable of measuring the concentrations of all of the compounds listed reliably.

An alternative approach is to measure the concentrations of one component, e.g. H_2S, by means of passive sampling techniques on Sparta's fence-line. These methods, however, provide average concentrations that prevail in ambient air over the sampling period and do not indicate the direction from which the odours originated.

9.2 CONTINUOUS EMISSIONS MONITORING

LAQS is of the opinion that no continuous emission monitoring equipment will be required to monitor the various emissions addressed by this report. Where required emissions should be verified annually by an independent contractor and reported to NMBM accordingly to meet regulatory requirements.

9.3 AIR QUALITY MANAGEMENT PLAN

Because of the low emissions and low impact on air quality, LAQS is of the opinion that a dedicated air quality management plan for Sparta’s operation is not required. All steps should, however, be taken to minimise the emissions of odorous compounds as is stipulated in Category 10 of GN893 which states the following:

"*Best practice measures intended to minimise or avoid odours must be implemented by all installations. These measures must be documented to the satisfaction of the Licensing Authority.*"