ORGANIC AND INORGANIC EMISSIONS FROM A MULTI-HEARTH SEWAGE SLUDGE INCINERATOR AT HIGHLAND CREEK WATER POLLUTION CONTROL PLANT

Prepared by

Environment Canada

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EXECUTIVE SUMMARY

Emissions from a multiple hearth sludge incinerator at the Highland Creek Water Pollution Control Plant in Scarborough, Ontario were studied in June 1987. Sludge feed, ash, scrubber water and stack gas samples were taken and analyzed for dioxins, furans, chlorophenols, chlorobenzenes, PCBs, PAHs and 28 inorganics including heavy metals. The stack gases were continuously monitored for NO_x, CO_2, CO, SO_2 and THCs (total hydrocarbons).

The emission data obtained was comparable to that found during Environment Canada's study of the Duffin Creek sewage treatment plant fluid bed sludge incinerator in October 1986. A comparison of the emissions of the two sludge incinerators to the emission test results of two garbage incinerators is presented. The results of leaching tests on the bottom ash from the Highland Creek sludge incinerator are discussed.

1 INTRODUCTION

In June 1987, Environment Canada tested emissions from a multiple hearth sewage sludge incinerator at the Highland Creek sewage treatment plant. The previous year, Environment Canada had tested emissions from a fluid bed sewage sludge incinerator at the Duffin Creek sewage treatment plant. These activities were carried out in support of Environment Canada's continuing mandate to promote the minimization of the release of toxic chemicals to the environment. Incineration has been identified as having the potential to be a major source of toxic emissions, particularly with regard to dioxins.

This report describes a study carried out in June 1987 by Environment Canada in cooperation with the Ontario Ministry of the Environment (MOE) and the Municipality of Metropolitan Toronto (Metro). The facility which was tested was the multi-hearth sewage sludge incinerator at the Highland Creek Water Pollution Control Plant (WPCP) in Scarborough (West Hill) Ontario, owned and operated by Metropolitan Toronto. The Urban Activities Division (UAD) of Industrial Programs Branch (IPB) of Environment Canada provided overall coordination for the study and drew upon the River Road Environmental Technology Centre's (RRETC) Pollution Measurement Division (PMD) and the Wastewater Technology Centre (WTC) for stack sampling and process (non-stack) sampling services.

The Highland Creek WPCP was, at the time of the study, a 48 MGD (216×10^3 m^3/d) plant. Originally constructed in 1956, the plant had a treatment capacity of 4 MGD (18×10^3 m^3/d). Plant extensions in 1962, 1967, 1975 and 1980 increased capacity to its present value of 48 MGD. The plant serves an area of approximately 13 880 ha (34 300 acres) with a connected population of 310 000. Sewage at Highland Creek is treated by the conventional activated sludge treatment process. Treatment includes phosphorus reduction, sludge digestion, thermal conditioning of sludge, sludge dewatering, and incineration of the dewatered sludge in multi-hearth incinerators.

A brief description of the sludge processing at Highland Creek now follows. Flotation is used with the addition of a polymer to thicken and condition waste activated sludge from 0.5-1.0% to at least 4.0% solids and preferably 7-8% solids. Five Komline Sanderson flotation units are used, each capable of treating 22 l/s of waste activated sludge. Two primary and two secondary digesters are used for the anaerobic digestion of a portion of the sludge. Gas from this process is used as supplementary fuel in the hot water boilers. Primary digesters contain mechanical mixers and are covered with fixed steel roofs, while secondary digesters have floating roofs which rise and fall with changing gas volume and/or liquid levels.

Raw, waste activated and digested sludges are mixed together in blending tanks before being pumped to the Porteous heat treatment process, where the sludge is heated to approximately 190°C-195°C and reaches a pressure of 1400-1500 kPa for approximately half an hour to break down the protein in the sludge and release the bound water.

After the heat treated sludge is conditioned with a polymer and centrifuged, the dewatered sludge cake is left with a composition of about 35% solids. It is then incinerated at a temperature slightly over 800°C in a multi-hearth incinerator capable of burning 200 tonnes/day of sludge cake composed of approximately 40% total solids. There are 4 burners on each of the no. 1, no. 3, no. 5 hearths and 2 on the no. 7 hearth. The ash produced is slurried and temporarily stored in a lagoon until it is full, at which time the ash is removed and stored on site. The combustion gases enter a scrubber before being discharged into the atmosphere via a 76 m incinerator stack.

2 GENERAL DESCRIPTION OF THE STUDY

The incineration system was sampled at five points and the samples were analyzed for toxic organics and various inorganic elements including heavy metals. The sample points are shown in Figure 1 and are described below.

1. dewatered sludge feed to the incinerator;
2. bottom ash;
3. scrubber water in;
4. scrubber water out;
5. stack gases.

The inorganic elements analyzed for were Ag, Al, As, B, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Mg, Mn, Mo, Na, Ni, P, Pb, Si, Sr, Th, Ti, V, Zn, and Zr. Total suspended solids (TSS) and percent moisture/solids were also determined as well as stack gas particulate loadings.

The organics analyzed for were chlorinated dioxins and furans, chlorinated benzenes and phenols, PCBs, and PAHs. In addition, the stack gases were sampled by continuous analyzers which monitored on a real-time basis for O_2, CO, CO_2, SO_2, NO_x, and THC (total hydrocarbons).

The stack gases were subject to two types of sampling; manual sampling using various sampling trains for inorganics and organics and automatic sampling using continuous analyzers. Both types required the use of sophisticated sampling techniques and equipment. The remaining samples from sampling points 1 to 4 in Figure 1, were taken on a grab sample basis and are referred to in this report as the "process" samples to distinguish them from the manual stack samples and continuous analyzer stack samples. Aqueous process samples to be analyzed for inorganic elements, except Hg, were acidified with 10 ml concentrated HNO_3. Aqueous process samples to be analyzed for Hg were acidified with concentrated HNO_3 and preserved with 1 g of $K_2Cr_2O_7$.

The three types of trains used in the manual stack sampling were as follows:

1) a total particulate/heavy metal train to collect samples which were later analyzed for inorganics,
2) a mercury train to collect samples which were later analyzed for mercury,
3) an organic train using the EPA Modified Method 5 (MM5) procedures to collect samples which were later analyzed for organics.

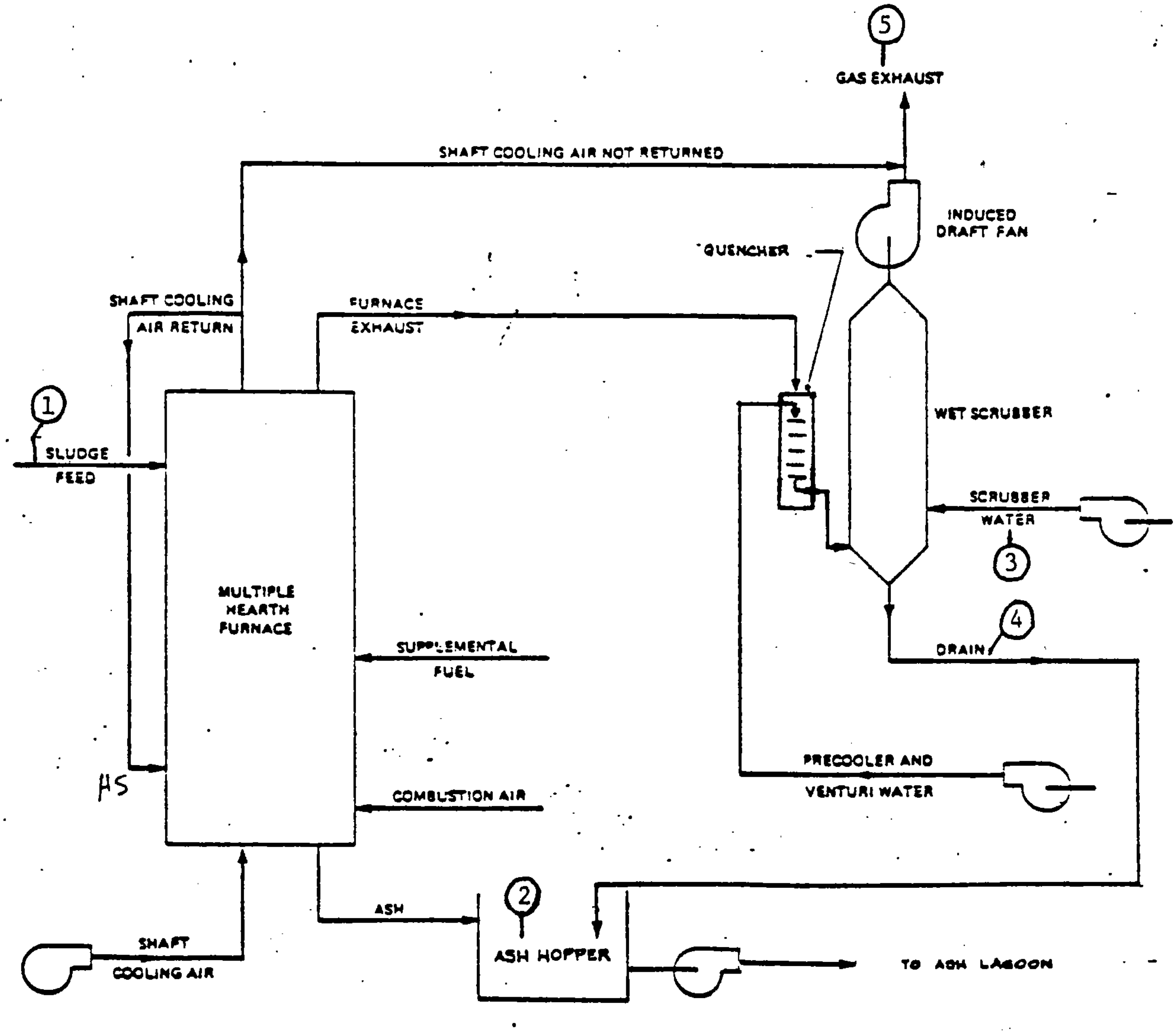


FIGURE 1 FLOWSHEET FOR SLUDGE INCINERATION PROCESS

The manual stack sampling was done over a six-day period and consisted of three particulate/heavy metal runs (Runs 1, 2 and 3), three mercury runs (Runs 4, 5 and 6), and three organic runs all at normal operating temperatures (Runs 7, 8 and 9) and one organic run at high operating temperature (Run 10). A particulate/heavy metal run consisted of sampling the stack using the total particulate/heavy metal train for a period of two hours. A mercury run consisted of sampling the stack using the mercury train for a period of three hours. An organic run consisted of sampling the stack using the organic train for a period of three hours. Process samples were taken during all the runs, stack gases were monitored on a real-time basis by continuous analyzers. It should be noted that because of the low stack gas flow rate all manual tests samples were extracted super-isokinetically (i.e. at a rate greater than the stack velocity) from one single point near the centre of the stack. This modification to the sampling method was made to assure that a sufficient volume of sample would be collected for chemical analyses within a reasonable period of time. The decision to proceed with the modified sampling method was made after consultations with managers from IPB, MOE, Metro and the Highland Creek plant. It was felt that non-isokinetic sampling would not significantly affect the test results, due to the expected small particle size of the particulates in the stack gas. The issue of isokinetic sampling is discussed in more detail in the Discussion of Results section of this report as well as the effect of non-isokinetic sampling on the test results. A more detailed description of the stack sampling activities now follows.

During the test period, the incinerator was at normal stable operating conditions. The average temperature of the combustion gas leaving the incinerator (gas exit temperature) is shown for each run in Table 1. Run no. 10, one of the organic train runs, was done at a higher than normal temperature, with four Hearth No. 1 afterburners on high fire. The average feed rates of the sludge to the incinerators for each run are shown in Table 1. The average flow for the "scrubber water in and out" for the six-day test period was 80 l/s.

3 STACK SAMPLING

Total particulates/heavy metals, mercury and all trace organics were sampled manually at the 33 m level of the incinerator stack (see Figure 2). The sampling ports for the continuous gas analyzers were located indoors on a horizontal duct between the scrubber outlet and the stack inlet.

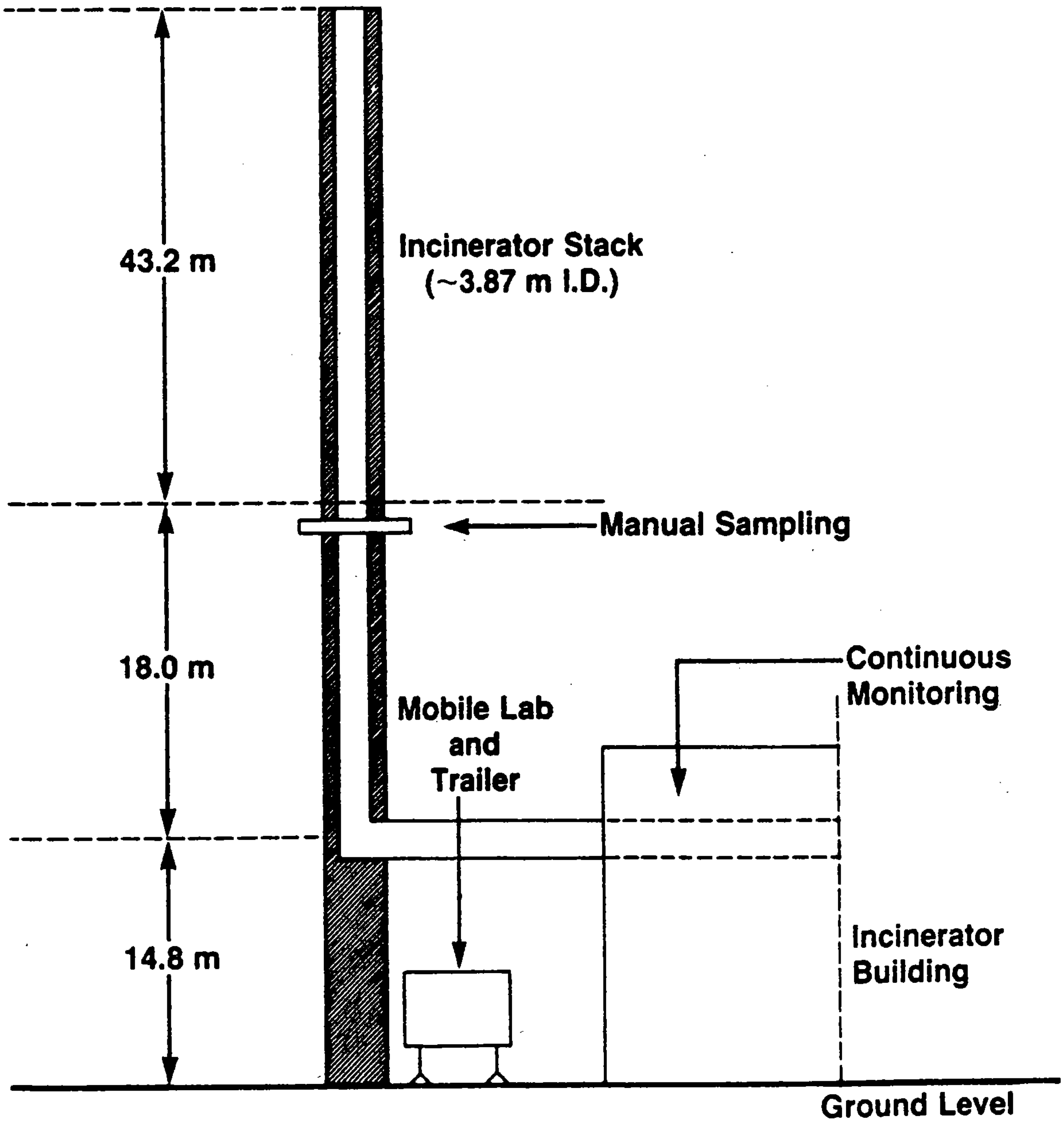


FIGURE 2 SAMPLING LOCATIONS

3.1 Manual Stack Sampling Methods

3.1.1 Total Particulates/Heavy Metals. The sampling method was a modified version of the Standard Reference Method for total particulates (8). Stack gas samples were withdrawn super-isokinetically (i.e. at a velocity greater than the stack gas velocity) from a single point near the centre of the stack. Total particulates were separated from the gaseous constituents by filtration. The particulate weight was determined gravimetrically after the removal of uncombined water. Any particulates and heavy metals escaping the filters were recovered in the two impingers containing aqua regia (see Figure 3).

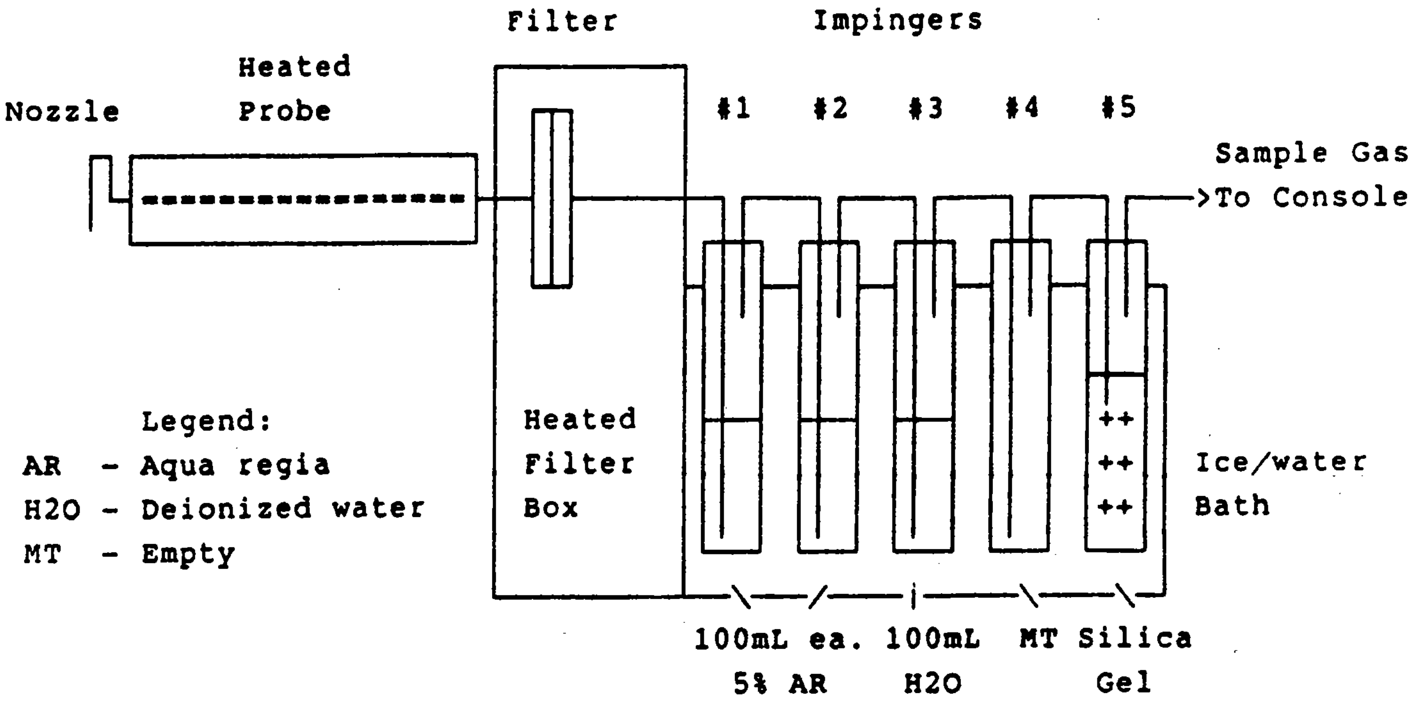
Upon completion of each run, particulates in the nozzle, the probe, and the front-half of the filter-holder were recovered by washing these train components with acetone. The washings were collected in a clean polypropylene bottle which was then sealed. The filter was removed from its holder and placed in a glass petri-dish. A second polypropylene bottle was used to store the aqua regia solutions and the distilled water rinses of the impingers. The liquid sample was preserved by adding more aqua regia into the bottle.

After the field survey, the samples were returned to RRETC for further processing. The probe acetone washings were evaporated and, together with the filters, desiccated to dryness. Both solid samples were weighed and the combined gravimetric results were used to determine the stack particulate concentration. All solid and liquid samples from the particulate/heavy metal runs were sent to a commercial laboratory for the analyses of 25 inorganic elements, namely, Ag, Al, As, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, P, Pb, Sr, Th, Ti, V, Zn, and Zr.

3.1.2 Mercury. Mercury samples were collected using the same basic techniques outlined previously for total particulates/heavy metals.

A composite stack gas sample was collected super-isokinetically from a point near the centre of the stack. Mercury present as particulate or adhering to particles was collected on a filter while mercury vapour escaping the filter was recovered in a series of ice-cooled potassium permanganate filled impingers (see Figure 4).

Upon completion of a test, samples in the nozzle, probe, and filter were recovered from the train and preserved using a 0.5% acidified dichromate solution. The impinger contents were reduced by hydroxylamine hydrochloride and preserved by a 10% dichromate solution. All samples were forwarded to a commercial laboratory for mercury analysis.

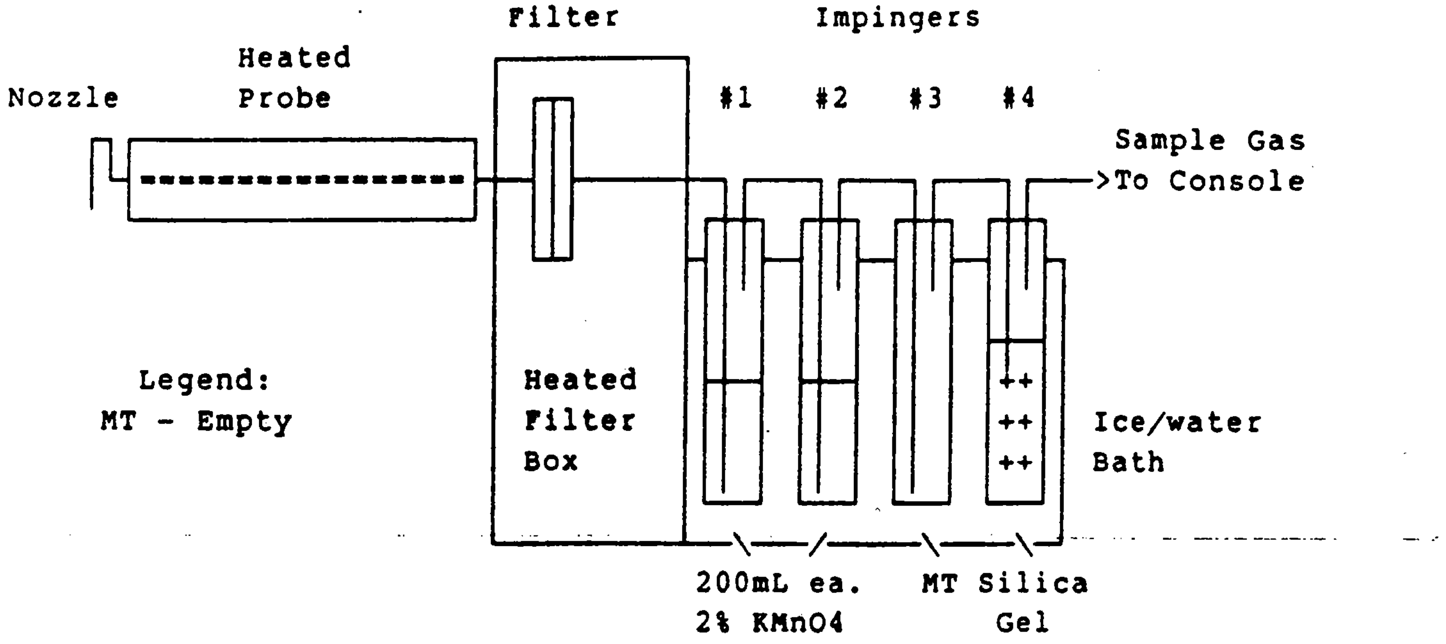


SAMPLE PARTITIONING AND RECOVERY PROCEDURES - TOTAL PART./HEAVY METALS

SAMPLE	Train components	Procedures
#1	Nozzle, probe, connector & front-half filter holder	Washed and brushed with acetone into a polypropylene bottle
#2	Filter	Stored in a glass petri-dish
#3	Imp#1 and #2, back-half of filter holder and glass connectors	Emptied content into a polypro bottle, rinsed glassware with H2O, added 5 mL conc.aqua regia per 100 mL sol'n

Note 1: Moisture gain was determined before sample recovery
Note 2: Contents of Imp. #3, 4, and 5 were discarded

FIGURE 3 TOTAL PARTICULATE/HEAVY METAL TRAIN



SAMPLE PARTITIONING AND RECOVERY PROCEDURES - MERCURY

Sample#	Train components	Procedures
1	Nozzle, Probe, connector & front-half filter holder Filter	- Washed and brushed w/ 0.5 % K2Cr2O7 solution into a glass bottle - Immersed in same solution
2	Impinger #1 Back-half of filter holder and connectors	- Reduced content with 3% NH2OH.HCl, poured sol'n into a vol. flask, rinsed impinger w/ H2O into same flask - Rinsed with 3% NH2OH.HCl and deionized water into same flask - Preserved flask content with 10 mL 10% K2Cr2O7, made up to volume
3	Impingers #2 and #3 Connectors	- Reduced content with 3% NH2OH.HCl, poured sol'n into a vol.flask, rinsed impinger w/ H2O into same flask - Rinsed with 3% NH2OH.HCl and deionized water into same flask - Preserved flask content with 10 mL 10% K2Cr2O7, made up to volume

Note 1: Moisture gain was determined before sample recovery
Note 2: Contents of Impinger #4 was discarded

FIGURE 4 MERCURY TRAIN

3.1.3 Dioxins, Furans, PCBs, CBs, CPs and PAHs. The basis for the sampling methodology of these organics is the EPA Modified Method 5 (MM5) procedures described in the draft ASME protocol (10). As with the previous two methods, samples were collected super-isokinetically from a point near the centre of the stack. Particulate matter was separated by filtration while the vapour fraction was collected downstream on Amberlite XAD-2 resin (see Figure 5). Some changes from the ASME protocol had been made; for example, ethylene glycol instead of water was used as a back-up collection medium in the impinger located immediately downstream of the Amberlite.

At the end of each run, stack samples were recovered from the MM5 train using the partitioning and recovery procedures summarized in Figure 5.

All field samples were stored in ice coolers and shipped to RRETC for dioxin, furan, PCB, CB, CP, and PAH analyses. To reduce the cost of analyses, the extracts of Samples No. 1a, 2a, and 3a were combined correspondingly with that of 1b, 2b, and 3b. The combined extracts were analyzed and reported in the Result Section as:

- Probe/Filter
- Amberlite XAD-2
- Glycol

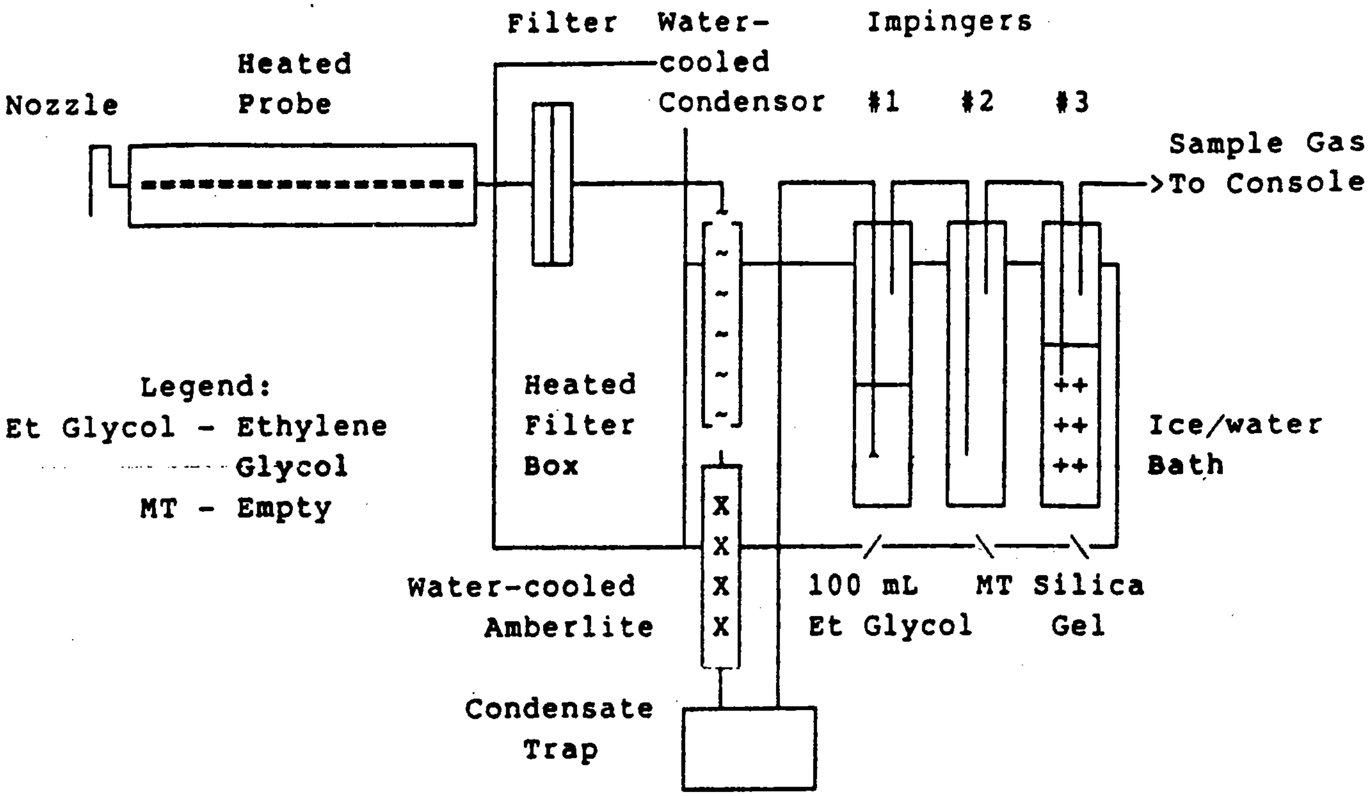
3.1.4 Quality Assurance and Quality Control (QA/QC).

3.1.4.1 General QA/QC procedures. A comprehensive in-house QA/QC program was implemented by the Pollution Measurement Division to ensure that all data collected would be representative of the source being tested.

Before the survey, all stack sampling equipment was overhauled and calibrated. Quality assurance results on nozzle diameter measurements, wind tunnel calibration of the probe/pitot-tubes/thermocouple assembly, calibration of thermocouples, and calibration of the dry gas meter were documented.

During the survey, all stack sampling trains were leak-checked at the beginning and end of the test and during port change-over. Other QA/QC procedures carried out in the field included the isokinetic analysis of selected field data at the end of each test day and the use of a coding and routing system to keep track of all the samples.

3.1.4.2 Total particulate/heavy metals. In addition to the general QA/QC protocols, special procedures were developed for the Total Particulate/Heavy Metal tests. All sampling train glassware and sample bottles were washed with aqua regia and rinsed with deionized water prior to the field survey. In addition to the field samples, reagent and



SAMPLE PARTITIONING AND RECOVERY PROCEDURES - ORGANICS (DIOXINS etc)

SAMPLE#	Train components	Procedures
1a	Nozzle, Probe, connector & front-half filter holder	Washed, brushed and rinsed 3X each w/ acetone (A) and hexane (H) into an amber glass bottle
1b	Filter	Placed on pre-cleaned aluminum foil, folded filter in half, sealed foil and stored in a glass petri-dish
2a	Back-half of filter holder, condensor and connectors	Soaked and rinsed 3X each with A and H into an amber glass bottle
2b	Amberlite cartridge	Capped ends, wrapped in aluminum foil
3a	Condensate trap, impingers #1 and 2 and connectors	Emptied contents into an amber glass bottle, rinsed each 3X with HPLC water
3b	All glassware (proof rinse sample)	Rinsed 3X each with A and H into an amber glass bottle

Note 1: Moisture gain was determined before sample recovery
Note 2: Contents of Impinger #3 was discarded
Note 3: All sample containers and teflon lid liners were pre-cleaned
Note 4: One set of A and H blank solutions was taken directly from teflon squeeze bottles

FIGURE 5 MODIFIED METHOD 5 (MM5) TRAIN

filter blank samples were also collected and sent to the commercial laboratory for inorganic analyses.

3.1.4.3 Mercury. QA/QC procedures for the mercury tests were similar to those for the Total Particulate/Heavy Metals tests, with all the glassware and sample bottles cleaned prior to the tests and reagent and filter blank samples taken during the survey.

3.1.4.4 Dioxins, furans, PCBs, CBs, CPs, and PAHs. Before Testing. Prior to the field survey, the following QA/QC procedures for organics were completed:

- All organic train glassware and sample bottles were washed in a dish-washer, rinsed with deionized water, and cleaned with distilled-in-glass grade methylene chloride, hexane, and acetone. All openings of the glassware were sealed with pre-cleaned aluminum foil prior to shipment to the field.
- Final proof rinses of the five sets of train glassware to be used in the field were analyzed.
- The Amberlite XAD-2 sorbent was solvent-extracted and proofed approximately one week before the tests.

During Testing. During the field survey, the following QA/QC procedures were carried out:

- In order to determine if there was any contamination of the stack samples from the ambient environment, a blank MM5 train identical to the one used for sample collection was set up at the sampling site during the fourth organic run. Approximately 0.01 m^3 of ambient air was drawn into the blank train to simulate the leak checking of the field train. After the test, samples from the blank train were recovered and analyzed in the same manner as the field train samples.
- One set of field reagent blanks (acetone/hexane, filter, ethylene glycol/distilled water, and Amberlite XAD-2) was collected at the end of the last organic run (Run no. 10). These blank samples were not analyzed, however, as the blank train showed non-detectable level of contamination.

Chemical Analyses. To ensure accurate organic emission results, QA/QC procedures were also applied to the chemical analysis aspect of the organic tests:

- Surrogate compounds representative of the range of molecular weights or the number of nuclear rings of the target organics under study were introduced quantitatively into the organic samples by the laboratory prior to analyses.

The target organics and their corresponding surrogate compounds are shown below:

Target Organics	Surrogate Compounds
Dioxins/Furans	13C12-T4CDD,-P5CDD,-H6CDD,-H7CDD,-OCDD and 13C12-1,2,3,4-TCDD
PCBs/CBs/CPs	13C12-CL5-PCB,13C12-CL8-PCB,13C6-CL4-CB, 13C6-CL6-CB,13C6-CL2-CP,13C6-CL3-CP, 13C6-CL5-CP and d-10 Fluoranthene
PAHs	d10-Acenaphthene,d10-Anthracene,d10-Pyrene, d12-B(a)A,d12-B(a)P,d14-D(ah)A,d12-B(ghi)P, and d-10 Fluoranthene

The surrogate compounds were analyzed in the same manner as the stack samples and the percentage recovery efficiency of each compound was determined by comparing the amount detected versus the quantity originally injected into the stack sample.

3.2 Continuous Monitoring Methods

The concentrations of the stack gases, O_2, CO_2, CO, NO_x, SO_2, and THCs were monitored on a real-time basis using the PMD's continuous monitoring system which consists of three basic units (Figure 6):

- Sample Extraction and Conditioning
- Continuous Analyzers
- Data Logging

3.2.1 Sample Extraction and Conditioning. The sample extraction and conditioning unit is designed to extract continuously a representative stack gas sample and to condition the sample so that accurate measurements can be made by the analyzers.

The sample for the O_2, CO_2, CO, NO_x, SO_2, and cold-THCs analyzers was extracted from a single point near the centre of the horizontal scrubber exit flue located inside the incinerator building. After the removal of coarse particulates by a sintered filter, the sample was transported via a heated line to a trailer where a second filter and a condensor removed the fine particulates and moisture in the gas stream. The gas sample was then split and distributed to the various continuous analyzers.

The sample for the hot-THCs analyzer was extracted from a separate point located 1 metre away. The sample was also transported and conditioned by a separate system.

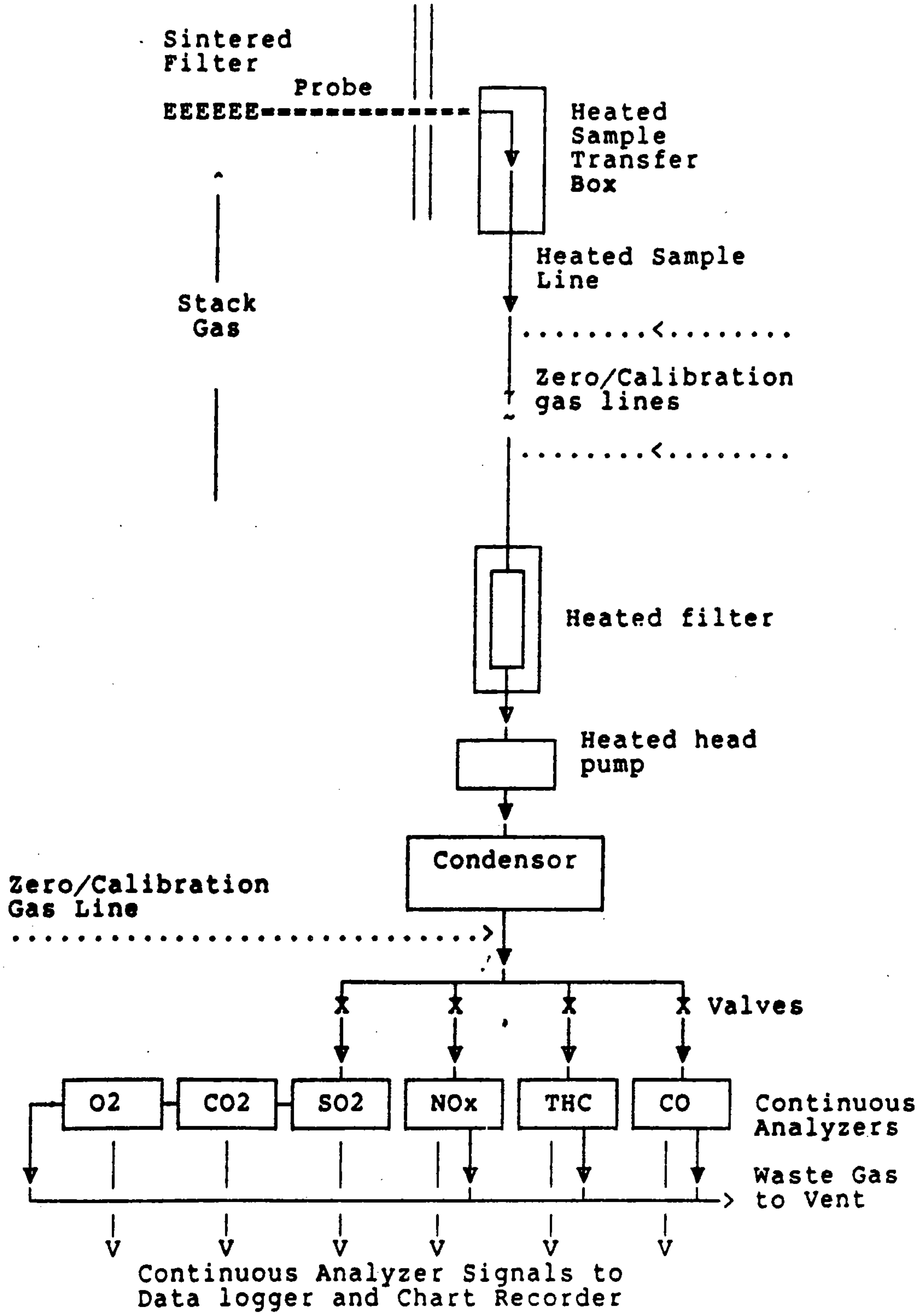


FIGURE 6 CONTINUOUS MONITORING SYSTEM FOR NO_x, SO_2, CO_2, CO, O_2, AND THC-COLD

3.2.2 Continuous Analyzers. Seven continuous gas analyzers were used at Highland Creek to measure the stack concentrations of NO_x, SO_2, CO_2, CO, O_2, and THCs (cold and hot). Signals from the analyzers were sent to the Data Logging unit. Table 2 summarizes the types and the principles of operation of these analyzers.

3.2.3 Data Logging/Recording. A computerized data logging system was used to scan the continuous analyzer channels and display the concentration data on a monitor every 20 seconds. A six-pen chart recorder traced the real-time concentration readings and a printer provided hard copies of the 5- and 15-minute average readings.

3.2.4 Quality Assurance/Quality Control. Prior to the survey, all continuous analyzers were overhauled and tested in the RRETC laboratory. The concentrations of the standard gases supplied by the gas companies were verified by wet chemical methods. During the survey, pre- and post-test calibrations of the continuous analyzers were performed using the verified standard gases. Periodic calibrations were also carried out during the test to correct instrument drifts. The calibration gas injection points are shown in Figure 6. The concentrations of the gases used are indicated in Table 2.

Other QA/QC procedures carried out in the field include the pre- and post-test leak tests of the continuous monitoring system at the probe outlet and the heated filter inlet and routine visual inspections of all analyzers and data logging system. All QA/QC information was documented in a field log book.

4 DISCUSSION OF RESULTS

In general, when stack gas contains entrained particulate matter, isokinetic sampling is one of the requirements for ensuring that the sample taken during manual stack sampling is representative. Isokinetic sampling means that the sample stream is drawn from the stack at the same velocity as the stack gas stream. However, when the particle size is sufficiently small, a representative sample can be obtained even under non-isokinetic sampling conditions. This is due to the fact that small particles tend to exhibit the same fluid dynamics as the gas stream in which they are entrained.

In order to collect a sufficient amount of sample in a reasonable amount of time, the RRETC sampling team did all the stack sampling super-isokinetically, i.e. the sampling rate was greater than the stack velocity. Since the particle size was expected to be small, it was assumed that this would not affect the test results. This assumption can be justified by comparing particulate stack concentrations obtained in this study to those obtained in another study(1) by Ontario Research Foundation (ORF) in December, 1987. Both studies were done under similar operating conditions and the average particulate concentrations for ORF's twelve runs and RRETC's 3 runs (Runs 1, 2, and 3) are shown in Table 37.

Both sampling teams encountered low stack velocities (less than 10 ft/s) and experienced significant fluctuations with time in the pitot tube velocity readings observed. The low stack velocities were a result of the normal practice at the plant of running one incinerator into a stack designed for three incinerators. The RRETC sampling team encountered fluctuations which were nearly 100% of the average velocity reading obtained, i.e. fluctuations of ± 2.4 ft/s (0.73 m/s) with an average reading of 2.7 ft/s (0.84 m/s). ORF encountered fluctuations of a similar absolute magnitude with average readings of 5.35 ft/s (1.63 m/s). In addition, both sampling teams observed that the particle size of the collected material was small. The stack gas velocity fluctuation was a major source of error affecting the determination of the isokinetic sampling rate in both the RRETC and the ORF studies. Despite this, both sampling teams obtained similar particulate stack concentration results, as can be seen in Table 37, indicating that the stack sampling results were not affected by non-isokinetic sampling (1, 2). Table 2A lists stack gas velocities and other stack gas characteristics for all of RRETC's 10 runs and describes the general conditions under which manual stack sampling was done by RRETC.

In discussing the results obtained in the Environment Canada study at Highland Creek, it is useful to compare them with the results of the Environment Canada study at

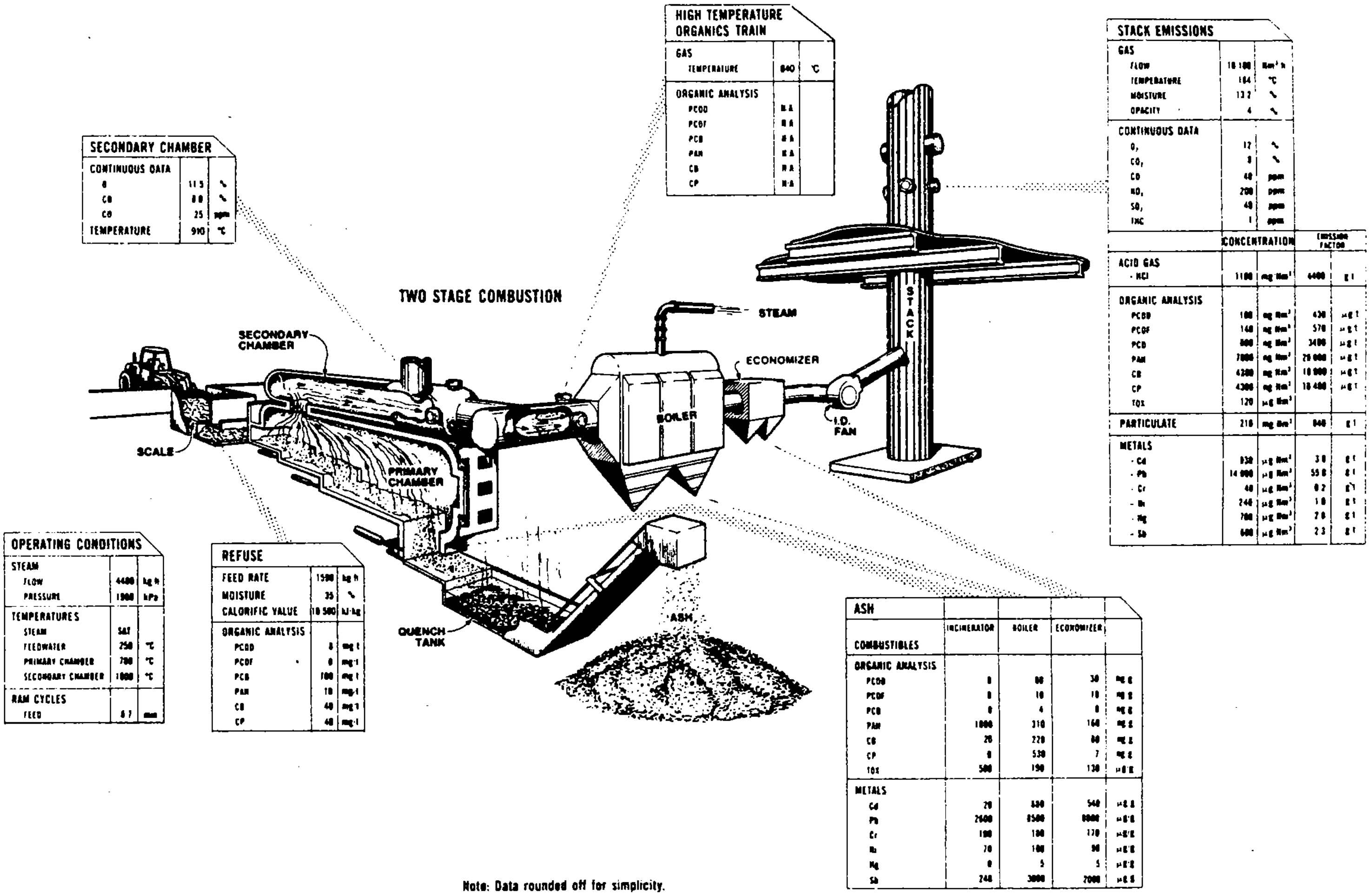
Duffin Creek (3) and the results obtained during Environment Canada's National Incinerator Testing and Evaluation Program (NITEP) testing of two garbage energy-from-waste incinerators (4, 5) shown in Figures 7 and 8. Figure 7 shows selected emissions from a two stage combustion garbage incinerator with no emission controls. Figure 8 shows selected emissions from a mass burn garbage incinerator with electrostatic precipitators.

4.1 Total Particulate and Inorganic Stack Emissions

Average particulate stack concentrations at Highland Creek (Table 3) were somewhat lower than those found at Duffin Creek, (61 mg/m^3 versus 116.8 mg/m^3, both corrected to 12% CO_2. Particulate stack emissions for the garbage incinerators in Figure 8, equipped with electrostatic precipitators were even lower at 22 mg/m^3. This is to be expected since electrostatic precipitators are more efficient at removing small particles than wet scrubbers.

Metal stack emissions at Highland Creek (Table 4) are comparable to those found at Duffin Creek. While metals such as Cd, Pb and Zn were significantly higher in the Highland Creek stack, others such as Cr, Fe and P were significantly higher in the Duffin Creek stack. The stack concentrations of Cd, Pb and Zn at Highland Creek averaged 541.8, 437.2 and 1128.6 μg/m^3 while at Duffin Creek the average levels were 13, 114 and 496 μg/m^3 respectively. However average Cr, Fe and P levels at Highland Creek were 23.3, 253.9 and 489.9 μg/m^3 while at Duffin Creek they were 258, 2795 and 7407 μg/m^3 respectively. These relationships were not found in the sludge feed except rather weakly for Cr. Average Cd, Pb and Zn levels in the sludge feed were 19.0, 329 and 1610 ppm respectively for Highland Creek (Table 11) and 34.9, 600 and 1350 ppm for Duffin Creek. Average Cr, Fe and P levels in the sludge feed were 468, 66 400 and 27 500 ppm respectively for Highland Creek (Table 11) and 1240, 17 400 and 29 100 ppm for Duffin Creek.

The metal stack emissions shown for the garbage incinerator with electrostatic precipitators in Figure 8 are comparable to metal stack emissions from Highland Creek (Table 4) and those from Duffin Creek. For example Figure 8 shows stack emissions for Cd to be the same order of magnitude at 24 μg/m^3 as at Duffin Creek (13 μg/m^3); for Pb to be the same order of magnitude at 670 μg/m^3 as at Highland Creek (437.2 μg/m^3) and as at Duffin Creek (114 μg/m^3); for Hg to be same order of magnitude at 700 μg/m^3 as at Duffin Creek (410 μg/m^3); and for Zn to be the same order of magnitude at 1130 μg/m^3 as at Highland Creek (1128.6 μg/m^3) and as at Duffin Creek (496 μg/m^3). However Ni stack emissions are an order of magnitude lower for the



SECONDARY CHAMBER

CONTINUOUS DATA		
O_2	11.5	%
CO_2	8.8	%
CO	25	ppm
TEMPERATURE	910	°C

HIGH TEMPERATURE ORGANICS TRAIN

GAS		
TEMPERATURE	840	°C
ORGANIC ANALYSIS		
PCDD	N.A	
PCDF	N.A	
PCB	N.A	
PAH	N.A	
CB	N.A	
CP	N.A	

STACK EMISSIONS

GAS		
FLOW	18 100	Nm³/h
TEMPERATURE	184	°C
MOISTURE	13.2	%
OPACITY	4	%
CONTINUOUS DATA		
O_2	12	%
CO_2	8	%
CO	40	ppm
NO_x	200	ppm
SO_2	40	ppm
THC	1	ppm

	CONCENTRATION		EMISSION FACTOR	
ACID GAS				
- HCl	1100	mg/Nm³	4400	g/t
ORGANIC ANALYSIS				
PCDD	100	ng/Nm³	430	µg/t
PCDF	140	ng/Nm³	570	µg/t
PCB	800	ng/Nm³	3400	µg/t
PAH	7000	ng/Nm³	29 000	µg/t
CB	4200	ng/Nm³	18 000	µg/t
CP	4300	ng/Nm³	18 400	µg/t
TOX	120	µg/Nm³		
PARTICULATE	210	mg/Nm³	840	g/t
METALS				
- Cd	830	µg/Nm³	3.0	g/t
- Pb	14 000	µg/Nm³	55.0	g/t
- Cr	40	µg/Nm³	0.2	g/t
- Ni	240	µg/Nm³	1.0	g/t
- Hg	700	µg/Nm³	2.0	g/t
- Sb	600	µg/Nm³	2.3	g/t

OPERATING CONDITIONS

STEAM		
FLOW	4400	kg/h
PRESSURE	1900	kPa
TEMPERATURES		
STEAM	SAT	
FEEDWATER	250	°C
PRIMARY CHAMBER	700	°C
SECONDARY CHAMBER	1000	°C
RAM CYCLES		
FEED	6.7	/min

REFUSE

FEED RATE	1500	kg/h
MOISTURE	35	%
CALORIFIC VALUE	10 500	kJ/kg
ORGANIC ANALYSIS		
PCDD	0	mg/t
PCDF	0	mg/t
PCB	100	mg/t
PAH	10	mg/t
CB	40	mg/t
CP	40	mg/t

ASH

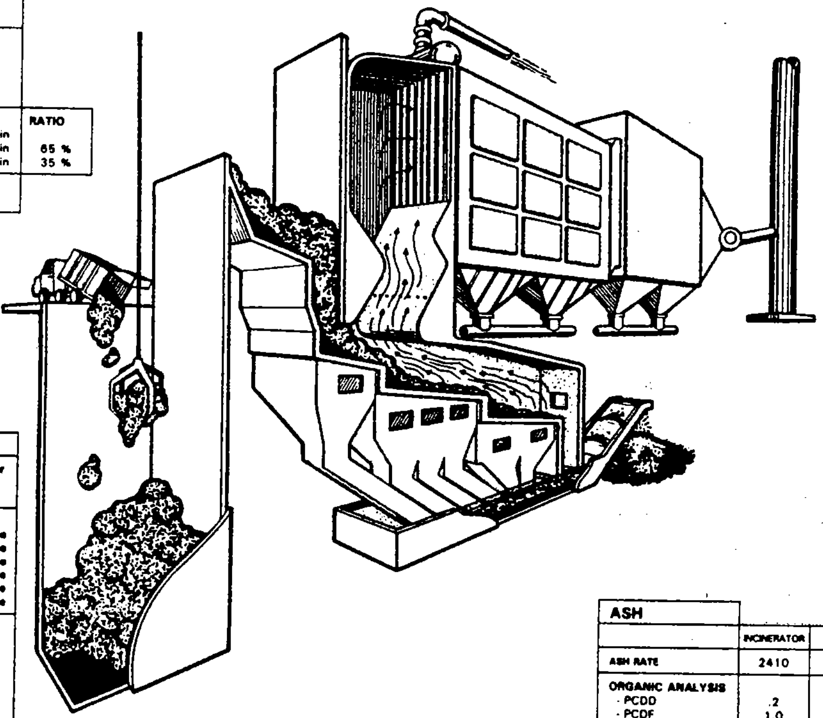
COMBUSTIBLES	INCINERATOR	BOILER	ECONOMIZER	
ORGANIC ANALYSIS				
PCDD	0	80	30	ng/g
PCDF	0	10	10	ng/g
PCB	0	4	0	ng/g
PAH	1000	310	160	ng/g
CB	20	220	80	ng/g
CP	0	530	7	ng/g
TOX	500	190	130	µg/g
METALS				
Cd	20	680	540	µg/g
Pb	2600	8500	8000	µg/g
Cr	100	100	170	µg/g
Ni	70	100	90	µg/g
Hg	0	5	5	µg/g
Sb	240	3000	7000	µg/g

Note: Data rounded off for simplicity.

FIGURE 7 GARBAGE INCINERATOR WITH NO EMISSION CONTROLS

OPERATING CONDITIONS			
STEAM			
· FLOW	28	tonne/h	
· PRESSSURE	4300	kPa	
· TEMPERATURE	320	°C	
TEMPERATURES			
LOWER INCINERATOR	1010	°C	
· UPPER INCINERATOR	780	°C	
· BOILER INLET	810	°C	
· COMBUSTION AIR	34	°C	
AIR FLOW			**RATIO**
· COMBUSTION	550	Am^3/min	
· PRIMARY	360	Am^3/min	65 %
· SECONDARY	190	Am^3/min	35 %
EFFICIENCY			
INPUT/OUTPUT	63.7	%	

REFUSE		
FEED RATE	8.9	tonne/hr
MOISTURE	35	%
CALORIFIC VALUE	2860	cal/g
ORGANIC ANALYSIS		
· PCDD	32	mg/tonne
· PCDF	3.2	mg/tonne
· PCB	45	mg/tonne
· PAH	1660	mg/tonne
· CB	72	mg/tonne
· CP	1570	mg/tonne
METALS		
· Cd	6.0	g/tonne
· Pb	660	g/tonne
· Cr	200	g/tonne
· Ni	27	g/tonne
· Hg	.62	g/tonne
· Sb	2.2	g/tonne
· As	1.3	g/tonne
· Cu	250	g/tonne
· Zn	220	g/tonne



STACK EMISSIONS		
GAS		
· FLOW	880	Sm^3/min
· TEMPERATURE	210	°C
· MOISTURE	15.7	%
· OPACITY	33.3	%
CONTINUOUS DATA		
· O_2	9	%
· CO_2	10	%
· CO	28	ppm
· NO_x	180	ppm
· SO_2	200	ppm
· THC	2	ppm
ACID GAS		
· HCl	450	ppm
ORGANIC ANALYSIS		
· PCDD	19	ng/Sm^3*
· PCDF	44	ng/Sm^3*
· PCB	3020	ng/Sm^3*
· PAH	4030	ng/Sm^3*
· CB	3300	ng/Sm^3*
· CP	5080	ng/Sm^3*
PARTICULATE	22	mg/Sm^3*
METALS		
· Cd	24	ug/Sm^3*
· Pb	670	ug/Sm^3*
· Cr	7	ug/Sm^3*
· Ni	5	ug/Sm^3*
· Hg	700	ug/Sm^3*
· Sb	36	ug/Sm^3*
· As	3	ug/Sm^3*
· Cu	33	ug/Sm^3*
· Zn	1130	ug/Sm^3*

* *Corrected to 12% CO_2*

ASH	INCINERATOR	BOILER	PRECIPITATOR	
ASH RATE	2410	34	57	Kg/h
ORGANIC ANALYSIS				
· PCDD	.2	37	580	ng/g
· PCDF	1.0	31	190	ng/g
· PCB	ND	ND	ND	ng/g
· PAH	540	25	110	ng/g
· CB	45	360	890	ng/g
· CP	16	80	1820	ng/g
METALS				
· Cd	4	210	1060	ug/g
· Pb	1760	7480	21100	ug/g
· Cr	250	300	480	ug/g
· Ni	130	120	110	ug/g
· Hg	0.03	7	72	ug/g
· Sb	18	330	760	ug/g
· As	7	91	170	ug/g
· Cu	2540	630	1480	ug/g
· Zn	1780	17400	60700	ug/g

FIGURE 8 GARBAGE INCINERATOR WITH ELECTROSTATIC PRECIPITATORS

garbage incinerator with electrostatic precipitators (Figure 8) at 5 µg/m^3 than for Highland Creek (44.9 µg/m^3) and Duffin Creek (112 µg/m^3).

The garbage incinerator with no emission controls (Figure 7) has generally higher metal stack emissions than the sludge incinerators. For example Figure 7 shows Cd and Pb levels of 930 and 14 000 µg/m^3 while for Highland Creek the levels are 541.8 and 437.2 µg/m^3 and for Duffin Creek the levels are 13 and 114 µg/m^3

The average value of the Hg stack emissions at Highland Creek (Table 4) was 2.72 µg/m^3. This compares to 410 µg/m^3 at Duffin Creek, 700 µg/m^3 for the garbage incinerator with no emission controls (Figure 7) and 700 µg/m^3 for the garbage incinerator with electrostatic precipitators.

4.2 Organic Stack Emissions

No dioxins or furans were detected in the stack gas samples at Highland Creek (Table 5) during manual stack sampling. This is comparable to what was found at the fluid bed sludge incinerator at Duffin Creek, where no dioxins were detected and only trace amounts of furans in the pg/m^3 range were detected. By contrast, the garbage incinerator with no emission controls (Figure 7) and the garbage incinerator with electrostatic precipitators (Figure 8) were emitting up to 100 ng/m^3 of PCDD and up to 140 ng/m^3 of PCDF.

Table 6 shows PCB stack emissions to be at low levels, comparable to what was found at Duffin Creek. Total PCB stack emissions range from below the detection limit to 155.2 ng/m^3. At Duffin Creek no PCBs were detected in the stack gases. Total chlorobenzenes stack emissions range from 289.6 to 466.6 ng/m^3 at Highland Creek. At Duffin Creek the range was from 453 to 10 902 ng/m^3, however due to its wide range and poor surrogate recovery this data is considered suspect.

Chlorobenzene stack emissions for the garbage incinerator with no emission controls (Figure 7) is 4 300 ng/m^3, and for the garbage incinerator with electrostatic precipitators (Fig. 8) is 3 300 ng/m^3. PCB stack emissions are 800 ng/m^3 for the garbage incinerator with no emission controls (Fig. 7) and 3020 ng/m^3 for the garbage incinerator with electrostatic precipitators (Fig. 8).

Table 7 shows that chlorophenols in the stack gas were at low levels ranging from 100 to 300 ng/m^3. Chlorophenols were not detected in the stack gas at Duffin Creek. Higher levels were found in the garbage incinerators; the one without emission controls (Fig. 7) had a level of 4 300 ng/m^3, the one with electrostatic precipitators (Fig. 8) had a level of 5080 ng/m^3.

Total PAH stack gas emissions at Highland Creek range from 400 to 2 000 ng/m^3 (Table 8). The range at Duffin Creek was 600 to 2 700 ng/m^3. The garbage incinerator without emission controls had a level of 7000 ng/m^3, the one with electrostatic precipitators had a level of 4030 ng/m^3.

Table 9 summarizes the surrogate recoveries of the train and blank samples. The acceptable recovery range is 100% plus or minus 40%. Virtually all the dioxin and furan surrogate recoveries are within this range indicating a high degree of confidence in the dioxin and furan analysis results of the stack gas samples. Many of the PAH surrogate recoveries fell outside the acceptable range indicating a low degree of confidence in the PAH stack gas results. Chlorobenzene analysis results are also suspect because of low surrogate recoveries. PCB and chlorophenol results appear to be good since most surrogates are within the acceptable recovery range.

4.3 Stack Gas Continuous Monitoring

The continuous monitoring results for Highland Creek are shown in Table 10. Generally Highland Creek had much poorer combustion than Duffin Creek. Highland Creek had CO values ranging upwards of 900 ppm initially although these were eventually reduced to less than 100 ppm during the last four runs (Runs 7, 8, 9 and 10). However despite improved combustion conditions during the last four runs, O_2, THCs, CO and SO_2 levels at Highland Creek remained consistently higher than what was found for Duffin Creek where THC ranged from 2 to 9 ppm, CO from <1 to 5 ppm, O_2 from 5 to 8% and SO_2 from 7 to 12 ppm. In contrast, at Highland Creek THC was from 12 to 165 ppm, CO ranged from below detection to >966 ppm, O_2 from 13.9 to 16.6% and SO_2 from 13 to 40 ppm.

4.4 Process Samples - Inorganic Analysis Results

Table 11 shows metal concentrations in sludge feed, bottom ash, "scrubber water in" and "scrubber water out" at Highland Creek. Similar levels of metals were found in the sludge feed and bottom ash at both Highland Creek and Duffin Creek although the levels at Duffin Creek tended to be somewhat higher. Metals such as Cd, Cr, Pb and Ni tended to be present at higher levels in Duffin Creek sludge feed and bottom ash, while metals such as Th, Ti, V and Mn tended to be higher in the Highland Creek process samples.

For example at Highland Creek Cd, Cr, Pb and Ni levels in the sludge feed were around 20, 460, 330 and 60 ppm respectively while at Duffin Creek the sludge feed contained levels of approximately 35, 1240, 600 and 275 ppm of these metals respectively. In the bottom ash, at Highland Creek these metals were found at about 5, 1200, 800, and 145 ppm respectively while the Duffin Creek bottom ash had levels of about 50, 2080, 1050 and 470 ppm respectively. Levels of Th, Ti, V and Mn at Highland Creek in the sludge feed were about 9, 8000, 225 and 500 ppm respectively and in the bottom ash were about 13, 2800, 630 and 1300 ppm respectively. Although Duffin Creek levels of these metals were lower in the sludge feed and bottom ash, they were within the same order of magnitude except for V which was an order of magnitude lower.

The "scrubber water in" and "scrubber water out" streams had low concentrations of metals and levels were similar to what was found at Duffin Creek. For example, Cd levels at Highland Creek in the "scrubber water in" and "scrubber water out" streams were <0.008 and about 0.04 mg/l respectively while at Duffin Creek these streams had <0.01 and about 0.03 mg/l of Cd respectively.

Tables 12 and 13 show the results of QA/QC work on the inorganic analyses. Table 12 shows the results of an inorganic analysis of three samples of a test solution labelled QA/QC-1, QA/QC-2 and QA/QC-3. This test solution was made up at WTC and split into the three samples. The actual concentrations are shown on the right side of the table and the concentrations as analyzed by the laboratory are shown on the left. As can be seen there is good agreement between the "actual" and "as analyzed" concentrations. This indicates a high degree of confidence in the aqueous inorganic results reported by the laboratory.

Table 13 shows some repeat analyses done by the laboratory and generally shows good agreement with the original analysis. This adds to the level of confidence regarding the validity of the inorganic analysis data.

However the levels shown in Table 11 for two of the elements, As and Si, appear to be in error. This can be seen by comparing the levels of the two elements in the bottom ash to the levels calculated in the sludge feed on a fixed solids basis.

The concentrations found in the bottom ash should not be significantly greater than the levels calculated in the sludge feed on a fixed solids basis. For volatile metals, the concentrations in the bottom ash would be expected to be lower than the calculated values in the sludge feed on a fixed solids basis. In the case of As and Si, the levels in the bottom ash are significantly greater than the calculated values in the sludge feed on a fixed solids basis. This discrepancy was brought to the attention of the laboratory that performed the analysis. The laboratory reported that the Si analysis was done using an acid digestion process which resulted in all the Si analyses results being invalid. However no reason for the discrepancy in the As results could be found. The reader should assume that all As and Si analysis results reported for Highland Creek in this report are unreliable.

Mercury levels in the process samples at Highland Creek are shown in Table 14. Hg levels were found to be about 4 ppm and 0.1 ppm in the sludge feed and bottom ash respectively at Highland Creek. Similar levels were found at Duffin Creek for the sludge feed (about 4 ppm) but the bottom ash levels were an order of magnitude higher at Duffin Creek.

Garbage incinerator bottom ash contain similar levels of metals as sewage sludge incinerator bottom ash. Typical ranges for garbage incinerator bottom ash (Figures 7 and 8) are: Cd, 4 to 20 ppm; Pb, 1760 to 2 600 ppm; Cr 100 to 250 ppm.

Mercury QA/QC results are shown in Tables 15 and 16. Table 15 shows the results of the analysis by the laboratory of a test solution of 0.5 μg/l Hg made up by WTC. There is good agreement between the "actual" and "as analyzed" values. Table 16 shows repeat Hg analysis by the laboratory giving good agreement with the original analysis. Tables 15 and 16 add confidence to the validity of the Hg analysis results.

4.5 Inorganic Leaching Test Results

Leaching tests were performed on a sample of bottom ash taken during the Highland Creek study. The leaching tests were performed by Environment Canada's Wastewater Technology Centre in Burlington, Ontario (6). It was found that the bottom ash was resistant to leaching and was considered to be suitable for landfill disposal. The leaching tests performed were the Ontario Regulation 309 Leach Test, the Multiple Sequential Batch Leaching Procedure and the Sequential Chemical Extraction Procedure, and are summarized in Table 38.

Results from the Sequential Chemical Extraction Procedure are given in Table 38A in terms of potential short- and long-term leachable fractions (%). Short-term leachability is the sum of Fractions A + B, while long-term leachability is calculated as the total of Fractions A + B + C. In general, the majority of the metals were measured in Fractions D and E, indicating that they are mainly present as relatively insoluble sulphides, silicates or oxides, and are not available for leaching even under the more aggressive conditions of a landfill. Similar results were recorded for ash from the Duffin Creek Sewage Sludge Incinerator Facility (Bridle et al., Evaluation of Heavy Metal Leachability from Solid Wastes. Env. Sci. Tech., 1987).

The results from the Ontario Regulation 309 Leach Test are presented in Table 39 along with the Ontario Drinking Water Quality Objectives x 100. Clearly, the concentrations of all the measured metals in the leachates were well below the guideline limits, therefore, this waste would be classified as non-hazardous in accordance with Regulation 309.

4.6 Process Samples - Organic Analysis Results

No dioxins or furans were detected in the bottom ash samples at Highland Creek. This is consistent with what was found at Duffin Creek. Also, no dioxins or furans were detected in the "scrubber water in" and "scrubber water out" streams. Again, this is consistent with the Duffin Creek findings, although at Duffin Creek levels of PCDF at around the detection limit were found in the "scrubber water out" stream.

PCDD and PCDF were found in the sludge feed samples at Highland Creek as indicated in Table 17. The levels of dioxins in the sludge feed at Highland Creek were found to be about 4 or 5 times greater than those at Duffin Creek (about 100 ng/g at Highland Creek vs. about 20 ng/g at Duffin Creek). PCDF levels in the sludge feed were found to be low at both Highland and Duffin (around the 1 ng/g range). No PCDD or PCDF were found at Highland Creek in the bottom ash, "scrubber water in" or "scrubber water out" as can be seen in Tables 18, 19, 20. At Duffin Creek, if PCDD and PCDF were detected at all in the ash and scrubber water streams, they were in the very low ppb range, 1 ng/g or less. Comparable PCDD and PCDF levels were found for the bottom ash from the garbage incinerators in Figures 7 and 8 (1 ng/g or less).

Chlorobenzenes and PCBs in the sludge feed, bottom ash, "scrubber water in" and "scrubber water out" streams (Tables 21 to 24) at Highland Creek are at or below detection limits and are comparable to those found at Duffin Creek. Chlorobenzenes in the bottom ash from garbage incinerators are somewhat higher than for the sludge incinerators, however PCBs were not detected. For example at Highland PCBs in the sludge feed range from about 60 to 350 ng/g, chlorobenzenes range from about 50 to 80 ng/g in the sludge feed. There were no PCBs or chlorobenzenes detected in the Highland Creek bottom ash. There were no PCBs detected in the Duffin Creek sludge feed or bottom ash and chlorobenzenes were in the same order of magnitude as at Highland. Both garbage incinerators show low levels of chlorobenzenes in the bottom ash (around 20 to 40 ng/g).

Tables 25 to 28 show chlorophenol (CP) levels at Highland Creek. CPs were found in higher amounts in the sludge feed at Highland Creek than at Duffin Creek. The "scrubber water in" and "scrubber water out" streams also had slightly higher levels of CPs at Highland Creek compared to Duffin Creek. The bottom ash from the garbage incinerators had comparable levels of CPs.

For example CPs in the sludge feed at Highland Creek were around 850 ng/g and at Duffin Creek were around 250 ng/g. Chlorophenols were not detected in Duffin Creek "scrubber water in" and "scrubber water out" (detection limit of 0.1 µg/l), however Highland Creek levels were around 0.5 µg/l.

At Highland Creek chlorinated effluent from the wastewater plant is used for the "scrubber water in", so it is not surprising that low levels of chlorophenols are found in that stream. This may also have some influence on the presence of chlorophenols and other chlorinated organics in the stack gas.

The bottom ash from the garbage incinerators (Figs. 7 and 8) have CP levels ranging up to 16 ng/g which is within the same range as Highland Creek.

PAH levels at Highland Creek (Tables 29 to 32) are comparable in the sludge feed and the bottom ash to those at Duffin Creek. "Scrubber water in" and "scrubber water out" streams were found to have comparable levels of PAHs at both Highland Creek and Duffin Creek. PAH levels in the bottom ash are significantly higher for the garbage incinerators in Figures 7 and 8 than for the sewage sludge incinerators at Highland Creek and Duffin Creek. However, given the nature of the feed to the garbage incinerators (large amounts of paper) this is to be expected.

PAH levels at Highland Creek in the sludge feed and the bottom ash are about 4000 ng/g and about 50 ng/g respectively while at Duffin Creek they are about 4000 ng/g and non-detectable respectively. PAH levels in the bottom ash of the garbage incinerators range from 540 to 1800 ng/g.

A surface water sample from the ash lagoon at Highland Creek was taken and analyzed for organics. The results of this can be seen in Tables 33-36. Levels are either below detection or very low. This supports the findings of the inorganic leaching tests (Table 38A) that sewage sludge incinerator bottom ash is not easily leached.

Tables 17 through 36 also included surrogate recovery data for the organics being analyzed. The acceptable recovery range is 100% plus or minus 40%. The data indicates good recoveries for dioxins and furans and PCBs and poorer recoveries for chlorobenzenes, chlorophenols and PAHs. Therefore the chlorobenzene, chlorophenol and PAH analysis results should be used with caution.

4.7 Dispersion Calculation Results

Tables 40 and 41 show the results of dispersion calculations done by Proctor and Redfern on stack emissions from Highland Creek. The emission rate data used in the calculations was taken from the ORF study (1) for the metals and from the RRETC results for the organics. The metal emission data was similar to that found by RRETC. In every case, as can be seen by the columns "% of Regulated Maximum" in Tables 40 and 41, all parameters were in compliance with both the current Ontario Regulation 308 and the proposed Ontario Regulation 308. The only parameter above 1% in the "% of Regulated Maximum" column in Table 40, the current reg. 308, is total suspended particulates at 2.591%. In Table 41, the proposed reg. 308, the levels are generally higher with several parameters over the 1% mark. The highest ones are SO_2 at 22% and particulates at 14%.

5 CONCLUSIONS

In general, toxic organic and metal concentrations in the stack gas and process samples at Highland Creek were comparable to those found at Duffin Creek. The fact that the sludge incinerators are of different types (multi-hearth at Highland Creek and fluid bed at Duffin Creek) did not significantly affect the overall results.

Based on the results obtained at Highland Creek and Duffin Creek and the results of the NITEP testing of garbage incinerators, stack emissions of toxic organics from sewage sludge incinerators were found to be significantly lower than for garbage incinerators and well within the regulated limits for Ontario. Stack emissions of heavy metals from sewage sludge incinerators were comparable to those from garbage incinerators equipped with emission control systems.

In general, concentrations of toxic organics in the bottom ash from sewage sludge incinerators and garbage incinerators were comparable, however PAHs were significantly higher in garbage incinerator bottom ash.

The leaching tests conducted on the sewage sludge incinerator bottom ash showed that the majority of metals in the ash are unavailable for leaching. These findings are consistent with a study by Bridle et al (7) which found that bottom ash from sewage sludge incinerators is less leachable than ash from other sources.

6. RESULTS

6.1 Listing of Tables

6.2 Data Tables

TABLE 1 AVERAGE VALUES FOR EXIT GAS TEMPERATURE AND SLUDGE FEED RATES - HIGHLAND CREEK - JUNE 24-29, 1987

Run Number	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8	Run 9	Run 10
Date	June 24/87	June 24/87	June 25/87	June 25/87	June 26/87	June 26/87	June 27/87	June 28/87	June 28/87	June 29/87
Average Exit Gas Temperature (°C)	530	547	612	638	623	670	685	716	744	810
Average Sludge Feed (tonnes/h)	3.81	3.65	3.91	4.70	5.44	4.70	5.78	5.85	5.44	5.74

TABLE 2 CONTINUOUS ANALYZER SPECIFICATIONS

Gas	Continuous Analyzer	Principle of Operation	Analyzer Range	Calibration Gas Conc.
NO_x	Teco 10AR	Chemiluminescent	0-250 ppm	214 ppm NO
SO_2	Western 721-A	NDUV	0-250 ppm	228 ppm
CO_2	Beckman 756	NDIR	0-20%	18.3%
CO	Bendix 8501-5BA	NDIR	0-250 ppm	208 ppm
O_2	Beckman 755	Paramagnetic	0-25%	22.5%
THCs	Beckman 400	FID (cold)	0-30 ppm	15.2 ppm

NOTES:
NDUV = Nondispersive ultraviolet
NDIR = Nondispersive infrared
FID = Flame ionization ('cold' hydrocarbon analyzer)

TABLE 2A SUMMARY OF STACK GAS CHARACTERISTICS AND MANUAL STACK SAMPLING CONDITIONS
HIGHLAND CREEK - JUNE 24-29, 1987

Run No.	1	2	3	4	5	6	7	8	9	10
Test for	Part.	Part.	Part.	Mercury	Mercury	Mercury	Organic	Organic	Organic	Organic
Date (d/m/y)	24/06/87	24/06/87	25/06/87	25/06/87	26/06/87	26/06/87	27/06/87	28/06/87	28/06/87	29/06/87
Sampling Time (hrs.)	2	2	2	3	3	3	3	3	3	3
Isokineticity (%)	502.87	506.17	465.01	342.64	302.78	336.48	294.25	352.69	243.26	240.66
Sample Volume (m3)	3.181	3.199	3.258	3.262	3.292	3.259	3.191	3.289	3.215	3.28
Stack Gas Characteristics										
Flowrate (m3/min)	367.5	367.2	413.7	369.9	423.9	377.2	421.4	368.9	526.8	529.3
Velocity (m/s)	0.73	0.73	0.84	0.75	0.86	0.76	0.85	0.74	1.06	1.09
Temperature (oC)	28.24	28.33	29.65	29.72	29.35	29.03	28.84	28.61	28.52	33.15
Moisture (%)	3.50	3.48	4.00	4.15	4.06	3.75	4.02	3.53	3.57	4.37
Dry Mol. Wt.	29.26	29.31	29.33	29.37	29.36	29.42	29.42	29.45	29.31	29.38
Oxygen 02 (dry)	16.64	15.88	14.85	14.65	14.5	14.54	14.12	14.32	15.07	13.85
Carbon Dioxide C02 (dry)	3.74	4.20	4.60	4.69	4.90	5.21	5.33	5.51	4.40	5.18
Particulate Catch Total (gm)	0.07081	0.07086	0.06281	-	-	-	-	-	-	-
Particulate Concentration Conc. (gm/m3)	0.022	0.022	0.019	-	-	-	-	-	-	-
Particulate Emissions Rate (kg/day)	11.78	11.71	11.49	-	-	-	-	-	-	-

NOTE: All volumes expressed on a dry basis at 25 C & 101.3kPa
Oxygen and carbon dioxide given on a dry basis

TABLE 3 Stack Samples - Total Particulate Test Results - Highland Creek June 24-25, 1987

Run Number	Run 1	Run 2	Run 3
Date	June 24, 1987	June 24, 1987	June 25, 1987
Carbon Dioxide in Stack Gas (%, dry)	3.74	4.2	4.6
Particulate Concentration			
Uncorrected (mg/m^3)	22	22	19
Corrected to 12% CO_2 (mg/m^3)	71	63	50

Note: All gas volumes are expressed on a dry basis at reference conditions of 25°C and 101.3 kilopascals.

TABLE 4 CONCENTRATIONS OF HEAVY METALS IN THE STACK GAS (ug/m^3 @ 12% CO_2) HIGHLAND CREEK - JUNE 24, 25, 26 1987 PARTICULATE/HEAVY METAL RUNS AND MERCURY RUNS

Run Number	1	2	3	
Date (1987)	June 24	June 25	June 25	Average
Ag	17.2	17.3	14.8	16.4
Al	ND	ND	ND	ND
Ba	ND	ND	ND	ND
Be	ND	ND	ND	ND
Ca	ND	ND	ND	ND
Cd	478.0	590.3	557.2	541.8
Co	ND	ND	ND	ND
Cr	25.8	25.9	18.2	23.3
Cu	226.8	229.4	164.0	206.7
Fe	334.9	238.5	188.2	253.9
K	ND	ND	ND	ND
Mg	ND	ND	ND	ND
Mn	ND	ND	ND	ND
Mo	ND	ND	ND	ND
Na	ND	ND	ND	ND
Ni	56.6	36.5	41.6	44.9
P	533.9	533.5	402.2	489.9
Pb	504.3	474.3	333.1	437.2
Sr	ND	ND	ND	ND
Th	ND	ND	ND	ND
Ti	ND	ND	ND	ND
V	23.8	23.1	19.2	22.0
Zn	1035.2	1354.3	996.3	1128.6
Zr	ND	ND	ND	ND
As	38.8	33.9	49.3	40.7

Run Number	4	5	6	
Date (1987)	June 25	June 26	June 26	
Hg	2.80	0.59	4.76	2.72

NOTES: All gas volumes are expressed on a dry basis at reference conditions of 25°C and 101.3 kilopascal.

Above results have been corrected for reagent and filter blank values.

ND indicates that the background levels in the blank filters were essentially identical to those found in the loaded filters.

TABLE 5 CONCENTRATIONS OF DIOXINS AND FURANS IN THE STACK GAS (ng/m^3 @ 12% CO_2) ORGANIC RUNS - HIGHLAND CREEK - JUNE 27, 28, 29 1987

Run Number	7				8				9				10			
Date	June 27, 1987				June 28, 1987				June 28, 1987				June 29, 1987			
Compound	Probe/ Filter	XAD-2	Glycol	Total	Probe/ Filter	XAD-2	Glycol	Total	Probe/ Filter	XAD-2	Glycol	Total	Probe/ Filter	XAD-2	Glycol	Total
DIOXINS																
T4CDD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P5CDD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H6CDD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H7CDD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0CDD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL PCDD's	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FURANS																
T4CDF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P5CDF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H6CDF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H7CDF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0CDF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL PCDF's	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

NOTE: XAD-2 contains the condenser wash; Glycol contains the condensate trap contents
"-" denotes values below the detection limit of 0.4-0.8 ng/sample/analyte peak
Volumes referenced to 25°C and 101.3 kPa

TABLE 6 CONCENTRATIONS OF CHLOROBENZENES AND PCB's IN THE STACK GAS (ng/m^3 @ 12% CO$_2$)
ORGANIC RUNS - HIGHLAND CREEK - JUNE 27, 28, 29 1987

Run Number	7				8				9				10			
Date	June 27, 1987				June 28, 1987				June 28, 1987				June 29, 1987			
Compound	Probe/ Filter	XAD-2	Glycol	Total	Probe/ Filter	XAD-2	Glycol	Total	Probe/ Filter	XAD-2	Glycol	Total	Probe/ Filter	XAD-2	Glycol	Total
CHLOROBENZENES																
CL3-CB	-	183.4	-	183.4	-	198.6	-	198.6	-	288.4	-	288.4	-	155.4	-	155.4
CL4-CB	-	63.5	-	63.5	-	53.0	-	53.0	-	76.3	-	76.3	-	56.5	-	56.5
CL5-CB	-	35.3	-	35.3	-	33.1	-	33.1	-	50.9	-	50.9	-	42.4	-	42.4
CL6-CB	-	28.2	-	28.2	-	33.1	-	33.1	-	50.9	-	50.9	-	35.3	-	35.3
Total CB's	-	310.4	-	310.4	-	317.8	-	317.8	-	466.6	-	466.6	-	289.6	-	289.6
PCB's																
CL1-PCB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CL2-PCB	-	56.4	-	56.4	-	13.2	-	13.2	-	17.0	-	17.0	-	-	-	-
CL3-PCB	-	28.2	-	28.2	-	26.5	-	26.5	-	17.0	-	17.0	-	-	-	-
CL4-PCB	-	70.6	-	70.6	-	-	-	-	-	-	-	-	-	-	-	-
CL5-PCB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CL6-PCB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CL7-PCB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CL8-PCB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CL9-PCB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CL10-PCB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total PCB's	-	155.2	-	155.2	-	39.7	-	39.7	-	33.9	-	33.9	-	-	-	-

NOTE: XAD-2 includes condensor, Glycol includes condensate trap contents
"-" denotes values below the detection limit
CB's - 0.01 ug/sample/analyte peak
PCB's - 0.02-0.04 ug/sample/analyte peak
Volumes referenced to 25°C and 101.3 kPa

TABLE 7 CONCENTRATIONS OF CHLOROPHENOLS IN THE STACK GAS (ng/m^3 @ 12% CO_2)
ORGANIC RUNS - HIGHLAND CREEK - June 27, 28, 29 1987

Run Number	7				8				9				10			
Date	June 27, 1987				June 28, 1987				June 28, 1987				June 29, 1987			
Compound	Probe/ Filter	XAD-2	Glycol	Total	Probe/ Filter	XAD-2	Glycol	Total	Probe/ Filter	XAD-2	Glycol	Total	Probe/ Filter	XAD-2	Glycol	Total
CHLOROPHENOLS																
CL2-CP	21.2	-	-	21.2	19.9	59.6	-	79.5	-	67.9	-	67.9	-	127.1	-	127.1
CL3-CP	-	21.2	-	21.2	-	33.1	-	33.1	-	33.9	-	33.9	-	113.0	-	113.0
CL4-CP	-	-	-	-	-	59.6	-	59.6	25.4	-	-	25.4	-	21.2	-	21.2
CL5-CP	-	56.4	-	56.4	-	125.8	-	125.8	-	67.9	-	67.9	-	56.5	-	56.5
TOTAL CP's	21.2	77.6	-	98.8	19.9	278.1	-	298.0	25.4	169.7	-	195.1	-	317.8	-	317.8

NOTE: XAD-2 includes condensor, Glycol includes condensate trap contents
"_" denotes values below the detection limit of 0.03-0.06 ug/sample/analyte peak
Volumes referenced to 25°C and 101.3 kPa

TABLE 8 CONCENTRATIONS OF POLYCYCLIC AROMATIC HYDROCARBONS IN THE STACK GAS (ng/m^3 @ 12% CO_2)
ORGANIC RUNS - HIGHLAND CREEK - June 27, 28, 29 1987

Run Number	7				8				9				10			
Date	June 27, 1987				June 28, 1987				June 28, 1987				June 29, 1987			
Compound	Probe/ Filter	XAD-2	Glycol	Total	Probe/ Filter	XAD-2	Glycol	Total	Probe/ Filter	XAD-2	Glycol	Total	Probe/ Filter	XAD-2	Glycol	Total
Acenaphthylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Acenaphthene	-	105.8	-	105.8	-	-	-	-	-	-	-	-	-	-	-	-
Fluorene	14.1	148.2	-	162.3	13.2	53.0	-	66.2	-	59.4	-	59.4	-	98.9	-	98.9
Phenanthrene	134.1	1326.4	49.4	1509.9	99.3	192.0	39.7	331.1	84.8	313.9	50.9	449.6	-	1017.0	42.4	1059.4
Anthracene	-	91.7	-	91.7	-	-	-	-	-	-	-	-	-	-	-	-
Fluoranthene	-	84.7	-	84.7	-	-	-	-	-	-	-	-	-	-	-	-
Pyrene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B(a)Anthracene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chrysene/Trip	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B(b)Fluoranthene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B(k)Fluoranthene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(e)Pyrene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(a)Pyrene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Perylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indeno Pyrene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
D(ac,ah)Anthracene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B(ghi)Perylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total PAH's	148.2	1749.8	49.4	1954.4	112.6	245.0	39.7	397.3	84.8	373.3	50.9	509.0	-	1115.9	42.4	1158.3

NOTE: XAD-2 includes condensor, Glycol includes condensate trap contents
"-" denotes values below the detection limit of 0.02-0.05 ug/sample
Volumes referenced to 25°C and 101.3 kPa

TABLE 9 SUMMARY OF SURROGATE RECOVERIES FOR THE TRAIN AND BLANK SAMPLES (%)
ORGANIC RUNS - HIGHLAND CREEK - JUNE 27, 28, 29 1987

Run Number	7			8			9			10			Blank		
Date	June 27, 1987			June 28, 1987			June 28, 1987			June 29, 1987					
Compound	Probe/ Filter	XAD-2	Glycol	Probe/ Filter	XAD-2	Glycol	Probe/ Filter	XAD-2	Glycol	Probe/ Filter	XAD-2	Glycol	Probe/ Filter	XAD-2	Glycol
DIOXINS AND FURANS															
13C12-T4CDD	57	89	83	60	81	76	53	79	75	58	86	77	43	79	76
13C12-P5CDD	66	97	107	62	83	98	62	82	104	73	102	99	55	86	100
13C12-H6CDD	74	98	90	65	88	78	70	83	85	86	105	86	76	91	88
13C12-H7CDD	85	102	81	69	99	113	73	97	107	102	117	117	77	99	107
13C12-0CDD	81	91	89	65	82	74	67	74	76	74	96	87	74	79	82
13C12-1234TCDD	97	108	117	95	99	119	90	123	116	98	117	116	84	112	115
PAH's															
d10-Acenaphthene	17	59	65	34	37	63	17	55	67	-	65	53	-	34	38
d10-Anthracene	16	63	3	17	53	3	16	66	9	3	75	32	-	51	23
d10-Pyrene	59	75	50	55	67	61	60	81	61	36	86	49	11	66	31
d12-B(a)Anthracene	60	69	45	50	70	29	49	83	25	24	87	18	31	76	5
d12-B(a)Pyrene	10	50	-	3	53	-	7	70	-	3	78	5	5	75	3
d14-D(ah)Anthracene	44	54	58	20	69	25	39	76	10	21	75	5	69	83	-
d12-B(ghi)Perylene	32	57	10	18	67	24	35	77	18	28	82	17	58	82	5
d10-Fluoranthene	91	98	98	82	93	104	102	100	104	97	108	95	95	94	104
CHLOROBENZENES AND PCB's															
13C6-CL4-CB	1	48	73	10	47	76	1	50	82	-	43	81	-	48	77
13C6-CL6-CB	4	60	79	30	61	80	6	63	84	1	56	92	-	62	85
13C12-CL5-PCB	55	94	91	40	109	89	28	102	104	22	99	94	4	100	93
13C12-CL8-PCB	73	74	86	37	91	80	46	102	100	58	97	101	37	101	90
d10-Fluoranthene	106	94	99	80	112	94	92	110	115	100	107	102	91	109	102
PCP's															
13C12-CL2-CP	57	59	18	60	92	7	83	64	15	53	94	60	36	79	92
13C12-CL3-CP	42	58	58	53	86	48	58	61	52	13	88	73	55	43	98
13C12-CL5-CP	81	83	48	75	121	76	97	79	37	108	113	65	90	3	103
d10-Fluoranthene	84	78	94	73	125	106	96	82	110	108	116	93	97	111	93

NOTE: XAD-2 includes condensor, glycol includes condensate trap contents
"-" denotes values below the detection limit

Dioxins/furans	0.4 - 0.8 ng/sample/analyte peak
PAH's	0.02 0.05 ug/sample/analyte peak
CB's	0.01 ug/sample/analyte peak
PCB's	0.02-0.04 ug/sample/analyte peak
CP's	0.03 - 0.06 ug/sample/analyte peak

TABLE 10 SUMMARY OF CONTINUOUS MONITORING DATA - HIGHLAND CREEK

Test Run	S02 (ppm)	N0x (ppm)	THCc (ppm)	CO (ppm)	02 (%)	C02 (%)	THCh (ppm)
Run No. 1	40	8	127	>966	16.6	3.7	165
Run No. 2	35	9	95	>922	15.9	4.2	127
Run No. 3	24	21	36	540	14.9	4.6	38
Run No. 4	24	24	36	584	14.7	4.9	37
Run No. 5	32	14	42	873	14.5	4.9	44
Run No. 6	22	33	19	268	14.5	5.2	20
Run No. 7	21	34	18	257	14.1	5.3	19
Run No. 8	23	47	14	86	14.3	5.5	14
Run No. 9	20	50	13	52	15.1	4.4	14
Run No. 10	13	72	12	ND	13.9	5.2	12

All results reported on a dry basis
Sample was extracted from flue between the scrubber outlet and breeching
ND indicates below detection limit

TABLE 11 PROCESS SAMPLES - TOTAL PARTICULATE/HEAVY METAL RUNS -- HIGHLAND CREEK

	June 24/87 Run 1				
Analyte	Sludge Feed* (ppm)	Sludge Feed - Fixed Solid Basis (ppm)	Bottom Ash (ppm)	Scrubber Water In (mg/l)	Scrubber Water Out (mg/l)
Ag	57.8	148	128	< 0.004	0.012
Al	20 800	53 300	51 600	0.110	2.70
As	1.70	4.36	30.0	< 0.001	0.004
B	288	738	667	0.326	0.185
Ba	431	1100	1650	0.032	0.128
Be	0.18	0.46	0.07	<0.0004	<0.0004
Ca	24 000	61 500	62 300	54.9	58.1
Cd	22.8	58.5	4.6	< 0.008	0.054
Co	< 3	< 7.69	< 3	< 0.04	< 0.04
Cr	456	1170	1250	< 0.008	0.063
Cu	1580	4050	4200	0.018	0.248
Fe	58 100	149 000	170 000	5.52	13.7
K	1690	4330	3600	10.8	10.9
Mg	3040	7800	7260	10.2	10.9
Mn	463	1190	1360	0.250	0.324
Mo	< 10	< 25.6	< 10	< 0.2	< 0.2
Na	2800	7180	3200	155	148
Ni	60	154	142	< 0.04	< 0.04
P	24 300	62 300	75 800	0.6	5.6
Pb	338	867	775	< 0.03	0.13
Si	99.8	256	652	0.36	0.64
Sr	142	364	368	0.196	0.220
Th	9.7	24.9	15.3	< 0.04	< 0.04
Ti	7700	19 700	28 200	0.018	0.726
V	220	564	618	0.009	0.043
Zn	1700	4360	4470	0.092	0.376
Zr	436	1120	1260	< 0.04	0.05
Moisture	64.0%		< 0.1%	-	-
TSS (mg/l)		-	-	9.4	42.6

* Volatiles = 61%

TABLE 11 PROCESS SAMPLES - TOTAL PARTICULATE/HEAVY METAL RUNS - HIGHLAND CREEK (cont'd)

	June 24/87 Run 2				
Analyte	Sludge Feed* (ppm)	Sludge Feed - Fixed Solid Basis (ppm)	Bottom Ash (ppm)	Scrubber Water In (mg/l)	Scrubber Water Out (mg/l)
Ag	47.3	121	127	< 0.004	0.011
Al	19 300	49 500	50 600	< 0.008	0.965
As	0.22	0.56	11.7	< 0.001	0.004
B	231	592	662	0.165	0.129
Ba	576	1480	1510	0.094	0.207
Be	0.04	0.10	0.04	<0.0004	<0.0004
Ca	25 100	64 400	60 500	54.6	56.1
Cd	17.3	44.4	2.9	< 0.008	0.042
Co	< 3	< 7.69	< 3	< 0.04	< 0.04
Cr	462	1190	1190	0.009	0.023
Cu	1450	3720	3830	0.014	0.122
Fe	61 500	158 000	171 000	5.30	5.29
K	1390	3560	3900	11.1	11.5
Mg	3550	9100	5140	10.4	10.9
Mn	491	1260	1270	0.226	0.245
Mo	< 10	< 25.6	< 10	< 0.2	< 0.2
Na	1340	3440	3230	147	148
Ni	52	133	151	< 0.04	< 0.04
P	26 000	66 700	74 700	1.2	3.0
Pb	325	833	800	0.03	0.10
Si	122	313	646	0.26	0.66
Sr	155	397	341	0.200	0.206
Th	9.2	23.6	14.4	< 0.04	< 0.04
Ti	8200	21 000	29 700	0.036	0.316
V	221	567	644	0.016	0.036
Zn	1440	3690	4670	0.222	0.250
Zr	422	1080	1260	< 0.04	< 0.04
Moisture	65.6%		< 0.1%	-	-
TSS (mg/l)	-		-	19.9	25.0

* Volatiles = 61%

TABLE 11 PROCESS SAMPLES - TOTAL PARTICULATE/HEAVY METAL RUNS - HIGHLAND CREEK (cont'd)

	June 25/87 Run 3				
Analyte	Sludge Feed* (ppm)	Sludge Feed - Fixed Solid Basis (ppm)	Bottom Ash (ppm)	Scrubber Water In (mg/l)	Scrubber Water Out (mg/l)
Ag	57.7	137	124	< 0.004	0.005
Al	23 200	55 200	54 400	< 0.008	1.05
As	0.39	0.93	9.70	< 0.001	0.003
B	302	719	629	0.193	0.225
Ba	542	1290	1630	0.511	0.170
Be	0.13	0.31	< 0.02	<0.0004	<0.0004
Ca	28 800	68 600	65 300	53.6	54.5
Cd	17.0	40.5	8.6	< 0.008	0.037
Co	< 3	< 7.14	< 3	< 0.04	< 0.04
Cr	486	1160	1180	< 0.008	0.111
Cu	1590	3790	3770	< 0.006	0.123
Fe	79 600	190 000	171 000	3.35	6.63
K	1990	4740	3820	11.2	10.5
Mg	4330	10 300	10 600	10.4	10.5
Mn	638	1520	1380	0.190	0.193
Mo	< 10	< 23.8	< 10	< 0.2	< 0.2
Na	2010	4790	3770	136	131
Ni	75	179	142	< 0.04	< 0.04
P	32 300	76 900	74 500	0.7	1.3
Pb	325	774	775	0.03	0.10
Si	97.7	233	678	1.71	0.10
Sr	169	402	400	0.193	0.206
Th	9.6	22.9	10.0	< 0.04	< 0.04
Ti	9640	23 000	26 800	0.022	0.161
V	234	557	652	0.015	0.080
Zn	1690	4020	4240	0.234	0.254
Zr	473	1130	1230	< 0.04	< 0.04
Moisture	66.5%		< 0.1%	-	-
TSS (mg/l)	-		-	14.8	22.0

* Volatiles = 58%

TABLE 12 PROCESS SAMPLES - INORGANIC QA/QC RESULTS .- HIGHLAND CREEK

	As Analyzed by Laboratory			Actual Concentrations		
	QA/QC-1 (mg/l)	QA/QC-2 (mg/l)	QA/QC-3 (mg/l)	QA/QC-1 (mg/l)	QA/QC-2 (mg/l)	QA/QC-3 (mg/l)
Ag	<0.004	0.021	<0.004	--	--	--
Al	0.272	<0.008	0.326	--	--	--
As	0.01	0.009	0.009	0.01	0.01	0.01
B	0.109	0.119	0.706	--	--	--
Ba	<0.004	<0.004	0.004	--	--	--
Be	<0.0004	<0.0004	<0.0004	--	--	--
Ca	0.456	0.577	0.516	--	--	--
Cd	0.104	0.106	0.101	0.1	0.1	0.1
Co	<0.04	<0.04	<0.04	--	--	--
Cr	0.066	0.086	0.081	0.1	0.1	0.1
Cu	0.098	0.089	0.089	0.1	0.1	0.1
Fe	0.158	<0.008	<0.008	--	--	--
K	7.2	7.2	6.9	--	--	--
Mg	<0.008	<0.008	<0.008	--	--	--
Mn	<0.008	<0.008	<0.008	--	--	--
Mo	<0.2	<0.2	<0.2	--	--	--
Na	<0.4	0.4	1.3	--	--	--
Ni	0.49	0.49	0.47	0.5	0.5	0.5
P	5.7	5.8	5.5	5.0	5.0	5.0
Pb	0.65	0.65	0.63	0.5	0.5	0.5
Si	<0.04	0.13	<0.04	--	--	--
Sr	0.0009	0.0018	0.0018	--	--	--
Th	<0.04	<0.04	<0.04	--	--	--
Ti	<0.004	<0.004	0.009	--	--	--
V	<0.004	<0.004	<0.004	--	--	--
Zn	0.541	0.512	0.504	0.5	0.5	0.5
Zr	<0.04	<0.04	<0.04	--	--	--
Tss (mg/l)	<0.5	<0.5	<0.5	--	--	--

-- indicates that data is not available

TABLE 13 PROCESS SAMPLES - INORGANIC REPEAT ANALYSES - HIGHLAND CREEK

Analyte	Run 1 Sludge Feed (ppm)	Run 1 Sludge Feed- Repeat Analysis (ppm)	Run 1 Bottom Ash (ppm)	Run 1 Bottom Ash- Repeat Analysis (ppm)	Run 2 Sludge Feed (ppm)	Run 2 Sludge Feed - Repeat Analysis (ppm)	Run 1 Scrubber Water In (mg/1)	Run 1 Scrubber Water In - Repeat Analysis (mg1)
Ag	52.3	63.3	127	130	47.3	--	< 0.004	< 0.004
Al	21400	20200	50600	52700	19300	--	< 0.008	0.217
As	1.70	--	30.0	--	0.25	0.20	< 0.001	< 0.001
B	274	301	678	656	231	--	0.202	0.451
Ba	509	353	1670	1630	576	--	0.033	0.032
Be	0.18	0.17	< 0.02	0.13	0.04	--	<0.0004	<0.0004
Ca	23900	24200	61500	63100	25100	--	55.9	53.9
Cd	22.1	23.4	4.4	4.7	17.3	--	< 0.008	< 0.008
Co	< 3	< 3	< 3	< 3	< 3	--	< 0.04	< 0.04
Cr	411	502	1270	1230	462	--	< 0.008	< 0.008
Cu	1500	1660	4120	4290	1450	--	0.013	0.022
Fe	55800	60400	164000	175000	61500	--	5.47	5.57
K	1700	1680	3850	3350	1390	--	11.1	10.5
Mg	3820	2270	7030	7480	3550	--	10.4	9.97
Mn	437	489	1390	1330	491	--	0.259	0.241
Mo	< 10	< 10	< 10	< 10	< 10	--	< 0.2	< 0.2
Na	4260	1330	3210	3180	1340	--	155	155
Ni	60	60	143	140	52	--	< 0.04	< 0.04
P	22800	25800	75900	75800	26000	--	0.7	0.5
Pb	325	350	775	775	325	--	< 0.03	< 0.03
Si	95.7	104	572	732	122	--	0.29	0.43
Sr	155	128	359	378	155	--	0.198	0.194
Th	12.1	7.3	16.4	14.2	9.2	--	< 0.04	< 0.04
Ti	6560	8830	27500	29000	8200	--	0.020	0.016
V	211	229	642	595	221	--	0.011	0.007
Zn	1650	1760	4480	4460	1440	--	0.085	0.098
Zr	426	447	1230	1280	422	--	< 0.04	< 0.04
Moisture	64.0%	--	< 0.1%	--	65.6%	--	--	--
TSS (mg/1)	--	--	--	--	--	--	9.4	--

-- indicates that data is not available

TABLE 14 PROCESS SAMPLES - MERCURY RUNS - HIGHLAND CREEK

Sample	Sludge Feed				Bottom Ash		Scrubber Water in		Scrubber Water out	
Analyte	Hg (ppb)	Volatile (%)	Hg - Fixed Solids basis (ppb)	Moisture (%)	Hg (ppb)	Moisture (%)	Hg (µg/l)	TSS (mg/l)	Hg (µg/l)	TSS (mg/l)
June 25/87 Run 4	4860	58	11 600	61.3	61	<0.1	0.63	6.	1.20	21
June 26/87 Run 5	3800	60*	9 500*	62.2	73	<0.1	0.48	8.	1.26	17
June 26/87 Run 6	4650	60*	11 600*	57.4	155	<0.1	0.72	5.	1.20	17

* Estimated

TABLE 15 PROCESS SAMPLES - MERCURY QA/QC RESULTS - HIGHLAND CREEK

Sample	QA/QC-4	QA/QC-5	QA/QC-6
Analyte	Hg (μg/l)	Hg (μg/l)	Hg (μg/l)
As Analyzed by laboratory	0.72	0.54	0.72
Actual Concentrations	0.5	0.5	0.5

TABLE 16 PROCESS SAMPLES - MERCURY QA/QC RESULTS - REPEAT ANALYSES - HIGHLAND CREEK

	Run 4 Sludge Feed (ppb)	Run 4 Sludge Feed - Repeat Analysis (ppb)	Run 4 Bottom Ash (ppb)	Run 4 Bottom Ash - Repeat Analysis (ppb)	Run 4 Scrubber Water in (μg/l)	Run 4 Scrubber Water in - Repeat Analysis (μg/l)
Hg	5060	4650	61	61	0.66	0.60

TABLE 17 PROCESS SAMPLES - ORGANIC RUNS - DIOXIN/FURAN (ng/g) - HIGHLAND CREEK - JUNE 27-29/87 - SLUDGE FEED TO THE INCINERATOR

Run Number	7	8	9	10
Date	June 27/87	June 28/87	June 28/87	June 29/87
Compound				
Dioxins				
T4CDD	0.30	-	-	0.14
P5CDD	0.78	-	0.97	1.43
H6CDD	6.66	4.93	2.86	1.55
H7CDD	31.20	26.46	18.46	16.62
OCDD	73.85	75.81	57.52	49.90
Total PCDD	112.79	107.20	79.81	69.64
Furans				
T4CDF	-	-	-	-
P5CDF	-	-	-	-
H6CDF	-	-	-	-
H7CDF	-	-	-	-
OCDF	1.30	1.60	0.75	0.48
Total PCDF	1.30	1.60	0.75	0.48
Recovery %				
13C12-T4CDD	86	111	95	95
13C12-P5CDD	97	146	113	100
13C12-H6CDD	86	107	95	95
13C12-H7CDD	89	120	113	126
13C12-OCDD	80	89	87	84
13C12-1234TCDD	106	122	124	116

Note: "-" denotes values below Detection Limit of 0.08-0.16 ng/g/analyte peak

TABLE 18 PROCESS SAMPLES - ORGANIC RUNS - DIOXIN/FURAN (ng/g) - HIGHLAND CREEK - JUNE 27-29/87 - BOTTOM ASH

Run Number	7	8	9	10
Date	June 27/87	June 28/87	June 28/87	June 29/87
Compound				
Dioxins				
T4CDD	-	-	-	-
P5CDD	-	-	-	-
H6CDD	-	-	-	-
H7CDD	-	-	-	-
OCDD	-	-	-	-
Total PCDD	-	-	-	-
Furans				
T4CDF	-	-	-	-
P5CDF	-	-	-	-
H6CDF	-	-	-	-
H7CDF	-	-	-	-
OCDF	-	-	-	-
Total PCDF				
Recovery %				
13C12-T4CDD	82	87	77	69
13C12-P5CDD	98	113	83	76
13C12-H6CDD	84	82	80	73
13C12-H7CDD	78	98	97	67
13C12-OCDD	76	68	66	66
13C12-1234TCDD	118	118	119	95

Note:"-" denotes values below Detection Limit of 0.08-0.16 ng/g/analyte peak

TABLE 19 PROCESS SAMPLES - ORGANIC RUNS - DIOXIN/FURAN (ng/l) - HIGHLAND CREEK - JUNE 27-29/87 - SCRUBBER WATER IN

Run Number	7	8	9	10
Date	June 27/87	June 28/87	June 28/87	June 29/87
Compound				
Dioxins				
T4CDD	-	-	-	-
P5CDD	-	-	-	-
H6CDD	-	-	-	-
H7CDD	-	-	-	-
OCDD	-	-	-	-
Total PCDD	-	-	-	-
Furans				
T4CDF	-	-	-	-
P5CDF	-	-	-	-
H6CDF	-	-	-	-
H7CDF	-	-	-	-
OCDF	-	-	-	-
Total PCDF	-	-	-	-
Recovery %				
13C12-T4CDD	71	87	85	95
13C12-P5CDD	66	89	86	112
13C12-H6CDD	69	89	87	95
13C12-H7CDD	72	118	82	92
13C12-OCDD	67	83	86	88
13C12-1234TCDD	106	115	107	110

Note: "-" denotes values below Detection Limit of 0.4-0.8 ng/g/analyte peak

TABLE 20 PROCESS SAMPLES - ORGANIC RUNS - DIOXIN/FURAN (ng/l) - HIGHLAND CREEK - JUNE 27-29/87 - SCRUBBER WATER OUT

Run Number	7	8	9	10
Date	June 27/87	June 28/87	June 28/87	June 29/87
Compound				
Dioxins				
T4CDD	-	-	-	-
P5CDD	-	-	-	-
H6CDD	-	-	-	-
H7CDD	-	-	-	-
OCDD	-	-	-	-
Total PCDD	-	-	-	-
Furans				
T4CDF	-	-	-	-
P5CDF	-	-	-	-
H6CDF	-	-	-	-
H7CDF	-	-	-	-
OCDF	-	-	-	-
Total PCDF	-	-	-	-
Recovery %				
13C12-T4CDD	76	85	57	74
13C12-P5CDD	75	101	57	88
13C12-H6CDD	79	93	59	86
13C12-H7CDD	72	91	61	88
13C12-OCDD	68	80	57	81
13C12-1234TCDD	104	110	91	96

Note: "-" denotes values below Detection Limit of 0.4-0.8 ng/g/analyte peak

TABLE 21 PROCESS SAMPLES - ORGANIC RUNS - CHLOROBENZENES AND PCB's (ng/g) - HIGHLAND CREEK - JUNE 27-29/87 - SLUDGE FEED TO THE INCINERATOR

Run Number	7	8	9	10
Date	June 27/87	June 28/87	June 28/87	June 29/87
Compound				
Chlorobenzenes				
CL3-CB	-	54	42	-
CL4-CB	-	-	-	-
CL5-CB	-	-	39	48
CL6-CB	-	-	-	-
Total CB's	-	54	81	48
PCB's				
CL1-PCB	-	-	-	-
CL2-PCB	-	149	-	-
CL3-PCB	355	-	249	156
CL4-PCB	-	-	-	-
CL5-PCB	-	-	85	-
CL6-PCB	-	-	-	64
CL7-PCB	-	-	-	-
CL8-PCB	-	-	-	-
CL9-PCB	-	-	-	-
CL10-PCB	-	-	-	-
Total PCB	355	149	334	220
Recovery %				
13C6-CL4-CB	17	20	27	25
13C6-CL6-CB	64	87	72	85
13C12-CL5-PCB	41	83	85	78
13C12-CL8-PCB	-	87	107	91
^{d}10-Fluoranthene	92	113	93	83

Note: "-" denotes values below Detection Limit (ng/g/analyte peak) of 20 for CB; 40-80 for PCB

TABLE 22 PROCESS SAMPLES - ORGANIC RUNS - CHLOROBENZENES AND PCB's (ng/g) - HIGHLAND CREEK - JUNE 27-29/87 - BOTTOM ASH

Run Number	7	8	9	10
Date	June 27/87	June 28/87	June 28/87	June 29/87
Compound				
Chlorobenzenes				
CL3-CB	-	-	-	-
CL4-CB	-	-	-	-
CL5-CB	-	-	-	-
CL6-CB	-	-	-	-
Total CB's	-	-	-	-
PCB's				
CL1-PCB	-	-	-	-
CL2-PCB	-	-	-	-
CL3-PCB	-	-	-	-
CL4-PCB	-	-	-	-
CL5-PCB	-	-	-	-
CL6-PCB	-	-	-	-
CL7-PCB	-	-	-	-
CL8-PCB	-	-	-	-
CL9-PCB	-	-	-	-
CL10-PCB	-	-	-	-
Total PCB	-	-	-	-
Recovery %				
13C6-CL4-CB	38	20	15	34
13C6-CL6-CB	70	50	51	59
13C12-CL5-PCB	96	85	75	75
13C12-CL8-PCB	106	100	78	79
^{d}10-Fluoranthene	122	111	94	103

TABLE 23 PROCESS SAMPLES - ORGANIC RUNS - CHLOROBENZENES AND PCB's (μg/l) - HIGHLAND CREEK - JUNE 27-29/87 - SCRUBBER WATER IN

Run Number	7	8	9	10
Date	June 27/87	June 28/87	June 28/87	June 29/87
Compound				
Chlorobenzenes				
CL3-CB	0.01	0.01	-	-
CL4-CB	-	-	-	-
CL5-CB	-	-	-	-
CL6-CB	-	-	-	-
Total CB's	0.01	0.01	-	-
PCB's				
CL1-PCB	-	-	-	-
CL2-PCB	-	-	-	-
CL3-PCB	-	-	-	-
CL4-PCB	-	-	-	-
CL5-PCB	-	-	-	-
CL6-PCB	-	-	-	-
CL7-PCB	-	-	-	-
CL8-PCB	-	-	-	-
CL9-PCB	-	-	-	-
CL10-PCB	-	-	-	-
Total PCB	-	-	-	-
Recovery %				
13C6-CL4-CB	29	50	51	64
13C6-CL6-CB	68	80	63	75
13C12-CL5-PCB	91	87	90	94
13C12-CL8-PCB	120	108	86	86
^{d}10-Fluoranthene	111	98	100	110

Note: "-" denotes values below Detection Limit (μg/L/analyte peak) of 0.01 for CB; 0.02-0.04 for PCB

TABLE 24 PROCESS SAMPLES - ORGANIC RUNS - CHLOROBENZENES AND PCB's (µg/L) - HIGHLAND CREEK - JUNE 27-29/87 - SCRUBBER WATER OUT

Run Number	7	8	9	10
Date	June 27/87	June 28/87	June 28/87	June 29/87
Compound				
Chlorobenzenes				
CL3-CB	-	-	-	-
CL4-CB	-	-	-	-
CL5-CB	-	-	-	-
CL6-CB	-	-	-	-
Total CB's	-	-	-	-
PCB's				
CL1-PCB	-	-	-	-
CL2-PCB	-	-	-	-
CL3-PCB	-	-	-	-
CL4-PCB	-	-	-	-
CL5-PCB	-	-	-	-
CL6-PCB	-	-	-	-
CL7-PCB	-	-	-	-
CL8-PCB	-	-	-	-
CL9-PCB	-	-	-	-
CL10-PCB	-	-	-	-
Total PCB	-	-	-	-
Recovery %				
13C6-CL4-CB	57	55	51	75
13C6-CL6-CB	90	79	77	88
13C12-CL5-PCB	104	98	105	109
13C12-CL8-PCB	115	83	105	96
d_{10}-Fluoranthene	120	100	101	112

Note: "-" denotes values below Detection Limit (µg/L/analyte peak) of 0.01 for CB; 0.02-0.04 for PCB

TABLE 25 PROCESS SAMPLES - ORGANIC RUNS - CHLOROPHENOLS (ng/g) - HIGHLAND CREEK - JUNE 27-29/87 - SLUDGE FEED TO THE INCINERATOR

Run Number	7	8	9	10
Date	June 27/87	June 28/87	June 28/87	June 29/87
Compound				
Chlorophenols				
CL2-Phenol	97	274	119	60
CL3-Phenol	85	83	94	74
CL4-Phenol	271	284	319	319
CL5-Phenol	261	279	298	346
Total CP's	714	920	830	799
Recovery %				
13C6-CL2-Phenol	1	2	1	1
13C6-CL3-Phenol	56	56	60	60
13C6-CL5-Phenol	90	86	81	86
^{d}10-Fluoranthene	107	84	116	113

Note: "-" denotes values below Detection Limit of 6-12 ng/g/analyte peak

TABLE 26 PROCESS SAMPLES - ORGANIC RUNS - CHLOROPHENOLS (ng/g) - HIGHLAND CREEK - JUNE 27-29/87 - BOTTOM ASH

Run Number	7	8	9	10
Date	June 27/87	June 28/87	June 28/87	June 29/87
Compound				
Chlorophenols				
CL2-Phenol	8	8	-	12
CL3-Phenol	-	-	-	-
CL4-Phenol	-	-	-	-
CL5-Phenol	-	-	-	-
Total CP's	8	8	-	12
Recovery %				
13C6-CL2-Phenol	62	82	86	99
13C6-CL3-Phenol	55	64	73	90
13C6-CL5-Phenol	65	89	91	81
^{d}10-Fluoranthene	94	100	108	103

Note: "-" denotes values below Detection Limit of 6-12 ng/g/analyte peak

TABLE 27 PROCESS SAMPLES - ORGANIC RUNS - CHLOROPHENOLS (µg/L) - HIGHLAND CREEK - JUNE 27-29/87 - SCRUBBER WATER IN

Run Number	7	8	9	10
Date	June 27/87	June 28/87	June 28/87	June 29/87
Compound				
Chlorophenols				
CL2-Phenol	0.18	0.15	0.19	0.15
CL3-Phenol	-	0.10	-	0.10
CL4-Phenol	0.05	0.09	0.08	0.09
CL5-Phenol	0.14	0.22	0.19	0.16
Total CP's	0.37	0.56	0.46	0.50
Recovery %				
13C6-CL2-Phenol	63	70	76	83
13C6-CL3-Phenol	58	75	70	80
13C6-CL5-Phenol	66	101	77	80
^{d}10-Fluoranthene	105	91	99	97

Note:"-" denotes values below Detection Limit of 0.03-0.06 µg/L/analyte peak

TABLE 28 PROCESS SAMPLES - ORGANIC RUNS - CHLOROPHENOLS (µg/L) - HIGHLAND CREEK - JUNE 27-29/87 - SCRUBBER WATER OUT

Run Number	7	8	9	10
Date	June 27/87	June 28/87	June 28/87	June 29/87
Compound				
Chlorophenols				
CL2-Phenol	0.32	0.18	0.20	0.18
CL3-Phenol	0.11	0.10	0.09	0.14
CL4-Phenol	0.12	0.07	0.08	0.11
CL5-Phenol	0.31	0.19	0.19	0.22
Total CP's	0.86	0.54	0.56	0.65
Recovery %				
13C6-CL2-Phenol	97	85	72	93
13C6-CL3-Phenol	97	83	71	94
13C6-CL5-Phenol	151	88	79	116
d_{10}-Fluoranthene	109	88	85	97

Note:"-" denotes values below Detection Limit of 0.03-0.06 µg/L/analyte peak

TABLE 29 PROCESS SAMPLES - ORGANIC RUNS - POLYCYCLIC AROMATIC HYDROCARBONS (ng/g) - HIGHLAND CREEK - JUNE 27-29/87 - SLUDGE FEED TO THE INCINERATOR

Run Number	7	8	9	10
Date	June 27/87	June 28/87	June 28/87	June 29/87
Compound				
Acenaphthylene	Int	Int	Int	Int
Acenaphthene	Int	190	210	Int
Fluorene	420	520	640	280
Phenanthrene	970	1130	1320	Int
Anthracene	170	-	Int	260
Fluoranthene	270	230	330	500
Pyrene	1000	560	1080	980
B(a)A	260	240	320	220
Chry/Trip	190	160	220	150
B(b)F	570	550	70	250
B(k)F	-	-	-	150
B(e)P	180	180	250	190
B(a)P	240	230	300	180
Perylene	50	60	70	-
IP	150	150	200	190
D(ac)A/D(ah)A	-	40	40	-
B(ghi)P	160	140	190	130
Total PAH	4630	4380	5240	3480
Recovery %				
d10-Acenaphthene	Int	Int	Int	Int
d10-Anthracene	114	121	135	119
d10-Pyrene	152	98	Int	149
d12-B(a)A	131	114	140	145
d12-B(a)P	113	97	114	135
d14-D(ah)A	52	91	88	Int
d12-B(ghi)P	98	91	104	166
d10-Fluoranthene	29	31	25	82

Note: (1) "-" denotes values below Detection Limit of 40-100 ng/g
(2) "Int" = interference

TABLE 30 PROCESS SAMPLES - ORGANIC RUNS - POLYCYCLIC AROMATIC HYDROCARBONS (ng/g) - HIGHLAND CREEK - JUNE 27-29/87 - BOTTOM ASH

Run Number	7	8	9	10
Date	June 27/87	June 28/87	June 28/87	June 29/87
Compound				
Acenaphthylene	-	-	-	-
Acenaphthene	11	7	-	-
Fluorene	7	12	4	4
Phenanthrene	39	79	22	28
Anthracene	-	-	-	-
Fluoranthene	-	-	-	21
Pyrene	-	13	-	-
B(a)A	-	-	-	-
Chry/Trip	-	-	-	-
B(b)F	-	-	-	-
B(k)F	-	-	-	-
B(e)P	-	-	-	-
B(a)P	-	-	-	-
Perylene	-	-	-	-
IP	-	-	-	-
D(ac)A/D(ah)A	-	-	-	-
B(ghi)P	-	-	-	-
Total PAH	57	111	26	53
Recovery %				
d10-Acenaphthene	35	35	24	32
d10-Anthracene	35	45	15	27
d10-Pyrene	54	83	65	61
d12-B(a)A	57	77	66	58
d12-B(a)P	41	49	23	32
d14-D(ah)A	60	69	63	47
d12-B(ghi)P	40	57	52	37
d10-Fluoranthene	88	118	112	96

Note: "-" denotes values below Detection Limit of 4-10 ng/g

TABLE 31 PROCESS SAMPLES - ORGANIC RUNS - POLYCYCLIC AROMATIC HYDROCARBONS (µg/L) - HIGHLAND CREEK - JUNE 27-29/87 - SCRUBBER WATER IN

Run Number	7	8	9	10
Date	June 27/87	June 28/87	June 28/87	June 29/87
Compound				
Acenaphthylene	-	-	-	-
Acenaphthene	-	-	-	-
Fluorene	-	0.02	0.02	0.02
Phenanthrene	0.09	0.08	-	0.06
Anthracene	-	-	-	-
Fluoranthene	-	-	-	-
Pyrene	-	-	-	-
B(a)A	-	-	-	-
Chry/Trip	-	-	-	-
B(b)F	-	-	-	-
B(k)F	-	-	-	-
B(e)P	-	-	-	-
B(a)P	-	-	-	-
Perylene	-	-	-	-
IP	-	-	-	-
D(ac)A/D(ah)A	-	-	-	-
B(ghi)P	-	-	-	-
Total PAH	0.09	0.10	0.02	0.08
<u>Recovery %</u>				
d10-Acenaphthene	30	48	47	48
d10-Anthracene	39	55	50	53
d10-Pyrene	53	68	63	62
d12-B(a)A	41	67	60	64
d12-B(a)P	25	59	48	57
d14-D(ah)A	22	56	44	54
d12-B(ghi)P	38	62	54	60
d10-Fluoranthene	81	86	80	85

Note:"-" denotes values below Detection Limit of 0.02-0.05 µg/L

TABLE 32 PROCESS SAMPLES - ORGANIC RUNS - POLYCYCLIC AROMATIC HYDROCARBONS (μg/L) - HIGHLAND CREEK - JUNE 27-29/87 - SCRUBBER WATER OUT

Run Number	7	8	9	10
Date	June 27/87	June 28/87	June 28/87	June 29/87
Compound				
Acenaphthylene	-	-	-	-
Acenaphthene	-	-	-	-
Fluorene	-	-	-	-
Phenanthrene	-	-	-	-
Anthracene	-	-	-	-
Fluoranthene	-	-	-	-
Pyrene	-	-	-	-
B(a)A	-	-	-	-
Chry/Trip	-	-	-	-
B(b)F	-	-	-	-
B(k)F	-	-	-	-
B(e)P	-	-	-	-
B(a)P	-	-	-	-
Perylene	-	-	-	-
IP	-	-	-	-
D(ac)A/D(ah)A	-	-	-	-
B(ghi)P	-	-	-	-
Total PAH	-	-	-	-
Recovery %				
d10-Acenaphthene	51	56	67	70
d10-Anthracene	63	59	82	74
d10-Pyrene	74	87	103	80
d12-B(a)A	77	94	110	86
d12-B(a)P	74	72	106	81
d14-D(ah)A	79	77	124	97
d12-B(ghi)P	79	78	116	92
d10-Fluoranthene	91	95	107	93

Note:"-" denotes values below Detection Limit of 0.02-0.05 μg/L

TABLE 33 PROCESS SAMPLES - ORGANIC RUNS - DIOXIN/FURAN (ng/L) - HIGHLAND CREEK - JUNE 29/87 - SURFACE WATER FROM ASH LAGOON

T4CDD	-
P5CDD	-
H6CDD	-
H7CDD	-
OCDD	-
Total PCDD	-
T4CDF	-
P5CDF	-
H6CDF	-
H7CDF	-
OCDF	-
Total PCDF	-
Recovery %	
13C12-T4CDD	90
13C12-P5CDD	88
13C12-H6CDD	82
13C12-H7CDD	75
13C12-OCDD	80
13C12-1234TCDD	93

Note:"-" denotes values below Detection Limit of 1.0 - 2.0 ng/l/analyte peak

TABLE 34 PROCESS SAMPLES - ORGANIC RUNS - CHLOROBENZENES AND PCB's (μg/L) - HIGHLAND CREEK - JUNE 29/87 - SURFACE WATER FROM ASH LAGOON

CL3-CB	-
CL4-CB	-
CL5-CB	-
CL6-CB	-
Total CB	-
CL1-PCB	-
CL2-PCB	-
CL3-PCB	-
CL4-PCB	-
CL5-PCB	-
CL6-PCB	-
CL7-PCB	-
CL8-PCB	-
CL9-PCB	-
CL10-PCB	-
Total PCB	-
Recovery %	
13C6-CL4-CB	70
13C6-CL6-CB	85
13C12-CL5-PCB	98
13C12-CL8-PCB	94
d_{10}-Fluoranthene	115

Note: "-" denotes values below Detection Limit (μg/L/analyte peak) of 0.01 for CB; 0.02 -0.04 for PCB

TABLE 35 PROCESS SAMPLES - ORGANIC RUNS - CHLOROPHENOLS (µg/L) - HIGHLAND CREEK - JUNE 29/87 - SURFACE WATER FROM ASH LAGOON

CL2-Phenol	0.14
CL3-Phenol	0.13
CL4-Phenol	-
CL5-Phenol	0.17
Total CP	0.44
Recovery %	
13C6-CL2-Phenol	109
13C6-CL3-Phenol	110
13C6-CL5-Phenol	95
d_{10}-Fluoranthene	98

Note:"-" denotes values below Detection Limit of 0.03 - 0.06 µg/L/analyte peak

TABLE 36 PROCESS SAMPLES - ORGANIC RUNS - POLYCYCLIC AROMATIC HYDROCARBONS (μg/L) - HIGHLAND CREEK - JUNE 29/87 SURFACE WATER FROM ASH LAGOON

Acenaphthylene	-
Acenaphthene	-
Fluorene	-
Phenanthrene	-
Anthracene	-
Fluoranthene	-
Pyrene	-
B(a)A	-
Chry/Trip	-
B(b)F	-
B(k)F	-
B(e)P	-
B(a)P	-
Perylene	-
IP	-
D(ah)A	-
B(ghi)P	-
Total PAH	
Recovery %	
d10-Acenaphthene	52
d10-Anthracene	77
d10-Pyrene	93
d12-B(a)A	93
d12-B(a)P	82
d14-D(ah)A	93
d12-B(ghi)P	95
d10-Fluoranthene	86

Note:(1) "-" denotes values below Detection Limit of 0.02 - 0.05 μg/L

TABLE 37 COMPARISON OF STACK GAS PARTICULATE RESULTS IN ORF AND RRETC STUDIES AT HIGHLAND CREEK

Average Particulate Concentration (mg/m^3)		Average Sludge Feed Rate (tonnes/h)	
RRETC	ORF	RRETC	ORF
21.0	25.6	3.79	3.8

TABLE 38 SUMMARY OF THE LEACHING TESTS ON THE BOTTOM ASH AT HIGHLAND CREEK (6)

Description	Interpretation
Multiple Sequential Batch Leaching Procedure	
Distilled water leach at 20:1 liquid-to-solid ratio, mixed slowly for 18 hours.	Use results to help determine metal speciation and fraction potentially available for leaching with water.
Reclaim solids and expose to fresh leaching medium. Repeat for 5 cycles.	
Sequential Chemical Extraction Procedure	
Fraction A - Digest ground sample with 1 M LiCl/CsCl in 60% CH_3OH - residue to B	Ion exchangeable fraction. Considered immediately available for leachi
Fraction B - 1 M CH_3COONa with Acetic Acid - pH 5 - residue to C	Surface oxide and carbonate bound ions. Considered potentially available for leachin under acidic leaching conditions.
Fraction C - 1 M $NH_2OH \cdot HCl$ in 25% Acetic Acid - residue to D	Iron and manganese bound metal ions. Considered potentially available for leachin under the more aggressive conditions of a landfill.
Fraction D - Nitric Acid with Peroxide Heat - add CH_3OONH_4 in 20% Nitric Acid - residue to E	Sulphide and organic matter bound metal ior Considered unavailable for leaching under normal landfill conditions.
Fraction E - Aqua regia/HF with peroxide and HCl	Residual metal ions. Considered unavailable for leaching.
Government of Ontario Regulation 309 Leach Test	
20:1 liquid-to-solid ratio leach with max. volume of 0.5 N Acetic acid to maintain pH at <= 5.	Results compared against 100 times Ontaric Drinking Water Quality Objectives.

TABLE 38A SHORT- AND LONG-TERM LEACHABLE FRACTION RESULTS FROM THE SEQUENTIAL CHEMICAL EXTRACTION OF BOTTOM ASH AT HIGHLAND CREEK (6)

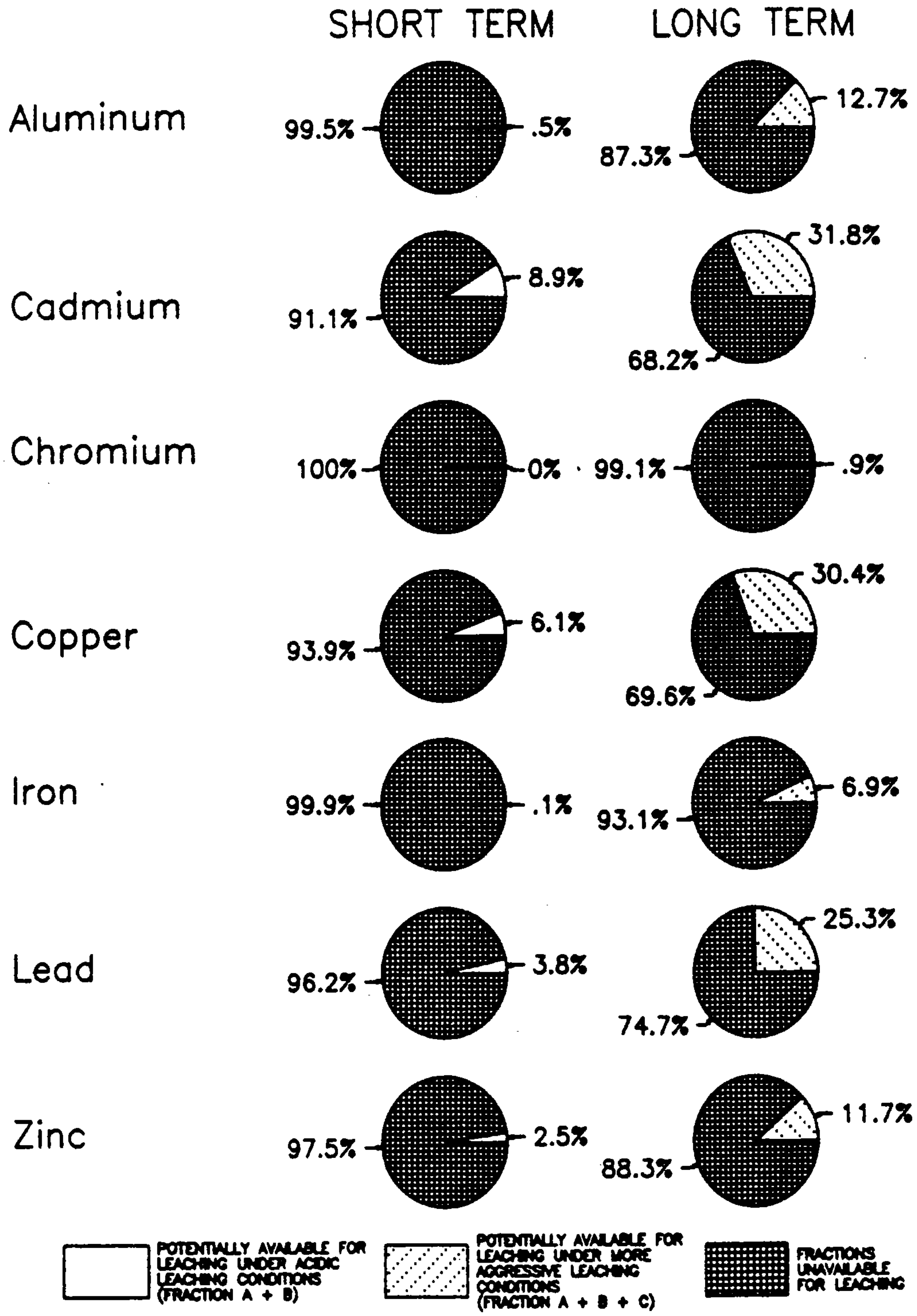


TABLE 39 HEAVY METAL CONCENTRATIONS IN THE REGULATION 309 LEACHATES COMPARED AGAINST 100 x ONTARIO'S DRINKING WATER OBJECTIVES (6)

Parameter	Bottom Ash Leachate Concentrations (ppm)	Drinking Water Objectives x 100 (ppm)
Al	0.61	Not Applicable
Cd	0.02	0.5
Cr	0.05	5.0
Cu	0.28	100
Fe	0.39	30
Pb	0.05	5.0
Zn	1.01	500

TABLE 40 HIGHLAND CREEK DISPERSION CALCULATIONS CURRENT REGULATION 308 (9)

Pollutant	Worst Case Emission Rate (mg/s)	From	Regulated Conc. @ POI 1/2h avg. ($\mu g/m^3$)	Main Stack to Ground at 1000 M Away (POI)	
				Calc'd max. Conc. ($\mu g/m^3$)	% of Regulated Maximum
Al as Al_2O_3	46.42	ORF	-	0.2236	-
Sb	0.16	ORF	75	0.0008	0.001
As	0.10	ORF	75	0.0005	0.001
Ba	0.93	ORF	-	0.0045	-
Be	0.01	ORF	0.03	0.0000	0.096
Bi	3.03	ORF	-	0.0146	-
B	0.91	ORF	100	0.0044	0.004
Cd	2.20	ORF	5	0.0106	0.212
Ca as CaO	17.39	ORF	20	0.0838	0.419
Cr	1.33	ORF	30	0.0064	0.021
Co	0.11	ORF	-	0.0005	-
Cu	2.12	ORF	100	0.0102	0.010
Fe as Fe_2O_3	66.37	ORF	75	0.3198	0.426
Pb	3.86	ORF	10	0.0186	0.186
Li	0.03	ORF	60	0.0001	0.000
Mg as MgO	2.37	ORF	100	0.0114	0.011
Mn	0.53	ORF	100	0.0025	0.003
Hg	0.69	ORF	5	0.0033	0.067
Mo	0.28	ORF	-	0.0013	-
Ni	0.50	ORF	5	0.0024	0.048
P as P_2O5	18.85	ORF	100	0.0908	0.091
K as KOH	1.35	ORF	-	0.0065	-
Se	0.03	ORF	-	0.0001	-
Si	14.25	ORF	-	0.0687	-
Ag	0.13	ORF	3	0.0006	0.021
Na	4.19	ORF	-	0.0202	-
Sr	0.13	ORF	-	0.0006	-
Te	0.04	ORF	30	0.0002	0.001
Sn	2.21	ORF	30	0.0107	0.036
Ti	3.22	ORF	100	0.0155	0.016
V	0.28	ORF	5	0.0013	0.027
Zn	7.39	ORF	100	0.0356	0.036
Total Suspended Particulates (<44 microns)	537.84	ORF	100	2.5913	2.591
THC as equivalent Methane (ppm)	165.00	ORF	100		-
HF	0.70	ORF	4.3	0.0034	0.078
HCl	2.00	ORF	100	0.0096	0.010
H_2SO_3	4.20	ORF	-	0.0202	-
H_2SO_4	18.10	ORF	100	0.0872	0.087
NH_3					

TABLE 40 HIGHLAND CREEK DISPERSION CALCULATIONS (cont'd)
CURRENT REGULATION 308 (9)

Pollutant	Worst Case Emission Rate (mg/s)	From	Regulated Conc. @ POI 1/2h avg. (µg/m^3)	Main Stack to Ground at 1000 M Away (POI)	
				Calc'd max. Conc. (µg/m^3)	% of Regulated Maximum
SO_2	783.67	EC	830	3.7757	0.455
NO_x	1 013.88	EC	500	4.8849	0.977
CO	8 280.00	EC	6000	39.8930	0.665
O_2 (%)	16.60	EC	-	-	-
CO_2 (%)	5.50	EC	-	-	-
Total PCDD	NA	EC	-	NA	-
Total PCDF	NA	EC	-	NA	-
Total PAH	0.01158	EC	-	0.0001	-
Total CB	0.00350	EC	-	0.0000	-
Total PCB	0.00116	EC	-	0.0000	-
Total CP	0.00238	EC	-	0.0000	-

TABLE 41 HIGHLAND CREEK DISPERSION CALCULATIONS PROPOSED REGULATION 308 (9)

Pollutant	Worst Case Emission Rate (mg/s)	From	Regulated Ambient Air Stnd. Conc. (µg/m^3)	Avg. Time	Main Stack to Ground at 1000 M Away (POI)	
					Calc'd max. Conc. (µg/m^3)	% of Regulated Maximum
Al as Al_2O_3	46.42	ORF	35	24h	$7.30X10^{-1}$	2.085
Sb	0.16	ORF	2.5	24h	$2.50X10^{-3}$	0.100
As	0.10	ORF	0.3	24h	$1.57X10^{-3}$	0.524
Ba	0.93	ORF	10	24h	$1.46X10^{-2}$	0.146
Be	0.01	ORF	0.01	24h	$9.43X10^{-5}$	0.943
Bi	3.03	ORF	-	-	$4.76X10^{-2}$	-
B	0.91	ORF	35	24h	$1.46X10^{-2}$	0.041
Cd	2.20	ORF	2	24h	$3.46X10^{-2}$	1.729
Ca as CaO	17.39	ORF	10	24h	$2.73X10^{-1}$	2.734
Cr	1.33	ORF	1.5	24h	$2.10X10^{-2}$	1.398
Co	0.11	ORF	-	-	$1.71X10^{-3}$	-
Cu	2.12	ORF	50	24h	$3.33X10^{-2}$	0.067
Fe as Fe_2O_3	66.37	ORF	25	24h	1.04	4.174
Pb	3.86	ORF	2	30d	$6.06X10^{-2}$	3.031
Li	0.03	ORF	20	24h	$4.56X10^{-4}$	0.002
Mg as MgO	2.37	ORF	100	24h	$3.72X10^{-2}$	0.037
Mn	0.53	ORF	10	24h	$8.32X10^{-3}$	0.083
Hg	0.69	ORF	2	24h	$1.09X10^{-2}$	0.544
Mo	0.28	ORF	-	-	$4.40X10^{-3}$	-
Ni	0.50	ORF	2	24h	$7.80X10^{-3}$	0.390
P as P_2O_5	18.85	ORF	100	24h	$2.96X10^{-1}$	0.296
K as KOH	1.35	ORF	14	24h	$2.12X10^{-2}$	0.151
Se	0.03	ORF	10	24h	$4.72X10^{-4}$	0.005
Si	14.25	ORF	-	-	$2.24X10^{-1}$	-
Ag	0.13	ORF	1	24h	$2.09X10^{-3}$	0.209
Na	4.19	ORF	10	24h	$6.58X10^{-2}$	0.658
Sr	0.13	ORF	-	-	$1.98X10^{-3}$	-
Te	0.04	ORF	10	24h	$6.45X10^{-4}$	0.006
Sn	2.21	ORF	10	24h	$3.48X10^{-2}$	0.348
Ti	3.22	ORF	35	24h	$5.07X10^{-2}$	0.145
V	0.28	ORF	2	24h	$4.39X10^{-3}$	0.219
Zn	7.39	ORF	100	24h	$1.16X10^{-1}$	0.116
Total Suspended Particulates (<44 microns)	537.84	ORF	60	1yr	8.45	14.091
THC as equivalent Methane (ppm)	165.00	ORF				
HF	0.70	ORF	0.34	30d	$1.10X10^{-2}$	3.236
HCl	2.00	ORF	40	24h	$3.14X10^{-2}$	0.079
H_2SO_3	4.20	ORF	-	-	$6.60X10^{-2}$	-
H_2SO_4	18.10	ORF	35	24h	$2.85X10^{-1}$	0.813
NH_3						

TABLE 41 HIGHLAND CREEK DISPERSION CALCULATIONS (cont'd)
PROPOSED REGULATION 308 (9)

			Regulated Ambient		Main Stack to Ground at 1000 M Away (POI)	
Pollutant	Worst Case Emission Rate (mg/s)	From	Air Stnd. Conc. ($\mu g/m^3$)	Avg. Time	Calc'd max. Conc. ($\mu g/m^3$)	% of Regulated Maximum
SO_2	783.67	EC	55	1yr	$1.23X10^{1}$	22.399
NO_x	1 013.88	EC	300	24h	$1.59X10^{1}$	5.313
CO	8 280.00	EC	36 200	1h	$1.30X10^{2}$	0.360
O_2 (%)	16.60	EC	-	-	$2.61X10^{-1}$	-
CO_2 (%)	5.50	EC	-	-	$8.65X10^{-2}$	-
Total PCDD (x)	NA	EC	x/30+y/30(50)=1		NA	-
Total PCDF (y)	NA	EC		1yr	NA	-
Total PAH	0.01158	EC	1	24h	$1.82X10^{-4}$	0.018
Total CB	0.00350	EC	-	-	$5.50X10^{-5}$	-
Total PCB	0.00116	EC	150	24h	$1.83X10^{-5}$	0.000
Total CP	0.00238	EC	35	1yr	$3.75X10^{-5}$	0.000

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