SECTION 10 INVESTIGATION OF ISSUES

This chapter describes the approach and methodology employed in determining the environmental risks arising from the proposed project. The previous chapters have provided the background information and results of the literature reviews conducted by MES, and provide information relevant to Secondary Materials in the cement manufacturing process in general. This chapter specifically looks at the PPC proposal and considers the options with regards to determining PPC's specific risks to the environment.

10.1 MASS BALANCES ACROSS THE KILN AND DETERMINATION OF ENVIRONMENTAL RISK ASSESSMENT METHODOLOGY

The key question to resolve in terms of this EIA application is as follows: what would be the environmental effects of changing the raw materials and fuels inputs into the process through the introduction of secondary materials?

In attempting to answer this, which is the purpose behind the Environmental Technical Review process undertaken by MES, one may view the kiln process in terms of simple inputs and outputs as follows:

Table 10-1: Inputs and Outputs from the cement manufacturing process

Inputs	Raw Materials (back end of kiln)	Limestone, fly ash, gypsum, etc. Tyres
	Fuels (flame side of kiln, or front end)	Coal Secondary Materials (such as solvents, hydrocarbons, sewage sludge, SPL,)
Outputs	Product (via front end)	Clinker
	Wastes (via back end, air cleaning equipment and stack)	Emissions

The challenge is to determine what changes occur to the current outputs as a result of changing the current inputs by using secondary materials.

Conventional chemical engineering approaches to such a problem are through mass balances: to model what happens in the kiln (i.e. in terms of physical and chemical reactions) and predict what the outcomes will be. Such a schematic would be similar to that in Figure 10-1. Our literature review quickly concluded that this is not possible, and this was further confirmed by PPC's engineers. MES were unable to find, either through literature review or consultation with PPC, any model which can successfully and accurately predict the reaction kinetics of the kiln, and which would be able to accommodate the type of inputs contemplated in this application.

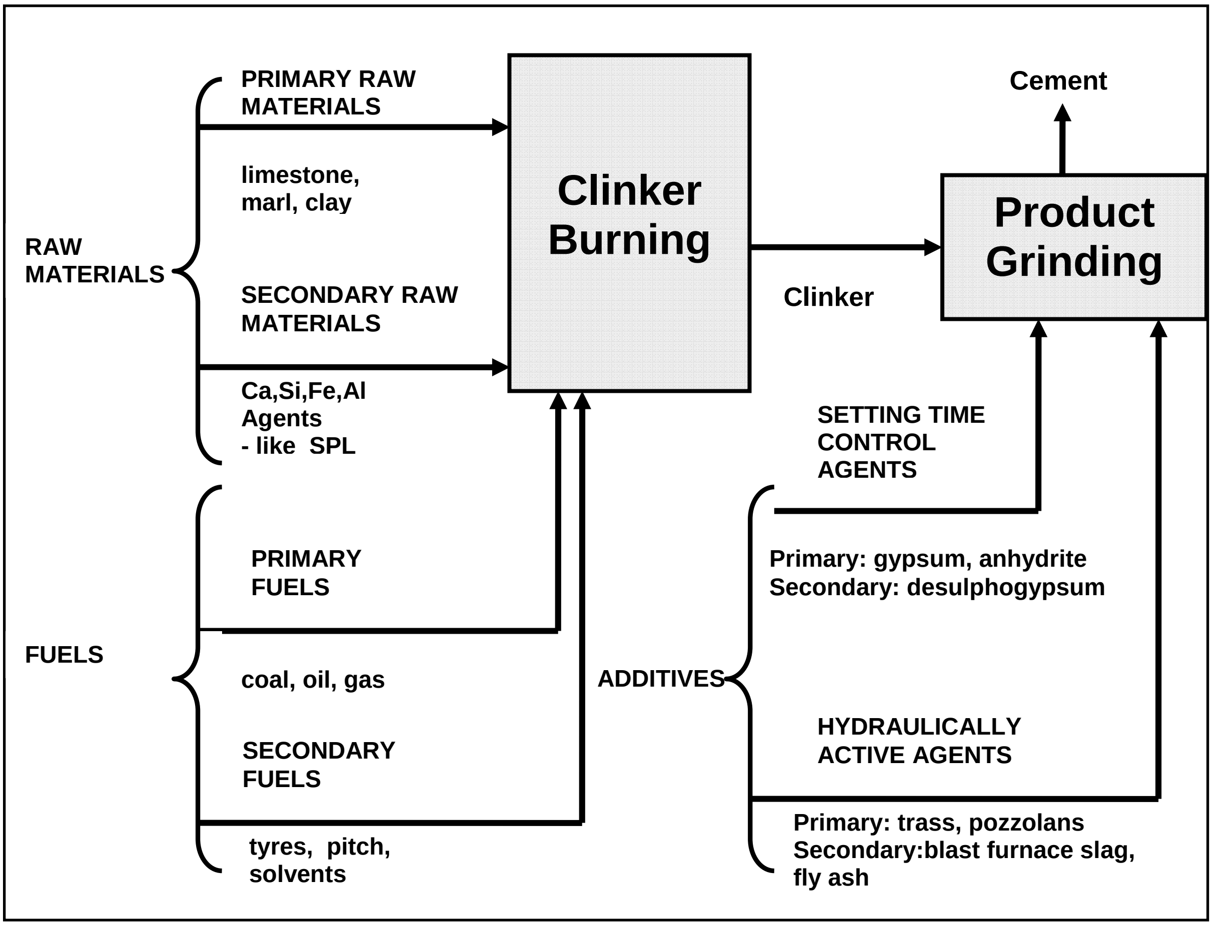

Figure 10-1: Mass Flow Scheme using Secondary Materials in Cement Manufacture[61]

It is our professional opinion that the absence of empiric models for the reaction profiles within a cement kiln using secondary materials is based on the following reasons[62]:

1. The complexity of the input compositions. Coal, alone, has over 600 different chemicals comprising its composition. If one adds to this a waste stream of relative complexity, such as hydrocarbon sludges, the opportunity for complex side-reactions is high.
2. The nature of waste streams is that they are varying in composition.
3. Each kiln is unique in its operational performance parameters (i.e. each kiln behaves differently).
4. An elemental mass balance would not be sufficiently accurate in that the speciation of the elements is poorly researched, or that the research available in the industry is derived from studying the outputs. Indeed, ALL the available literature on the effects of secondary materials on cement manufacture relies exclusively on the monitoring of the process outputs. An example of this is chlorine: one can empirically study the possible reactions that any chlorine introduced into the kiln may undergo, but one cannot predict with sufficient accuracy how and where they will leave the system (i.e. as salts embedded in the clinker, or as HCl gas and be scrubbed by the alkaline environment in the preheater, or whether they will react to form dioxins and leave as a gas. ***The value of the empiric approach therefore, is to provide important indications as to what outputs need to***

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[61] *Austrian Standard ÖNORM B 3310*

[62] *As confirmed via personal communication with Prof. Herman Eric, Dept of Chemical Engineering, University of Witwatersrand*

be measured and what analyses need to be performed. The preceding chapters of this report, therefore, provide a comprehensive review of the results of previous studies to determine an empirical understanding of the potential risks of the project, so that the appropriate monitoring and measurement controls are implemented.

5. Monitoring of the outputs is a reliable and accurate means of measuring the outputs in the same form and quantity as they will effect the environment.
6. Any model developed for a kiln would need to be calibrated anyway by measurement of the outputs. This would require a complete balance of all inputs and outputs under changing circumstances, with continuous monitoring during this period for a minimum of 24 hours for a full emissions inventory of all possible emissions. This would therefore be very expensive. Furthermore, preheater exit gas flow measurement and analysis takes an hour for each sample, the physical weighing of one day's production input and output (several thousand tons) and calibration of all scales and meters would need to be performed.

Two approaches were therefore available to MES:

6. To develop our own empiric model of the kiln reaction dynamics. The problem with this approach would be:
    - Such an approach would be extremely time-consuming and expensive;
    - The accuracy of the model would be questionable; and
    - The results of the model would have to be verified by trial burns, which would be recommended anyway by the latter option.
7. To hypothetically determine an emissions inventory and clinker quality (following the application of secondary materials) and determine whether such represent an acceptable risk to the environment and community health. Once these are determined, control mechanisms can be put in place to ensure that such emissions and clinker quality are achieved. Such controls would include (and are further discussed in the body of this report and recommendations section):
    - Controls on the input material (i.e. the components of the secondary materials which may contribute to the environmental impacts of the outputs. Example of such are carbon content and chlorides as they may affect the generation of dioxins and furans in the emissions gases);
    - Controls on the emissions monitoring programme: PPC would need to ensure that they detect changes in their emissions as a result of introducing secondary materials and report such to the authorities timeously; and
    - Controls on the implementation of the project subject to an acceptable environmental risk: that PPC would only be able to burn secondary materials if they are able to demonstrate that their emissions are not introducing a significant risk to the environment and community health.

There are other controls which have resulted from this study, but they are essentially expansions on these three concepts. It is worth noting, at this point, that these three controls have been recommended as conditions of any Record of Decision issued by the authorities, and that PPC have accepted such controls as reasonable and best practice.

10.2 ASSUMED OUTPUTS AND EMISSIONS FOR ENVIRONMENTAL RISK ASSESSMENT

The key question which therefore needs to be answered is therefore modified as follows: what outputs (i.e. emissions inventory and clinker quality) from the kiln process (using secondary materials) are achievable by PPC, given their existing processes and proposed waste streams, and within acceptable risk limits to the environment and community health.

In order to determine this, an iterative process needed to be established as follows:

- Stage 1: Assume an emissions inventory & clinker quality achievable by PPC.
- Stage 2: Perform an environmental risk assessment based on this assumption.
- Stage 3: If the environmental risk is acceptable, then proceed with the assumption. If not, return to Stage 1 and assume a stricter quality (with lower concentrations of toxic substances, for example) and repeat Stage 2 using the new emissions inventory and clinker quality.

As our initial assumption regarding the emissions, MES considered all the discussion contained in the previous sections of this report and proposed the emissions inventory for its first iteration listed in Table 10-2, which was deemed achievable by PPC and was acceptable to the company for all their kilns accepting secondary materials.

Table 10-2: Secondary Materials emission limits

MAXIMUM ALLOWABLE EMISSION LIMITS	
POLLUTANT	**LIMIT**
Total dust	As per current APPA permits
CO	See note
HCl	10 mg/Nm^3
HF	1 mg/Nm^3
NO_x	See note
SO_2	As per current emissions
TOC	10 mg/Nm^3
Cd +Tl	0.05 mg/Nm^3
Hg	0.05 mg/Nm^3
Sb, As, Pb, Cr, Co, Cu, Mn,Ni + V	0.5 mg/Nm^3
Dioxins toxic equivalence	0.1 ng/Nm^3

(NOTE: No SA legislation is applicable to CO and NO_x emissions limits, and PPC shall therefore commit to adhering to current emissions for these gases for future operations with Secondary Materials. PPC, however, is committed to reduce NO_x to Internationally accepted standards with its on-going kiln upgrading programme.).

This emissions inventory was developed on the following philosophy:

1. That the introduction of secondary materials should not affect the emission of particulates and therefore PPC's commitment is to continue to comply with their current APPA permits

for each kiln. MES' literature review agrees that no increase in particulates accompanies the introduction of secondary materials.

2. That CO and NO_x levels should not increase as a result of the introduction of secondary materials. MES' literature review, as discussed in Environmental Technical Review (Appendix D1), has identified that a reduction of NO_x normally accompanies the introduction of secondary materials. We therefore felt that it was in accordance with the precautionary principle of NEMA to propose that the current NO_x levels are used for our impacts assessment process.
3. That, for the other parameters, current EU limits are assumed. These limits are discussed in Section 3.14 of this report. We believe, again, that this is in accordance with the principles of NEMA since Europe has a far greater industrial density than South Africa, and that the EU standards were developed in cognisance of a greater residential proximity to the cement kilns than that which occurs in general around PPC's facilities.

The proposed emissions standards for Thermal Waste Treatment and Cement Kiln Alternative Fuel Use are available on the Department of Environmental Affairs website, and are in line with the EC limits that this environmental assessment was developed around.

In terms of assuming a clinker quality, the clinker quality acceptable to PPC will have to meet the requirements of SANS 50197-1. Although there exist no quality limits for chlorine in this standard, chloride is a source of corrosion for reinforcing and is therefore monitored by PPC in their quality assurance programmes. Both Cl and F levels in clinker are monitored to ensure compliance with quality aims (external and internal). For Cl there is a limit of 0.1% in cement, in line with the requirements of EN197-1. For F, there is no formal specification limit. PPC applies an internal standard of 2000 ppm (maximum) in clinker. At higher concentration levels, the presence of F in cement may affect setting times and, ultimately, the cement strength. Thus, it is in PPC's interest to regulate the Cl and F introduced into the kiln from a quality assurance point of view.

We believe that sufficient evidence exists, as documented the Environmental Technical Review (Appendix D1), to discount the effects of community health risk due to use of cement produced with secondary materials.

Using this as a basis, the following stage is to determine the impacts associated with the assumed emissions inventory.

In addition, there are other risks not associated with the inputs and outputs, which are discussed later in this report, namely:

- Process risks to operational and environmental health and safety (Hazop studies, see Section 13.9);
- Risks associated with the transportation and storage of the waste streams (see Sections 13.8); and
- Risks associated with the impact of this project on the broader context of waste management in South Africa (see Sections 13.7).

10.3 SPECIALIST STUDIES FOR IMPACTS OF EMISSIONS

In order to determine the impact on the environment and community health of the assumed emissions inventory, various specialist studies were identified through an understanding of the relationship between the inputs and outputs. This is represented in a simplified graphic, in Figure 10-2.

During a 6-month process of workshops with PPC, government, specialists in the market and NGO's, MES established that three principal relationships exist in the secondary materials process which may pose impacts on the environment, and which may require specialised studies to better understand. These relationships are summarised in Table 10-3.

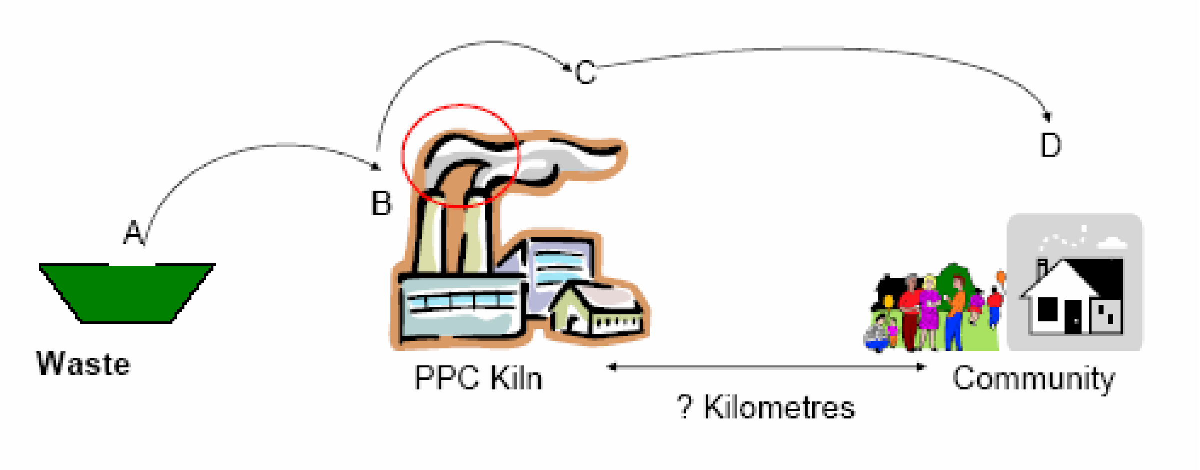

Figure 10-2: Relationship between secondary materials input and possible downstream receptors

During the required Public Participation Process comments from the public and Non-Governmental Organisations included concerns regarding the cumulative / compounded health impacts on the communities living near PPC factories. In order to assess this, a Baseline Community Health Survey was undertaken to establish the current potential health impacts of the current PPC emissions. The results of this study will form the baseline against which the impacts of secondary materials will be measured. Further, a request from key stakeholders to investigate the alternative waste disposal and treatment options for the various waste streams was received. As a result MES has also commenced with a Waste Disposal Study to determine the feasibility of waste treatment and disposal alternatives the findings of this study will be included with this report.

Thus the need for four specialist studies for each kiln was identified and the results of which are contained in full in separate reports, but which have been summarised in Sections 6 and 10 of this report.

Table 10-3: Identification of Specialist Studies

Relationship in Fig 8.2	Nature	Type of study required	Performed by:	Located where?
A → B	Relationship between the secondary materials and other raw materials and coal (inputs) and the emissions (output)	None possible (see Section 9.2) for stack emissions (i.e. assumed)	Not applicable	Not applicable
		Ambient dust	Marsh	Included in

Relationship in Fig 8.2	Nature	Type of study required	Performed by:	Located where?
		emissions inventory (I.e. from stockpiles, roads, mines, etc)	Environmental Services	Airshed report
B → C	Relationship between emissions inventory and air quality	Emissions dispersion model, to calculate ground level concentrations where sensitive receptors[63] are located	Airshed Planning Professionals	Separate Report
C → D	Effects of changes to air quality due to use of secondary materials on the health of the sensitive receptors	Community Health Risk Assessment	Infotox	Separate Report
		Community Health Survey (Baseline study)	Marsh Environmental Services	Separate Report

10.4 POTENTIAL FOR DIOXINS AND FURANS

Any chlorine introduced to the kiln system in the presence of organic material may form polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) in combustion processes under certain conditions:

- PCDDs and PCDFs can form in/after the preheater and in the air pollution control device if chlorine and hydrocarbon precursors from the raw materials are available in sufficient quantities.
- The reformation of dioxins and furans is known to occur by *de novo*[64 & 65] synthesis in the temperature range from 450 to 200° C.

Thus it is important that, as the gases are leaving the system, they are cooled rapidly through this range. In practice, this is what occurs in preheater systems as the incoming raw materials are preheated by the kiln gases. Due to the long residence time in the kiln and the high temperatures, emissions of PCDDs and PCDFs are generally low during steady kiln conditions.

The generally very low emission level of PCDD/F is due to the thermal conditions in the cement clinker burning process which are inherently unfavourable to PCDD/F formation. Limits to chlorine input are therefore required more from a process operation and product specifications (and possibly corrosion considerations) point of view than because of the emissions of PCDD/F.

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[63] *Sensitive receptors in this case are schools, clinics, creches, old age homes, etc. For the purposes of this study, these sensitive receptors are believed to be the most reliable indicators of air quality changes in the total receiving environment, not only the human component of the environment. No other sensitive receptors, such as specific species of flora or fauna, were considered as sensitive receptors.*

[64] *Formation and Release of POP's in the Cement Industry; Cement Sustainability Initiative March 2004*

[65] *Dioxin Emissions - Cement Kiln Operations, R Schreiber and W Winders, Proceedings of the International Specialty Conference for Waste Combustion in Boilers and Industrial Furnaces, Kansas City MO, March 1995*

10.5 EMISSIONS DISPERSION MODELLING

The terms of reference required to assess the impact of air pollution emanating from the current and proposed operations at PPC De Hoek, were as follows:

1. Obtain and analyse local meteorological data (wind speed, wind direction and ambient air temperature);
2. Carry out dispersion modelling;
3. Prepare isopleth plots of ground level concentrations for the site including:
    - The current impacts from all sources at the PPC De Hoek plant; and
    - Future impacts from all sources at the PPC De Hoek plant taking into account the change due to secondary materials usage.
4. Comparison of predicted concentrations to local and international guideline values and standards.

The emissions inventory compiled by Marsh formed the basis for assessing the impact from the proposed operating conditions at PPC De Hoek on the receiving environment. The following sources of pollutants were included (dust and CO_2 data from the raw mill and finishing mill stacks was not available for modelling):

- Emissions data for DHK5 and DHK6 stacks;
- Mining activity
- Vehicle entrainment from paved and unpaved roads.

For the purpose of the current study, it was decided to use the well-known US-EPA Industrial Source Complex Short Term model (ISCST3). The ISCST3 model is included in a suite of models used by the US-EPA for regulatory purposes. ISCST3 (EPA, 1995a and 1995b) is a steady state Gaussian Plume model, which is applicable to multiple point, area and volume sources. Gently rolling topography may be included to determine the depth of plume penetration by the underlying surface. A disadvantage of the model is that spatial varying wind fields, due to topography or other factors cannot be included. A further limitation of the model arises from the models treatment of low wind speeds. Wind speeds below 1 m/s produce unrealistically high concentrations when using the Gaussian plume model, and therefore all wind speeds below 1 m/s are simulated using 1m/s.

The hourly average wind speed, wind direction and air temperature data was obtained from the South African Weather Service's station in Porterville for the period January 2001 to November 2006.

The dispersion of pollutants emanating from the PPC De Hoek manufacturing plant was modelled for an area covering ~25 km by ~25 km. The area was divided into a grid matrix with a resolution of ~500 m, with the PPC De Hoek plant located at the centre of the receptor area. The ISCST3 model simulates ground-level concentrations for each of the receptor grid points.

Dispersion simulations were undertaken for two scenarios at PPC De Hoek namely:

- Scenario A: Current operating conditions at PPC De Hoek
- Scenario B: Future operations at PPC De Hoek including the usage of secondary materials.

The simulation results were compared against local and international ambient air quality standards and guidelines to serve as an initial health risk screening assessment.

The maximum concentrations were compared to the standard and guideline values in order to determine the contribution of the operations at PPC De Hoek to the ambient air quality in the region as well as within the plant vicinity. These highest predicted ground level concentrations for future operations are given in Figures 10-3 to 10-14.

For a full copy of the report, with all results, please refer to Appendix D2.

10.5.1 Results for Criteria Pollutants

Inhalable Particulates (PM10)

The future predicted ground level concentrations for PM10 were the same as for the current operations. All predicted concentrations complied with the standards at the plant boundary and were equal to the proposed SA standard at Piketberg for daily averages. Over annual averages the predicted concentrations complied with both standards. The PM10 emission rates from the two kilns remained unchanged since it were based on the APPA Registration Certificate limits and will not exceed these in future.

Oxides of Nitrogen (NO_X)

For future operations the predicted NOx concentrations remained the same as for current operations. This was expected since the emission rates remained the same (also based on the APPA Registration Certificate limits). Highest hourly, daily and annual average ground level concentrations were 124 µg/m³, 19.8 µg/m³ and 3.6 µg/m³, respectively falling within the SA Standards for the relevant averaging periods.

Sulphur dioxide (SO_2)

The future predicted ground level concentrations of SO_2 due to the use of secondary materials were predicted to be the same as current operations. The highest hourly and highest daily concentrations were predicted to be 26.7 µg/m³ and 4.3 µg/m³ and annual average was 0.77 µg/m³, respectively. These all occurred at Piketberg, ~1.5 km to the north of the De Hoek site. These predicted SO_2 concentrations are all well within the current and proposed SA Standards.

Carbon monoxide (CO)

The predicted ground level concentrations were within the hourly South African standard of 30 000 µg/m³. Highest hourly concentration was predicted to be 41 µg/m³ at the identified sensitive receptor (Piketberg). No change in the emission rates for CO between current and future operations were indicated resulting in the same ground level concentrations for the two scenarios.

Metals

Various metals such as antimony (Sb), arsenic (As), lead (Pb), chromium (Cr), cobalt (Co), cadmium (Cd), copper (Cu), manganese (Mn), nickel (Ni) and vanadium (V), associated with the proposed operations were included in Scenario B for the future operations at PPC De Hoek. Even though target values (as published by the WHO) exist for As, Cd and Ni, the emissions rates were provided as a group emission rate and hence the screening criteria could not be applied. The same applied to the proposed SA Standards for lead concentrations. These predicted ground level concentrations have been assessed as part of the health risk assessment conducted by Infotox.

Dioxin Concentrations

No health screening guidelines exist for Dioxin concentrations and this will be assessed as part of the health risk assessment to be conducted by Infotox (Pty) Ltd. The highest off-site concentrations predicted were 1.47E-08 ng/m³, 2.34E-09 ng/m³ and 4.23E-10 ng/m³ for highest hourly, highest daily and annual averages respectively. The highest concentrations were predicted at Piketberg. The longer term averages correlates with the prevailing wind field of the site.

Halogen Compounds

The halogen compounds (i.e. hydrogen chloride (HCl) and hydrogen fluoride (HF)) were screened against the Californian OEHHA (Office of Environmental Health Hazard Assessment) Acute and Chronic RELs (Reference Exposure Levels) health screening criteria. Concentrations of HF were higher than for current operations, with the maximum predicted ground level concentrations of 0.15 µg/m³, 0.02 µg/m³ and 0.004 µg/m³ for highest hourly, highest daily and annual averages. Similar increases in HCl ground level concentrations were predicted with an average increase of 7.3 times. The concentrations have also been assessed as part of the health risk assessment conducted by Infotox.

Mercury (Hg)

Mercury associated with the proposed use of secondary materials was included in the future operations at PPC De Hoek. No screening criteria are available for concentrations of mercury and these have been assessed as part of the health risk assessment conducted by Infotox.

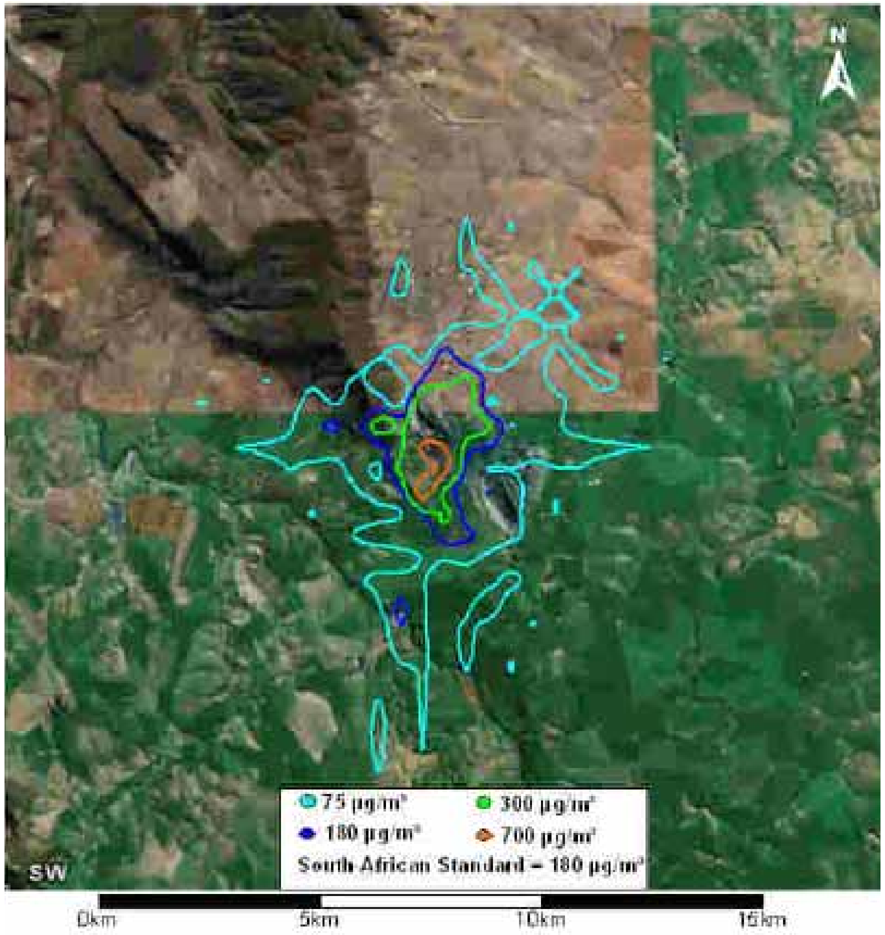


Figure 10-3: Highest daily predicted PM10 concentrations (no increase for future emissions)

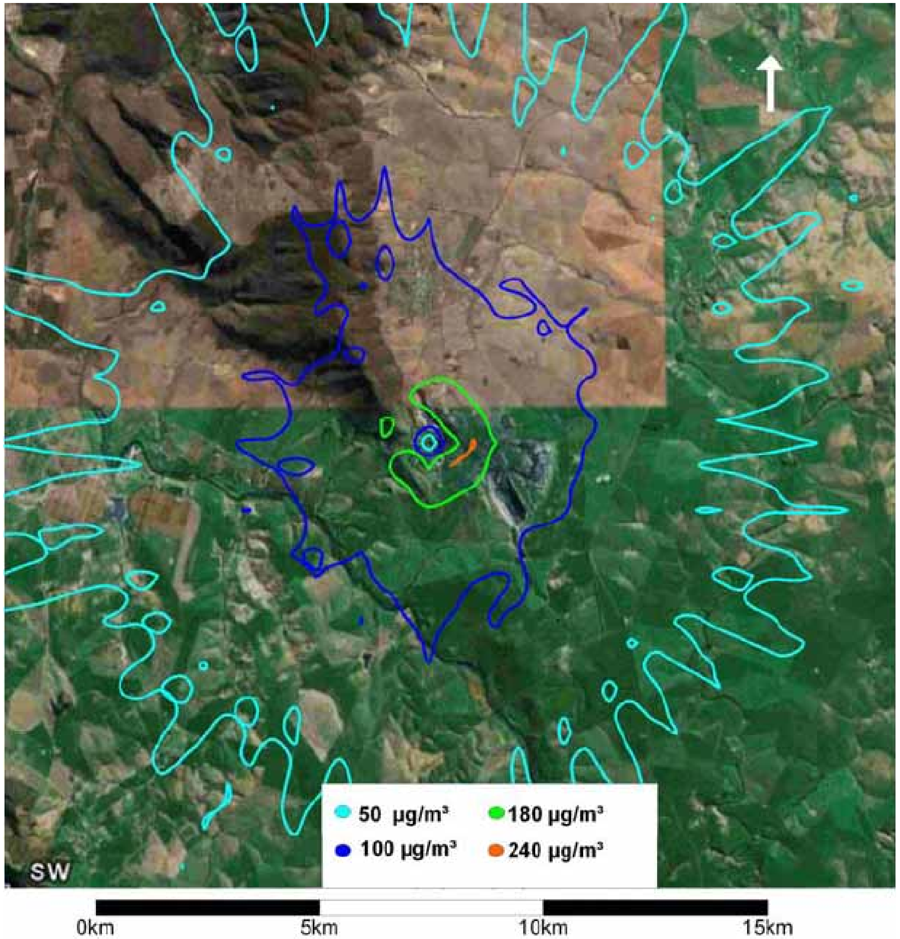


Figure 10-4: Highest daily predicted NO_x concentrations (no increase for future emissions)

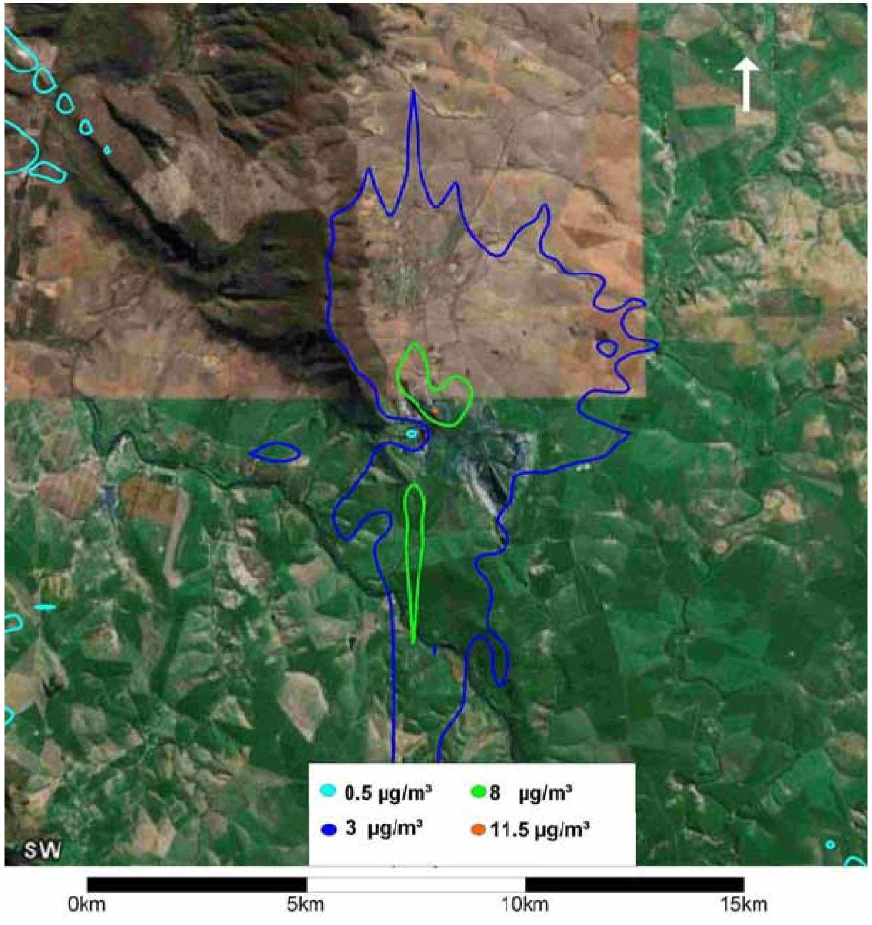


Figure 10-6: Highest daily predicted SO_2 concentrations (no increase for future emissions)

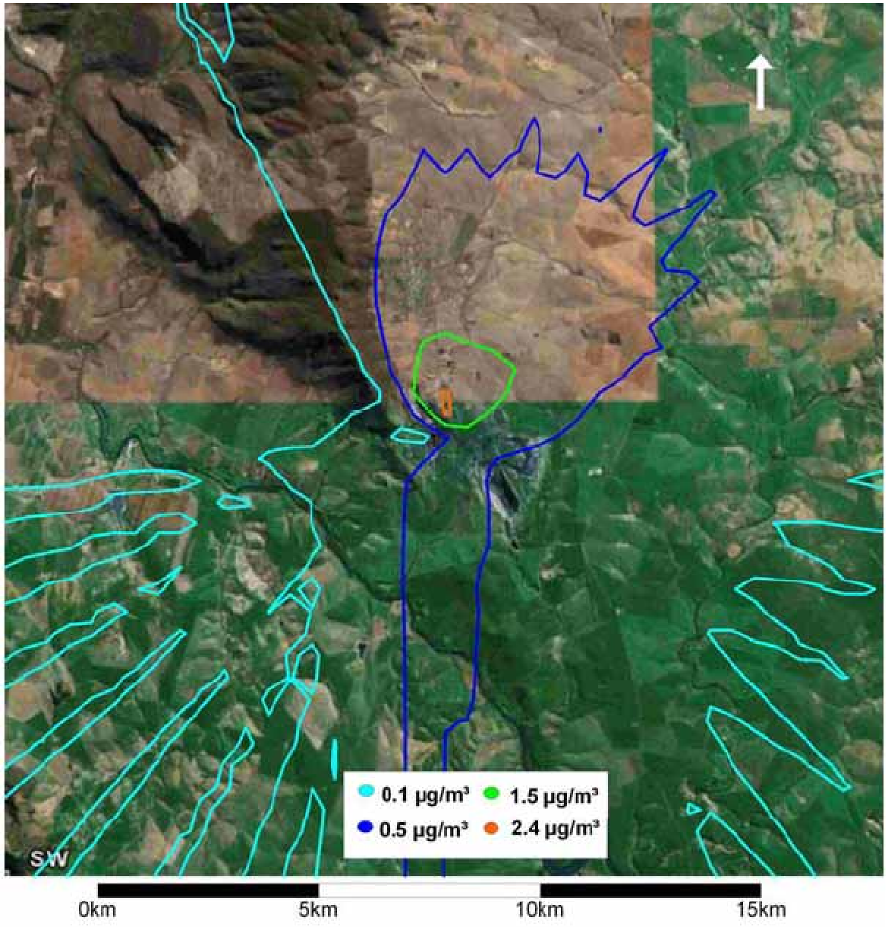


Figure 10-5: Highest daily predicted CO concentrations (no increase for future emissions)

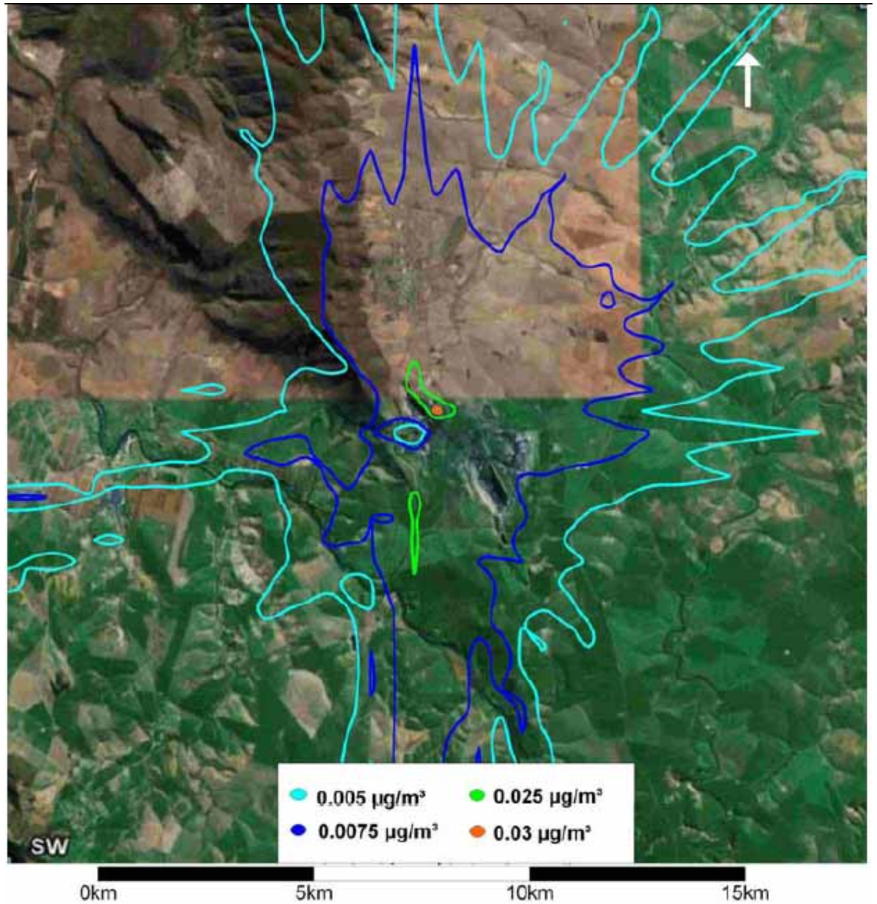


Figure 10-8: Highest daily predicted Metals concentrations

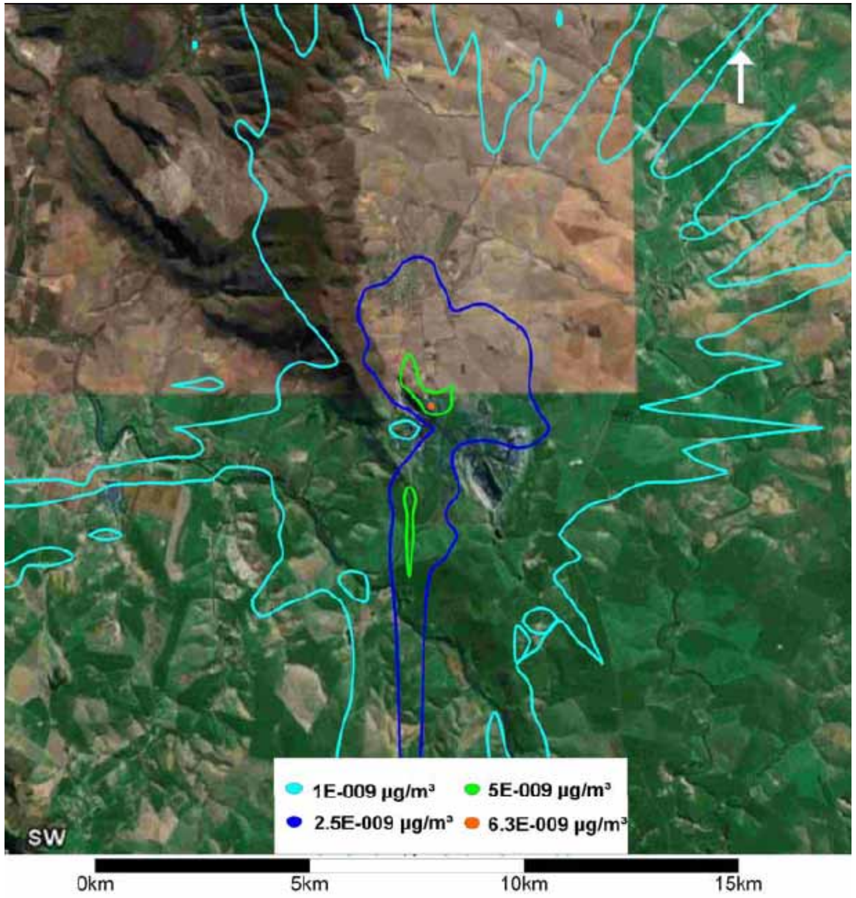


Figure 10-7: Highest daily predicted Dioxin concentrations

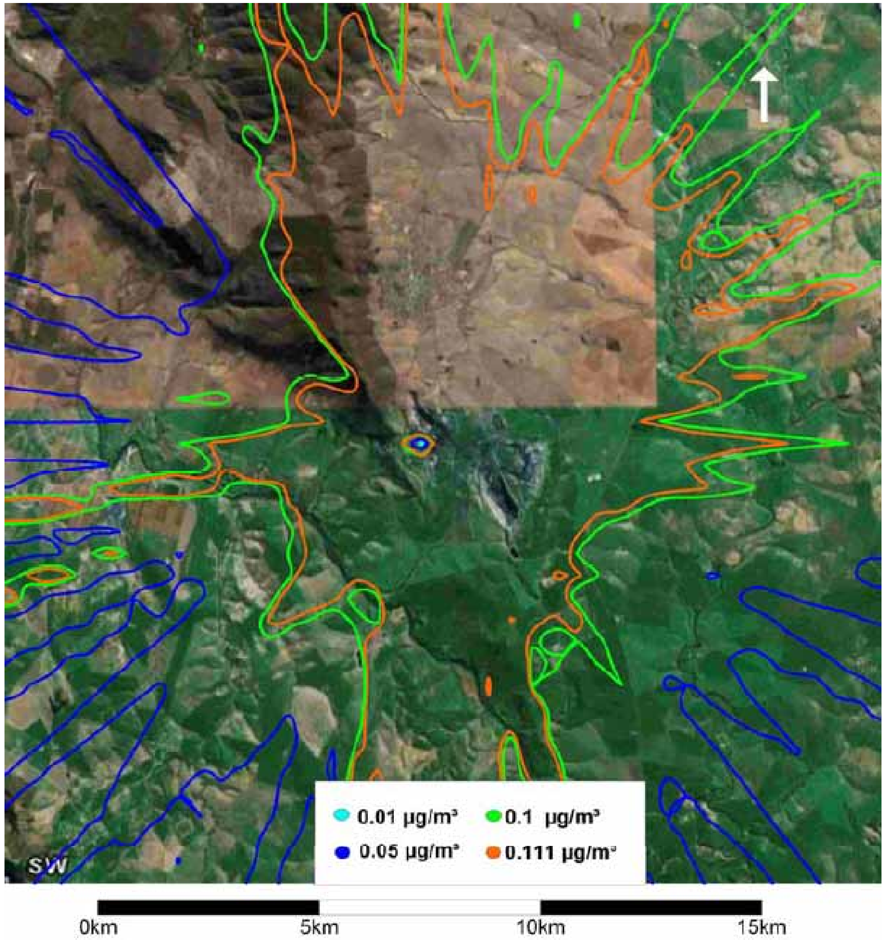


Figure 10-10: Highest daily predicted HCl concentrations

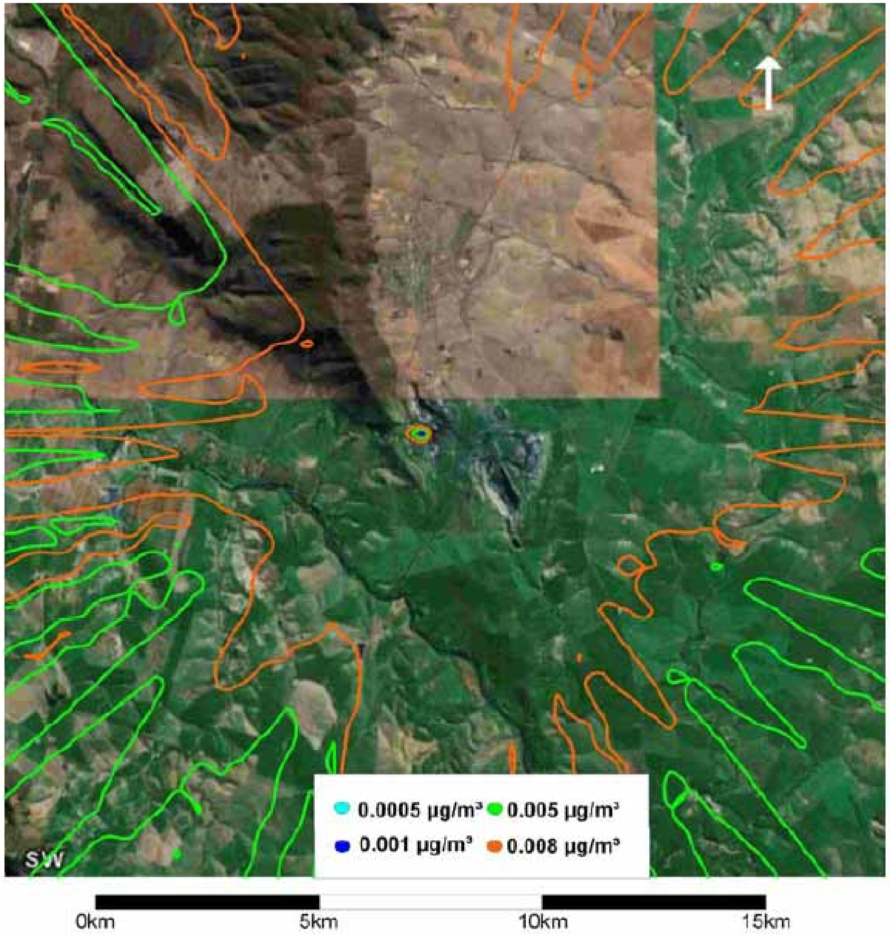


Figure 10-9: Highest daily predicted HF concentrations

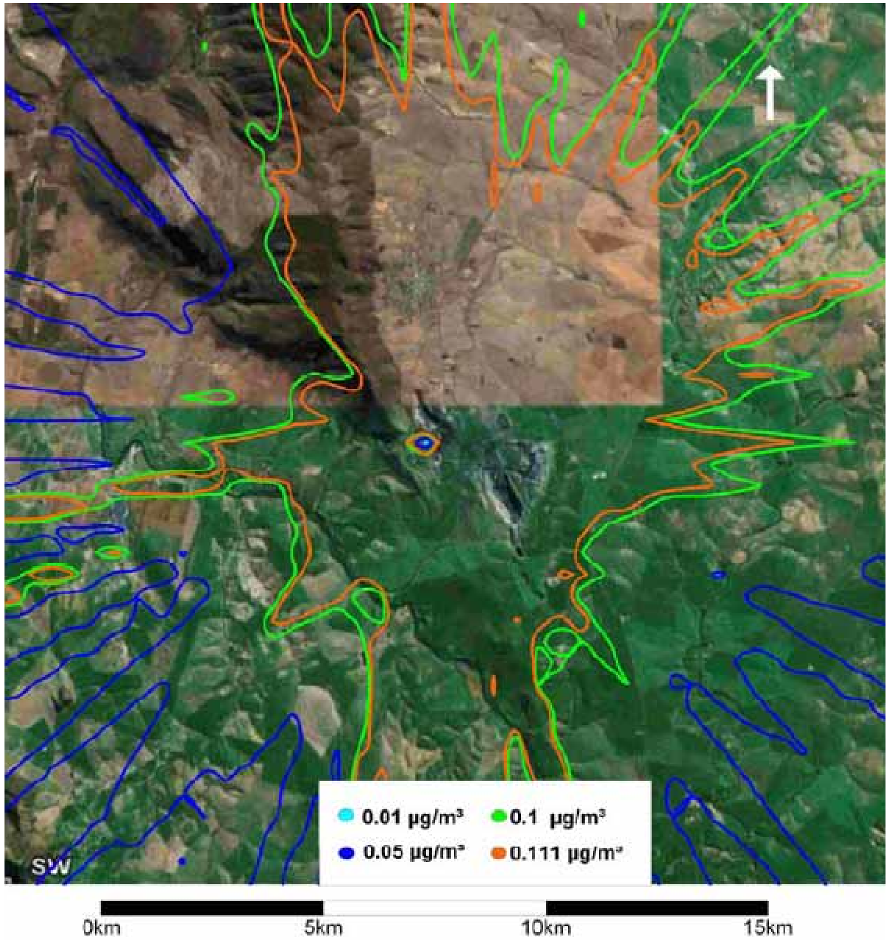


Figure 10-12: Highest daily predicted Hg concentrations

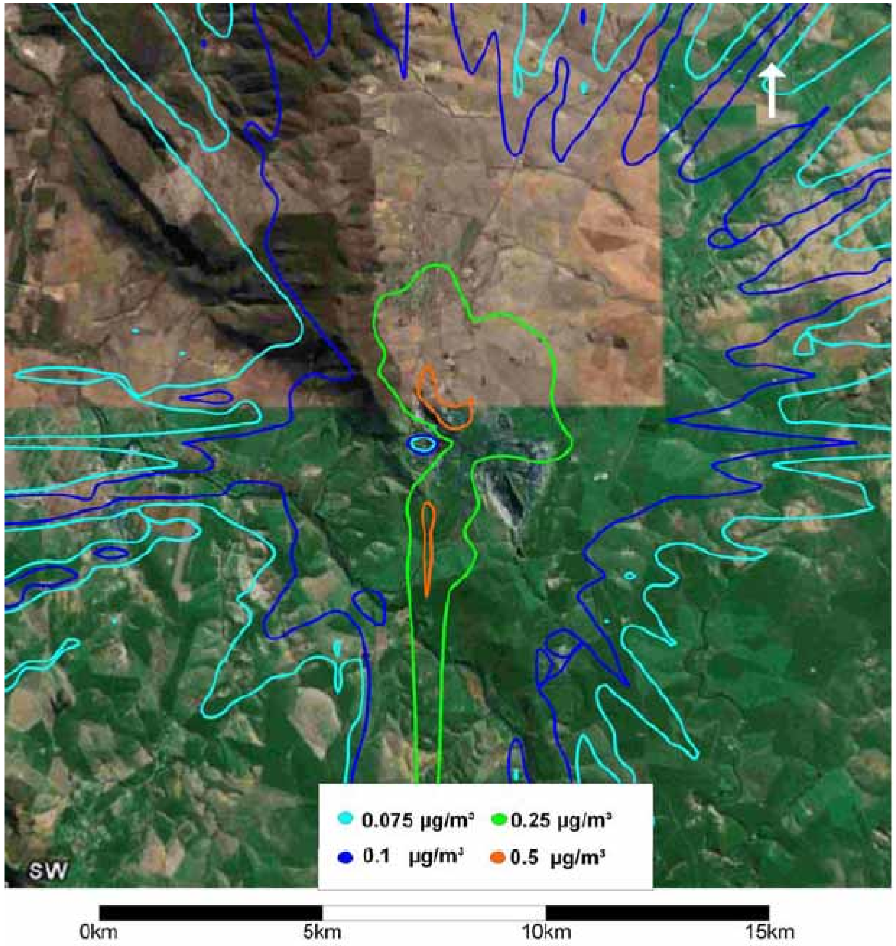


Figure 10-11: Highest daily predicted TOC concentrations

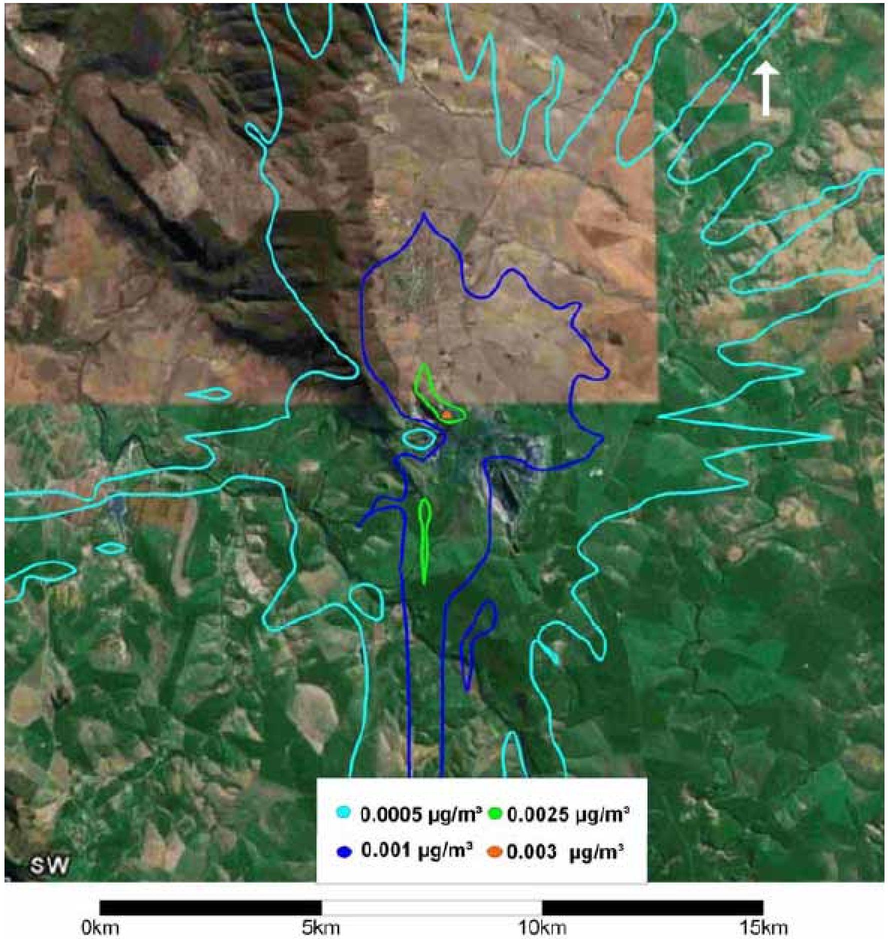


Figure 10-13: Highest daily predicted Cd and Ti concentrations

10.6 BASELINE COMMUNITY HEALTH SURVEY

The results of the Community Health Study show, however, that in the current situation, there is no information or study that demonstrates that PPC, in itself, has any negative effect on its surrounding communities. The available data cannot be utilized to make any conclusive decision as to whether PPC has a negative effect at any one of its sites. In order to do this, extensive epidemiological studies are needed. Even with such a study, clear association would be doubtful, as these studies often has fairly low specificity. This is evident in the myriad of publications in Occupational Medical literature 'suggesting' association. It is only H_2SO_4, (sulphuric acid) that has been classified as a human carcinogen on the basis of epidemiology alone.

10.7 COMMUNITY HEALTH RISK ASSESSMENT

10.7.1 Introduction

Infotox (Pty) Ltd was commissioned by Marsh Environmental Services to conduct a human health risk assessment associated with exposure to contaminants using the simulated air concentration data. The scope of the investigation was limited to generic exposure scenarios, not taking specific characteristics of the population into account. Sensitive features such as schools, places of worship and farming activities were taken into account in a qualitative context. The Community Health Risk Assessment Report presents the results of cancer and noncancer risk assessment, including a statement of uncertainties. It also presents a review of cancer unit risk factors and noncancer reference concentrations from the latest international peer-reviewed literature.

10.7.2 Findings

The main pollutants of concern resulting from current operations at PPC De Hoek include SO_2, NO_2, CO, HCl, HF, As, heavy metals and dioxins from the two kilns, and PM10 (particulates with aerodynamic diameter equal to or smaller than 10 µm) and total suspended particulates (TSP). Annexure 1 of the specialist report describes an overview of toxicological properties of the substances of interest and provides background data in support of the selection of guideline concentrations that were used in the assessment.

The Environmnetal Technical Review indicated that co-processing of secondary materials as fuels in cement kilns at PPC De Hoek would not lead to any noteworthy changes in emissions of hazardous substances from the operations. Therefore, based on the assumptions that underlie the study and the available data on the air pathway of exposure, there would be no difference between current health risks associated with the PPC production plant and the scenario where alternative fuels would substitute coal as the energy source for fuelling the kiln.

The human health risk assessment has been based on the assumption that emissions of toxic substances from the PPC factory would not exceed internationally-acceptable emission guidelines. This would however depend on the characteristics of the kiln and other auxiliary equipment at the factory. Generally, the efficiency of a kiln in combusting fuels that contain organic substances is expressed as a DRE (destruction and removal efficiency) value. This has to be obtained through a trial burn, which entails the demonstration that a facility is in compliance with regulatory requirements.

Furthermore, there has to be acceptance criteria for alternative fuels with regard to maximum permissible levels of halogens, metalloids and metals. The current human health risk assessment has assumed that these considerations have been, or will be, covered in the overall alternative fuels assessment for the PPC De Hoek factory. The assumption that stack emission guidelines will be met can be justified more fully when acceptance criteria have been developed for alternative fuels. The current dispersion modelling and risk assessment have been limited to the demonstration that operation within the respective stack emission guidelines would not lead to unacceptable risks through the air pathway of exposure. This is not surprising, because there is a tacit assumption in the setting of stack emission guidelines that these would be protective to human health within a large margin of safety.

It should be noted that the assessment has been based only on the air pathway of exposure. However, there are other factors that have to be considered. Mercury, for example, is a global issue and the introduction of alternative fuels should not be allowed to increase releases of mercury. Also, the primary concern about lead is not exposure through inhalation, but ingestion of lead by children. Should the alternative fuels programme release more lead into the environment than the current operations, deposition of lead and its contribution to house dust in residential areas might lead to unacceptable risks to children, even at modelled air concentrations that might be acceptable for the inhalation route of exposure. Cadmium should be considered on the same basis.

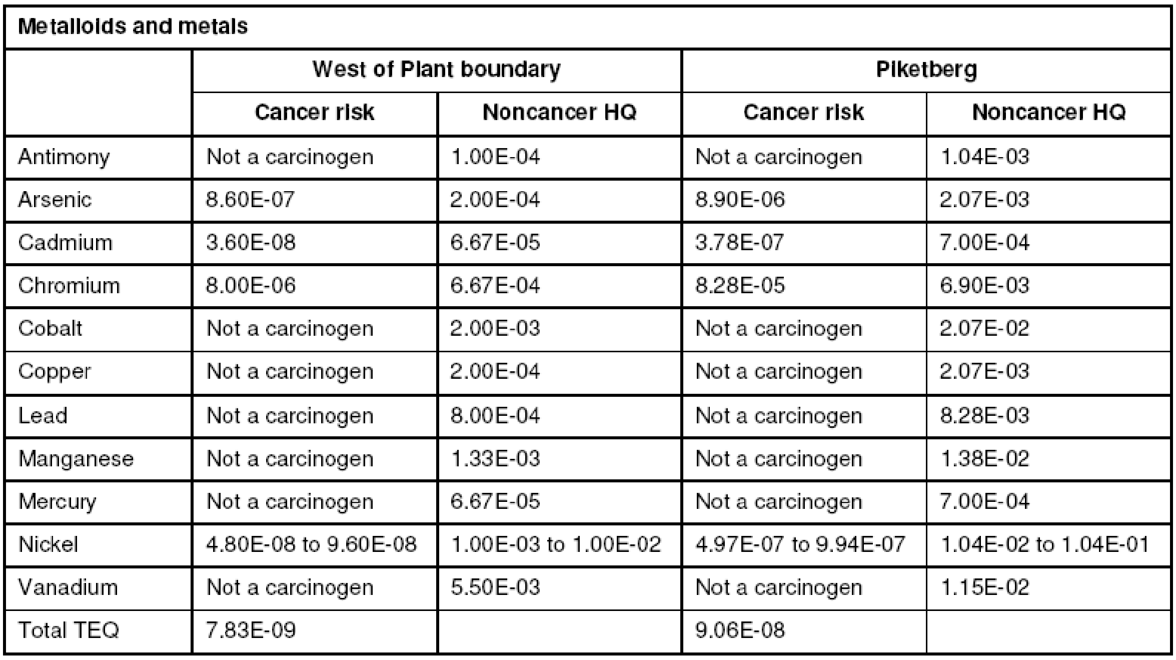
Table 10-4: Summary of exposure levels for gaseous pollutants for future emissions

Substance	Guideline	Averaging time	West of Plant boundary	Piketberg
Gaseous pollutants (µg/m^3)				
PM$_{10}$	50	24-hour	53.47	75.00
	20	Annual	8.9E-01	3.51
NO$_2$	200	1-hour	11.19	12.38
	40	Annual	3.1E-02	3.59E-01
SO$_2$	20	24-hour	2.03	4.26
CO	30 000	1-hour	37.09	41.04
Noncancer hazard quotients				
HCl		1-hour	5.08E-04	5.62E-04
		Annual	2.00E-04	2.10E-03
HF		1-hour	1.63E-04	1.84E-04
		Annual	2.86E-05	3.04E-04

For hydrochloric and hydrofluoric acids, the calculated hazard quotients for both acute and chronic exposures at sensitive receptors were orders of magnitude below 1. These clearly indicated insignificant health risks.

Table 10-5 shows that the total cancer risk associated with exposure to arsenic and metals would be lower than a few cases in a hundred thousand, even when all the cancer risks were added. In the calculation of cancer risk according to the original USEPA paradigm, all cancer risks from the individual carcinogens have to be added, irrespective of target organ, across all pathways and routes of exposure. This is a conservative way of assessing cancer risks. It should be noted that the highest risk was allocated to chromium in the hexavalent state. This is a large overestimate, because very little, if any, chromium would actually be in the Cr (VI) state.

Table 10-5: Summary of risk exposure for metalloids, metals and dioxins for future emissions



Metalloids and metals				
	West of Plant boundary		Piketberg	
	Cancer risk	Noncancer HQ	Cancer risk	Noncancer HQ
Antimony	Not a carcinogen	1.00E-04	Not a carcinogen	1.04E-03
Arsenic	8.60E-07	2.00E-04	8.90E-06	2.07E-03
Cadmium	3.60E-08	6.67E-05	3.78E-07	7.00E-04
Chromium	8.00E-06	6.67E-04	8.28E-05	6.90E-03
Cobalt	Not a carcinogen	2.00E-03	Not a carcinogen	2.07E-02
Copper	Not a carcinogen	2.00E-04	Not a carcinogen	2.07E-03
Lead	Not a carcinogen	8.00E-04	Not a carcinogen	8.28E-03
Manganese	Not a carcinogen	1.33E-03	Not a carcinogen	1.38E-02
Mercury	Not a carcinogen	6.67E-05	Not a carcinogen	7.00E-04
Nickel	4.80E-08 to 9.60E-08	1.00E-03 to 1.00E-02	4.97E-07 to 9.94E-07	1.04E-02 to 1.04E-01
Vanadium	Not a carcinogen	5.50E-03	Not a carcinogen	1.15E-02
Total TEQ	7.83E-09		9.06E-08	

Similarly, noncancer risks as reflected in the calculated hazard quotients, are very low. Generally, hazard quotients are orders of magnitude below 1 and even if hazard quotients were added to determine a total hazard index, very low health risks through the inhalation route of exposure are indicated.

Dioxin emissions were of special concern and require specific discussion. The highest cancer risk at receptor locations associated with exposure to dioxins from the PPC De Hoek factory under conditions where secondary materials were used as supplementary fuel was shown to be approximately 9 cases in a hundred million (9.06E-08). Dioxin concentrations in ambient air have been shown to range from below 1 fg TEQ/m^3 to several hundred fg TEQ/m^3 (Fiedler, 1999). Without taking exposure of members of a community to indirect sources of dioxins (such as food) into account, background exposure to air would in itself already lead to a cancer risk of higher than one in a hundred thousand, if the most recent USEPA cancer slope factor were used to calculate a unit risk factor for inhalation. It should be made clear that the USEPA upper bound slope factor has a very specific application. It allows the calculation of the high end (greater than 95 per cent) of the probability of cancer risk in the population. This means that there is a greater than 95 per cent chance that the calculated cancer risks will be less than the upper bound. The contribution from the PPC De Hoek factory to risk through inhalation under conditions of usage of alternative fuels would be insignificant against this background.

The study initiated by Marsh Environmental Services has indicated that co-processing of secondary materials as fuels in cement kilns at PPC De Hoek would not lead to any noteworthy changes in emissions of hazardous substances from the operations. Therefore, based on the assumptions that underlie the study and the available data on the air pathway of exposure, there would be no difference between current health risks associated with the PPC production plant and the scenario where alternative fuels would substitute coal as the energy source for fuelling the kiln.

10.7.3 Assumptions and Recommendations

The human health risk assessment has been based on the assumption that the predicted emissions of toxic substances from the PPC De Hoek Cement Factory are valid. Emissions from a cement plant would however depend on the characteristics of the kiln and other auxiliary equipment at the factory. Generally, the efficiency of a kiln in combusting fuels that contain organic substances is expressed as a DRE (destruction and removal efficiency) value. This has to be obtained through a trial burn, which entails the demonstration that a facility is in compliance with regulatory requirements. Alternatively, trial-burn data from a similar facility maybe assessed for applicability.

Furthermore, it is recommended that there be acceptance criteria for alternative fuels with regard to maximum permissible levels of halogens, metalloids and metals. The current human health risk assessment has assumed that these considerations have been, or will be, covered in the overall alternative fuels assessment for the PPC De Hoek Cement Factory. In particular, it should be noted that no additional mercury emissions should be allowed and emission of cumulative elements such as lead should be judged not only on air concentrations, but also on the basis of long-term deposition at receptor locations and exposure through ingestion, such as ingestion of house dust by infants and children.

The full copy of this report is available as Appendix D3.

10.8 ON-SITE STORAGE OF SECONDARY MATERIALS

Although the storage of the waste materials on-site will be minimised as the waste should be processed as it is received, the risk of spills, leaks, accidents and discharges of liquid and gaseous pollutants need to be planned for. All dry material should be stored in protected bunkers and liquid material in engineered and bunded storage facilities. In particular, transfer of wastes from the transporter should occur within an enclosed or bunded area. Emergency Response Plans will be developed for any accidents and incidents, and spill kits should be maintained on-site. The storage areas of hazardous waste should be as close to the points of application to the kiln as possible, but far enough away to prevent being heated by the radiant heat from the kiln and to allow truck delivery access. Pumps and piping systems for liquid and sludge transfers should be able to tolerate varying viscosities and solid particles (or filters should be installed to remove such). Adequate maintenance of these pumping systems needs to be performed to prevent pipe bursts. Transfer of dry materials (especially paper, sewage pellets and plastic) should be enclosed to prevent wind-blown litter. PPE should be used by all staff exposed these waste streams (gloves, face shields for toxic waste streams and dust masks).

10.9 HAZOP STUDY

PPC embarked on a high-level HAZOP study on the secondary materials project in early 2006. It was initiated at the Hercules facility under the chairmanship of Mr. J Meyer of PPC and included senior personnel from PPC head office, operational and risk management from Hercules and Slurry as well as Mr I Labuschagne of Marsh Environmental Services as an independent observer.

There was an initiating workshop lasting 3 days. PPC stated that this process will be continued during different sessions at its various sites until the full risk profile has been established for the company concerning secondary materials utilization. As a high level assessment i.e. overall risk assessment, the identified significant risks would require further detailed assessments and any action plan programs to be rolled down to operational level, to ensure all mitigating measures are correctly addressed.

During the 3 days available, HAZOP studies for paper pulp use at Slurry and waste tyre utilisation at Hercules were completed and the use of hydrocarbons at Hercules was partially addressed.

The general risk categories that the team identified were:

- Occupational Health;
- Safety;
- Air Pollution;
- Water pollution;
- Soil pollution;
- Process Stability;
- Product Quality;
- Community Impact;
- Impact on Plant & Equipment;
- Impact on Maintenance;
- Company Image;
- Infra-structure; and
- Special / Legal Requirements.

The distinct areas in the typical cement production process, where risk could occur, were identified as:

- Sourcing;
- Materials Handling (Offloading, Transport to storage and Storage);
- Processing (Transport to point of application, Feeding and Control, Kiln Operation (Normal), Kiln Operation (Abnormal), Kiln Operation (Emergency));
- Quality Assurance (Process QA, Product Quality (clinker)); and
- Measuring and monitoring.

A relative rating system as depicted in Appendix B of the Environmental Technical Review was used to determine the risk priorities. A generic list of possible secondary materials was decided on for the HAZOP study. These were:

- Rubber and used tyres;
- Sorted plastics waste (PET, PTFE, etc. excluding PVC);
- Paper pulp (alumina rich pulp from water treatment);
- Wood chips;
- Hydrocarbon sludges (solvents, waste pitch, tar etc.); and
- Thermally-treated sewage.

10.9.1 Interim HAZOP Conclusions

The process followed is thorough enough to highlight definite problem areas both in terms of hazards and operability. For instance, the relatively innocuous alumina paper pulp, which was previously considered to be a viable replacement for fly-ash as a source of silica and alumina, was found to pose too much risk to the stability of the kiln operation and product quality. Similarly, the very high risks to safety, health and environment, posed by the failure of the correct sourcing procedures for hydrocarbon secondary materials, was highlighted. Tyres used as secondary material was found to be relatively low in environmental risks but would require special attention in handling and storage.

In general therefore the HAZOP process started by PPC is believed to be a valuable preparatory tool but should be completed at all levels of the company's operations. Details of specific sources of secondary materials should be used as a second level study, once the generic study has been concluded. Consideration should also be given to making the results accessible to interested and affected parties.

Further high-level studies will be performed by PPC prior to the commencement of the Secondary Materials programme. The recommendations of such studies will be included in any audits recommended in Section 13.

10.10 A REVIEW OF THE WASTE HIERARCHY AND A LIFE CYCLE APPROACH TO DISPOSAL BY CEMENT KILN

(This is a summary report based on the full report which has been written and compiled as a component to PPC EIA application for the co-processing of secondary materials in cement kilns in South Africa.)

The waste management hierarchy in South Africa (previously published by the Department of Water Affairs and Forestry, and now by the Department of Environmental Affairs and Tourism) prescribes a philosophy of waste management. During the initial stages of public participation for this EIA application, it became evident that there were valid concerns from the NGO sector regarding the role that cement kiln disposal of waste can play in the fulfilment of this philosophy. The concerns included the following:

- The disposal of waste by cement kiln is not seen as recycling, but just another form of disposal (such as landfilling), and is therefore not a preferable option for waste (with only economical benefits);
- PPC is taking waste which could have been recycled;
- By creating a market for waste, PPC is giving generators an 'excuse' to generate waste, which will therefore create disincentives for the minimisation of waste generation; and
- The incineration of paper and cardboard is not environmentally positive as it cannot be recycled (back into paper or cardboard products), and is therefore wasting usable resources.

As part of this application, therefore, it is vital that the role that the disposal of cement kiln can play in relation to the waste hierarchy, and the potential impacts and benefits of this disposal option, be clearly understood.

MES were therefore appointed by PPC to perform a Waste Disposal Study to examine this issue. This study addressed the different perspectives through a review of **Waste Hierarchy,** examining the role that disposal by cement kiln may plays in each of the respective tiers; and includes a **Life Cycle Approach** discussion on the environmental footprint of disposal by cement kiln in comparison to other waste management options.

The waste streams discussed in the full report are based on the five proposed waste streams PPC propose using as secondary fuels in the cement kilns:

- Scrap tyres and rubber waste;
- De-watered, treated sewage pellets;
- Hydrocarbon waste (such as used oil, oil-contaminated general waste, oil-contaminated soil and coal fines);
- Plastic waste; and
- Biomass (such as paper waste, sawdust, wood chips and waste from bio-fuel production).

10.10.1 Cement kiln disposal in terms of DEAT's Waste Hierarchy

The Waste Hierarchy, which is generally divided into 5-7 tiers, is grouped into three broader tiers to better define the overall approach towards waste. These tiers, each based on a separate key principle of waste management are:

- Tier 1: Avoiding Waste Generation;
- Tier 2: Recovering the Value of Waste; and
- Tier 3: Treatment and Disposal.

The discussion on the waste hierarchy concludes that disposal by cement option is Tier 2, a preferred option to landfilling (Tier 3) where the reduction in waste (Tier 1) or recycling (Tier 2) of waste is not viable. Not only is the energy value of the waste utilised, thus replacing the need for other fossil fuels (coal), but the ash elements are needed and therefore incorporated into the production of cement.

The roles that PPC, the generator and the landfill operators play in the waste hierarchy are illustrated in the figure below.

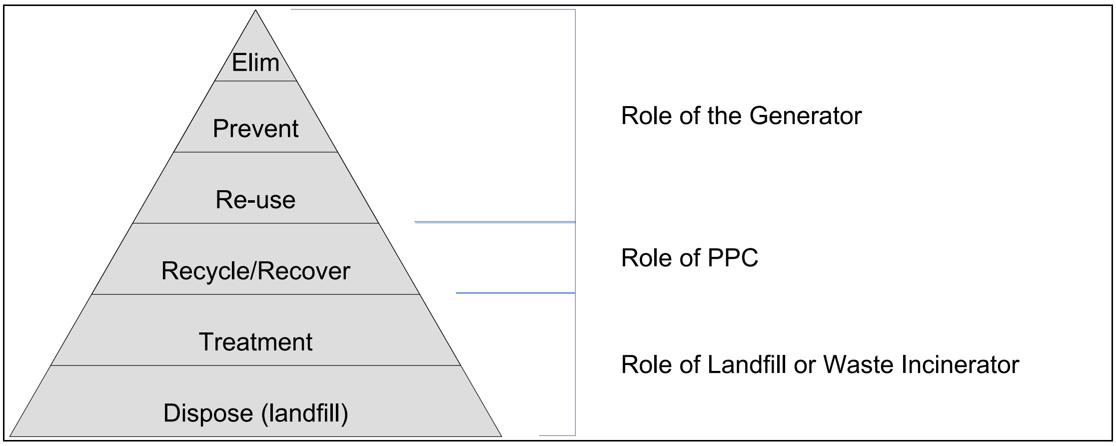


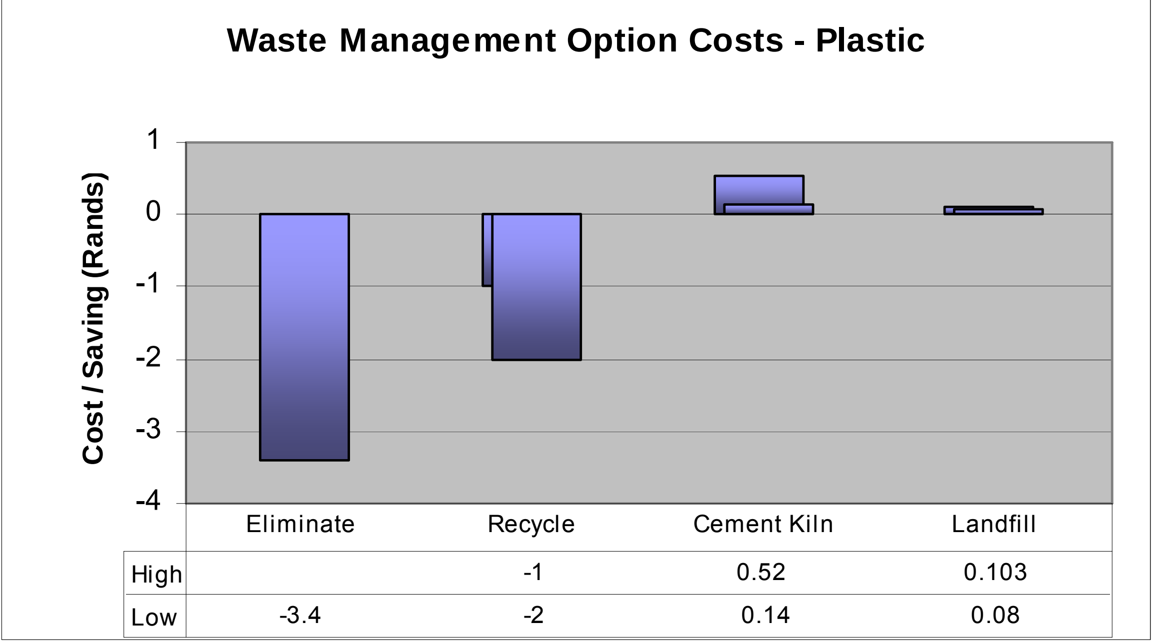
Figure 10-14: Roles in the Waste hierarchy

10.10.2 Market Forces

There is a concern that because the disposal by cement kiln is expected to be a cheaper waste management option than lower tiers of the hierarchy such as landfilling, that this new option will give generators an ‘excuse’ to generate waste, which will therefore create disincentives for the minimisation of waste generation (the upper tiers).

Market forces are shown to be favourable for the upper tiers of the waste hierarchy (reduction and recycling), thus ensuring that where viable, industries generating the waste will benefit more (financially) from any waste minimisation and avoidance programmes than disposal by cement kiln. Where landfill fees exceed the fees charged by PPC, or where the landfilling is not feasible, disposal by cement kiln will be an acceptable option.

The costing of disposal options for plastics and tyres are provided below, which indicates the range of costs or savings expected for the respective waste streams.



	Eliminate	Recycle	Cement Kiln	Landfill
High		-1	0.52	0.103
Low	-3.4	-2	0.14	0.08

Figure 10-15: Waste Management Costs for Plastics

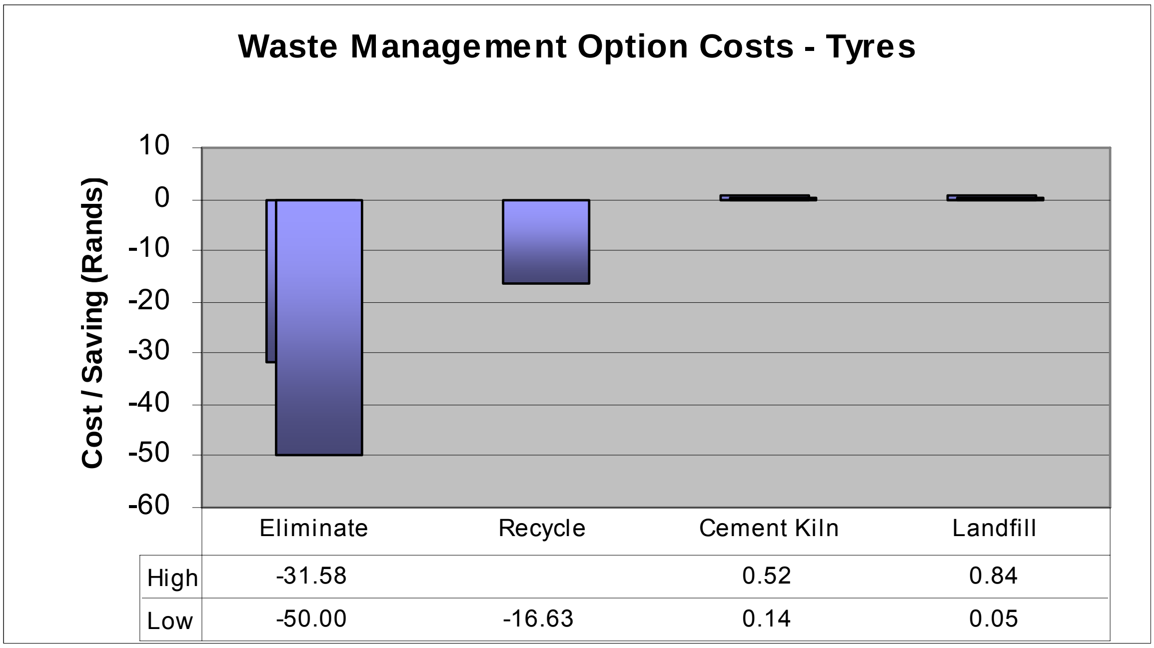


Figure 10-16: Waste Management Costs for Tyres

The difference in savings and costs for the waste management options clearly indicate that disposal by cement kiln is not providing disincentive to recycling or reduction options.

10.10.3 SA Policy and Legislation

It is important the any new waste option that is introduced to South Africa, benefits waste management in South Africa as a whole, and is aligned with the policies, strategies and regulations of South Africa. It must therefore provide opportunities that push the status quo of waste management up the tiers of the waste hierarchy.

South Africa waste management legislation and policies developed over the last few years are moving away from the end-of-pipe management and encouraging waste prevention and minimisation. The National Waste Management Strategy (NWMS) supports and encourages waste minimisation. PPC can reuse waste as an alternative fuel in cement kilns: this does not improve minimisation of generated waste but can reduce the volume of waste landfilled.

The following legislation, policies and strategies of South Africa identified holds supports for cement kiln as a waste management option. International trends further indicate that this option is practised and supported in various other countries (Europe in particular).

Table 10-6: Legislation, policies and principles reviewed

Legislation / Policy / Principle	Year of publication/ promulgation
National Environmental Management Act - Waste Management Principles	Act no. 107 of 1998
Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste	2nd Edition (DWAF, 1998)
Polokwane Declaration	*September, 2001*

Legislation / Policy / Principle	Year of publication/ promulgation
National Waste Management Strategy (NMWS-SA)	1999 adopted NWMS
White Paper on Integrated Pollution and Waste Management for South Africa	*DEAT, Planned in NWMS,* 2000
Gauteng Provincial Integrated Waste Management Policy	*March 2006, Draft*
Sewage Sludge Guidelines	*DWAF and WRC, March 2006*

Disposal by cement kiln, which reduces the use of natural resources by means of using wastes as an alternative fuel, together with reusing the wastes will result in waste being diverted from the landfill. The use of alternative fuels in cement kilns is therefore in alignment with the objectives set in Polokwane Declaration (reducing waste disposal), and to the holistic approach embodied in the NWMS. This option adhered to the objectives of the NWMS project, and to the Gauteng Policy (final draft), Policy no.10 (for the recovering and recycling of other materials).

10.10.4 Waste Disposal by Cement Kiln – A Comparative Approach

The Waste Disposal Study includes a life cycle approach takes a wider view for each disposal option for the five waste streams proposed for disposal by PPC. All impacts (including energy, resources, emissions and land use and water) must be identified, addressed and compared for the different waste management options.

This approach is based on the principles and framework for the accepted international standards for comprehensive Life Cycle Assessments (LCA) which is contained in IS0 14040 (1997), this standard outlines and describes following four iterative phases required for an LCA:

- Goal and scope definition;
- Inventory analysis;
- Impact assessment; and
- Interpretation.

In general, it was established that greater impacts are avoided for the recycling options compared to disposal by cement kiln or landfilling. Although additional resources and utilities are required for recycling operations (such as water for the washing of recyclable material or electricity for a shredder), the impacts of raw material production (which would be avoided for recycling) are generally higher than the impacts of the preparation of the waste materials to be used in recycling. Both recycling/use and disposal by cement kiln generally recover energy, avoid resource extraction (including non-renewable resources), and do not have an impact on land use, when compared to landfilling. There is a greater risk of ground and water contamination from landfilling (contaminants leaching to ground), and for the soil application of sewage sludge for agricultural purposes. The consumption of water and generation of wastewater are expected to be higher for recycling activities where substantial washing of the materials is required prior to being of use in the manufacturing process.

A literature review of case studies based on Life Cycle Assessments was conducted to further provide support of the environmental footprint, including impacts and benefits, of disposal by cement kiln compared to other options.

There is no single or ideal waste management strategy that will meet the needs of every community. In addition to assessing the impacts of the life cycle stages for the different waste management options, an integrated approach to waste management must incorporate the evaluation of the relevant economic, technical, political and social factors.

An integrated waste management strategy will therefore need to strike a balance between the various tiers and waste management approaches, and continue to push industry to assess opportunities higher up in the waste hierarchy. Disposal by cement kiln offers an additional waste management option, higher up in the hierarchy than landfilling. The cement kiln recovers energy and utilises the material value of the ash in the clinker. Waste materials less suitable for recycling and which have high calorific value should be processed through energy recovery rather than landfilling. Using such residual wastes as sources of energy displacing fossil fuels such as coal and can provide a reduction in GHG emissions. The availability of this option in South Africa is expected to divert a substantial amount of waste that would otherwise have been landfilled or illegally dumped, thus improving the status of waste management in South Africa.

Although source reduction provides the maximum benefit for many impacts, this practice does not always receive the attention it deserves, and the waste manager seldom has the opportunity to implement waste minimization programmes that would reduce wastes at source. However, the financial gains from source reduction are far greater than any other option, and therefore the option of disposal by cement kiln is not expected to provide a disincentive for industry considering minimisation options.

10.10.5 Conclusion from the Life Cycle Assessment on Waste Disposal

The practice of employing alternative fuels in cement plants does not hinder the establishment of a sound waste management industry. The practice can co-exist alongside a vigorous and thriving materials recovery and recycling and incineration industry, without distorting the essential principles of the waste management hierarchy.

10.11 PPC EXPERIENCE WITH SECONDARY MATERIALS

In South Africa, PPC was the first cement company to investigate the feasibility of the use of secondary materials including waste material as a fuel supplement. From 1993 - 1994, Feasibility and Environmental Impact studies were carried out at the Jupiter cement manufacturing plant in Johannesburg, the results of which are discussed in the following sections.

Trial burns with chemical waste were also conducted and these showed that the addition of these secondary and waste materials had no negative effect on the stack emissions or on the health risk to the surrounding community. These trials also showed that the quality of the cement was not compromised. However, PPC did not continue the use of secondary materials at the Jupiter kiln due to temporary closure of the Jupiter kiln operation, due to low market demand.

The Jupiter factory was re-commissioned for production in 2006, but has not continued the use of secondary materials and is not included in this EIA. PPC does, however, use spent pot lining (SPL) as a secondary material in some of its kilns. This is discussed further in section 10.11.

10.12 AEC SURVEYS & TRIALS[66]

10.12.1 Background

PPC contracted the Atomic Energy Corporation of South Africa Limited (AEC) during 1993 and 1994 to conduct studies relating to emissions and potential health effects as part of a feasibility study for the co-processing of high-energy wastes in the Jupiter production facility.

It was the first time that such comprehensive baseline, test-burn and trial-burn surveys had been conducted in South Africa for the regulation of a waste-incineration facility. The analytical survey and subsequent environmental health risk assessment provided information regarding the capability of the cement kiln to destroy wastes.

A baseline study and test burn using an organic compound that is known to be difficult to destroy (carbon tetrachloride) were conducted, as well as a trial burn with a pitch-derived secondary material. The aim was to provide information on the background distribution of metals and organic compounds in feed materials, emissions and the cement product, and to demonstrate the efficiency of incineration that can be achieved. These studies were to provide the background data for an assessment of the viability of co-processing of wastes in an actual trial burn. These studies were conducted in strict accordance with the USA Environmental Protection Agency (EPA) guidelines as governed under the Resource Conservation and Recovery Act.

10.12.2 The Guideline Regulation Used for the AEC Studies

In February 1991 the United States Environmental Protection Agency (USEPA or EPA) promulgated the Burning of Hazardous Waste in Boilers and Industrial Furnaces (BIF) regulations. The then newly promulgated BIF regulations govern virtually every aspect of operations at a facility where flammable wastes are used to supplement fuel demand. These BIF regulations are:

- Particulate emissions are limited to 180 mg per dry standard cubic meter (mg/dscm) of gas emitted at 7 % O_2,
- The destruction and removal efficiency (DRE) for POHCs (principal organic hazardous constituents) must be at least 99,99% (99, 9999% for dioxin-listed wastes).

  $DRE = [W_{in} – W_{out}]/ W_{in} \times 100;$
  W_{in} = mass POHC entering combustion device;
  W_{out} = mass POHC exiting in stack gas[67]
- Metal emissions must be controlled at a level that does not pose a cancer risk of greater than one in 100,000 for carcinogens or a level which may produce adverse health effects after a lifetime of exposure for non-carcinogens.
- Products of incomplete combustion (PIC) are controlled by monitoring carbon monoxide or hydrocarbon emissions. If limits are exceeded the waste feed should be automatically cut off.
- Dioxins and furan emissions cannot exceed a lifetime cancer risk of one in 100,000.
- The baseline survey and test burn at the Jupiter production facility were designed to use sampling and analytical methods as well as the appropriate quality assurance approach that would meet the RCRA criteria. Similar protocols were followed in the trial burn with waste derived fuel.

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[66] *AEC Projects codes BAW 0815,0820,0823,& 0827:1993-1994*

[67] *Burning Hazardous Wastes in Cement Kilns; Environmental Toxicology International 1992*

10.12.3 Baseline Survey

The baseline survey was required to characterize the Jupiter production plant comprehensively in terms of the chemical composition of gaseous and particulate emissions, feed materials (raw meal and coal) electrostatic precipitator (ESP) dust and product (clinker). This data was to provide a baseline reference for the assessment of materials and emissions after the introduction of secondary materials. All aspects relating to the baseline survey have been described in the baseline survey plan[68]. These tests included volatile and semi-volatile organic compounds, particulate emissions, BIF metals in stack gas, semi-volatile organics and metals in coal and raw meal, and metals in the kiln dust and clinker. Gaseous emissions of oxygen (O_2), sulphur dioxide (SO_2), nitrogen oxides (NO), carbon monoxide (CO) and carbon dioxide (CO_2) were also measured.

As pointed out above, EPA permit application protocols require the submission of comprehensive planning documentation for the relevant field surveys.

10.12.4 Test Burn

The test burn to determine the typical destruction and removal efficiency (DRE) of the Jupiter kiln for organic compounds and the formation of dioxins was accomplished through the incineration of carbon tetrachloride (CCl_4). This chemical is extremely difficult to destroy and is used internationally as a benchmark test material to assess incinerator efficiency. Furthermore it is classified as a toxic material[69] and is, due to its high chloride content, ideal to evaluate dioxin emissions.

The CCl_4 was introduced into the burning zone of the kiln at a rate of 100 kilograms per hour over two days. The emission rates of CCl_4 from the stack were measured and the DRE values calculated. Clinker was tested for chloride. All aspects relating to the DRE tests had been fully described in a DRE survey plan[18].The purpose of a test burn is to demonstrate that an incinerator has the ability to destroy hazardous materials efficiently to levels of emission that would not pose risks of any significance to public health or the environment.

10.12.5 Trial Burn

A comprehensive trial burn was conducted using a pitch-type waste-derived fuel as a supplement to the coal feed. Over a five week period during mid-1993 some 900 tons of waste was consumed replacing on average 20% of the coal requirements of the plant. All aspects relating to the trial burn have been fully described in the trial burn document.[70]

The waste derived fuel contained more sulphur than coal. It is significant to note that of the metals listed in the BIF regulations for emission control, only chromium was present at a significantly higher concentration in the waste derived fuel than in the normal coal feed. The input into the kiln of other metals listed as carcinogenic (arsenic, beryllium and cadmium) were in fact reduced when this waste material is used as a fuel supplement. Coal contains much higher levels of barium.

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[68] *AEC document ATP/8*

[69] *Class 6.1 SANS 10228*

[70] *AEC document ATP/12*

The organic composition of the pitch-type material is presented in Table 9-5. It should be noted that the material intended as secondary material did not contain chlorinated substances, the major precursors of dioxins and furans, in significant quantities.

Table 10-7: Organic substances that composed the waste derived fuel for trial burn

Phenol	C_6H_6O
Methylphenol	C_6H_8O-isomers
Dimethylphenol	$C_8H_{10}O$-isomers
Ethylphenol	$C_8H_{12}0$-isomer
Ethylmethylphenol	$C_9H_{12}0$-isomer
Propylphenol	$C_9H_{12}0$-isomer
Hexamethylcyclotrisiloxane	$C_6H_{18}O_3Si_3$
Decamethylcyclopentasiloxane	$C_6H_{30}H_5Si_5$
Dodecamethylcyclohexasiloxane	$C_{12}H_{36}O_6Si_6$

The waste characterization results are presented in Table 9-6. These values have been compared with the composition of the normal coal feed material.

Table 10-8: Ash, water and elemental compositions of waste derived fuel and coal feed material for trial burn of pitch feed at Jupiter

	Waste Derived Fuel		**Coal**	
Component	**%**	**Mg/kg**	**%**	**Mg/kg**
Ash	0,06		15-20 (typical)	
Water	<1		Not determined	
S	5,7		0,7	
Cl		44		
F		<0,5		Not determined
Sr		<0,5		Not determined
I		<0,5		Not determined
Ag		6		<2,5
As		0,2		1,1
Sa		7		156
Se		<0,5		2
Cd		<1		1
Cr		101		18
Hg		<0,1		<0,1
Pb		<0,5		20
Sb		0,1		0,1
Se		0,1		0,4
Tl		24		15

The TCDD equivalents and release rates into atmosphere is summarized in Table 9-7.

Table 10-9: TCDD equivalents and release rates (rounded-off values) for Jupiter trial burn of pitch feed

TEST NO	TCDD eq mg/m^3 at NTP	RELEASE RATE (g/s)
10.1	1,42 X 10^{-6}	4,25 X 10^{-8}
10.2	2,28 X 10^{-6}	8,55 X 10^{-8}
10.3	1,77 X 10^{-6}	6,67 X 10^{-8}

10.12.6 Conclusions

The conclusions made at the time by AEC are summarized below:

- The DRE tests with CCl_4 confirmed that the Jupiter cement kiln has the ability to incinerate hazardous wastes efficiently to levels of emissions that are within the standards set by the United States of America Environmental Protection Agency. Dioxin measurements were not recorded for this test burn.
- DRE values based on the quantitative determination of CCl_4 in the emitted gas were greater than 99,9999 %. This value adequately meets the EPA requirements for hazardous waste incineration that has been conducted in the USA and elsewhere in cement kilns.
- CO and CO_2 levels indicated a combustion efficiency of better than 99,9 % throughout all of the tests.
- The higher sulphur levels in the secondary material did not result in any measurable SO_2 emissions.
- NO_x emissions were unaffected by the use of waste as a supplement to the coal fuel. Very little changes occurred in the level of emission of metals and organic substances. These were assessed in terms of environmental health impact.
- No evidence of compositional changes of kiln dust and clinker could be found that would support the possibility of a change in risk to humans or the environment when waste is used as a fuel supplement.
- Quantification of emissions from operation with conventional fuel and from the use of waste derived fuel indicated that the waste had no effect on both cancer and non-cancer health risks to the community. Emissions were well within the health-based standards for such facilities. Estimated cancer risks were less than one in a million. These are indeed extremely low risks.
- The TCDD values given in Table 10.6 above were used to estimate annual average ground level concentrations of dioxins and furans, using the EPA-based computer dispersion models. This data was subsequently used to quantify cancer risks to exposed communities due to dioxins and furans released from the Jupiter cement kiln when coal fuel is partly replaced with selected waste materials.
- The AEC reports clearly concluded that all calculated risks were insignificant.

10.13 XYLENE TRIAL BURN[71]

10.13.1 Background

The safe disposal of pesticide and herbicide contaminated solvents are expensive and not many disposal facilities exist in South Africa. The World Bank together with the Global Environmental Fund (GEF) and the Food and Agricultural Organization (FAO) of the UN launched an initiative during the late 90's to collect and dispose of all obsolete pesticides and herbicides worldwide. The name for the Africa part of the project is "The African Stockpile Programme" or ASP. The World Bank's estimate was 45,000 tons over 15 years for Africa. The estimate from the Agricultural industry however is 30,000 tons. Xylene is known to be a toxic, flammable and carcinogenic compound, and special legislative requirements exist for its handling, storage and transportation.

To determine the viability of disposing of these materials in the clinker manufacturing process as well as gain experience in the correct transport, handling and storage thereof, PPC decided to conduct a trial burn with xylene-contaminated solvents (from the company Syngenta in Brits) at the Slurry facility on Kiln 8. The solvent was delivered in 210 litre drums, transferred into two 300 litre holding tanks and pumped into the kiln primary air stream. Slurry received a total of 200 drums for the trial burn purpose. The project was conducted from February to June 2005.

10.13.2 Regulatory Requirements

PPC obtained information from Syngenta pertaining to typical analysis and characteristics. A mass balance prediction was used to determine the potential influence in product characteristics and emission levels. The mass balance spreadsheet was forwarded to the Western Cape Province CAPCO with all relevant permit application documentation. Approval for a trial burn was granted for 50 tons over 2.5 months in 2005.

10.13.3 Risks Assessment

To ensure proper handling, transport and storage of the waste a risk assessment study was performed and the following main potential risks were identified:

- Impact on people health through skin contact, eyes, inhalation of fumes or ingestion;
- Soil contamination;
- Water contamination;
- Air pollution, and
- Fire and explosions.

To mitigate or avoid these risks the following measures was put in place:

- A separate storage area with the necessary bunding was provided to minimize the risks of fire as well as possible soil and groundwater contamination.
- The feed system was designed to feed directly into the fine coal transport air duct to ensure delivery into the flame.

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[71] *Xylene Trial Burn – PPC Slurry 07 July 2005: JJ Meyer*

- All staff working with the contaminated solvent were trained on the safe handling of the material and were issued with the necessary PPE (personal protective equipment).
- Medical surveillance tests were conducted before and during the trial burn on eight employees, with four employees exposed to Xylene and four used as a control group, with no negative effect reported.
- The process and basis for the trial burn was communicated to interested and affected parties.

Test Procedures

- The feed rate was kept low at between 25 and 30 l/h to ensure complete combustion and to prevent any process upsets to the kiln operation. The feeding started at 3.5 drums per day and was later reduced to 3 drums due to frequent build-ups in the firing fan duct.
- The material was only fed during steady state conditions i.e. kiln producing at >90% of normal production rate.
- It was decided to feed during morning and afternoon shifts only to ensure adequate supervision.

10.13.4 Emission Results

Stack emissions tests were conducted by an independent emission monitoring company (Levego CC) before and during the trials to determine any increase in emission of volatile organic compounds during the trial. The results are depicted graphically in Figure 9.6.

- The benzene emission level increased from 93 ppb (parts per billion) before the test to 120 ppb during the test. The toluene emission levels also increased; from 29.84 to 62.96 ppb while the Ethyl-Benzene emission level dropped from 16.4 to 4.19 ppb. The total xylene emissions during the trial burn were above the baseline emissions and increased from 21.07 to 33.01 ppb.
- The addition rate of boiler ash as a raw material changed during the trail burn. Since boiler ash contains varying percentages of carbon and other organic materials, this could have contributed to the results.
- No standards for the emission of volatile organic compounds (VOC) exist in current environmental legislation for South Africa. The results were, however, discussed with Mr. Witold Bryszewski, previous CAPCO of the Western Cape province, and he indicated that these levels were within acceptable limits.

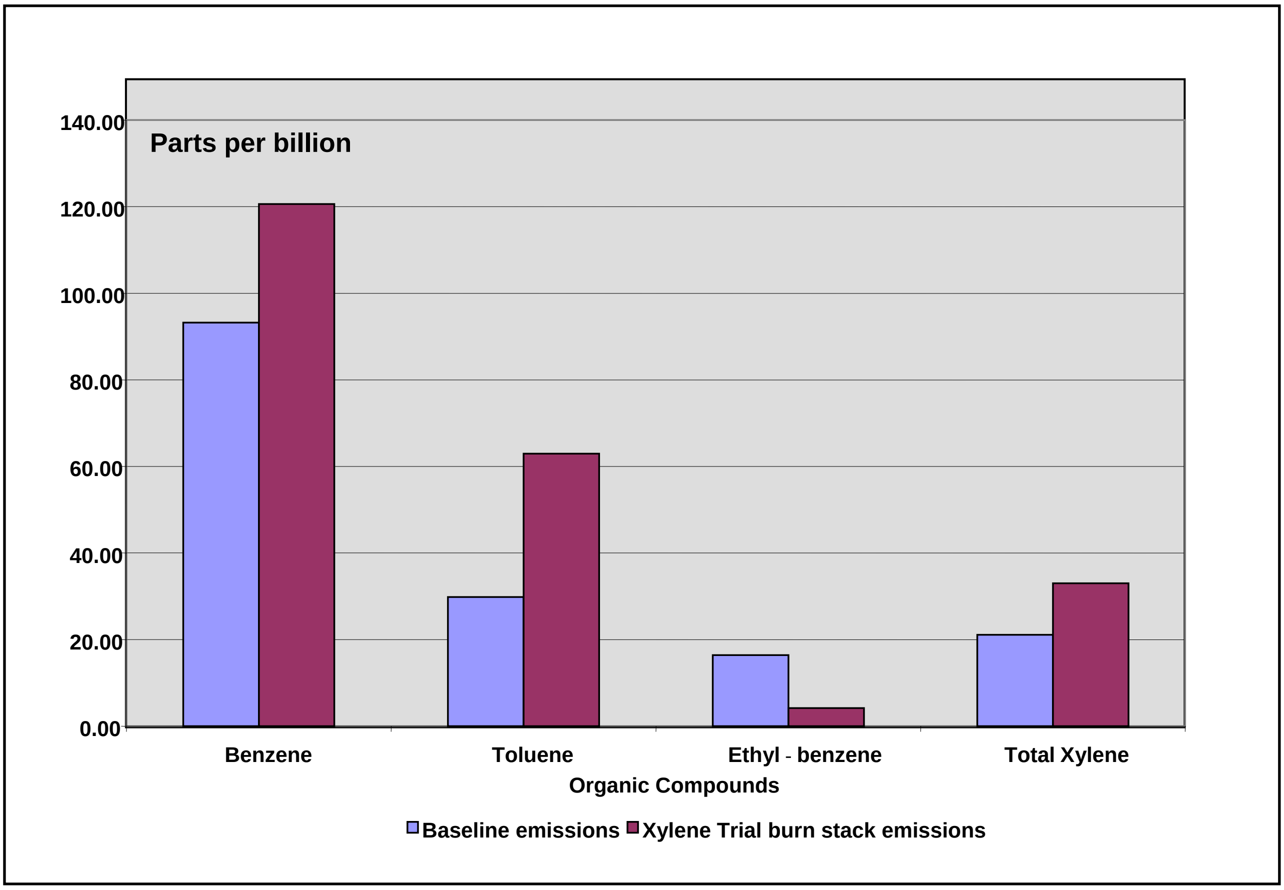

Figure 10-17: Xylene Trial burn: SK8 VOC Measurements by external monitoring group (Levego)

Conclusions: The conclusions made by PPC management team are as follows:

- The emissions during the test were within the limits set by the CAPCO of the Western Cape Province.
- Conclusive evidence regarding the destruction and removal efficiency of the burning process however was not possible mainly due to the (more than expected) variability in the quality of the feed material.
- Various process problems were highlighted during the trial and as a result on-site personnel gained valuable experience that will be applicable to the storage, handling and disposal of any future liquid waste materials.

10.14 BACKGROUND TO SPL PROCESSING

PPC has been using small quantities of the hazardous waste called Spent Pot Lining (SPL) at several of its production facilities since 2001. The SPL arises at the Billiton Hillside and Bayside aluminium smelting plants at Richards Bay, and Mozal in Maputo. At the end of each campaign, aluminium electrolysis pots have to be shut down to replace the cathode and lining which is worn out and possibly damaged. After removing as much bath and metal as possible and separating out the cathode bars, the materials left are spent pot lining comprising carbonaceous materials (first cut) and refractory materials (second cut). SPL is impregnated with fluoride and sodium salts and contains impurities, including traces of cyanides (particularly in the first cut). It also contains aluminium and crystalline silica, both important clinkering compounds. It can therefore be viewed as both a secondary raw material and fuel in the cement process. A typical analysis of SPL, indicating the range in composition, is set out in Table 10-10.

Table 10-10: Typical SPL Composition (ALCOA data)

Constituent	First cut	First and second cut
Carbon	55 +/- 5 %	30 +/- 5 %
Fluoride	13 +/- 3 %	15 +/- 3 %
Sodium	12 +/- 5 %	15 +/- 3 %
Aluminium	10 +/- 2 %	15 +/- 5 %
Silicon	3 %	4 %
Calcium	3 %	4 %
Sulphur	0.2 +/- 0.1%	0.2 +/- 0.1%
Cyanide	50 – 10000 ppm	0.2 % average
Aromatic hydrocarbons	0 – 300 ppm	
Calorific value (MJ/kg)	18.5	10.5

There exist various hazards associated with the SPL material use, namely:

- Explosion hazard*:* on contact with water, humidity or basic solutions, the material may release flammable gases (e.g. hydrogen, methane and acetylene) which can cause an explosion in a confined, unventilated area.
- Toxic gases*:* on contact with water, humidity or basic solutions, ammonia is emitted. On contact with acids or at high temperatures, fluorides, hydrogen fluoride, hydrogen cyanide and sulphur oxides can be emitted.
- Dust hazard*:* dust from SPL includes toxic and/or carcinogenic components, including fluorides, cyanides and crystalline silica.
- Pollution hazard*:* SPL has the potential to cause environmental contamination, particularly the fluoride and cyanide content.

A serious incident in Canada, where an explosion occurred on board a ship carrying bulk SPL, highlighted the importance of ensuring the product is kept dry and adequately ventilated. In France, where SPL has been used in a cement kiln since 1997 at an addition rate of up to 0.6%, no significant incidents or impacts on air quality, product quality, or kiln operation have been noted. A similar operation in Brazil is reported to have been operating for approximately 7 years, without any significant incidents.

Before PPC started utilizing SPL at their various facilities on an ongoing basis various studies were conducted:

10.14.1 Particulate, Fluoride and Cyanide Emissions[72,73]

Specialist studies aimed at assessing the major gaseous emission concerns from utilising SPL in a cement kiln were conducted at the De Hoek facility from 1999 to 2000. The following Table 10-11 is

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[72] *CSIR Contract Report 86DD/HT240:June 2000*

[73] *Levels of fluoride and cyanide, soluble dust 1999-2000:Illenberger & Associates*

a summary of the results of the trials with a 1% inclusion rate compared to the DEAT Limit for a Class 1 incinerator:

Table 10-11: SPL Emission Trials 1999-2000

Parameter	Unit	PPC-PE Trial	DEAT Limit
Dust (PM10)	mg/Nm^3	68.1	150
HF	mg/Nm^3	0.6	30
HCN	mg/Nm^3	< 0.01	-
H_2O	vol %	9.9	-
O_2	vol %	5.2	-
CO_2	vol %	27.3	-
CO	ppm	461.5	-
Temperature	^{o}C	295.9	-

The following general conclusions were made:

- Dust emissions were not affected by the inclusion of SPL and were well below DEAT limits;
- Although gaseous fluoride emissions were well within DEAT limits, the value was 2.5 times higher than baseline tests done, indicating that the combination of higher inclusion rates of SPL does lead to elevated fluoride emissions, and
- No gaseous emissions of cyanide were detected.

10.15 SPL HAZARD & OPERABILITY STUDY[74]

In June 2000 Marsh Risk Consulting conducted a risk assessment on the planned use/disposal of Spent Pot Lining (SPL) at PPC. The assessment included a consideration of risks associated with the following processes:

- Handling and storage of the SPL at BHP Billiton's Hillside aluminium smelter;
- Transport of the SPL to PPC sites, and
- Storage arrangements, crushing, milling and co-processing in cement/lime kilns at PPC Dwaalboom, Port Elizabeth, Slurry, Hercules and Lime Acres.

A Hazard and Operability (HAZOP) approach was used and the general findings were as follows:

- A fire involving SPL material will present risks, including toxic gas release.
- Contact with water/moisture could lead to an unacceptable increase in the rate of release of such harmful gases.
- Environmental impacts may result such as contamination of surface/groundwater and air emissions.
- Inadequate ventilation may lead to a build-up of explosive/toxic gases and a possible explosion.

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[74] *Risk Assessment of SPL Project-June 2000:Marsh Risk Consulting*

- Non-conformance with procedures.
- Plant/equipment may be adversely affected by the processing of SPL e.g. possible reduction in refractory life, etc.
- Possible contamination of SPL and/or variability in SPL quality could significantly impact on product quality.
- The SPL could pose an increased risk to staff health, due to potential exposure to harmful dust/gases.

The recommendations from the assessment report were as follows:

- Adequate ventilation must be provided in all areas where a gas build-up may occur.
- All legal requirements relating to SPL usage must be met.
- Billiton should ensure that supplied SPL is strictly controlled to agreed specifications. Responsibilities and liabilities in this regard should be clearly specified in the contract.
- Certification/signing off systems should be implemented where responsibilities for the SPL are transferred e.g. from Billiton to PPC Logistics, and from PPC Logistics to PPC Cement/Lime. Responsibilities at transfer points must be clearly defined.
- Environmental parameters should be closely monitored, particularly air pollution and possible water contamination.
- Likely increases in operating/maintenance costs should be taken into account when setting a price for SPL disposal, and the contract should preferably allow for later price adjustments if costs differ from those anticipated.
- Measures must be put in place to ensure the SPL does not come into contact with water.
- Occupational hygiene assessments must be performed to assess staff exposure to SPL material and associated gases.
- Plant maintenance trends/costs should be monitored to confirm continued feasibility of SPL use/disposal.
- PPC should implement a checking system to ensure the above.
- Procedures must be put in place to ensure staff are not exposed to toxic gases/dust, particularly during maintenance activities/hot work/confined space entry, and in the event of a fire.
- Product quality management should be viewed as a priority in areas where SPL is used.
- The abovementioned risks should be carefully managed in order to ensure the success of the SPL project.
- When evaluating the overall benefit of the SPL project, the above-mentioned risks should not be viewed in isolation from the benefits (financial as well as environmental) of the proposed process.
- Written procedures and staff training should be viewed as a priority in SPL processing areas.

As far as could be determined most of these recommendations have been accepted by PPC at the time of the report.