REPORT

Generic Risk
Assessment Study

Durham – York Residual Waste Study

REPORT NO. 1009497.02

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REPORT TO	**Durham – York Residual Waste Study**
FOR	**1019963**
ON	**Energy-From-Waste Generic Risk Assessment Feasibility Study**

June 14, 2007

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Executive Summary

The Regions of Durham and York in Ontario, Canada are undertaking an Individual Environmental Assessment (EA) termed the "Residual Waste Study". The purpose of the Environmental Assessment is to establish the preferred treatment (physical, biological and/or thermal treatment) of the waste that remains after the application of at source waste diversion programs in order to recover resources – both material and energy – and to minimize the amount of material requiring landfilling disposal.

At this point in the EA a thermal treatment energy-from-waste (EFW) facility has been determined to be the preferred option. However, at this point there are five potential short listed sites and no vendor or specific technology has been selected for implementation. Through the EA public consultation process, concerns have been raised about the potential for emissions from an EFW facility to adversely impact human and environmental health.

Although previous human health and ecological risk assessments of thermal treatment conducted in Ontario have concluded that there would be no significant impact on the environment, recent regulatory changes have prompted a re-examination of these findings. The purpose of this report is to study the potential health and environmental impacts and feasibility of siting an EFW facility in the Durham and York Regions. Given that a specific site has not been selected, nor has a vendor or technology been chosen, a regional generic risk assessment was conducted based on emissions data from an existing facility and Ontario emissions guidelines.

This report is in no way meant to replace the requirement for a detailed site specific human health and ecological risk assessment to be conducted upon selection of the preferred site and selected vendor and technology. This report is meant as a feasibility study only and to identify potential issues of concern that should be closely examined during the conduct of the site-specific risk assessment.

Selection of Chemicals of Potential Concern

Given that a specific vendor and technology have not been selected the list of chemicals of potential (CoPCs) was derived from previous studies conducted on similar facilities in Ontario. The majority of the exhaust stack air emission estimates used in this study are based on pollutant emission concentration values obtained from annual stack testing of the 150,000 t/y KMS Peel thermal treatment facility located in Brampton, Ontario. Maximum emission concentrations for all selected COPCs were considered for the air dispersion modelling to illustrate a realistic worst-case scenario for the proposed technology.

For the eight air contaminants found in the Ontario Ministry of Environment (MOE) A-7 guideline (i.e., particulate matter, cadmium, lead, mercury, dioxins and furans, hydrochloric acid, sulphur dioxide, and nitrogen oxides), guideline emission concentration limits were used as default exhaust stack air emission estimates to evaluate the potential risk to the surrounding environment. Furthermore, in addition to stack emissions, vehicular traffic for waste delivery and ash removal were also considered a source of emissions that could potentially impact human and ecological health.

Chemicals of Potential Concern Evaluated in the Risk Assessment

Metals	Chlorinated Monocyclic Aromatics	Chlorinated Polycyclic Aromatics	Polycyclic Aromatic Hydrocarbons	Volatile Organic Compounds
Antimony Arsenic✓ Barium Beryllium Boron Cadmium✓+ Chromium ✓ Cobalt Lead✓+ Mercury✓+ Nickel Phosphorus Silver Vanadium Zinc	1,2-Dichlorobenzene 1,2,4-Trichlorobenzene 1,2,4,5-Tetrachlorobenzene Pentachlorobenzene Hexachlorobenzene 2,4-Dichlorophenol 2,4,6-Trichlorophenol 2,3,4,6-Tetrachlorophenol Pentachlorophenol	PCBs 2,3,7,8-TCDD - (dioxin/furan)TEQ✓+ **Combustion Gases** PM_{10} + $PM_{2.5}$ + CO HCl✓+ HF NO_x✓+ SO_x✓+	*Benzo(a)pyrene group* Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Benzo(g,h,i)perylene Benzo(k)fluoranthene Chrysene Dibenz(a,h)anthracene Indeno(1,2,3-cd)pyrene Anthracene Napthalene Phenanthrene	Benzene✓ Chloroform Dichloromethane Formaldehyde Tetrachloroethylene Vinyl chloride✓

Notes: Chemical list derived from Cantox Report for Human Health Risk Assessment for the Proposed Expansion of the KMS Peel, Inc. Brampton, Energy-From-Waste Facility (2000)

✓ Chemicals also reviewed by MOE in Environmental Risks of Municipal Non-Hazardous Waste Landfilling and Incineration (1999)

\+ Chemical also included in GUIDELINE A-7 Combustion and Air Pollution Requirements for New Municipal Waste Incinerators (MOE 2004)

Air Quality Baseline and Modelling

The Residual Waste Study is examining thermal treatment EFW options of processing up to 400,000 t/y of municipal solid waste (MSW). It is important to note that the final annual throughput of MSW has yet to be decided. To that end, three facility scenarios were modelled for both their aerial emissions from the stack, as well as for vehiclar truck traffic that would be required to operate the facility. The three scenarios were as follows:

Operating Scenario 1: 3 process units running at full capacity - 400,000 t/y

Operating Scenario 2: 2 process units running at full capacity - 266,666 t/y

Operating Scenario 3: 1 process units running at full capacity - 133,333 t/y

The physical layout of this theoretical facility is based on current design of EFW facilities operating around the world. The Durham/York facility would occupy a space of 6.1 hectares (256 m by 240 m property) and is assumed to have a single emissions stack with a stack height of 65 meters.

Air Dispersion Modelling

The MOE approved air dispersion model AERMOD (version 04300) was used together with MOE regional MET files (meteorology) modified to include precipitation for the air dispersion modelling of the emissions released from the theoretical MSW thermal treatment facility. Particle phase and vapour phase average concentrations, as well as dry depositions and wet depositions of the selected COPCs were determined at all ground level receptor locations.

The air dispersion modelling included estimates of the 1-hour, 24-hour and annual averaging periods of the COPCs from the facility at the maximum point of impingement (MPOI). The MPOI represents the maximum concentration of COPC at the nearest point where air contamination emitted by a source will fall at or beyond the property line.

The 1-hour maximum ground level concentrations of COPCs were located approximately 700 m from the EFW facility stack or over 680 m outside the fenceline of the facility, while the 24-hour concentrations were typically located within 300 m of the facility. The annual average MPOI concentrations were located between approximately 280 m and 340 m from the fenceline of the facility.

Regional Background Air Quality

To evaluate the potential cumulative risk of exposure to airborne contaminants in this study, background ambient air concentrations of the relevant COPCs were collected. Although the specific location of the facility was unknown at the time of preparation of this report, there are several MOE ambient air quality stations located within the Durham and York Regions. These ambient air quality stations were used to assess the potential background, existing ambient air quality for the Regions.

Results of Air Quality Modelling

The modeled air results were all below the acceptable concentrations provided in Ontario Regulation 419/05. Moreover, even with the addition of ambient concentrations from Durham/York air quality monitoring stations concentrations were below air standards.

Estimating Exposure Point Concentrations in Environmental Media

Maximum predicted ground-level concentrations and wet and dry deposition rates of each CoPC at the MPOI were calculated and carried forward into the risk assessment. The air dispersion modeling and multi-exposure pathway fate and transport of chemicals in the environment was carried out using guidance provided by the United States Environmental Protection Agency (US EPA)

> *US EPA. 2005. Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (HHRAP), Final. EPA520-R-05-006*

Although Canadian regulatory authorities do not publish specific guidance for these types of risk assessments, standard MOE, Health Canada, and Environment Canada protocols for contaminated site risk assessment were adopted in this assessment where guidance exists.

Concentrations of CoPCs were modeled for air, soil, water, sediment, vegetation, produce, agricultural products, fish, and breast milk. These concentrations were then used in exposure estimates in the human health and ecological risk assessment (HHERA).

Human Health Risk Assessment

Selection of exposure scenarios for use in this risk assessment was in general accordance with the recommended exposure scenarios proposed by US EPA (2005) with the addition of a First Nations receptor. All receptors were assumed to live full-time at the MPOI (highest ground level concentration of contaminants), with the exception of the Commercial receptor, who was assumed to commute in only to work at a commercial building located at the MPOI. A brief description of each receptor scenario, highlighting significant assumptions, is provided below.

In general, for carcinogenic CoPCs, intakes were averaged over a lifetime of exposure from birth to 75 years old. For non-carcinogenic CoPCs, an infant, toddler and lifetime-averaged receptor were modelled.

Summary of Receptors and Exposure Pathways Modelled

	Receptors			
Exposure Pathways	**Durham – York Resident [1]**	**Durham – York Subsistence Farmer [2]**	**Durham – York First Nations/ Métis [3]**	**Durham – York Worker[4]**
Direct inhalation	✓	✓	✓	✓
Soil contact	✓	✓	✓	✓
Drinking water	✓	✓	✓	✓
Garden produce	✓	✓	✓	
Fish	✓	✓	✓	
Breast Milk	✓	✓	✓	
Wild game			✓	
Agriculture (meat, poultry)		✓		

1) Resident includes an adult, toddler, and nursing infant.
2) Subsistence Farmer includes an adult, toddler, and nursing infant.
3) First Nations and Métis includes an adult, toddler, and nursing infant.
4) Commercial includes an adult worker and a toddler at a daycare facility

Toxicity Assessment

The purpose of a toxicity assessment is to weigh available evidence regarding the potential for the environmental contaminants to cause adverse effects in exposed populations and to provide an estimate of the relationship between the extent of exposure and the increased likelihood and/or severity of those adverse effects.

Toxicity reference values (TRVs) were reviewed from a number of credible international agencies. In this study preference was first given to US EPA and Health Canada values, whereby the date of the review and validity of the studies were used for selection of TRVs. In the event that IRIS or Health Canada values were not available, or more current TRVs had been established by reputable agencies based on sound toxicological studies they were selected for use.

Chemical Mixtures

In order to properly assess health risks to the human receptors, certain groups of chemicals were assessed as mixtures. For the purposes of this assessment, the carcinogenic PAHs have been assessed as a mixture as have the dioxin and furans as 2,3,7,8 TCDD TEQ.

Additivity of Risks

Combined toxic effects may be produced in a receptor due to exposure to interacting CoPC. Such combined effects may be additive, synergistic (greater than additive), or antagonistic (less than additive). In order to assess these combined effects quantitatively, however, detailed studies of the interactions between CoPC are required, and little information is available in this regard. However, the additive risk of CoPC with the same target organ and toxicological endpoint has been evaluated as part of this risk assessment.

Exposure Assessment

The exposure assessment estimated the amount of a CoPC each receptor may take into his or her body (i.e., a dose) through all applicable exposure pathways. For the purposes of this assessment, the dose of a CoPC depends on the concentrations in air, water, soil, agriculture, (e.g., poultry, cows, milk) fish, plants, breast milk and wild game; the amount of time a person is in contact with these media; and the characteristics of the receptor (e.g., ingestion rate, inhalation rate, body weight, food preferences).

Risk Characterization

Risk characterization is essentially a comparison of the predicted human intake of a CoPC to the toxicity reference value (TRV) for that CoPC to estimate the potential risks to human health from the CoPC evaluated. In Ontario the regulated acceptable level of risk for non-carcinogens is a hazard quotient <0.2, and an incremental lifetime cancer risk of <1 predicted cancer case in an exposed population of one million (1E-06).

Results

Commercial Worker and Daycare Toddler

The Durham-York commercial receptor is assumed to live outside of the region but work full time in the vicinity of the facility. All risk estimates for the Durham-York commercial receptor met the appropriate benchmarks. This suggests that up to a 400,000 t/y EFW facility could be located within a commercial zone of land use without appreciable risk to receptors over its 35 year timeframe.

Durham-York Resident

The Durham-York resident is assumed to live full time in the region, have a backyard garden, and eat some locally caught fish. All risk estimates for the Durham-York resident met the appropriate benchmarks.

Durham-York Subsistence Farmer

The Durham-York subsistence farmer is assumed to live full time in the region and obtain 100% of their food (e.g., meat, fish, poultry, eggs, milk, produce) year-round from their farm. All risk estimates for the Durham-York subsistence farmer met the appropriate benchmarks, with the

exception of the potential risk from dioxins to an infant arising from ingestion of breast milk. When actual dioxin emission rates from the KMS Peel facility were modeled this risk was reduced to below the acceptable regulatory benchmark of HQ=0.2.

Durham-York First Nations and Métis

The Durham-York First Nations and Métis receptor is assumed to live full time in the region, have a backyard garden, and eat locally caught fish and wild game. All risk estimates for the Durham-York First Nations and Métis receptor met the appropriate benchmarks, with the exception of the potential risk from dioxins to an infant arising from ingestion of breast milk and the potential risk from methyl mercury to a toddler arising from ingestion of fish.

There were several uncertainties associated with this risk assessment. These are discussed in detail within the report. A qualitative analysis of uncertainties associated with the risk assessment process supports the conclusion that the risk estimates provided in this report are conservative and likely overstate the potential risks to the local community.

Ecological Risk Assessment

A generic ecological risk assessment was undertaken to help classify potential ecological impacts of EFW facility activities by identifying CoPC, the likely pathways leading to wildlife exposure, and the possible population effects of such exposure. Considering this pro-active approach, results of the ERA will be used to determine if the proposed EFW facility is potentially environmentally acceptable. Furthermore, results of the ERA can be used to guide monitoring and mitigation programs, and guide the site-specific risk assessment priorities.

Problem Formulation

During the problem formulation stage, the chemicals to be assessed in the ERA were identified as being the same as those for the HHRA. The terrestrial ecological receptors selected for evaluation in the ERA were: Masked Shrew, Meadow Vole, Muskrat, Mink, Red Fox, American Robin, Belted Kingfisher, Mallard, and Red-Tailed Hawk. For some ecological receptors it is more appropriate to evaluate risk at the population level (rather than species level). This method was used to evaluate risks to fish, terrestrial plants, soil invertebrates, and benthic (aquatic) invertebrates.

Exposure Assessment

For this generic ERA, oral ingestion of contaminated foods/substances is considered the major source of CoPC exposure. Exposure estimates were also calculated for: soil/sediment ingestion; ingestion of terrestrial vegetation, soil invertebrates, and mammalian prey; water ingestion; ingestion of aquatic invertebrates and fish.

Exposure to ecological receptors was calculated for each of the three Operating Scenarios. To minimize the likelihood of underestimating risks in the ERA, the exposure assessment was conducted in a manner that is likely to lead to an overestimation of actual exposure levels.

Toxicity Assessment

The toxicity assessment identified the potential adverse ecological health effects associated with oral exposure for each CoPC. TRVs were established for each CoPC by reviewing toxicological literature from a variety of sources (i.e., Oakridges National Laboratory (ORNL), US EPA, Agency for Toxic Substances and Disease Registry (ATSDR), primary scientific literature, etc.). TRVs define the amount of each CoPC, a specific ecological receptor can be exposed to on a daily basis below which unacceptable adverse effects are not expected to occur.

Risk Characterization

Risk Characterization combines the information developed in the toxicity and exposure assessments to identify potential sources of unacceptable ecological risk. The likelihood of unacceptable risk is established through the calculation of a Hazard Quotient. HQs are calculated as the ratio of the predicted exposure to the toxicity reference value. For this generic ERA, HQs were calculated at the EFW facility for all three operating scenarios. Typically, a HQ greater than 1.0 (daily exposure greater than TRV) is considered an indication that unacceptable adverse effects could be expected in ecological receptors. However, for this ERA a HQ value of 0.2 was used, in acknowledgement of the fact that existing concentrations of CoPCs in the environment were not incorporated into the exposure assessment.

The highest HQ for a terrestrial ecological receptor was 0.17 for the Belted Kingfisher, as a result of exposure to methyl mercury under scenario one conditions (three process units in operation). Hazard quotients for the remaining ecological receptors did not exceed 0.1, indicating that unacceptable adverse effects were not expected to occur.

The highest HQ for an aquatic receptor was 0.8 for dioxins exposure to aquatic organisms under scenario one operating conditions. This HQ was calculated on the basis of exposure levels resulting from maximum allowable emission rates as defined by the MOE. When dioxins emission rates from a similar EFW facility were used, the HQ decreased substantially, to 0.1

Study Limitations

There are a number of limitations to conducting a human and ecological risk assessment feasibility study for a theoretical facility. These limitations should be taken into consideration in the event that Durham and York Regions pursue a thermal treatment EFW facility, as one option for dealing with their residual municipal solid waste.

The greatest source of uncertainty and the principal limitations for this study are two fold:

1. The final preferred site for the thermal treatment EFW facility has yet to be determined.
2. The final technology and vendor have not yet been selected.

Conclusions

A limited number of potential human health and ecological concerns were identified in this conservative, generic EFW facility risk assessment. These include exposure of Subsistence Farm and First Nations infants and aquatic receptors to dioxin and furans (2,3,7,8-TCDD TEQ) if the concentration being emitted from the stack was at the MOE A-7 Guideline. In addition, methyl mercury posed a potential risk to the First Nations toddler and approached a level of

concern for the Belted Kingfisher. These are issues that deserve particular attention in the site-specific risk assessment. These potential estimates of risk were based on a very conservative set of assumptions that were carried through all phases of the assessment.

Overall, it was determined that a thermal treatment EFW facility could be sited in the Durham and York Regions.

Next Steps

Environmental Baseline Chemical Collection

This generic risk assessment did not account for existing baseline chemical concentrations in the environment. In any site-specific risk assessment this information will be critical to understand the potential cumulative impact that the EFW facility would have on health and the environment. At the time of preparation of this report, a baseline monitoring program for a suite of contaminants of potential concern had been initiated in Durham and York Regions. Once the preferred site has been selected there are plans to conduct an extensive baseline chemical analysis of soil, water, sediment and biota in the area.

Site Specific Risk Assessment

A detailed site specific human health and ecological risk assessment and air dispersion modelling project should be undertaken once a preferred site and vendor is selected. This detailed site specific HHERA should address the concerns raised in this generic risk assessment and should include, at a minimum, consideration of cumulative environmental effects.

In the event that the initial results of the site-specific risk assessment reveal an unacceptable risk to either health and the environment, this does not automatically suggest that the facility could not still be built. Rather, discussions between the risk assessment team and the pollution control engineers could take place to enhance the performance of the technology to reduce the emission of chemicals to the environment.

Ultimately, prior to regulatory approval of the project, it will need to be clearly demonstrated that on a site-specific basis the emissions from the facility would not pose an unacceptable regulatory risk to either humans or the environment.