QUALITY ASSURANCE (QA)
AND QUALITY CONTROL (QC) PLAN
FOR THE LANDFILL MONITORING PROGRAM
AT THE
FOX-2 (LONGSTAFF BLUFF)
DEW LINE SITE

September 2008

Prepared by:
ENVIRONMENTAL SCIENCES GROUP
for
DEFENCE CONSTRUCTION CANADA
&
UMA ENGINEERING LTD.

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1. Introduction

A landfill monitoring plan was developed by the Department of National Defence (DND) in cooperation with Nunavut Tunngavik Incorporated (NTI) to address post-closure monitoring requirements for landfills at the DEW Line sites. This monitoring requirement was outlined in the Environmental Provisions of the DND/NTI Cooperation Agreement.

The objective of the landfill monitoring program is to collect sufficient information to assess the performance of the landfills from both an environmental and geotechnical perspective and consists of four main components:

1) visual monitoring;
2) soil monitoring;
3) active layer water monitoring; and
4) thermal monitoring.

Only the soil and active layer water monitoring programs are included in this QA/QC plan.

The soil and active layer water monitoring program is composed of background and baseline assessment as well as contaminant evaluation. The methodology used for the sampling and analysis of landfill monitoring program samples remains the same regardless of whether the samples are background samples, baseline samples or samples used for contaminant evaluation.

2. Sample Collection

2.1. Location

Sample locations were marked with a disk stamped with the sample number and a piece of flagging tape, attached with a 150-mm nail. Each sample location was assigned a distinct sample number. These sample numbers were recorded on a map as well as in a field notebook along with a description of the associated sample location. GPS coordinates of sample locations are collected and recorded. Photographs of the sample location are also taken.

2.2. Sampling Equipment

The following table summarizes the equipment and storage requirements for each soil sample type collected. New bottles were used in all cases for the collection of the soil samples.

Contaminant	**Container**	**Amount**	**Storage**
Polychlorinated Biphenyls (PCBs)	Amber glass jar with Teflon-lined lid	30 g	Cool or ambient temperature
Total Petroleum Hydrocarbons (TPH) as F1, F2 & F3	Amber glass jar with Teflon-lined lid – no headspace	30 g	$< 4\ ^0C$
Inorganic Elements (See note 1)	Whirlpak	50 g	Cool or ambient temperature

1- arsenic, cadmium, chromium, cobalt, copper, lead, mercury, nickel, zinc

The following table summarizes the equipment and storage requirements for each water sample type collected. New bottles were used in all cases for the collection of these samples.

Contaminant	**Container**	**Amount**	**Rinse**	**Storage**	**Special Treatment**
pH	1L Plastic Bottle	Full	No	Cool	Do not filter
Inorganic Elements (See note 1)	1L Plastic Bottle	Full	No	Cool	Do not filter
Polychlorinated Biphenyls (PCBs)	1L Amber glass *or Teflon*, with Teflon-lined lid	Full	Glass – no Teflon - yes	Cool	Do not filter
Total Petroleum Hydrocarbons (TPH)	Amber glass *or Teflon* with Teflon-lined lid	Full – no headspace	Glass – no Teflon - yes	Cool	Do not filter

1-total arsenic, total cadmium, total chromium, total cobalt, total copper, total lead, total mercury, total nickel, total zinc

2.3. Sampling Methods

2.3.1. Soil Sampling

Soil samples were collected in duplicate at predetermined upgradient and downgradient locations of the landfills created during the construction phase of the cleanup. Every sample location was marked with an implanted 150-mm stainless steel nail, to which was attached a plastic disk stamped with the sample number and a long strip of brightly coloured flagging tape (i.e. a "sample tag").

The soil samples were collected using one of two methods. Samples were obtained using a plastic scoop and stored in both Whirl Pak^{TM} bags and 125-mL amber glass jars fitted with Teflon-lined lids certified to be free of organic materials. All soil samples were kept at ambient temperature. Each sample was given a blind number that was the only number provided on the labels of samples submitted for analysis. This number matched that stamped on the sample tag left at the sample location. Sample locations and descriptions were recorded independently by at least two team members, in note pads and/or on field maps, and a photographic record was made of each general area that was to be delineated.

Soil was sampled from the upper 10 cm and was collected so as to obtain representative material. Shallow depth samples to 30 cm were also collected at each sample location. All samples were shipped by guaranteed air-freight to the Environmental Sciences Group (ESG) at the Royal Military College (RMC). Soil samples destined for total petroleum hydrocarbon (TPH) analysis in the south were kept below 4 ^{0}C where possible and samples to be analyzed for inorganic elements (As, Cd, Cr, Co, Cu, Pb, Zn, Hg) or PCBs were kept either cool or at ambient temperature prior to and during shipping. One sample from each duplicate pair was analyzed by the Analytical Services Unit (ASU) at Queen's University or by the Analytical Services Group (ASG) at RMC. An additional 10% of these analyses were repeated for quality control purposes.

2.3.2. Active Layer Water Sampling

Monitoring wells were installed around landfills during the cleanup of the site according to the cleanup's contract drawings and specifications to determine whether contaminants were migrating from the facility. The wells consisted of 5-cm diameter stainless steel pipe with 100-cm long screen surrounded by a filter sock. The wells were installed with the use of a drill rig. The hole was backfilled with grout at the base and filter sand around the screen, then capped with a bentonite seal. The wells were typically protected from damage by wildlife and the elements with a lockable external metal casing.

Monitoring wells were sampled so as to avoid alteration of groundwater chemistry through contact with drilling fluid, cross-contamination between wells, or by exposure to the atmosphere. Wells that had been installed in the current season were sampled after as much time as possible had elapsed following installation, to allow the groundwater to reach physical and chemical equilibrium. Each well was purged before it was sampled. Purge water was monitored for pH, temperature, and conductivity, using an Extech Oyster Model 34145A or equivalent, with the appropriate probes immersed directly into a flow-through cell. The pH probe was calibrated using the accompanying buffer solutions of pH 4 and pH 7. When conductivity calibration standards were available, the conductivity probe was also calibrated.

Sampling commenced once those parameters had stabilized. The sampling bottles were labeled with a unique sample number. Purging and sampling were done using a low flow rate to minimize turbulence in the well and aeration of the water sample. The pump and tubing were rinsed with groundwater from the sampling location before the sample was taken. For TPH analysis, water samples were collected in 250-mL amber glass bottles which were not pre-rinsed, and were completely filled to avoid any gas pockets in the sample. Teflon bottles were used for organic, non-TPH analysis, and were pre-rinsed with the sample water. For inorganic analysis, water samples were collected the same way, but in 1-L polyethylene bottles.

Ideally, samples collected for inorganic analyses should be acidified in the field, at the time of collection. However, regulations concerning the transportation of dangerous goods make supplying concentrated nitric acid in the field difficult. Where samples cannot be acidified in the field, it will be requested that the samples are acidified immediately upon receipt in the lab, *prior* to decanting or sample extraction. When acidifying in the lab, the container will be rinsed with 35% HNO_3 and included with the sample.

Samples are not to be filtered at any time. If samples contain excessive sediment, the samples will simply be decanted in the southern laboratory (*following* acidification, for metal analyses) prior to analysis.

The water samples will be kept cool (approximately 4^0 C) prior to and during shipping. In general, water samples will be collected when transportation from the site will be available almost immediately after, as many types of the required analyses should be performed as quickly as possible after collection.

2.4. Shipment of Samples

Samples are to be shipped by guaranteed airfreight in coolers from the site to their respective accredited laboratory for analysis. Chain-of-custody forms will be filled out and checked for each sample before shipment from the North, and the contents of shipments will be verified upon receipt in the laboratory.

3. Lab Analysis

3.1. Lab Accreditation

All laboratory analysis is carried out at accredited labs. The following laboratories are the ones primarily responsible for the analysis of water samples collected at FOX-2 (Longstaff Bluff):

1) Analytical Services Unit, Queen’s University, Kingston ON; and
2) Analytical Sciences Group, Royal Military College of Canada, Kingston ON.

Proof of accreditation from these laboratories is available upon request.

3.2. Detection Limits

The following table provides a summary of the detection limits for the analysis to be performed on water samples collected at FOX-2 (Longstaff Bluff).

Parameter	**Detection Limit**
Soil	
Polychlorinated Biphenyls (PCBs)	3.0 ng/g
Total Petroleum Hydrocarbons (TPH) as F1, F2 & F3	40 µg/g
Inorganic Elements (See note 1)	Cu = 5.0 µg/g; Ni = 5.0 µg/g; Co = 5.0 µg/g; Cd = 1.0 µg/g; Pb = 10 µg/g, Zn = 15 µg/g; Cr = 20 µg/g; As = 1.0 µg/g; Hg = 0.1 µg/g

Parameter	Detection Limit
Water	
pH	-
Inorganic Elements (See note 2)	µg/L levels
Polychlorinated Biphenyls (PCBs)	0.020 µg/L
Total Petroleum Hydrocarbons (TPH)	1 mg/L

1- arsenic, cadmium, chromium, cobalt, copper, lead, mercury, nickel, zinc
2 -total arsenic, total cadmium, total chromium, total cobalt, total copper, total lead, total mercury, total nickel, total zinc

3.3.Methodology

The following is a summary of the methods to be used in the analysis of the water samples collected from FOX-2 (Longstaff Bluff).

3.3.1. Digestion of Various Matrices for Inorganic Elements

Analyses were conducted by the Analytical Services Unit, Queen's University, Kingston, Ontario. Each sample was clearly labeled and stored in a secured area (before and after analysis) at a temperature appropriate for the analytical method.

3.3.1.1. Soil

Samples were air-dried and ground to a fine powder with a mortar and pestle. Large stones were removed, as they would not be expected to contain any anthropogenic environmental contaminants. Approximately 0.5 g of powdered sample was heated with 2 mL of nitric acid and 6 mL of hydrochloric acid overnight so that the volume was reduced to 1-2 mL. This solution was then made up to 25 mL with distilled deionized water. Although not all metals may be brought into solution by this procedure (some may be locked into silicate minerals), metals that are released are considered to be of greater environmental significance than are true total metals.

3.3.1.2. Water

For total metals, the sample was vigorously shaken. A 400-mL aliquot of sample was used, acidified with nitric acid, and concentrated by boiling to dryness. The sample was acidified, refluxed, transferred to a volumetric flask, and made up to 25 mL. The sample was then filtered and analyzed for the requested elements.

3.3.2. Inorganic Elements by Inductively Coupled Plasma Atomic Emission Spectroscopy

Analyses were conducted by the Analytical Services Unit, Queen's University, Kingston, Ontario. Each sample was clearly labeled and stored in a secured area (before and after analysis) at a temperature appropriate for the analytical method.

Concentrations of the following eight elements were measured: arsenic (As), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), lead (Pb), nickel (Ni), and zinc (Zn). Samples were analyzed in batches of up to 36, which comprised up to 28 samples, 2 blanks, 4 duplicates and 2 samples of reference material (NRC MESS-3 or SS-2).

3.3.3. Mercury in Soil and Water

Analyses were conducted by the Analytical Services Group, Royal Military College, Kingston, Ontario. Each sample was clearly labeled and kept at a low temperature before and after analysis.

The samples were treated in one of two ways:

(i) Water samples reported as total mercury were similarly preserved. A 5-mL aliquot was digested with 5 mL of a 1:4 concentrated nitric acid: concentrated sulphuric acid mixture. Digestion conditions were 195 ^{o}C for 6 hours. The final digest was made up to a volume of 10 mL with distilled deionized water. A set of standards, duplicate samples, triplicate blanks, and a reference control solution were digested with each total mercury run.

(ii) Mercury in soil samples was similarly digested (0.25 g dry soil, 195 ^{o}C for 6 hours, 5 mL of 1:4 concentrated nitric acid: concentrated sulphuric acid). After the digestion, the samples were made up to 25 mL with distilled deionized water. A set of standards, a duplicate, a blank, and a soil reference were digested with each soil run.

The samples were analyzed using cold vapour generated mercury hydride atomic absorption spectrophotometry. Water samples and digests were analyzed using a Perkin-Elmer FIMS-100 Mercury System equipped with a 253.7 ηm source mercury lamp, quartz cell, Perkin-Elmer AS-90 autosampler, and the Perkin Elmer AA WinLab Analyst software. The carrier solution was 3% HCl and the reducing agent was 1.1% tin chloride ($SnCl_2$) in 3% HCl. Ultrahigh-purity argon was used as the carrier gas, with the flow rate set between 40 and 70 mL/min. Three 500-μL replicates for each sample were analyzed. A signal was generated in the quartz cell by measuring the amount of light (wavelength 253.7 ηm) absorbed. The mercury concentrations in the samples were determined by comparing sample absorbance responses to a calibration curve generated from standards of known concentration. Duplicates, blanks, and control samples were included in each run. Soil and dissolved mercury data are not background corrected. Total mercury data are corrected for mean background absorbance. The sample results were reported to detection limits of 0.1 μg/g (ppm) for mercury in soil and 0.0004 mg/L (ppm) for total mercury in water.

3.3.4. pH Measurement

Measurements on water and soil samples were conducted by the Analytical Services Group, Royal Military College, Kingston, Ontario.

Water samples were measured directly using a 50-mL sample; the pH of soil was determined by mixing 10 g of soil with 10 mL of distilled water, allowing the mixture to settle, and measuring the pH of the supernatant. The pH was measured with a Denver Instruments model 220/300729.1 pH meter and probe, relative to buffered reference standards and control.

3.3.5. Polychlorinated Biphenyls in Soil

Analyses were conducted by the Analytical Services Group, Royal Military College, Kingston, Ontario. Each sample was clearly labeled and stored at low temperatures in a secured area before and after analysis.

All samples were thoroughly homogenized before they were sampled for the analysis. Soil samples were subsampled for determination of wet/dry weight ratio. Accurately weighed samples of wet soil (10 g) to which the surrogate standard DCBP, sodium sulphate (40 g) and Ottawa sand (20 g) were added, were extracted three times for 20 minutes with 50 mL of dichloromethane on an orbital shaker. Accurately weighed samples of soil that could not be extracted by shaker were added, and were extracted by Soxhlet for 4 hours at 4 - 6 cycles per hour with 250 mL of dichloromethane. In both cases, the extract was then concentrated by rotoevaporation to approximately 1 mL, and 5 mL of hexane were added and again evaporated to 1 mL. This was repeated twice more, resulting in 1 mL of hexane solvent, which was then applied to a Cu-Florisil (Diagnostix) column for cleanup. The column was thoroughly rinsed with hexane and the eluate containing the PCBs diluted to 10.0 mL. A 2-mL GC vial was filled in preparation for analysis.

An alternative extraction method used for solid samples was pressurized solvent extraction (PSE). Extractions were performed according to ASG Procedure 02-38 ‘Extraction by PSE.’ An Applied Separations PSE system capable of six simultaneous extractions was used in conjunction with 33-mL stainless steel extraction vessels, frits, and filters. Each vessel was filled to a depth of approximately 1 cm with Cu-Florisil (Diagnostix) cleanup reagent, to which a mixture of 5-10 g of sodium sulphate, 10 g soil, and appropriate surrogate spikes was added. The remaining void was filled with Ottawa sand and glass wool. Six extraction vessels containing samples, blanks, or controls were placed in the automated PSE system. Extraction proceeded according to the following parameters: solvent hexane, static temperature 100 ^{o}C, static time 5 minutes, 1 extraction cycle. The extracts were flushed to 45-mL collection vessels using a 3-minute solvent flush and 2-minute nitrogen gas flush.

The samples were analyzed by gas chromatography (GC) with electron capture detection (ECD), using an HP/Agilent 6890 Plus Gas Chromatograph equipped with a ^{63}Ni Electron Capture Detector (GC/ECD), a SGE HT-8 fused silica capillary column (10 m, 0.1 mm i.d. x 0.1 μm film thickness) and HP ChemStation software. The conditions were as follows: Sample volume 0.5 μL, splitless injection, temperature programmed ramp and constant helium carrier gas pressure. Nitrogen was used as a makeup gas for the ECD. All values were reported as μg/g dry weight (ppm).

Samples requiring ultra-low detection limit analysis were similarly treated, using Soxhlet or PSE extraction techniques. In each case, the samples were concentrated to a known volume of approximately. 0.5 mL. A 0.5-μL injection volume was used for GC analysis. All values were reported as ng/g dry weight (ppb).

3.3.6. Polychlorinated Biphenyls in Water

Analyses were conducted by the Analytical Services Group, Royal Military College, Kingston, Ontario. Each sample was clearly labeled and stored at low temperatures in a secured area before and after analysis.

A 500-mL sample was placed in a 1-L separatory funnel and spiked with decachlorobiphenyl (DCBP), an internal standard. Dichloromethane (25 mL) was added to the separatory funnel, which was then shaken with frequent venting. The bottom layer was decanted through a funnel containing anhydrous sodium sulphate and into a round-bottom flask. This extraction step was repeated twice more, giving a collected volume of 75 mL in the round-bottom flask. The solvent in the flask was then exchanged for hexane by rotary evaporation of the original 75 mL down to 1 mL, and 5 mL of hexane were added and again evaporated to 1 mL. The addition of 5 mL of hexane was repeated twice more to give a final volume of 1 mL after the last rotary evaporation. The 1-mL volume remaining in the flask was pipetted onto a Cu-Florisil (Diagonstix) solid phase extraction tube (Supelco) and eluted with hexane. The column was thoroughly rinsed with hexane and the eluate containing the PCBs was diluted to 10 mL. A GC vial (2 mL) was then filled in preparation for analysis.

All samples were analyzed by gas chromatography (GC) with electron capture detection (ECD), using an HP/Agilent 6890 Plus Gas Chromatograph equipped with a ^{63}Ni Electron Capture Detector (GC/ECD), an SGE HT-8 column (10 m, 0.1 mm i.d. x 0.1 μm film thickness) and HP ChemStation software. The conditions were as follows: Sample volume 0.5 μL, splitless injection, temperature programmed ramp, and constant helium carrier gas pressure. Nitrogen was used as a makeup gas for the ECD. All values were reported as μg/g dry weight (ppm). Analyses requiring ultra-low detection limits were similarly treated, but were extracted from 800 mL water and concentrated to a known volume of approximately 0.5 mL after Cu-Florisil (Diagnostix) elution.

3.3.7. CCME Method of Petroleum Hydrocarbons in Soil and Water

Analyses were conducted by the Analytical Services Group, Royal Military College, Kingston, Ontario. Each sample was stored in an appropriate, clearly labelled container and kept at low temperatures in a secured area before and after analysis. Soil analysis was performed as prescribed in the CCME Reference Method for Canada Wide Standard for Petroleum Hydrocarbons in Soil, 2001.

(a) Soil Fraction F1

Accurately weighted samples of wet soil (5 g) were extracted on a shaker for 1 hour with 10 mL of methanol. The methanol layer was then transferred into a vial and refrigerated until analysis. A 50-μL aliquot of the extract, made up to 5 mL with water, was directly syringed into a Tekmar autosampler/purge-and-trap apparatus. The sample was purged with high purity helium gas for 11 minutes. The trapped components were desorbed from the trap in the unit by heating to 225 °C and holding for 4 minutes. A Hewlett Packard 6890 GC-FID system was used for analysis in conjunction with an SPB-1 fused silica capillary column (30 m, 0.25 mm i.d. x 0.25 μm film thickness). The retention time was marked using nC6 and nC10 hydrocarbons, and calibration was performed with toluene. Blanks, control samples and duplicates were run at a frequency of approximately 20%. A wet/dry ratio for the sample was determined using a sub-sample. The final result was calculated using the dry weight of the sample (μg/g). When analyses for benzene, toluene, ethylbenzene and xylenes (BTEX) were requested, the BTEX results were subtracted from the F1 fraction results.

(b) Soil Fraction F2 to F4

Soil samples were homogenized and subsamples dried for moisture determination. Accurately weighed samples of wet soil (10 g) were extracted by Soxhlet for 6 hours at 4-6 cycles per hour with 250 mL of hexane/acetone (1:1). The extract was filtered through sodium sulphate and 3 mL of toluene were added. The extract was then concentrated by rotoevaporation. A column of 15 mm diameter containing 5.0 g activated silica below 1 cm of sodium sulphate was prepared and eluted with 10 mL 50:50 dichloromethane: hexane. The concentrated extracted was added to the head of the column and eluted with 20 mL 50:50 dichloromethane:hexane. Toluene (1 mL) was added and the collected eluent was concentrated to approximately 1 mL using rotary evaporation.

Analysis was performed by GC-FID using an Agilent 6890 instrument fitted with a cool on-column injection system. A DB-1 capillary column (15 m, 0.53 mm diameter, 0.15μm film) was used to achieve separation. Blanks, control samples, and duplicates were run at a frequency of approximately 20%. Calibrations were performed and the retention time was marked using nC10, nC16, and nC34 hydrocarbons. NC50 was analyzed as the performance standard, with a required response of less than 70% of that obtained using nC10, nC16, and nC34 response factors. The final result was reported as mg/kg for each fraction. In any samples that underwent analysis for polycyclic aromatic hydrocarbons (PAH), naphthalene was subtracted from fraction F2, and the other 15 priority pollutant PAHs were subtracted from fraction F3.

(c) Water Fraction F1

For water samples, 5 mL of sample were directly syringed into the water purge-and-trap apparatus. Chromatography and calibration were as described for soil samples.

(d) Water Fraction F2-F4

A 200-mL portion of the water sample was accurately measured and transferred to a clean 125-mL glass separatory funnel. Hexane (5 mL) was added and the mixture was shaken vigorously and allowed to separate. If emulsions formed, the funnel was briefly sonicated to ensure adequate phase separation. Some of the hexane phase was then transferred to a GC vial and the extract analyzed by GC under the same conditions as for soil samples, and using the same calibration and retention time markers. The final result was reported as mg/L for each fraction..

3.4. Reporting Requirements

The following types of QA/QC samples will also be collected as part of the landfill monitoring sampling program. Note that if more than one type of bottle is used for a sample, QA/QC samples will be submitted in each type of bottle used for the collection of the samples.

Field duplicates*:* Approximately 10% of the samples were collected as field duplicates. That is, two samples were collected from one sample location. These samples were handled in the same way and submitted blindly to the laboratories for analysis.

Field blanks: Field blanks consisted of distilled water and were collected to ensure that there is no corruption of samples from the sampling method. The distilled water was poured from its container into the sample container at the same time and using the same techniques as used to collect the regular water samples.

Travel blanks: The purpose of travel blanks is to ensure that there is no corruption of the sample or sample container during travel. Ideally, a full set of travel blanks should accompany each shipment of water samples. However, in cases where very few samples are shipped at a time, this guideline can be extended to a more reasonable number. Travel blanks were filled at ESG prior to leaving for the field. They were shipped with the sample bottles, stored with the sample bottles on site, brought out to the sampling location in the field, returned to the lab, and shipped to the labs with the water samples. They should not be opened unless the other bottles or water samples are opened for some reason during shipping.

Appendix A: Proof of Laboratory Accreditation

ACLAE
CAEAL

CAEAL Directory of Laboratories

Membership Number: 2709
Laboratory Name: Queen's Analytical Services Unit
Parent Institution: Queen's University
Address: Environmental Studies Biosciences Complex Kingston ON K7L 3N6
Contact: Dr. Allison Rutter
Phone: (613) 533-2642
Fax: (613) 533-2897
Email: ruttera@queensu.ca; kettlewb@queensu.ca

Standard: Conforms with requirements of ISO/IEC 17025
Clients Served:
Revised On: August 11, 2008
Valid To: September 18, 2009

Scope of Accreditation

Oil
PCB - Oil (004)
ASU 04; based on EPA 8081

GC/ECD - EXTRACTION	RDL Range
Total PCB	1 - 5 µg/g

Soil (Inorganic)
Mercury - Soil (014)
ASU012; based on MILESTENE METHODS

COLD VAPOUR AA	RDL Range
Mercury	5 - 25 ng/g

Soil (Inorganic)
Metals - Soil (007)
ASU007; based on EPA 200.7

ICP/OES - DIGESTION	RDL Range
Aluminum	50 - 250 µg/g
Antimony	10 - 50 µg/g
Arsenic	1 - 5 µg/g
Barium	5 - 25 µg/g
Beryllium	1 - 5 µg/g
Boron	10 - 50 µg/g
Cadmium	1 - 5 µg/g
Calcium	
Chromium	10 - 50 µg/g
Cobalt	5 - 25 µg/g
Copper	5 - 25 µg/g
Iron	50 - 250 µg/g
Lead	10 - 50 µg/g
Magnesium	
Manganese	1 - 5 µg/g

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† "OSDWA" indicates the appendix is used for the analysis of Ontario drinking water samples, which is subject to the rules and related regulations under the Ontario "Safe Drinking Water Act" (2002).

Molybdenum	
Nickel	5 - 25 µg/g
Phosphorus	
Potassium	
Selenium	
Silver	
Sodium	
Strontium	5 - 25 µg/g
Sulphur	
Thallium	
Tin	1 - 5 µg/g
Titanium	10 - 50 µg/g
Uranium	10 - 50 µg/g
Vanadium	10 - 50 µg/g
Zinc	10 - 50 µg/g

Solids

Metals - Solids (015)

ASU015; based on MOE TCLP-LEACH E9002

ICP/AES - TCLP	RDL Range
Arsenic	
Barium	
Boron	
Cadmium	
Chromium	
Lead	
Mercury	
Selenium	
Silver	
Uranium	

Water (Inorganic)

Ammonia - Water (009)

ASU09; based on TECHNICON METHOD

AUTO COLOR	RDL Range
Ammonia	.1 - .5 mg/L

Water (Inorganic)

Dissolved Metals - Water (008)

ASU08; based on EPA 200.7

ICP/AES	RDL Range
Aluminum (High)	.1 - .5 mg/L
Antimony	
Arsenic	
Barium (High)	.05 - .25 mg/L
Beryllium	
Boron (High)	.1 - .5 mg/L
Cadmium	
Calcium	
Chromium (High)	.01 - .05 mg/L
Cobalt (High)	.01 - .05 mg/L
Copper (High)	.1 - .5 mg/L
Iron (High)	.05 - .25 mg/L
Lead (High)	.01 - .05 mg/L
Magnesium	
Manganese (High)	.05 - .25 mg/L
Molybdenum (High)	.05 - .25 mg/L
Nickel (High)	.1 - .5 mg/L

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Phosphorus	
Potassium	
Selenium	
Silver	
Sodium	
Strontium (High)	.01 - .05 mg/L
Sulphur	
Thallium (High)	.01 - .05 mg/L
Tin	
Titanium (High)	.01 - .05 mg/L
Uranium	
Vanadium (High)	.01 - .05 mg/L
Zinc (High)	.01 - .05 mg/L

Water (Inorganic)
Major Ions - Water (003)
ASU 03; based on DIONEX MANUAL

ION CHROMATOGRAPHY	RDL Range
Bromate	
Bromide	.1 - .5 mg/L
Chloride	.05 - .25 mg/L
Fluoride	.05 - .25 mg/L
Fluoride	
Nitrate	.05 - .25 mg/L
Nitrite	.05 - .25 mg/L
Phosphate	.1 - .5 mg/L
Sulfate	.1 - .5 mg/L

Water (Inorganic)
Mercury - Water (013)
ASU015; based on MILESTONE METHODS

COLD VAPOUR AA	RDL Range
Mercury	.005 - .025 µg/L

Water (Inorganic)
Oil and Grease - Water (010)
ASU10; based on SM 5520 (20TH EDITION)

GRAVIMETRIC - EXTRACTION	RDL Range
Total Oil and Grease	1 - 5 mg/L

Water (Inorganic)
Total Metals - Water (012)
ASU08; based on EPA 200.7

ICP/AES	RDL Range
Aluminum	.1 - .5 mg/L
Antimony	
Arsenic	
Barium	.05 - .25 mg/L
Beryllium	
Boron	.1 - .5 mg/L
Cadmium	
Calcium	
Chromium	.01 - .05 mg/L
Cobalt	.01 - .05 mg/L
Copper	.1 - .5 mg/L
Iron	.05 - .25 mg/L
Lead	.01 - .05 mg/L

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Magnesium	
Manganese	.05 - .25 mg/L
Molybdenum	.05 - .25 mg/L
Nickel	.1 - .5 mg/L
Potassium	
Selenium	
Silver	
Sodium	
Strontium	.01 - .05 mg/L
Sulphur	
Thallium	.01 - .05 mg/L
Tin	
Titanium	.01 - .05 mg/L
Uranium	
Vanadium	.01 - .05 mg/L
Zinc	.01 - .05 mg/L

Water (Inorganic)

Total Phosphorus (TP) - Water (016)
ASU06; based on TECHNICON METHOD

AUTO COLOR	RDL Range
Total Phosphorus	.01 - .05 mg/L

Water (Organic)

Biphenyl - Water (005)
ASU 05; based on EPA 3510 C

GC/FID - EXTRACTION	RDL Range
Biphenyl	
Biphenyl Ether	

Water (Organic)

Phenols - Water (001)
ASU 01; based on MOE METHOD 1983

AUTO COLOR	RDL Range
Total Phenolics	.001 - .005 mg/L

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ACLAE
CAEAL

CAEAL Directory of Laboratories

Membership Number: 2965
Laboratory Name: RMC Analytical Sciences Group
Parent Institution: The Royal Military College of Canada
Address: Dept. of Chemistry & Chemical Engineering RMC, PO Box 17000 Stn. Forces Kingston ON
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Standard: Conforms with requirements of ISO/IEC 17025
Clients Served: Specified Clients
Revised On: August 11, 2008
Valid To: October 10, 2009

Scope of Accreditation

Oil

Total Chlorine - Oil (003)
ASG003; based on J. RADIONAL CHEM., 50, 229-234 (1979), ANAL. CHIM. ACTA., 108, 137-147 (1979).

NAA		RDL Range
Total Chlorine		

Soil (Inorganic)

Mercury - Soil (026)
ASG014; based on EPA 7470 A

COLD VAPOUR AA - MICROWAVE DIGESTION		RDL Range
Mercury		

Soil (Organic)

BTEX - Soil (039)
ASG016; based on EPA 624, EPA 8260 B

GC/MS - EXTRACTION		RDL Range
Benzene		
Ethylbenzene		
m/p-xylene	(Parameter suspended on 8/11/2008)	
o-xylene	(Parameter suspended on 8/11/2008)	
Toluene		

Soil (Organic)

Petroluem Hydrocarbons (PHC) - Soil (025)
ASG053; CCME REFERENCE METHOD FOR THE CANADA-WIDE STANDARD FOR PETROLEUM HYDROCARBONS IN SOIL - TIER 1 METHOD, 2001

GC/FID - EXTRACTION		RDL Range
F2: C10-C16		
F3: C16-C34		
F4: C34-C50		

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Soil (Organic)

Petroluem Hydrocarbons (PHC) - Soil (038)
ASG053; CCME REFERENCE METHOD FOR THE CANADA-WIDE STANDARD FOR PETROLEUM HYDROCARBONS IN SOIL - TIER 1 METHOD, 2001

GC/FID - PURGE AND TRAP	RDL Range
F1: C6-C10	

Soil/Sediment

Polycyclic Aromatic Hydrocarbons (PAH) - Soil (001)
ASG002; based on EPA 8100

GC/MS - EXTRACTION	RDL Range
Acenaphthene	
Acenaphthylene	
Anthracene	
Benzo (a) anthracene	
Benzo (a) pyrene	
Benzo (b) fluoranthene	
Benzo (g,h,i) perylene	
Benzo (k) fluoranthene	
Chrysene	
Dibenzo (a,h) anthracene	
Fluoranthene	
Fluorene	
Indeno (1,2,3 - cd) pyrene	
Naphthalene	
Phenanthrene	
Pyrene	

Soil/Sediment

Total Petroleum Hydrocarbons (C8-C34) - Soil (010)
ASG010/ASG 064/ ASG 065; based on EPA 3550B, EPA 8015C

GC/FID - EXTRACTION	RDL Range
Total Petroleum Hydrocarbons (C8-C34)	

Soil/Sediment

Trace Elements - Soil (030)
ASG057; based on EPA 6020

ICP/MS	RDL Range
Antimony	.1 - .5 µg/g
Arsenic	
Beryllium	
Cadmium	
Chromium	
Cobalt	
Copper	
Lead	
Nickel	
Uranium	
Uranium-235	
Uranium-238	
Zinc	

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Soil/Sediment (Radiochemistry)

Radionuclide Activity- Soil (007)
ASG030; based on SM 7120 and EPA 901.1.

GAMMA SPECTROSCOPY	RDL Range
Barium-140	
Cerium-144	
Cesium-134	
Cesium-136	
Cesium-137	
Cesium-138	
Iodine-131	
Iodine-132	
Iodine-133	
Iodine-134	
Iodine-135	
Lanthanum-140	
Molybdenum-99	
Niobium-95	
Rubidium-86	
Rubidium-88	
Ruthenium-103	
Ruthenium/Rhodium-106	
Strontium-91	
Tellurium-129m	
Tellurium-131m	
Tellurium-132	
Uranium - 235	
Uranium - 238	
Yttrium-90m	
Yttrium-91m	
Zirconium-95	

Tissue (Radiochemistry)

Radionuclide Activity - Biota (008)
ASG031; based on SM 7120 and EPA 901.1.

GAMMA SPECTROSCOPY	RDL Range
Barium-140	
Cerium-144	
Cesium-134	
Cesium-136	
Cesium-137	
Cesium-138	
Cobalt-60	
Iodine-131	
Iodine-132	
Iodine-133	
Iodine-134	
Iodine-135	
Lanthanum-140	
Molybdenum-99	
Niobium-95	
Rubidium-86	
Rubidium-88	
Ruthenium-103	
Ruthenium/Rhodium-106	
Strontium-91	
Tellurium-129m	
Tellurium-131m	
Tellurium-132	
Yttrium-90m	
Yttrium-91m	

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Zirconium-95

Urine and Water
Alpha/Beta Radiation - Urine and Water (035)
ASG 069; based on RMC-CMR LSC PROCEDURES MANUAL VEC 1.0 (IN-HOUSE)

LIQUID SCINTILLATION COUNTING	RDL Range
Alpha radiation	
Beta radiation	

Water (Inorganic)
Biochemical Oxygen Demand (BOD) - Water (Surface/Sewage/Ground) (019)
ASG042; based on NAQUADAT NO. 08201, EPA 405.1, SM 5210

D.O. METER	RDL Range
BOD (5 day)	

Water (Inorganic)
Conductivity - Water (Drinking/Surface/Sewage/Ground) (016)
ASG038; based on SM 2510, EPA 120.1

CONDUCTIVITY METER	RDL Range
Conductivity (25°C)	

Water (Inorganic)
Dissolved and Extractable Mercury - Water (Ground/Surface/Drinking) (011)
ASG021; based on EPA 7470A

COLD VAPOUR AA - MICROWAVE DIGESTION	RDL Range
Mercury	.1 - .5 µg/L

Water (Inorganic)
Dissolved and Extractable Metals - Water (024)
ASG049; based on EPA 200.8, SM 3125 D

ICP/MS-MICROWAVE EXTRACTION	RDL Range
Aluminum	
Antimony	
Arsenic	
Beryllium	
Boron	
Cadmium	
Chromium	
Cobalt	
Copper	
Lead	
Manganese	
Molybdenum	
Nickel	
Silver	
Strontium	
Thallium	
Tin	
Uranium	
Vanadium	

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Water (Inorganic)
pH - Water (Drinking/Surface/Sewage/Ground) (015)
ASG037; based on SM 4500-H+ B, EPA 150.1

pH METER	RDL Range
pH	

Water (Inorganic)
Solids - Water (Drinking/Surface/Sewage/Ground) (017)
ASG039; based on EPA 160.2, SM 2540D

GRAVIMETRIC	RDL Range
Total Dissolved Solids	
Total Suspended Solids	

Water (Microbiology)
Coliforms - Water (Drinking/Surface/Sewage/Ground) (014)
ASG036; based on MOE MICROMEFDC-E3407, SM 9225

MEMBRANE FILTRATION (DC)	RDL Range
Escherichia coli (E. coli)	
Total Coliforms	

Water (Microbiology)
Fecal Coliforms - Water (Drinking/Surface/Sewage/Ground) (022)
ASG044; based on MOE MICROMEFDC-E3407, SM 9222D

MEMBRANE FILTRATION (m FC)	RDL Range
Fecal (Thermotolerant) Coliforms	

Water (Microbiology)
Heterotrophic Plate Count (HPC) - Water (Drinking/Surface/Sewage/Ground) (023)
ASG041; based on SM 9215D

MEMBRANE FILTRATION	RDL Range
Heterotrophic Plate Count (HPC)	

Water (Organic)
Total PCB - Water (021)
ASG006; based on EPA 8082, EPA 617, FRAME, ET. AL. J. HIGH RESOL. CHROMATOGR., 19: 657-668, 1996.

GC/ECD - EXTRACTION	RDL Range
Total PCB	

Water (Organic)
Total PCB - Water (Surface/Sewage/Ground) (009)
ASG015, ASG022; based on EPA 8082, EPA 617, FRAME, ET. AL. J. HIGH RESOL. CHROMATOGR., 19: 657-668, 1996

GC/MS - EXTRACTION	RDL Range
Total PCB	

Water (Organic)
Volatile Organic Compounds (VOC) - Water (Drinking/Surface/Ground) (012)
ASG023; based on EPA 624, EPA 8260B

GC/MS - PURGE AND TRAP	RDL Range
1,1-Dichloroethane	
1,1-dichloroethylene	
1,1,1-Trichloroethane	
1,1,2-Trichloroethane	

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1,1,2,2-Tetrachloroethane
1,2-dichlorobenzene
1,2-dichloroethane
1,2-Dichloropropane
1,3-Dichloropropane
1,3,5-Trimethylbenzene
1,4-dichlorobenzene
Benzene
Bromodichloromethane
Bromoform
Bromomethane
Carbon Tetrachloride
Chlorobenzene
Chlorodibromomethane
Chloroethane
Chloroform
Chloromethane
cis-1,2-Dichloroethylene
cis-1,3-Dichloropropene
Dichloromethane
Ethylbenzene
Ethylene Dibromide
m/p-xylene
o-xylene
Tetrachloroethylene
Toluene
trans-1,2-Dichloroethylene
trans-1,3-Dichloropropene
Trichloroethylene
Trichlorofluoromethane
Vinyl Chloride

Water (Radiochemistry)
Alpha/Beta Radiation (Swab) (004)
ASG004; RMC-CMR LSC PROCEDURES MANUAL VER. 1.0

LIQUID SCINTILLATION COUNTING	RDL Range
Alpha radiation	
Beta radiation	

Water (Radiochemistry)
Radionuclide Activity - Water (006)
ASG024; based on SM 7120, and EPA 901.1.

GAMMA SPECTROSCOPY		RDL Range
Barium-140		
Cerium-144		
Cesium-134	(Parameter suspended on 7/3/2008)	
Cesium-136		
Cesium-137	(Parameter suspended on 7/3/2008)	
Cesium-138		
Cobalt-60	(Parameter suspended on 7/3/2008)	
Iodine-131		
Iodine-132		
Iodine-133		
Iodine-134		
Iodine-135		
Lanthanum-140		
Molybdenum-99		
Niobium-95		
Rubidium-86		
Rubidium-88		

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Ruthenium-103
Ruthenium/Rhodium-106
Strontium-91
Tellurium-129m
Tellurium-131m
Tellurium-132
Uranium - 235
Uranium - 238
Yttrium-90m
Yttrium-91m
Zirconium-95

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