MARSH

EXECUTIVE SUMMARY

Background

Marsh Environmental Services (MES) has been appointed by Pretoria Portland Cement (PPC) to conduct the Environmental Impact Assessment relating to the proposed use of secondary materials to supplement the coal supply for the firing of the cement kilns. The proposed project is identified as an activity, which may have detrimental effects on the environment, thus requiring environmental assessment in terms of the Environmental Conservation Act (Act 73 of 1989); Section 21: Listed Activity 1(c), 8 and 9. The content of the Scoping Report and the Public Participation Process is dictated by the Regulations (Regulation 1183) promulgated in terms of the said act.

The proposed activity

PPC Cement is currently utilising coal as their main source of energy required for the manufacturing of cement. Cement manufacture is an energy-intensive process, and therefore large amounts of coal (a non-renewable resource) are utilised. PPC has been seeking means of minimising their use of coal by investigating the use of secondary materials in the cement manufacturing process. Secondary Materials under considerations are:

- 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).

PPC currently operates seven cement manufacturing facilities in 5 provinces in South Africa. PPC is applying for the use of these secondary materials at 5 (five) of its cement manufacturing plants. **This application only refers to the Slurry Cement Manufacturing Plant situated between Mafikeng and Zeerust.** Applications for the proposed activity for the other applicable PPC Plants have been submitted to the relevant provincial authorities.

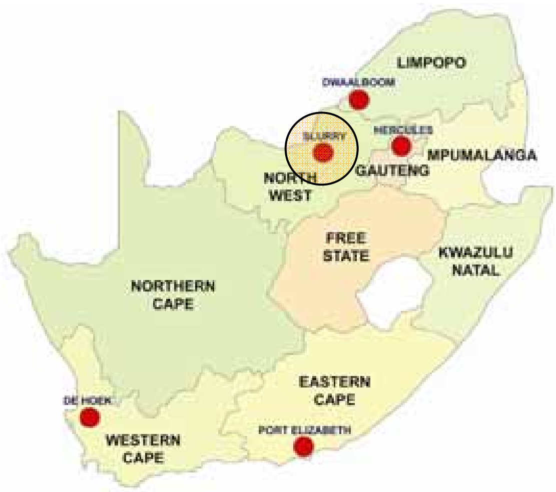

Figure 1: Positions of the PPC Manufacturing Plants where the use of secondary materials is proposed.

The Slurry Cement Manufacturing Plant is located in the North West Province in the Mafikeng Municipality. The plant is situated on the road between Mafikeng and Slurry, approximately 40 km from Zeerust and 20 km from Zeerust.

Process background

A preliminary site investigation was undertaken by MES and PPC and MES conducted a project initiation meeting with NW DACE in October 2005 to discuss the requirements to be included in the Plan of Study for Scoping (PoSS), the application and PoSS was duly submitted in November 2005. Approval of the PoSS was received in March 2006.

PPC Slurry

Slurry manufactures Ordinary Portland Cement (OPC), Surebuild and Rapid Hardening Cement (RHC). A portion of this is distributed to other plants such as Port Elizabeth, Jupiter or Hercules, to supplement their production and for further processing, and a portion is also exported to Botswana for further processing. PPC Slurry further distribute an small portion of the raw materials mined at Slurry is also distributed to the said plants, to supplement their raw material supply. Slurry currently has 4 operating kilns:

- Kiln 5 (SK5) and Kiln 6 (SK6) were commissioned 1959 and 1960, respectively. Both are long dry kilns, which are not equipped with preheaters. Each kiln is 145m long and 3.45m in diameter;
- Kiln 7 (SK7) was commissioned in 1968, and has a 1-stage preheater. SK7 is 4.55m in diameter and 120m long ; and
- Kiln 8 was commissioned in 1976. SK8 has a diameter of 5.25m and is 83m long, and is fitted with a 4-stage preheater.

The Slurry kilns are all equipped with planetary clinker coolers. Kiln 8 is fitted with a conditioning tower for cooling of the hot exit gases. All the kilns and the raw mill are equipped with Electrostatic Precipitators (ESPs) to limit dust emissions.

The cement making process

Cement clinker is made by crushing, blending and fine milling of limestone (calcium carbonate) and other materials containing silica, alumina and iron oxides, which are then heated to temperatures as high as 1,450°C in a kiln where the compounds react chemically to form clinker. The clinker is then cooled and ground with small quantities of gypsum and other additives to produce cement. The heating process is performed in a rotary kiln, which is inclined at 3 - 4° to the horizontal. The length and diameter of the kiln is dependent on the type of manufacturing process.

Many waste products have a significant energy content, and this energy can be recovered by combusting the waste materials (whole or in some other form) as additional fuel sources. There is an increasing trend in the international cement industry to substitute some of the primary fuel (coal) with waste materials; the most common waste stream internationally being tyres.

Environmental Technical Review

Marsh Environmental Services (MES) was contracted by PPC Cement to conduct an Environmental Technical Review as part of the supporting documentation of the Environmental Impact Assessment application for authorization. The purpose of this study was to establish the technical principles underlying the burning of waste streams in cement kilns and to provide the basis for a thorough understanding of the environmental risks and benefits of the proposed development. In particular, this study is aimed at collating and applying the extensive body of international research and previous studies (conducted by PPC and other cement companies internationally) in a form accessible to Interested and Affected Parties and authorities.

In terms of predicting the environmental effects of changing the raw materials and fuels inputs into the process through the introduction of secondary materials, one may view the kiln process in terms of simple inputs and outputs as follows:

Table 1: Inputs and Outputs from the cement manufacturing process

Inputs	Raw Materials (back end of kiln)	Limestone, Shale, Boiler Ash, Magnetite, 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

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. MES' literature review concluded that this is not possible, and this was further confirmed by PPC's engineers. MES were unable to find any successful model at predicting the reaction kinetics of the kiln which would be able to accommodate the type of inputs contemplated in this application, either through literature review or consultation with PPC.

After due consideration, an emissions inventory was proposed which was deemed achievable by PPC and was acceptable to the company for all their kilns proposing to accept secondary materials. This is inventory is presented below.

Table 2: Secondary Materials emission limits

MAXIMUM ALLOWABLE EMISSION LIMITS	
POLLUTANT	**LIMIT**
Total dust	As per current APPA permits
CO	As per current emissions
HCl	10 mg/Nm^3
HF	1 mg/Nm^3
NO_x	See note
$S0_2$	50 mg/Nm^3
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

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 NO_x and CO levels should not increase as a result of the introduction of secondary materials. MES' literature review 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. 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.

If PPC are unable to operate Slurry Kiln 8 while adhering to these emissions, then the Secondary Materials program shall be either modified to achieve compliance, or ceased entirely.

The findings of the Environmental Technical Review may be summarised in terms of the following benefits and risks to the environment and community:

1. Regional Presence: The geographic distribution of PPC Cement operations throughout South Africa provides a “localised” solution for hazardous waste disposal and a positive alternative to land filling for all major urban areas except KwaZulu-Natal.
2. Precautionary Approach: A conservative approach and gradual implementation to this project has been designed, based on international research but also the principles of the National Environmental Management Act of 1998. PPC shall embark on a gradual process of detailed baseline studies, trial burns, independent audits and reporting to government before commencing with full implementation of the use of the secondary materials applied for (subject to approvals from government). Detailed sampling and analysis of waste streams shall be performed prior to acceptance of waste streams by PPC.
3. Self-imposed emissions limits and policies: No empirical models exist to predict reliably the exact effect of waste streams on the emissions from a kiln. As a result, MES adopted an iterative approach to understanding the relationship between emissions changes and the effects on community health. PPC has adopted EU limits for those parameters which may be affected by secondary materials co-processing. Current emissions levels for NO_x and dust will be adhered to.
4. If PPC is unable to attain these emissions limits, the burning of secondary materials will cease. In addition, PPC has in place many process controls to regulate the production of clinker, and the priority for the company will always be the production of cement, rather than the burning of waste. Thus, there exist self-imposed process control mechanisms to maximise the stability of the kiln and the circumstances under which the burning of waste will occur.
5. Risks of dioxin and furan formation: Together, the introduction of chlorides and organics with the raw materials into a kiln system may present pre-cursors for dioxin formation, and their input into the raw materials of the kiln should be limited. A suitable limit for Cl input into the kiln would need to be established for each kiln which would not prevent PPC from being able to adhere to their emissions commitments. 310 mg total input (fuel and raw materials) per kg clinker produced is used as a guideline in the industry. It is the opinion of MES that this risk does not exist for secondary material fuels introduced at the flame-side of the kiln (the front end) as the alkaline environment present inside a cement kiln allows the acid components of gases to be neutralized before combustion gas is released into the atmosphere.
6. Metals: The metals of concern, and whose input into the kiln should be limited are:
   a) The volatile and semi-volatile metals (Mercury, Thallium and Cadmium) for their potential to pass through the kiln system and any gas cleaning equipment without removal,
   b) Chromium for its ability to be oxidised to Cr VI and become incorporated in the final cement product, where it may present risks of it may present risks of dermatitis to sensitive skin should adequate protection not be worn by the user.

   Other principal emissions risks: Inorganic and organic Sulphur compounds introduced with the fuels will be subjected to the same internal cycle consisting of thermal decomposition, oxidation to SO_2 and reaction with alkalis or with calcium oxide. With this closed internal cycle, all the Sulphur which is introduced via fuels or via raw material Sulphates will leave the kiln chemically incorporated in the clinker, and will not give rise to gaseous SO_2 emissions. On the other hand, Sulphur entering the kiln via raw materials as pyrites may oxidise to SO_2 at between 370°C and 420°C and partly leave as in the stack.

   Gaseous emissions such as SO_2, VOC, dioxins and furans, are almost entirely determined by the chemical characteristics of the raw materials used, and not by the fuel composition. Emissions are lowest with raw materials which are low in volatile components, and injection of materials containing significant quantities of volatile components (Cl, S and carbon) should occur at the flame-side of the kiln.

7. The advantages of disposal by cement kilns over land filling or incinerators are numerous. The principal benefit, however, is that any calorific or mineralogical value in the waste stream is recovered and will reduce the consumption of coal and other raw materials which would have been used in the manufacture of cement, resulting in an overall reduction of greenhouse gas emissions. A significant additional benefit is the volume of waste which a kiln may accept. This implies that cement kilns have the potential to provide a meaningful contribution to the reduction of waste sent to landfill. Cement kiln disposal by PPC alone (by kilns servicing the Gauteng area) is, on a volumetric basis, equivalent to constructing another H:H landfill site without the capital costs and long-term environmental risks of landfill disposal.

   Any "waste ash" produced in the kiln becomes incorporated in the final cement.

8. Emergencies such as fire, explosions or spillage/leakage during transportation and storage are extremely rare in the cement industry and adequate control measures have been recommended in this report.

9. The emissions leaving the process are the largest potential source of environmental impact from the process, and the emissions that are of significance are nitrogen oxides (NO_x), Sulphur dioxide (SO_2) and dust. Other important emissions include carbon monoxide (CO), volatile organic compounds (VOC), dioxins (PCDD's), furans (PCDF's), and metals. The potential environmental effects of these emissions are of two principal categories:

   a) Community Health Effects:

      Respiratory impacts and possible toxic and carcinogenic effects may be related to the emissions of dust, CO, metals, VOC's and dioxins and furans in the gaseous phase.

   b) Environmental Effects:

      Emissions such as NO_x and SO_2 will contribute to acid deposition (also known as acid rain) in the regional context, and CO_2 to climate change in the global context. VOC's contribute to photochemical smog (subject to ultraviolet radiation degradation), which with dust, will also contribute to a visual impact if dispersion is poor. Given the flat terrain surrounding Slurry, it is expected that the potential visual impacts will be minimal. A minor degree of soil and surface water contamination may occur from dust settling out from the atmosphere. Current dust emissions result predominantly in an insignificant increase in pH of soil and surface water and possible increase in suspended solids in surface water courses. For dust, there may be an increase in metals accompanying the dust and an increase in the dioxins and furans possibly absorbed into the dust. This may result in toxicological (cancer and non-cancer) risks to receiving flora and fauna and the community.

   In order to determine whether this emissions inventory will generate any unacceptable environmental and community health effects, the following specialist studies have been undertaken as part of the assessment process.

   a) Air Dispersion Modelling; and

   b) Community Health Risk Assessment.

Air dispersion modelling

MES calculated a comprehensive emissions inventory based on current operations, including mining operations, and an emissions model was developed by Airshed Planning Professionals (Pty) Ltd using known meteorological data and recognized modeling software. For predicted emissions, the assumed emissions inventory was used, with the following results:

Inhalable Particulates (PM10)

The future predicted ground level concentrations for PM10 were within the daily and annual SA Standards of 180µg/m³ and 60 µg/m³ as well as daily and annual proposed SA Standards (SANS limit values) of 75µg/m³ and 40 µg/m³. The predicted PM10 off-site ground level concentrations remained the same as for current operations. These plots are similar to that of the current operations, indicating that the main sources of PM10 ambient concentrations to be fugitive sources. The PM10 predicted ground level concentrations from the stack releases alone also remained fairly similar, indicating a slight increase when compared to the current scenario.

Total Suspended Particulates (TSP)

Dust fallout levels due to TSP emissions from the future operations remained the same as for the current scenario, thus falling well within the SANS residential limit and target values. The main sources resulting in off-site dust fallout is the fugitive sources, primarily vehicle entrained dust from unpaved roads.

Oxides of Nitrogen (NO_x)

For future operations the NO_x concentrations the predicted ground level concentrations remained the same as for current operations. This was expected since the emission rates remained the same. Highest hourly, daily and annual average ground level concentrations were 125 µg/m³, 13 µg/m³ and 2 µg/m³, respectively falling within the SA Standards for the relevant averaging periods.

Sulphur Dioxide (SO_2)

The predicted ground level concentrations were well within the hourly SA Standard of 30 000 µg/m³. Highest hourly, daily and annual average concentrations were predicted to be 30 µg/m³ (at Bultfontein), 3.2 µg/m³ and 0.4 µg/m³ (the latter two at Rietvlei) respectively.

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 30 µg/m³. No change in the emission rates for CO between current and future operations were expected 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 the Scenario B for the future operations at PPC Slurry. 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 will however be assessed as part of the health risk assessment conducted by Infotox.

Dioxin/Furan 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 1.4E-05 ng/m³, 1.6E-06 ng/m³ and 2.5E-07 ng/m³ for highest hourly, highest daily and annual averages respectively. As with the other compounds the highest hourly concentration was predicted at Bultfontein to the north of the plant whereas the highest daily and annual average concentrations were predicted at Rietvlei to the south of the plant. 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 0.14 µg/m³, 0.014 µg/m³ and 0.0025 µg/m³ for highest hourly, highest daily and annual averages.

Similar increases in HCl ground level concentrations were predicted with an average increase of 20 times. The concentrations will also be assessed as part of the health risk assessment conducted by Infotox.

Mercury

Mercury associated with the proposed use of secondary materials was included in the future operations at PPC Slurry. No screening criteria area available for concentrations of mercury and these will be assessed as part of the health risk assessment conducted by Infotox.

Community Health Risk Assessment

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. This 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.

The study has indicated that particulate and nitrogen dioxide emissions will not be affected where coal is replaced with alternative fuels and no change in the level of risk associated with exposure to particulates can thus be expected at the locations where sensitive receptors have been identified. The simulations indicated slight variations in sulphur dioxide emissions, but the changes in air concentrations would be very small and would not lead to any measurable health effects.

The study indicated that the highest potential cancer risks would be in the range between one in a hundred thousand and one in a million, even when all the cancer risks were added. At this level, cancer risks are regarded in the world as insignificant. Cancer risks associated with exposure to dioxins were even lower and thus insignificant, even should indirect pathways of exposure be considered. Similarly, noncancer risks were also shown to be low.

Having considered generic exposure scenarios at sensitive receptors that relate to activities at the PPC Slurry Cement Factory, it should be concluded that the introduction of alternative fuels under the conditions of the current investigation would have insignificant effects on emissions and associated human health risks in the study area.

The human health risk assessment has been based on the assumption that the predicted emissions of toxic substances from the PPC Slurry 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, 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 Slurry 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.

Baseline Community Health Survey

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 Risk

Assessment 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.

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.

Waste Disposal by Cement Kiln – A Comparative Approach

The specialist study investigating Waste Disposal by Cement Kiln (Life Cycle Assessment) concluded that, co-processing of hazardous and non-hazardous waste presents a positive alternative to land filling and incineration, and does not present a financial disincentive to the preferred alternative of recycling. Where recycling is not an established option in terms of the South African market, cement kiln disposal is the preferred means of disposal if the components of the waste stream are suitable to the cement process. The five waste streams included in this EIA application have been chosen on this basis.

Identified Environmental Impacts

Based on the Environmental Technical Review and the specialist investigations, the following table (Table 4 below) summarizes the environmental impacts expected from the proposed activity.

Table 4: Identified Environmental Impacts

Issue	General Impact	Specific Impact	Cause / Aspect
Emissions	Community Health	Cancer and non-cancer health effects on sensitive receptors in the community (i.e. children, sick and elderly) who are exposed to emissions at ground-level concentrations	Input of high Cl and VOC materials into preheater stages of kiln
			Input of SM containing volatile metals at either end of kiln
	Community Health, Air Quality	Particulate Matter falling out from dust emissions (Cement Kiln Dust) resulting respiratory ailments and visual pollution (from stack plume)	Operation of cement kiln
	Climate Change	Anthropogenic contribution to climate change through CO_2 emissions	Combustion of fossil fuels (coal)
	Air Pollution	Acid Deposition resulting in acidification of soil and surface water	HCl, HF, NO_x and SO_2 emissions
	Community Health	CO emissions resulting toxic effects on blood	Calorific value of fuel too low

Issue	General Impact	Specific Impact	Cause / Aspect
	Community Health, Air Pollution, Soil and Surface water pollution	Dust and gas releases	Fire, explosion, failure of kiln, spills and leaks from kiln
Groundwater & soil	Pollution	Sterilisation of soil (loss of biodiversity) and health effects on downstream water users of groundwater	Leaks and spills from waste storage areas seeping into soil and groundwater
Odour & air emissions	Air Pollution	Fugitive emissions of VOCs and odours	Storage of hazardous waste either in vented tanks (hydrocarbons) or open bunkers (sewage pellets)
Leaching of metals from concrete	Water Pollution (potable, surface and/or groundwater)	Public health and environmental health effects may result from the toxicity of the metals incorporated into clinker	Leaching of heavy metals from concrete products when in contact with water
Dust from concrete or cement	Air Pollution	Occupational health effects from use of cement and concrete made from Secondary Materials	Dust exposure from use of cement in construction activities, or concrete from demolition activities.
Waste Disposal	Groundwater Pollution	The secondary impacts of disposal of general and hazardous waste to landfill	Disposal of general and hazardous waste to cement kiln
	Loss of land use	Construction of further general and hazardous waste landfills	Disposal of general and hazardous waste to cement kiln
Traffic	Disruption, Dust and Noise along route	Impacts to communities resident along routes to Slurry	Spills and accidents during transport
	Soil and water Pollution	Contamination of surface water and soil with high pH, high COD waste streams	Spills and accidents during transport

MITIGATION MEASURES AND RECOMMENDATIONS

Based on our findings in this report, MES recommends the following measures to be implemented by PPC to mitigate and minimise any negative environmental impacts associated with the proposed activity and the maximise/enhance and positive impact that may result form the introduction of Secondary Material in the cement making process:

Compliance with Policies

PPC comply with its own Secondary Materials Policy.

MARSH

Cautionary approach

PPC may only proceed with one waste stream category from trial burn to full-scale production. Only once stable operation is attained for cement production for the first waste stream, will PPC consider application of a second waste stream category (which will be one of the other 5 waste streams included in this application).

This second waste stream will commence with a trial burn, following the same monitoring, measurement and auditing procedures as required. Only once authorisation is granted for the second waste stream, in addition to the first, will full-scale implementation of both streams commence**.** This process shall be repeated for each additional waste stream. Thus PPC shall implement a cautionary, step-by-step process of gradually adding a waste stream through the "trial burn-approval-stabilising of kiln" process before commencing the same process with another waste stream.

Under no circumstances will a new waste stream be introduced without stable kiln operation (whether or not waste streams are currently being burnt), a proper trial burn and reporting to the authorities and independent audit.

Trial Burns

1. Trial burns are to be conducted prior to full-scale implementation of any new secondary material category per kiln and per waste stream.
2. The emissions from the trial burn shall be reported, and that full-scale production be allowed to commence only once the emissions profile and the other conditions in this section are met.
3. For the purposes of the trial burn, PPC may perform preparation of the waste streams in order to facilitate the safe feeding and metering of such to the kiln. Such preparation will be limited to physical preparation in such a manner as to avoid the generation of noxious or offensive gases and any chemical alteration of the waste streams.
4. Given the minor quantity of wastes to be burnt in the trial burn, a dedicated storage area shall be constructed adjacent to the kiln facility according to guidelines set out by DEAT.
5. The waste streams shall be present on-site for no longer than 90 days, and residual waste not consumed in the trial burn shall be removed from site and disposed of to a suitably permitted facility within 7 days of completion of the trial burn.
6. The feeding of the waste streams to the kiln during the trial burn shall occur by means of formal and controlled feeding equipment to the kiln only. Temporary or informal conveying systems to these feed systems shall be employed only for the trial burn.
7. Full baseline and emissions monitoring, and independent auditing shall be performed and reported on to the authorities. Only once written approval of these results has been received from the authorities, may full-scale production commence.
8. If dioxin emissions measured during the trial burn warrant it, then PPC shall apply suitable mitigation measures. A repeat of the trial burn employing such measures shall be performed before full-scale implementation may proceed.
9. Specific limits for compounds and elements tolerated in waste materials should be determined and published as the "Acceptance Criteria" for each kiln. This shall be submitted as part of the Trial Burn report to the authorities within 90 days of the trial burn occurring, and shall specifically be approved by the authorities prior to full-scale implementation for that waste stream commencing.
10. In order to ensure that the waste streams to be burnt in the trial burn are representative, as far as practicable, of the normal operational scenario, PPC will ensure the following:

Table 5: Waste Streams to be sourced for Trial Burn

Waste Stream	Source of Waste Stream
Waste tyres	As the chemical composition of tyres does not deteriorate significantly with time, there are no specific requirements relating to the age of the sample.
Sewage Sludge Pellets	Pellets shall be prepared off-site by an independent contractor/municipality from a normal sample of sewage over several days. The preparation process shall be inspected by the independent auditor for the presence of any other contaminants or pre-treatment.
Pulp and Paper Waste:	Industrially produced paper waste will be sourced or paper waste generated at Slurry, and prepared to the requirement of the kiln concerned. The material will be shredded and analysed to ensure that the waste is suitable for the kiln process.
Plastic waste:	Plastic waste will be sourced from municipalities after being sorted. The material will be shredded and analysed to ensure that the waste is suitable for the kiln process.
Hydrocarbon sludges and liquids:	Arisings from an industrial source will be used.

11. PPC will maintain normal operating conditions during trial burn. It is important that the coal and feed material quality remains constant during the entire trial burn so as to avoid introducing any variables into the process. PPC will therefore ensure the consistency of such feed in advance (such as moisture content of feed, etc) by monitoring weather and preparation conditions.
12. During the trial burning exercise, the waste shall be fed at a constant rate, most closely resembling that of anticipated operating conditions or until a feed rate is established which complies with the predicted emissions rate.
13. No further burning of waste streams applied for in this application may occur until:
    a) Written confirmation has been received from the authorities to proceed with full-scale operations;
    b) Formal storage and feed systems have been constructed and tested on site.

Full-Scale Production

1. Secondary Materials combustion will cease if PPC is unable to meet the emissions inventory (measured as dry and at 10% O_2) as stipulated above in Table titled "Secondary Materials emission limits".
2. An automatic cut-off device must at all times be installed in the feed line of secondary materials to enable immediate discontinuation of feed during upset conditions. Feed should only be possible again once the kiln operation is stable again under normal loads. This device should be linked to a continuous carbon monoxide monitor.
3. In general, a "failsafe" design philosophy on control instrumentation should be adopted for SM utilization. Feed of secondary materials shall be cut off when instability exists or kiln stoppages occur. Secondary fuels are only utilized if the kiln is operating above 70% of kiln rated production. (This limit is only an indication, and is different from kiln to kiln and will have to be established for each kiln independently). This excludes the current practice of using waste oil

for kiln start-up purposes. In most cases, waste fuels should not be used during start-up and shut-down of kilns, except where kiln temperatures are achieved to produce clinker that meets quality standards. Waste fuels should not be used during failure of the air pollution control devices (i.e. ESP at the stack of the kiln). This does not apply to CO purging.

4. When using hazardous waste such as hydrocarbons as a secondary material, dual flow measurement should be considered, to prevent undetected incorrect feed rates.

5. For quality assurance reasons, a limit for Cl content in total feed (fuel and raw material) would be 310 mg total input (fuel and raw materials) per kg clinker produced. The majority of this chlorine (i.e. > 90%) should only be used on the fuel input for preheater/calciner kilns such as Kiln 8 at Slurry to ensure low PCDD/F emissions. This limit will, however, be reviewed subject to emissions monitoring results during trial burns and commissioning.

6. When using secondary raw materials which contain volatilizable organics, these must be fed to the kiln on the fuel path (and not on the raw material path). PPC must establish the maximum organic carbon content for all secondary materials to be considered as secondary raw materials.

7. In cases where the concentration of Cr VI (i.e. hexavalent chromium, or chrome six) exceeds the normal range found in cements made without secondary materials, leaching tests should be conducted.

8. PPC shall employ the approaches detailed in Table 6 to feeding the various waste streams into the kiln:

Table 6: Feed systems for Secondary Materials

Waste Stream	Method of Feed to Kiln
Waste tyres	Back end of preheater or calciner kiln. Mid kiln injection of tyres to long dry kin.
Sewage Sludge Pellets	Feed through main burner. In calciner of preheater kilns, the sewage sludge can be fed to secondary firing point.
Pulp and Paper Waste:	
- Dry	Feed to the calciner or back end. (less that 15% moisture)
Plastic waste:	
- Dry	Small granules fired through the main burner. Larger pellets to the back end or the calciner. (The material will be fed either depending on the character)
Hydrocarbon sludges and liquids:	
- Received in drums	Drums are decanted into a feed system that can feed the material to the back end, calciner or the main burner depending on the characteristics of the liquid or sludge.
- Received in tankers	Unloaded into a liquid feeding system for use at the main burner or back end of the kiln.

Monitoring and measurement

1. A full baseline assessment shall be conducted prior to the introduction of the waste streams in the trial burn, using normal fuels (i.e. coal) and feed material.

2. No burning of secondary materials will occur post trial-burn until Opsis monitors are installed and calibrated. The Opsis monitor will measure the following parameters: NO, NO_2, SO_2, HCl,

HF, CO and benzene. The Codel monitors currently installed at each stack will continue to monitor the particulates concentrations on-line.

3. Any measurement of emissions will have to be reported at a specified oxygen level (typically 10%) and dry (i.e. no water vapour). PPC will need to ensure that this is communicated to any external specialists performing such measurement, and that their Opsis on-line emission monitors will be able to accommodate such.

4. All monitoring shall involve isokinetic sampling and analysis at SANAS- or equivalent accredited laboratories according to ISO, EPA or ASTM methods for the following parameters:

   a) CO, CO_2,

   b) NO_x, SO_2,

   c) HCl, HF,

   d) All metals (as per standard ICP analysis) and Mercury and Thallium,

   e) Total Chromatographable Organics or TCO (which includes all VOC's and SVOC (semi-volatile organics)),

   f) Dioxins and furans, PCB's, PAH (polycyclic aromatic hydrocarbons). This is compulsory for the baseline and trial burn monitoring, but for further monitoring, please refer to the next point (5).

   g) Total Particulate Matter (TPM, or cement kiln dust).

5. Dioxin measurements, given their cost, will be performed only when required based on the nature of the secondary materials and their entry into the kiln system. Dioxin measurements will only be performed if the secondary materials contain chlorides ***or*** carbon in any quantities above detection limits, ***and*** are being introduced into the back-end (i.e. the raw material feed side) of the kiln. When dioxin measurements are required on this basis, the following dioxin monitoring schedule be adhered to for each waste stream introduced to the kiln:

   a) Before (i.e. baseline) and during the trial burn, as well as

   b) After one month of running full scale secondary materials consumption, and

   c) Annually thereafter.

6. All the above scenarios will be performed with the raw mill running and the raw mill down (in the case of in-line mill system) for the first year of sampling. The emissions monitoring exercise conducted for the baseline assessment shall be repeated for the trial burn in exactly the same fashion as for the baseline monitoring.

External audits and reporting

1. PPC shall employ an independent environmental auditor to audit the operations against the conditions of the Record of Decision and legal requirements, on the following frequency:

   a) During the trial burn;

   b) Commencement of full-scale production;

   c) 6 months after commencement of full-scale production;

   d) One year after commencement of full-scale production, and

   e) Annually thereafter.

2. The scope of the audit shall cover all operations and supporting paperwork of the sourcing, sampling and analysis, acceptance, transportation, storage and preparation on site, operation,

monitoring, reporting, staff training, emergency preparedness and response procedures and processes.

3. A report shall be compiled by the auditor within 2 weeks of completing the audit, documenting his/her findings and recommendations. This report shall be made available to the relevant authorities.
4. The acceptance of a new waste stream (i.e. from a new waste source, or a new waste category or type within the 5 listed in terms of this application) shall be reported to the authorities (Provincial Environmental Department) with full details regarding its source, quantity and composition 14 days prior to the planned combustion thereof.
5. All external analysis results shall be provided directly from the emissions sampling contractor to the independent auditor, along with original laboratory results. The auditor shall then compile a report on the trial burn, and provide this to the authorities within 30 days of the date of the trial burn.

Other authorisations required after trial burns but before full-scale production

1. All new applications of secondary materials not included in the list of waste materials included in this application, shall be subject to a separate EIA application.
2. All relevant legal requirements must be met and specifically assessment in terms of the OSH Act concerning "Major Hazard Installation Regulations" must be submitted to the Department of Labour prior to commencing with full-scale production.
3. PPC will need to register their waste storage facilities as Waste Disposal Sites in terms of the Environment Conservation Act, 1989 (Act 73 of 1989), section 20, and ensure compliance with DWAF's Minimum Requirements for temporary storage of hazardous waste.
4. PPC must apply for and comply with the requirements of Scheduled Process No. 39 of the Atmospheric Pollution Prevention Act of 1965 as applicable to Class 1 incinerators, subject to guidance from DEAT in terms of the APPA review process current at the time of writing.

Sampling and acceptance, transportation, handling and storage of waste streams

1. PPC shall comply with the sampling and analysis protocol for all waste samples prior to acceptance, as described in Section 4.1. Specialized analytical facilities and resources for such will be required at PPC Jupiter, and PPC shall demonstrate compliance of such to SANS 17025 and SANAS accreditation of such centralised facilities. Satellite laboratories will be available at Slurry for fingerprint confirmation. Thus an "accept-refuse" model for secondary materials based on known information concerning limits and restraints as well as principles as set out in PPC's policy should be developed.
2. Due cognizance should be given to possible incompatibility of secondary materials during handling and transport in accordance with SANS 10232-1, Annexure F. Liquid streams shall be stored separately to solid wastes. Flammable liquids (i.e. hydrocarbon sludges) shall be stored separately to substances with a high oxidizing potential. Waste streams with toxic components (such as metals, PCB's) shall be stored separately from other toxic waste streams.
3. Where hazardous wastes are to be used as secondary materials, assessment of all their safety and health hazards will be required and MSDS information will be compulsory.
4. Procedures governing the transportation of hazardous waste will be compiled in accordance with the relevant SANS codes under the National Road Traffic Act (i.e. SANS 10232-1 to 3).

These procedures, as well as the Sampling and Acceptance Procedure, shall be included in all audits recommended by this report.

5. The appointment of the waste transport contractor shall be subject to the contractor complying with the following:
   a) Compliance with all requirements of the National Road Traffic Act and associated SANS codes for Transportation of Dangerous Goods.
   b) All Emergency Response equipment as stipulated in the Transport Emergency Card (as prescribed by SANS 10232-4) shall be carried on the vehicle.
   c) All drivers shall carry a Professional Driver's Permit and should be trained in HAZMAT response.
   d) All documentation relevant to the load is accurate and complete.
   e) The contractor has contracted adequate emergency response facilities along the route from the Generator to the PPC plant.
   f) All placarding and emergency information relevant to the load is displayed by the transport contractor.
6. Establish suitable and safe transfer systems from transportation to the storage area to avoid SHEQ risks from spillage such as fugitive emissions or vapour displacement. Suitable vapour filtration and capture equipment should be in place to minimize impact to the reception point and surrounding areas from unloading activities.
7. Ensure that storage facilities fit their purpose. Appropriate storage for liquids should meet relevant safety and design codes for storage pressures and temperatures.
8. Solid materials handling systems should have adequate dust control systems.
9. Storage design should be appropriate to maintain the quality of the materials: for solids, prevent build-up of old materials; for liquids, mix or agitate to prevent settlement, etc.
10. Design transfer and storage areas to manage and contain accidental spills into rainwater or firewater, which may be contaminated by the materials. This requires appropriate design for isolation, containment and treatment. Appropriate storage for liquids should have adequate secondary containment.
11. There should be written procedures and instructions in place for the unloading, handling, and storage of the solid and liquid fuels and raw materials used on site.
12. Designated routes for vehicles carrying specified fuels and raw materials should be clearly identified within the site.
13. Appropriate signs indicating the nature of materials should be in place at storage, stockpiling, and tank locations. Storage halls should be fitted with water sprinkler systems and be vented to control accumulation of solvent vapours (which could be sent to the kiln).
14. Tanks containing hydrocarbons should be fitted with an explosion safety device. Additional devices may be considered such as atmosphere control (e.g N_2 inertization) and temperature control (e.g. shell cooling), etc. depending on the results of the HAZOP study.
15. Equipment should be grounded and appropriate anti-static devices and adequate electrical devices selected (e.g. motors, instruments, etc.).
16. All dry material should be stored in protected warehouses 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.
17. Emergency Response Plans will be developed for any accidents and incidents, and spill kits should be maintained on-site.

18. 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.
19. 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.
20. Transfer of dry materials (especially paper, sewage pellets and plastic) should be enclosed to prevent wind-blown litter.
21. Only pre-sorted or waste that does not require separation will be accepted.
22. The general principles of storage and handling as set out in table 7 are to be followed.

Table 7: Storage guidelines for specific waste streams

Waste Stream	Storage Facility	Environmental Risk
Waste tyres	Whole Tyres Stock pile on a walled concrete slab with storm water control Tyre chips Stockpile in open, walled bunkers on a concrete slab. Ensure proper storm water runoff.	Fire risk, and for whole tyres, rodents and mosquitoes.
Sewage Sludge Pellets	Store in a dry ventilated place under roof on concrete floor. Ensure fugitive dust control. Keep away from water.	Fire risk, soil and surface water contamination Self heating when in contact with water
Pulp and Paper Waste:		
- Dry	Store in a dry ventilated place under roof on concrete floor. Ensure fugitive dust control. Keep away from water.	Dust (occupational), Litter, Surface Water
- Wet	Will not use due to high moisture content.	Surface Water and Soil contamination
Plastic waste:		
- Dry	Stockpile in open bunkers on a concrete bed. Ensure proper storm water runoff.	Dust (occupational), Litter, Surface Water
- Wet	Will not use due to high moisture content.	Surface Water and Soil contamination
Hydrocarbon sludges and liquids:		

Waste Stream	Storage Facility	Environmental Risk
- Received in drums	Store in a dry ventilated place under roof on concrete floor.	Fire, explosions, air emissions (VOC's), contaminated soil and surface water
- Received in tankers	Well designed tank installation with bunds, fire protection and water management system.	

HAZOP Studies

1. The HAZOP studies should be concluded prior to trial burns commencing. These studies would apply for all possible facility/material combinations envisaged and rolled down to plant level for further detailed investigation.
2. Specific sources of secondary materials should be used as a second level HAZOP study, once the generic study has been completed.

Staff training and awareness

Appropriate training and certification in hazardous operations for all workers and sub-contractors should be given before commencement of co-processing.

Occupational Health and Safety

1. Air monitoring: A measurement program must be established to determine the airborne concentration of any hazardous chemical in the workplace. This program should include an air quality survey which is to be performed by an approved independent inspection authority in order to determine whether occupational exposure limits (OEL) are exceeded. The prescribed OEL's of substances is part of this Act under Regulations for Hazardous Chemical Substances, 1995.
2. Medical surveillance: Where employees may be exposed to potentially hazardous chemical substances, a comprehensive medical surveillance program must be established.
3. Respiratory zone: Where OEL's may be exceeded in the workplace, a clearly demarcated zone should exist where the use of suitable respiratory equipment is compulsory.
4. Record keeping: Apart from the records of the previously mentioned required programs, i.e. training, air quality surveys and medical surveillance, a complete record of all material safety data sheets (MSDS) should be kept.
5. Adequate personal protective equipment should be made available to employees and contractors, and to individuals visiting the installation. Its use should be required. This includes but is not limited to: helmet, glasses, gloves, hearing protection, safety shoes, respiratory protection, and other protective equipment specified in the Safety Data Sheets.
6. Storage areas should be kept clear of uncontrolled combustible materials. Clear safety warnings, no smoking, fire, evacuation route, and any procedures signs should be posted.
7. An emergency shower and eye washing station should be clearly marked and located near the storage of liquid alternative fuels.
8. A fire protection system must be available at all times and should meet all standards and specifications from local authorities (e.g. local fire department).

9. Adequate alarms should be provided to alert all personnel about emergency situations. Communications equipment (e.g. telephone) should be maintained at the site so that the site control room and the local fire department can be contacted immediately in case of a fire.
10. Adequate systems and procedures should be in place to minimize the risk of unauthorized access to hazardous materials used on-site.
11. Carefully consider plant layout to ensure access for day-to-day operations, emergency escape routes, and maintainability of the plant and equipment.
12. Modifications to installations and equipment shall be documented.
13. Automated handling equipment should be used wherever possible.
14. Special procedures, instructions, and training should be in place for such routine operations as:
    a) Working at height, including proper tie-off practices and use of safety harnesses;
    b) Confined space entry where air quality, explosive mixtures, dust, or other hazards may be present;
    c) Electrical lock-out, to prevent accidental reactivation of electrical equipment undergoing maintenance, and
    d) “Hot works” (i.e. welding, cutting, etc.) in areas that may contain flammable materials.

Emergency response plan

A plan shall be developed prior to the trial burns which:

a) Identifies potential spill or contamination areas;
b) Defines clean-up procedures;
c) Identifies areas of high risk on site or in the local community;
d) Provides written instructions in the event of an emergency;
e) Documents equipment required in the event of an emergency;
f) Assigns responsibilities to employees and local officials;
g) Details emergency response training requirements, and
h) Describes reporting and communication requirements both within the company and with interested external stakeholders.
i) The emergency response plan shall be reviewed with relevant external emergency services.
j) Emergency drills shall be arranged with the local community emergency response services to ensure a coordinated response under emergency conditions.

CONCLUSION

Construction Phase

Relative to the operational phase, the impacts of the construction phase will be minor. Issues are largely limited to the construction of the waste storage area (bunkers for solid waste and bunded tanks for liquids and sludges). The final location of the waste storage area is not yet determined but the risk assessment assumed that it will be on exposed soil. It will, however be within the plant boundary and will therefore present minimal risk to surrounding land owners and the environment outside of the plant. The only negative impacts worth mentioning, post mitigation, are the potential for increased traffic and noise due to construction vehicles and machinery, and the positive impact of job creation in the area.

MARSH

Operational phase (including trial phase)

The impacts associated with the operations of a secondary materials program may be defined as follows:

1. The impact of highest significance relates to the expected emissions from the Secondary Materials Co-Processing Programme.

   When the cement kiln is operated without secondary materials, the most significant emissions are:

   a) Cement kiln dust (visual and community health effects),

   b) NO_x (which contributes to acid deposition),

   c) Carbon Monoxide (community health effects),

   d) VOC's (volatile organic compounds, which result in photochemical smog and other forms of community health risks and air pollution) and

   e) CO_2 (which contributes to climate change).

   It is our professional opinion that these impacts are not affected by the addition of secondary materials as the quantity of these emissions will not be increased. If anything, a small decrease should result in the emissions of NO_x and a nett reduction in the emissions of CO_2 depending on how much replacement of coal by waste occurs.

   These negative impacts will be largely due to the change in emissions which may result from the burning of hazardous waste, which may result in impacts on community health and the surrounding (ambient) air quality. These emissions include sulphur dioxide (SO_2), dioxins and furans, acids (such as hydrochloric and hydrofluoric acid) and metals (especially the volatile and semi-volatile metals such as Mercury, Thallium and Cadmium).

   The mitigation measures accepted by PPC aim to limit the inputs of certain chemicals which may generate these emissions and to perform trial burns before moving to full-scale burning of waste streams to confirm that these emissions are within acceptable limits. PPC's commitment is to adhere to stringent and self-imposed emissions limits which comply with existing air pollution certificates and European Union limits. If these emissions limits are adhered to, then the resulting impact on the health of the community, according to various specialist studies, is negligible and legal compliance against SANS standards is achieved.

   In addition to accepting emissions limits, PPC has agreed to a program of external monitoring, auditing and reporting in addition to their normal legal compliance and ISO 14001 audits.

   Sufficient previous studies performed by PPC, international studies and research as well as a technical understanding of the underlying mechanisms of the generation of emissions result in PPC being confident of being able to achieve EU emissions limits for all parameters of concern (with the exception of dust and NO_x, where current emissions levels will be maintained).

2. Another significant risk is that of process accidents or incidents, including fires, explosions or spills and leaks from the kiln when the kiln contains uncombusted hazardous wastes. Although the occurrence of such is very rare in the cement industry, a HAZOP study will be undertaken by PPC to consider all of the possible risks. For the purposes of this study, the trial burn will determine the Maximum Safe Feed Rate of waste at which kiln stability is maintained and the emissions limits are achieved. Thus the gradual addition of waste to the kiln will be performed during the trial burn to ensure no unstable kiln operation results.

3. The storage of large volumes of waste (especially the liquid hydrocarbons) will present risks to soil, surface water and groundwater during storage, unloading, transport and transfer to the kiln. Comprehensive mitigation measures have been proposed to ensure containment or emergency response to accidents and risks of leaks and spills. It is believed that these are

industry norms and will be adequate to bring these impacts to an acceptable level. The same applies to fugitive emissions of dust, vapours and gases from the transfer and storage of these waste streams on-site. Again, mitigation measures which are standard to the industry will prevent unacceptable impacts from arising, such as vapour recovery systems or similar, and protection of the stored dry waste from wind and rain.

4. Several concerns have been raised by I&AP's and our internal risk assessment process regarding the end-use of the final product. This includes the leaching of toxic components from the final cement (i.e. concrete) or when users of the cement (i.e. the public or workers in construction companies) are exposed to cement dust which has been made from secondary materials. The reason for this concern is that the final product which is made from secondary materials may have higher concentrations of metals than the 'normal' cement made currently. While it is expected that higher metals concentrations will be present in secondary material cement, the impact of metals leaching into water cement water pipes and reservoirs (the 'worst case scenario') has been dismissed by international literature as negligible, as long as the concentration of Chrome VI (hexavalent chromium) is limited. PPC will therefore limit the amount of chromium added to the kiln through waste streams to ensure that the chrome VI content in secondary materials cement is the same as for 'normal' cement (i.e. cement made without secondary materials). With regards to dust emissions during the use of secondary materials cement, it is always recommended, as with normal cement, that personal protective equipment (i.e. dust masks be worn) as normal cement also contains metals. The unprotected exposure to cement dust is always a health risk, whether or not the cement is made from secondary materials or not (although the health risk of secondary materials cement, due to its higher metals content, is believed to be higher).

5. The positive impacts arising from this proposal is the potential diversion of significant quantities of waste streams from Gauteng's landfills to PPC, whereby the mineral and energy value of the waste stream is recovered. If these waste streams continue to be disposed of to landfill, then the construction of future landfills is expedited (accompanied by the risks of groundwater contamination from landfills) and the value of the waste remains buried underground. Furthermore, the replacement of coal (a non-renewable fossil fuel, which has to be transported even greater distances than the waste) results, implying an improvement in the energy efficiency of the cement industry.

All of the impacts are sufficiently mitigated by the proposed control actions as required in terms of the National Environmental Management Act, thereby reducing the significance of each impact.