


Document Front Sheet



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FINAL

**Muskrat Falls Soil Sampling Program
2016**

Submitted to:

Nalcor Energy

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1.0 INTRODUCTION

Amec Foster Wheeler Environment & Infrastructure, a division of Amec Foster Wheeler Americas Limited (Amec Foster Wheeler), was retained by the Lower Churchill Project in December, 2016 to conduct a soil sampling program to determine potential concentrations of total mercury (THg), methyl mercury (MeHg), and organic soil volume within the existing shallow soil horizons of the future reservoir area of Muskrat Falls, Newfoundland and Labrador (NL) (herein referred to as the “site”). Also included are measures of the total organic carbon (TOC) within the existing near surface organic soil horizons to be used to generate estimates of the quantity of TOC available for potential methylation upon inundation. We understand that these estimates of Hg content and TOC are to support further work conducted by others to better understand the potential issue of mercury methylation from the future inundated soils.

2.0 SCOPE OF WORK

The scope of work included collecting soil samples in the future reservoir area, from each of the Ecological Land Classifications (ELCs). The program was designed to obtain samples in approximate proportion to corresponding ELC areas (i.e. higher numbers of samples for the largest ELC areas). Samples were collected according to the sampling protocol outlined in Azimuth (2010).

3.0 METHODOLOGY

In general, the procedure followed the Azimuth (2010) methodology for soil sampling. The sampling design and methodology are described in more detail in the following sections.

3.1 Sampling Design

A total of 11 different Ecological Land Classifications have been identified within the boundary of the Muskrat Falls reservoir area. Mapping of the ELCs within the reservoir is provided in **Appendix A**. To obtain a representative estimate of mean THg, MeHg, and TOC within the future inundated area, the samples were apportioned to each of the ELCs on the basis of their area, but otherwise sites were chosen on a random basis. In total, there are 11 different land classifications that are sub-divided into 1,331 separate ecological land GIS polygons within the Muskrat Falls reservoir area (**Table 1**). The ELC polygons were chosen as units for sample site selection because each is considered a separate habitat area and therefore samples collected relatively close to each other (i.e., from within the same polygon) would be avoided. A total of 45 locations for sampling were identified on the following basis:

- ▶ The total number of sample blocks per ELC were determined based on the percentage of each ELC category.
- ▶ Within each ELC, the specific polygons sampled were chosen using random number generation. It should be noted that the classification “Water” was not included within those selected for sampling as existing river habitat is not considered a type that will contribute new TOC upon

inundation. It also allowed as many samples as possible to be collected from other classifications.

- While the Wetland ELC represents a relatively small proportion of the overall reservoir area, (approximately 2%), additional samples were designated to this classification due to its potential for greater TOC and THg/MeHg contribution.

The number of sample targets within each ELC category are presented in **Table 1** and the specific sample locations are shown on Figures 1-4 in **Appendix A**.

Table 1 Summary of Ecological Land Classifications (ELCs) and sample numbers chosen per ELC.

Ecological Land Classification	ELC Block Counts	Percent of Block Counts	Samples per ELC	Total Area (ha)
Black Spruce/Feathermoss Forest	404	30	12	856
Black Spruce/Lichen Woodland	155	11	5	91
Black Spruce/Sphagnum Woodland	2	0	1 ²	16
Fir-White Spruce Forest	179	13	5	803
Gravel Bar	103	8	3	693
Hardwood Forest	65	5	2	221
Mixedwood Forest	213	16	6	696
Riparian	101	8	3	655
Spruce Fir/Feathermoss Forest	82	6	2	113
Water	461	n/a	0	5690
Wetland	26	2	6 ³	219
Total¹	1,331	100	45	10,053

¹ Excludes blocks associated with Water ELC.

² Each ELC was sampled at least once for inclusion in mean TOC regardless of percent count.

³ Wetland ELC was increased in sample proportion due to potential for higher contribution to TOC.

3.2 Soil Sampling Procedures

Soil sampling was conducted on December 1, 4 and 5, 2016. Each sample location was reached via helicopter, piloted by Canadian Helicopters based out of Goose Bay, NL. Temperatures ranged from -15 °C to - 6 °C for the entire program. The helicopter was grounded due to freezing rain on December 2nd and 3rd.

Of the 45 sample targets, 41 were collected over the course of the three field days. The four samples not collected included: the three samples located on gravel bars that had no soil horizon layer present and one target location (Fir-White Spruce Forest type) was unreachable (BN122). Sample collection locations, with northings and eastings, are summarized in **Table 2**.

As per the procedures outlined in Azimuth (2010), the following steps were completed at each sample location:

1. Collected GPS reading.
2. Removed the Litter (i.e., living or recently deposited vegetation) and fermentation (decomposing but still recognizable) layers, to focus on the humic soil layer where the vast majority of labile carbon and mercury resides (Azimuth, 2010).
3. Used a shovel to cut representative sample blocks of soil from each sample location.
4. Photographed one face of the block with a ruler for scale and the station ID.
5. Recorded the depth of organic soil horizon exposed and collected a representative sample of the humic layer. Samples from the mineral layer was collected at 16 sites.
6. Labelled sample bags.
7. Transferred soil samples from the organic or most organic rich surface horizon into three medium sized Ziploc bags.
8. Collected three sets of duplicate samples for the upper-most horizon sampled.
9. Stored all samples in a cooler.
10. Recorded a brief description of each sample.

At the end of each day of sampling, samples were transferred to a chest freezer. All samples were shipped to St. John's at the end of the field program. Once in St. John's, samples were sorted and all samples from the upper-most humic soil horizon were transported to AGAT Laboratories for analysis. Based on a review of the initial results it was identified that improved detection limits may be required and the samples were shipped in coolers for additional analysis. Additional preparation and analysis was conducted under the direction of Azimuth with further analysis conducted by ALS labs in May 2017.

Preparation included homogenization of subsamples prior to shipment to the ALS laboratory. It is also noted that the follow up analysis was completed at ALS laboratories beyond standard hold times; however, the THg and TOC analysed are not vulnerable to degradation and exceeding hold times for these parameters was not considered consequential.

Table 2 Summary of ELC sample locations, 2016. All samples were analyzed for TOC and Total Mercury.

Sample Name	Ecological Land Classification	Location (UTM) Zones 20 and 21	
		Easting	Northing
AC147A	Black Spruce/Feathermoss Forest	641233.2	5897956
AP126A	Black Spruce/Feathermoss Forest	635941	5894728
BR102A	Black Spruce/Feathermoss Forest	629943.2	5887692
CS79A	Black Spruce/Feathermoss Forest	624184.8	5880984
DP52A	Black Spruce/Feathermoss Forest	617440.4	5875229
DP53A	Black Spruce/Feathermoss Forest	617676.4	5875250
DY36A	Black Spruce/Feathermoss Forest	613462	5872966
DY47A	Black Spruce/Feathermoss Forest	616206.6	5872993
EE40A	Black Spruce/Feathermoss Forest	614436.5	5871427
EJ19A	Black Spruce/Feathermoss Forest	609172	5870272
EK17A	Black Spruce/Feathermoss Forest	608680.2	5870033
N153A	Black Spruce/Feathermoss Forest	642638.4	5901716
AX117A	Black Spruce/Lichen Woodland	633685.1	5892701
BM121A	Black Spruce/Lichen Woodland	634672.3	5888989
DT41A	Black Spruce/Lichen Woodland	614666	5874267
I164A	Black Spruce/Lichen Woodland	645444.1	5902975
K153A	Black Spruce/Lichen Woodland	642704.1	5902459
DQ50A	Black Spruce/Sphagnum Woodland	616959.4	5874977
AW136A	Fir-White Spruce Forest	638484.9	5893009
AX134A	Fir-White Spruce Forest	637935	5892734
AZ132A	Fir-White Spruce Forest	637413.3	5892228
DV46A	Fir-White Spruce Forest	615977.6	5873717
EF27A	Hardwood Forest	611149.8	5871183
W137A	Hardwood Forest	638678.8	5899493
AJ139A	Mixedwood Forest	639175.1	5896244
BN117A	Mixedwood Forest	633692.5	5888717
BQ116A	Mixedwood Forest	633451.9	5887972
BV86A	Mixedwood Forest	625972	5886700
I159A	Mixedwood Forest	644231.1	5902917
K161A	Mixedwood Forest	644630.6	5902520
D153A	Riparian	641733	5899853
DM46A	Riparian	616749	5876019
P152A	Riparian	642450.9	5901243

Sample Name	Ecological Land Classification	Location (UTM) Zones 20 and 21	
		Easting	Northing
EQ29A	Spruce Fir/Feathermoss Forest	611666.3	5868457
ER25A	Spruce Fir/Feathermoss Forest	610691.5	5868227
AW129A	Wetland	636692.1	5893021
AY130A	Wetland	636932.4	5892492
BB122A	Wetland	634980.3	5891742
BF125A	Wetland	635666	5890742
CG83A	Wetland	625215.2	5883970
DH72A	Wetland	622446	5877197

3.3 Laboratory Analysis

Homogenized samples of the humic soil horizon were delivered to ALS laboratories for analysis of TOC, inorganic mercury, and pH. Total mercury in soil is typically dominated by inorganic mercury; however, a subset of samples was also analysed by Flett Laboratories for methylmercury analysis to confirm this assumption. General metals analysis completed by AGAT are also provided for reference (**Appendix D**). Analytical methods for the analyses completed are summarized below with additional descriptions provided in **Appendix B**.

TOC was determined by difference in total carbon (TC) and total inorganic carbon (TIC). TC is measured using a high temperature combustion method, while the TIC is measured separately by acetic acid digestion followed by evaluation against a pH standard curve.

Total mercury (THg) in soil samples involved digestion with nitric and hydrochloric acids, followed by analysis by Cold Vapour Atomic Fluorescence Spectroscopy (CVAFS). Methylmercury (MeHg) was analyzed on a subset of the samples using method M10240: Methyl Mercury in Sediment by Distillation, Aqueous Ethylation, Purge and Trap, and with Automated Instruments.

3.4 Health and Safety

Prior to the start of the field program, a HSE kickoff meeting was held (December 1, 2016) with representatives from Amec Foster Wheeler. An Amec Foster Wheeler Health and Safety Plan was prepared for the program including job hazard analyses (JHA). Daily toolbox forms were completed prior to the start of each field component.

4.0 RESULTS

The following section describes results of sampling and analysis related to quantification of Hg and TOC in soil for this study. These results are being provided to support further interpretation and analysis on mercury methylation to be reported under separate cover. Laboratory certificates of analysis documenting results of this study including additional raw data not interpreted at this time are provided in **Appendix D**.

4.1 Field Observations

Sampling was conducted in early winter weather. The soil, however, was generally not frozen in forested areas and little snow cover was encountered, making sample collection possible. Sampling difficulties were only encountered in ELCs designated as “wetland” or “riparian” in which the soil was highly saturated and therefore frozen. Ideally samples would be collected when seasonal air temperatures are above zero, however project schedules did not allow for work to be completed in warmer temperatures and samples were nevertheless collected successfully and we expect frozen conditions had minimal influence on sample quality. Photos of each field site are included in **Appendix C**.

4.2 Soil Horizon Thickness and Volume Estimate

Measurements of the collected near surface humic soil horizon thicknesses at each sample locations are included in **Table 3** along with TOC concentrations. The TOC results and measurements of the thickness of the humic surface horizon were used to estimate the targeted volume of humic organic material within the Muskrat Falls reservoir area that will be inundated upon creation of the reservoir. The overall aerial extent of each ELC along with its mean surface organic-rich horizon depth, based on the random locations sampled for each ELC, is provided in **Table 4**. The proportional mean of all those ELC types with organics present within the reservoir area (0.08 m) and the overall aerial coverage of these ecotypes (37,100,100 m²) provides an estimate of 2,968,008 m³ of surface organic material within the Muskrat Falls reservoir area (at full supply water elevation of 39 masl). The 95% confidence interval around the mean (0.07-0.10 m) provides a volume estimate range of 2,597,007 – 3,710,010 m³.

Table 3 Thickness of the humic soil horizon and TOC concentrations at each sampling location. Mean values presented along with 95% Confidence Intervals in brackets.

Sample Description	Ecotype	Horizon Thickness (m)	TOC (%)
AC147A	Black Spruce/Feathermoss Forest	0.14	26.55
AP126A	Black Spruce/Feathermoss Forest	0.19	40.10
BR102A	Black Spruce/Feathermoss Forest	0.07	42.60
CS79A	Black Spruce/Feathermoss Forest	0.15	45.70
DP52A	Black Spruce/Feathermoss Forest	0.08	44.65
DP53A	Black Spruce/Feathermoss Forest	0.1	49.95

Sample Description	Ecotype	Horizon Thickness (m)	TOC (%)
DY36A	Black Spruce/Feathermoss Forest	0.1	28.60
DY47A	Black Spruce/Feathermoss Forest	0.05	35.00
EE40A	Black Spruce/Feathermoss Forest	0.04	11.10
EJ19A	Black Spruce/Feathermoss Forest	0.07	44.00
EK17A	Black Spruce/Feathermoss Forest	0.08	32.90
N153A	Black Spruce/Feathermoss Forest	0.06	6.41
AX117A	Black Spruce/Lichen Woodland	0.02	36.05
BM121A	Black Spruce/Lichen Woodland	0.08	18.40
DT41A	Black Spruce/Lichen Woodland	0.05	47.00
I164A	Black Spruce/Lichen Woodland	0.04	9.29
K153A	Black Spruce/Lichen Woodland	0.06	8.84
DQ50A	Black Spruce/Sphagnum Woodland	0.08	45.70
AW136A	Fir-White Spruce Forest	0.12	14.10
AX134A	Fir-White Spruce Forest	0.05	6.67
AZ132A	Fir-White Spruce Forest	0.02	42.90
DV46A	Fir-White Spruce Forest	0.05	44.45
EK27A	Hardwood Forest	0.09	24.80
W137A	Hardwood Forest	0.2	46.85
AJ139A	Mixedwood Forest	0.05	39.00
BN117A	Mixedwood Forest	0.06	42.50
BQ116A	Mixedwood Forest	0.08	47.90
BV86A	Mixedwood Forest	0.06	28.00
I159A	Mixedwood Forest	0.08	5.71
K161A	Mixedwood Forest	0.05	33.50
D153A	Riparian	0	0.37
DM46A	Riparian	0.08	7.24
P152A	Riparian	0.11	1.26
EQ29A	Spruce Fir/Feathermoss Forest	0.15	49.50
ER25A	Spruce Fir/Feathermoss Forest	0.1	33.55
AW129A	Wetland	0.03	8.87
AY130A	Wetland	0.03	42.80
BB122A	Wetland	0.1	15.30
BF125A	Wetland	0.3	41.15
CG83A	Wetland	0.15	33.10
DH72A	Wetland	0.05	29.90
Mean		0.08 (0.07-0.10)	29.57 (24.6-34.5)

4.3 TOC Mass Estimate

The TOC analytical results were further determined on a mass basis interpreted from estimated soil density relationships and considering different depth intervals (0 to 5cm and total measured humic layer).

Bulk density of each sample was calculated using the relationship between TOC and bulk density developed for arctic and sub-arctic samples by Hossain et al. (2015). Since the analytical results (**Table 3**) indicated that both organic soils (>17% TOC) and mineral soils (<17% TOC) were present in the humic soil materials sampled, the bulk soil densities (BD) were first calculated using the overall combined organic and inorganic relationship identified by Hossain et al (2015) which is:

$$BD = 0.071 + 1.322 \exp (-0.071 \times TOC)$$

Bulk densities (BD) were also calculated using the organic soil and mineral soil specific relations provided by Hossain et al (2015) which are:

$$BD = 0.074 + 2.632 \cdot \exp (-0.076 \times TOC) \text{ [organic soils]}$$

$$BD = 0.701 + 0.952 \cdot \exp (-0.29 \times TOC) \text{ [mineral soils]}$$

Applicable soil mass was calculated by multiplying the density by the thickness of the soil horizon and the organic carbon content (t/ha) was calculated from the TOC content of the soil. This was completed for each of the applicable intervals (0 to 5cm and total measured humic layer). For samples where the measured humic layer thickness was less than the calculation interval (0 to 5 cm) an assumed mineral soil with a TOC of 0.5% and density of 1.5 g/cc was inferred for the calculation interval beneath the measured organic layer.

Results were grouped by ecotype and the mean carbon measurements were multiplied by the number of hectares in each ecotype to determine the organic carbon content (t/ha) for the three intervals assessed. It should be noted that the calculations do not account for the presence of coarse inorganic material removed in preparation of the samples as a matter of standard practice (where present). Observations during sampling indicate that the presence of such material was limited. The effect of additional coarse inorganic material would lead to lower organic carbon content than those measured in the samples. All calculations and results are tabulated in **Appendix E**.

Results by Ecotype and totals for the future inundated area are provided in **Table 4**. Total overall organic carbon mass estimates range from approximately 99,000 to 127,000 tonnes of carbon for the top 5 cm of soil to the full humic soil horizon depth, respectively for the full reservoir area (to 39 masl).

Table 4 Estimated Carbon Mass within surface humic soils of the Muskrat Falls Reservoir area at full supply (39 masl) elevation.

Ecotype	Mean Humic Layer Depth (m)	Sum Area (ha) ¹	Mean TOC (%)	Mean Density (g/cc) ³	Mean Density (g/cc) ⁴	Total C (tonnes) ⁵			
						Total Humic Soil Horizon Depth		0 - 5 cm Thickness	
Black Spruce/Feathermoss Forest	0.09	856.3	34.0	0.3	0.3	49,671	66,959	26,039	34,406
Black Spruce/Lichen Woodland	0.05	90.9	23.9	0.5	0.5	3,137	4,152	2,593	3,312
Black Spruce/Sphagnum Woodland	0.08	16.0	45.7	0.1	0.2	716	910	448	569
Fir-White Spruce Forest	0.06	802.5	27.0	0.4	0.5	32,866	40,264	21,931	26,157
Hardwood Forest	0.15	221.4	35.8	0.2	0.3	19,663	27,143	7,168	10,362
Mixedwood Forest	0.06	695.5	30.2	0.3	0.4	27,133	36,326	21,838	30,055
Riparian	0.13	655.1	3.0	1.2	1.3	16,939	16,945	9,114	8,957
Spruce Fir/Feathermoss Forest	0.13	113.5	41.5	0.2	0.2	8,325	11,017	3,388	4,559
Wetland	0.11	219.0	28.5	0.3	0.4	15,498	21,163	6,357	4,559
Anthropogenic / Disturbed ²	n/a	0.0							
Black Spruce on Bedrock Outcropping ²	n/a	0.0							
Gravel Bar ²	0	692.6							
Water ²	n/a	5689.8							
Unvegetated ²	n/a	0.0							
Totals		10054.1				173,949	224,879	98,875	127,000

¹ Coverage is based on GIS mapping of ELC within the Muskrat Falls Reservoir area full supply (39 masl).

² Not applicable for organic volume estimation (no organics present or ELC not present)

³ Density calculated based on Hossain et al (2015) with combined mineral and organic soil equation.

⁴ Density calculated based on Hossain et al (2015) with organic and mineral soil specific equations.

⁵ Range of carbon mass is provided based on the two estimated densities.

4.4 Mercury Concentrations

Total mercury concentrations were relatively low within the soil samples analyzed (**Appendix D**) and ranged between non-detect (<0.005 mg/kg) and 0.194 mg/kg. A comparison between THg values and TOC indicate that a weak positive relationship exists (**Figure 1**). Results that were less than the method detection limit (one sample) were set to the method detection limit of 0.005 mg/kg.

Methylmercury concentrations were very low and ranged between 0.04 and 1.41 ng/g within the subset of soil samples analyzed (**Appendix D**). These values are generally less than one percent of the THg concentrations. Two locations had MeHg concentrations greater than one percent; I159A (Mixedwood forest) had a MeHg concentration of 1.41 ng/g which is approximately 3.1% of THg and CG83A (Wetland) had a MeHg concentration of 0.76 ng/g which is approximately 1.6%.

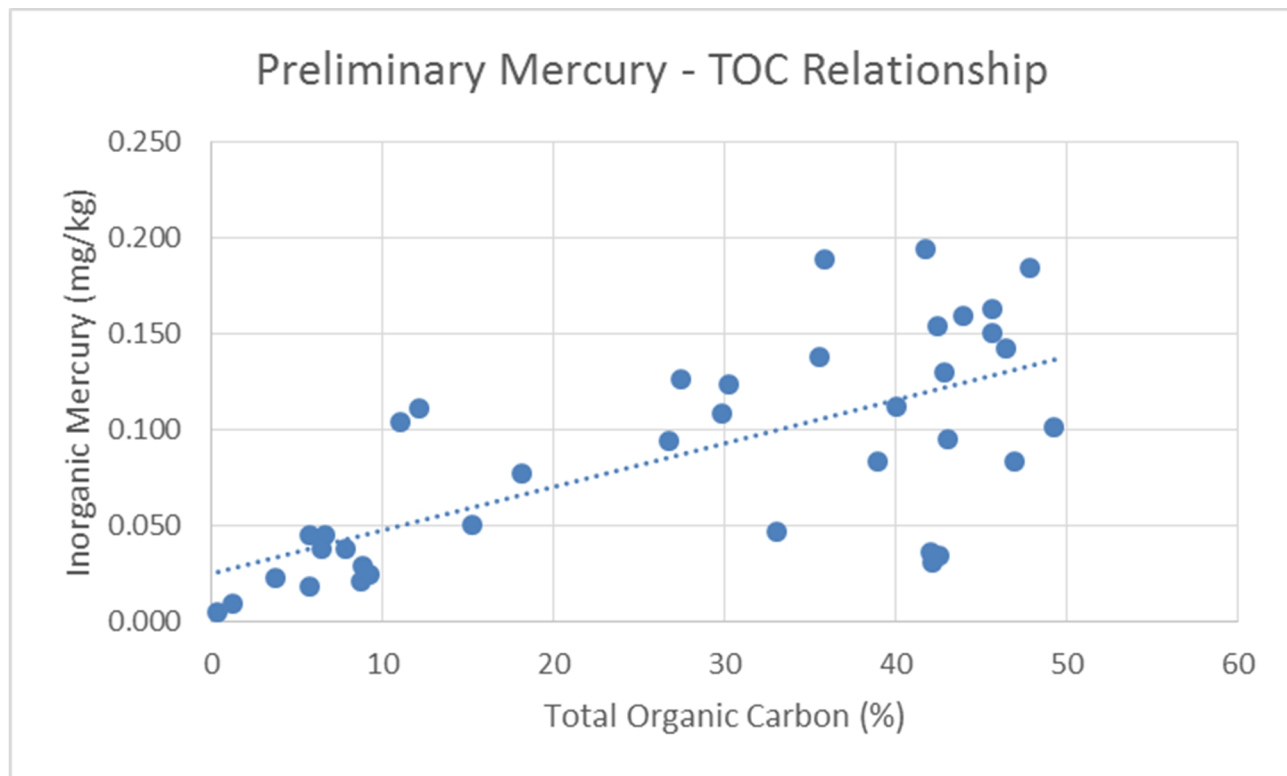


Figure 1 General relationship between TOC and inorganic mercury in soil. Values of method detection limits if results were less than the method detection limit.

5.0 CLOSURE

This report has been prepared for the exclusive use of Nalcor Energy. The project was conducted using standard assessment practices and in accordance with verbal and written requests from the client. No further warranty, expressed or implied, is made. The conclusions presented herein are based solely upon the scope of services and time and budgetary limitations described in our contract. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Amec Foster Wheeler Environment & Infrastructure accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

Yours sincerely,

**Amec Foster Wheeler Environment & Infrastructure,
a Division of Amec Foster Wheeler Americas Limited**

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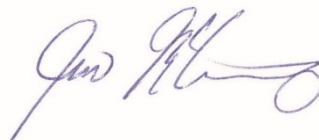


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- Azmith Consulting Group, 2010. Phase 1 Site C Data Collection – Sampling and Analysis Plan. Prepared for BC Hydro for Site C investigations, June, 2010. Project No. BCH-10-01.
- Hossain, M.F., Chen, W., and Zhang, Y. 2015. Bulk density of mineral and organic soils in the Canada's arctic and sub-arctic. Information Processing in Agriculture 2: 183-190.



APPENDIX A: MAPS

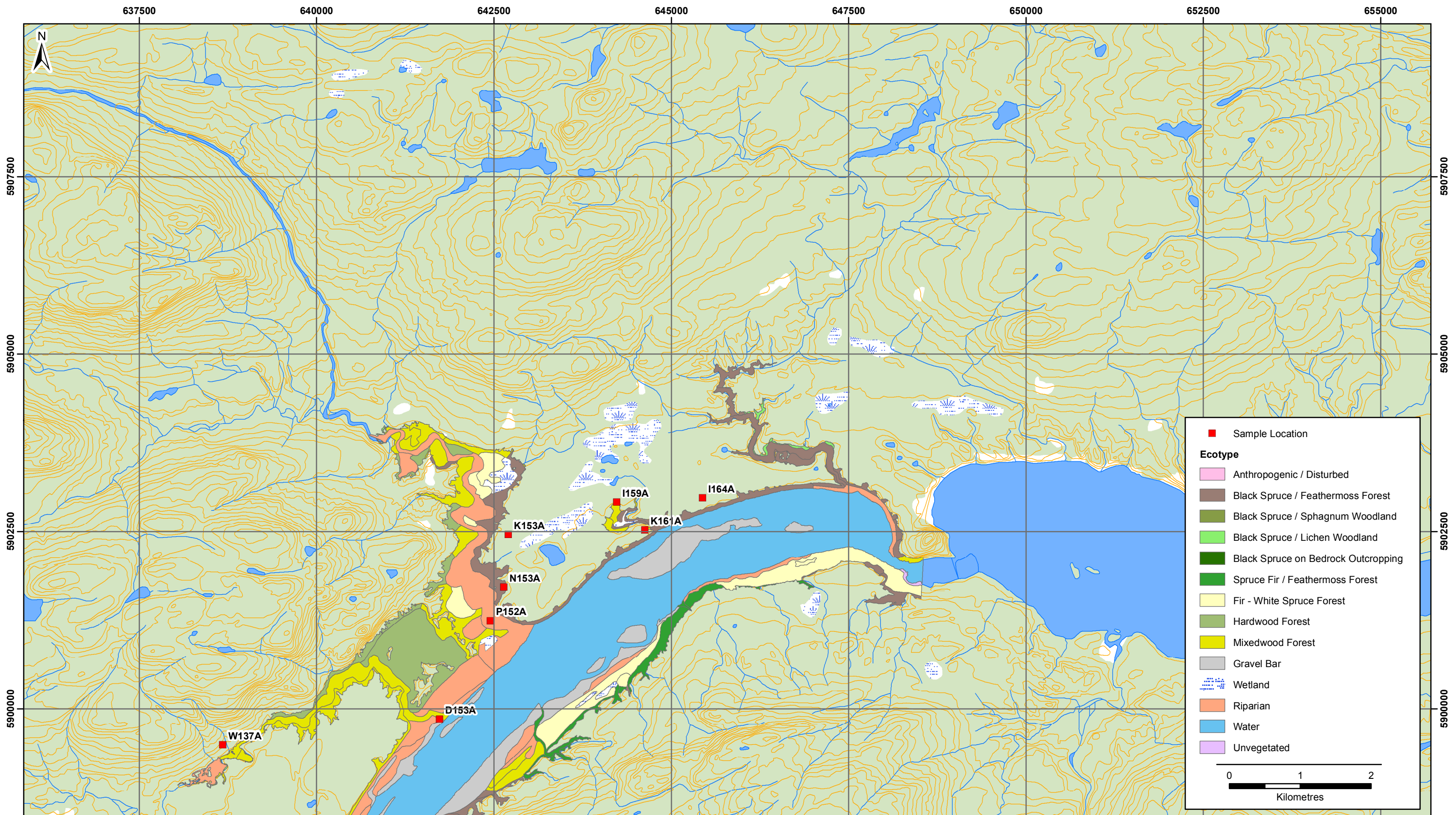


FIGURE 1

RESERVOIR AREA - ECOLOGICAL LAND CLASSIFICATION WITH SAMPLING LOCATIONS

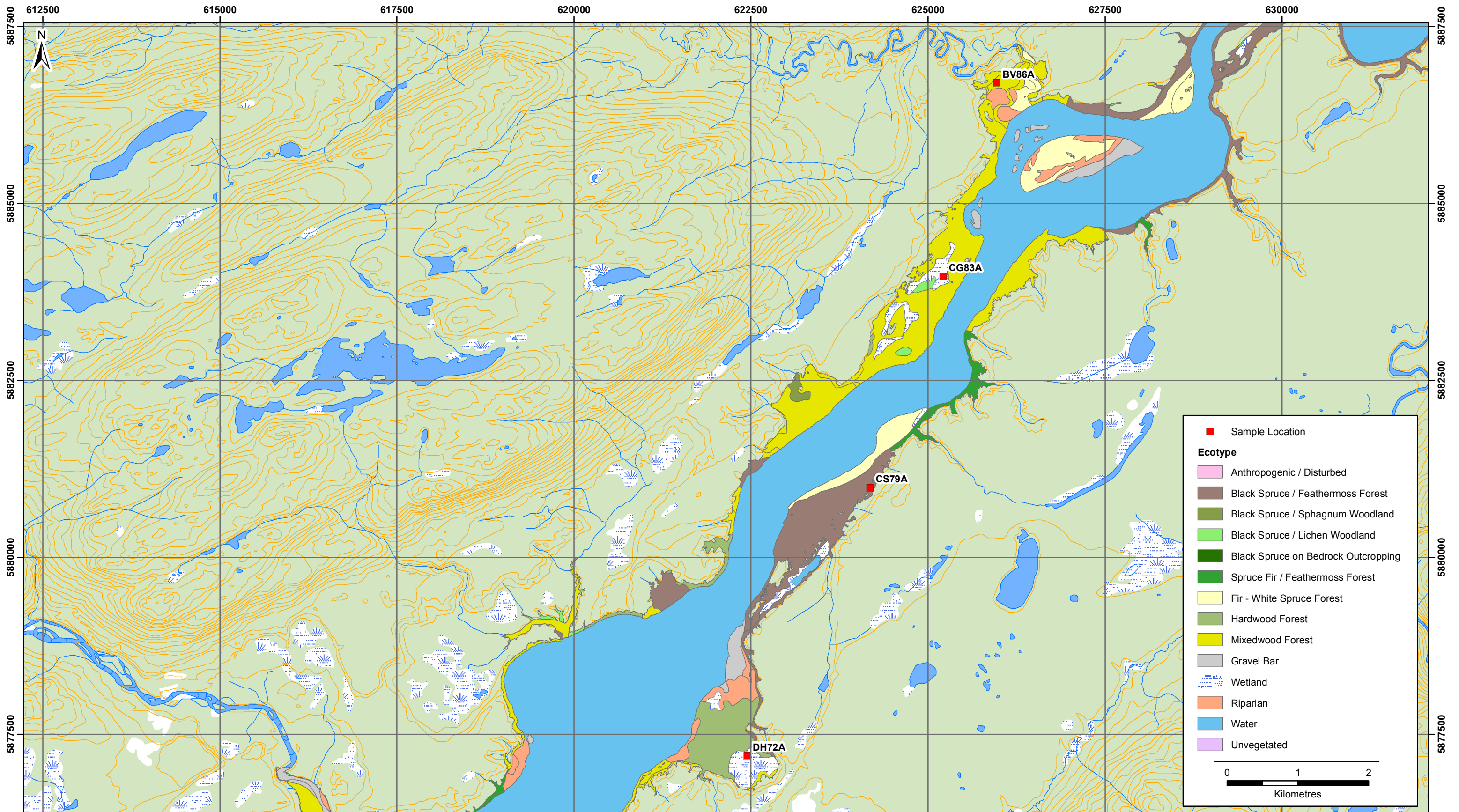


FIGURE 2

RESERVOIR AREA - ECOLOGICAL LAND CLASSIFICATION WITH SAMPLING LOCATIONS

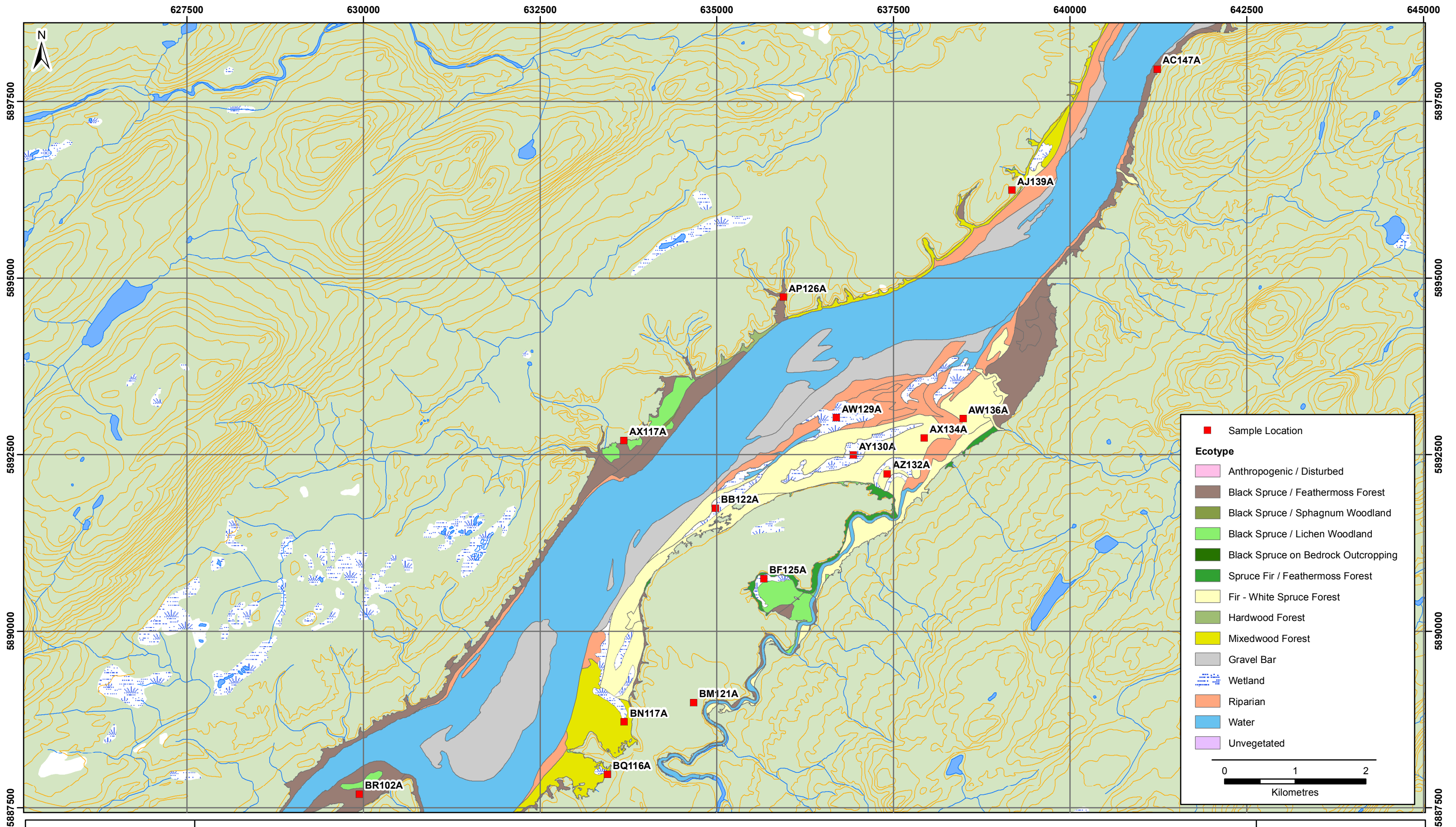


FIGURE 3

RESERVOIR AREA - ECOLOGICAL LAND CLASSIFICATION WITH SAMPLING LOCATIONS

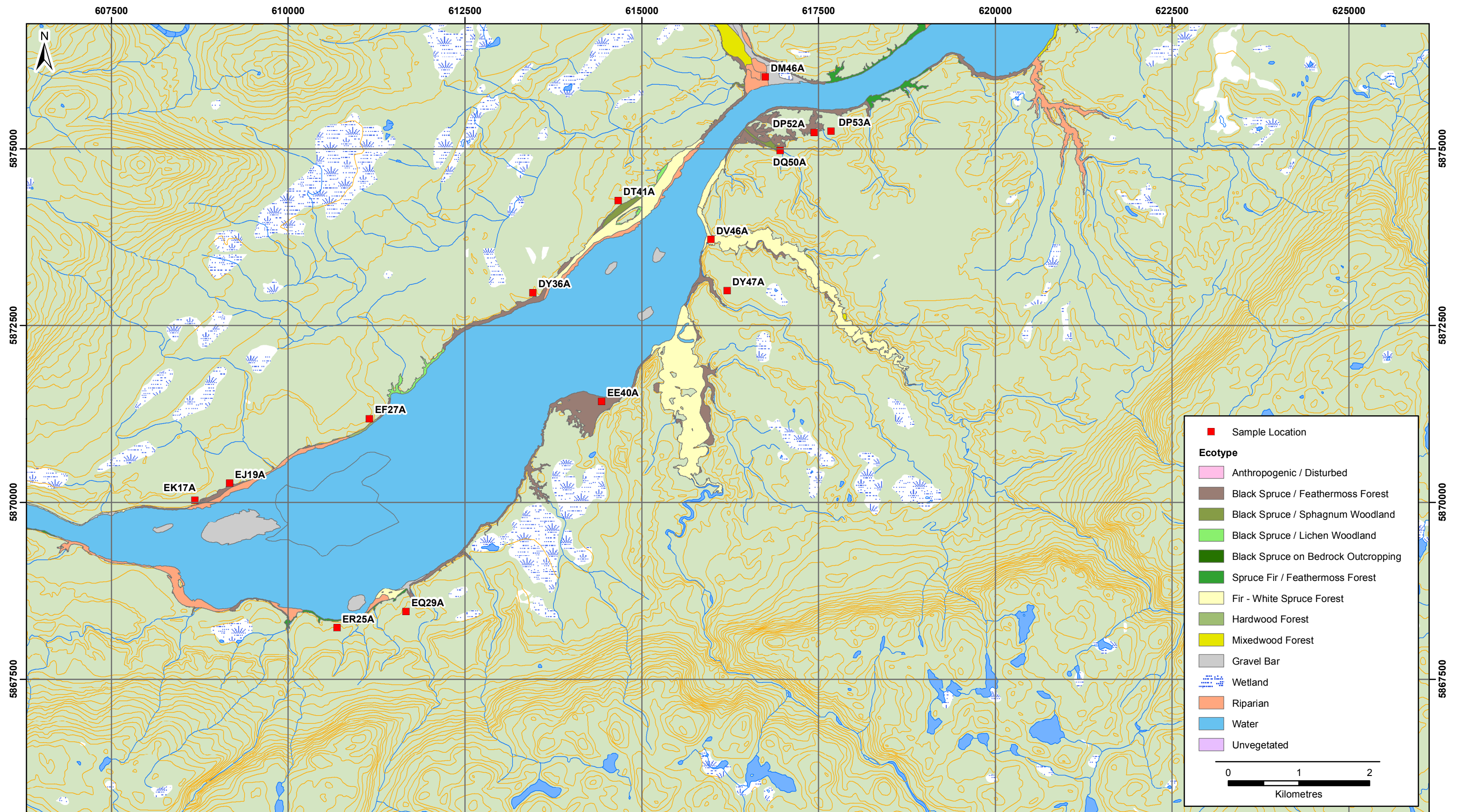


FIGURE 4

RESERVOIR AREA - ECOLOGICAL LAND CLASSIFICATION WITH SAMPLING LOCATIONS



APPENDIX B: LABORATORY METHODS

Method Summary: Total Organic Carbon in Sediment and Soil

Total organic carbon (TOC) is a calculated parameter which is derived from the difference between total carbon (TC) and Total Inorganic Carbon (TIC). TC is measured using a high temperature combustion method (SSSA (1996) Part 3 pg. 973-974) while the TIC is measured separately by acetic acid digestion followed by evaluation against a pH standard curve (CSSS (2008) 20.2).

Sample Preparation:

The sample is dried at <40°C in a forced air oven and then is disaggregated by flail grinder to <2 mm. The sample is then finely ground to <150 µm by mortar and pestle.

Total Carbon by high temperature combustion:

A representative subsample is weighed in a tin capsule. The tin capsule is inserted into a high temperature furnace where the sample is ignited in the presence of oxygen. The resulting gases are carried in a helium stream through an oxidizer tube and reducing tube. The total carbon content is reduced to carbon dioxide which is then detected by a thermal conductivity detector.

Total Inorganic Carbon by acetic acid pH standard curve:

A representative subsample is weighed into a known quantity of acetic acid solution. The acetic acid is consumed by the reaction with carbonates in the soil producing carbon dioxide and water. The pH of the resulting solution is measured by pH meter and compared against a standard curve relating pH to weight of carbonate.

Method 200.2, Revision 2.8: Sample Preparation Procedure for Spectrochemical Determination of Total Recoverable Elements

METHOD 200.2

**SAMPLE PREPARATION PROCEDURE FOR SPECTROCHEMICAL
DETERMINATION OF TOTAL RECOVERABLE ELEMENTS**

**Revision 2.8
EMMC Version**

T.D. Martin, E.R. Martin, and S.E. Long (Technology Applications, Inc.) - Method 200.2, Revision 1.1 (1989)

T.D. Martin, S.E. Long (Technology Applications Inc.), and J.T. Creed - Method 200.2, Revision 2.3 (1991)

T.D. Martin, J.T. Creed, and C.A. Brockhoff - Method 200.2, Revision 2.8 (1994)

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U. S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268**

METHOD 200.2

SAMPLE PREPARATION PROCEDURE FOR SPECTROCHEMICAL DETERMINATION OF TOTAL RECOVERABLE ELEMENTS

1.0 SCOPE AND APPLICATION

- 1.1 This method provides sample preparation procedures for the determination of total recoverable analytes in groundwaters, surface waters, drinking waters, wastewaters, and, with the exception of silica, in solid type samples such as sediments, sludges and soils.¹ Aqueous samples containing suspended or particulate material $\geq 1\%$ (W/V) should be extracted as a solid type sample. This method is applicable to the following analytes:

Analyte		Chemical Abstract Services Registry Number (CASRN)
Aluminum	(Al)	7429-90-5
Antimony	(Sb)	7440-36-0
Arsenic	(As)	7440-38-2
Boron	(B)	7440-42-8
Barium	(Ba)	7440-39-3
Beryllium	(Be)	7440-41-7
Cadmium	(Cd)	7440-43-9
Calcium	(Ca)	7440-70-2
Chromium	(Cr)	7440-47-3
Cobalt	(Co)	7440-48-4
Copper	(Cu)	7440-50-8
Iron	(Fe)	7439-89-6
Lead	(Pb)	7439-92-1
Lithium	(Li)	7439-93-2
Magnesium	(Mg)	7439-95-4
Manganese	(Mn)	7439-96-5
Mercury	(Hg)	7439-97-6
Molybdenum	(Mo)	7439-98-7
Nickel	(Ni)	7440-02-0
Phosphorus	(P)	7723-14-0
Potassium	(K)	7440-09-7
Selenium	(Se)	7782-49-2
Silica ^a	(SiO ₂)	7631-86-9
Silver	(Ag)	7440-22-4
Sodium	(Na)	7440-23-5
Strontium	(Sr)	7440-24-6

^aThis method is not suitable for the determination of silica in solids.

Analyte		Chemical Abstract Services Registry Number (CASRN)
Thallium	(Tl)	7440-28-0
Thorium	(Th)	7440-29-1
Tin	(Sn)	7440-31-5
Uranium	(U)	7440-61-1
Vanadium	(V)	7440-62-2
Zinc	(Zn)	7440-66-6

- 1.2 For reference where this method is approved for use in compliance monitoring programs [e.g., Clean Water Act (NPDES) or Safe Drinking Water Act (SDWA)] consult both the appropriate sections of the Code of Federal Regulation (40 CFR Part 136 Table 1B for NPDES, and Part 141 § 141.23 for drinking water), and the latest Federal Register announcements.
- 1.3 Samples prepared by this method can be analyzed by the following methods given in this supplement: Method 200.7, Determination of Metals and Trace Elements by Inductively Coupled Plasma-Atomic Emission Spectrometry; Method 200.8, Determination of Trace Elements By Inductively Coupled Plasma-Mass Spectrometry; and Method 200.9, Determination of Trace Elements by Stabilized Temperature Graphite Furnace Atomic Absorption Spectrometry. Also, this method can be used prior to analysis by direct aspiration flame atomic absorption for the above list of analytes with the exception of the following: As, B, Hg, P, Se, SiO₂, Th, and U.
- 1.4 The preparation procedures described in this method are *not* recommended prior to analysis by the conventional graphite furnace technique, commonly referred to as "off-the-wall", non-platform or non-delayed atomization. It is believed that the resulting chloride concentration in the prepared solutions can cause either analyte volatilization loss prior to atomization or an unremediable chemical vapor state interference for some analytes when analyzed using the conventional graphite furnace technique.
- 1.5 This method is suitable for preparation of aqueous samples containing silver concentrations up to 0.1 mg/L. For the analysis of wastewater samples containing higher concentrations of silver, succeeding smaller volume, well mixed aliquots must be prepared until the analysis solution contains <0.1 mg/L silver. The extraction of solid samples containing concentrations of silver >50 mg/kg should be treated in a similar manner. Also, the extraction of tin from solid samples should be prepared again using aliquots <1 g when determined sample concentrations exceed 1%.
- 1.6 When using this method for determination of boron and silica in aqueous samples, only plastic or quartz labware should be used from the time of sample collection to the completion of the analysis. For accurate determinations of boron in solid samples only quartz or PTFE beakers should

be used during acid extraction with immediate transfer of an extract aliquot to a plastic centrifuge tube following dilution of the extract to volume. When possible, borosilicate glass should be avoided to prevent contamination of these analytes.

- 1.7 This method will solubilize and hold in solution only minimal concentrations of barium in the presence of free sulfate. For the analysis of barium in samples having varying and unknown concentrations of sulfate, analysis should be completed as soon as possible after sample preparation.
- 1.8 This method is not suitable for the determination of volatile low boiling point organo-mercury compounds.

2.0 SUMMARY OF METHOD

- 2.1 Solid and aqueous samples are prepared in a similar manner for analysis. Nitric and hydrochloric acids are dispensed into a beaker containing an accurately weighed or measured, well mixed, homogeneous aqueous or solid sample. Aqueous samples are first reduced in volume by gentle heating. Then, metals and toxic elements are extracted from either solid samples or the undissolved portion of aqueous samples by covering the beaker with a watch glass and refluxing the sample in the dilute acid mixture for 30 minutes. After extraction, the solubilized analytes are diluted to specified volumes with ASTM Type I water, mixed and either centrifuged or allowed to settle overnight before analysis. Diluted samples are to be analyzed by the appropriate mass and/or atomic spectrometry methods as soon as possible after preparation.

3.0 DEFINITIONS

- 3.1 **Field Reagent Blank (FRB)** - An aliquot of reagent water or other blank matrix that is placed in a sample container in the laboratory and treated as a sample in all respects, including shipment to the sampling site, exposure to the sampling site conditions, storage, preservation, and all analytical procedures. The purpose of the FRB is to determine if method analytes or other interferences are present in the field environment (Section 8.3).
- 3.2 **Solid Sample** - For the purpose of this method, a sample taken from material classified as either soil, sediment or sludge.
- 3.3 **Total Recoverable Analyte** - The concentration of analyte determined to be in either a solid sample or an unfiltered aqueous sample following treatment by refluxing with hot dilute mineral acid.
- 3.4 **Water Sample** - For the purpose of this method, a sample taken from one of the following sources: drinking, surface, ground, storm runoff, industrial or domestic wastewater.

4.0 INTERFERENCES

- 4.1 In sample preparation, contamination is of prime concern. The work area, including bench top and fume hood, should be periodically cleaned in order to eliminate environmental contamination.
- 4.2 Chemical interferences are matrix dependent and cannot be documented previous to analysis.
- 4.3 Boron and silica from the glassware will grow into the sample solution during and following sample processing. For critical determinations of boron and silica, only quartz and/or PTFE plastic labware should be used. When quartz beakers are not available for extraction of solid samples, to reduce boron contamination, immediately transfer an aliquot of the diluted extract to a plastic centrifuge tube for storage until time of analysis. A series of laboratory reagent blanks can be used to monitor and indicate the contamination effect.

5.0 SAFETY

- 5.1 All personnel handling environmental samples known to contain or to have been in contact with human waste should be immunized against known disease causative agents.
- 5.2 The acidification of samples containing reactive materials may result in the release of toxic gases, such as cyanides or sulfides. Acidification of samples should be done in a fume hood.
- 5.3 Material safety data sheets for all chemical reagents should be available to and understood by all personnel using this method. Specifically, concentrated hydrochloric acid and concentrated nitric acid are moderately toxic and extremely irritating to skin and mucus membranes. Use these reagents in a hood whenever possible and if eye or skin contact occurs, flush with large volumes of water. Always wear safety glasses or a shield for eye protection when working with these reagents.^{2,3,4}

6.0 EQUIPMENT AND SUPPLIES

- 6.1 Analytical balance, with capability to measure to 0.1 mg, for use in weighing solids, and for determining dissolved solids in extracts.
- 6.2 Single pan balance, with capability of weighing to 0.01 g, for use in rapid weighing solids and liquids or samples in excess of 10 g.
- 6.3 A temperature adjustable hot plate capable of maintaining a temperature of 95°C.
- 6.4 (Optional) A temperature adjustable block digester capable of maintaining a temperature of 95°C and equipped with 250 mL constricted digestion tubes.

- 6.5 (Optional) A steel cabinet centrifuge with guard bowl, electric timer and brake.
- 6.6 A gravity convection drying oven with thermostatic control capable of maintaining $180^{\circ}\text{C} \pm 5^{\circ}\text{C}$.
- 6.7 (Optional) An air displacement pipetter capable of delivering volumes ranging from 0.1 to 2500 μL with an assortment of high quality disposable pipet tips.
- 6.8 Mortar and pestle, ceramic or nonmetallic material.
- 6.9 Polypropylene sieve, 5-mesh (4 mm opening).
- 6.10 Labware - For determination of trace levels of elements, contamination and loss are of prime consideration. Potential contamination sources include improperly cleaned laboratory apparatus and general contamination within the laboratory environment from dust, etc. A clean laboratory work area designated for trace element sample handling must be used. Sample containers can introduce positive and negative errors in the determination of trace elements by (1) contributing contaminants through surface desorption or leaching, (2) depleting element concentrations through adsorption processes. All reusable labware (glass, quartz, polyethylene, PTFE, FEP, etc.) should be sufficiently clean for the task objectives. Several procedures found to provide clean labware include soaking overnight and thoroughly washing with laboratory-grade detergent and water, rinsing with tap water, and soaking for four hours or more in 20% (V/V) nitric acid or a mixture of dilute nitric and hydrochloric acid (1+2+9), followed by rinsing with ASTM Type I grade water and storing clean.

Note: Chromic acid must not be used for cleaning glassware.

- 6.10.1 Glassware - Volumetric flasks, graduated cylinders, funnels and centrifuge tubes (glass and/or metal free plastic).
- 6.10.2 Assorted calibrated pipettes.
- 6.10.3 Conical Phillips beakers (Corning 1080-250 or equivalent), 250 mL with 50 mm watch glasses.
- 6.10.4 Griffin beakers, 250 mL with 75 mm watch glasses and (optional) 75 mm ribbed watch glasses.
- 6.10.5 (Optional) PTFE and/or quartz beakers, 250 mL with PTFE covers.
- 6.10.6 Evaporating dishes or high-form crucibles, porcelain, 100 mL capacity.
- 6.10.7 Wash bottle - One piece stem, Teflon FEP bottle with Tefzel ETFE screw closure, 125 mL capacity.

7.0 REAGENTS AND STANDARDS

- 7.1 Reagents may contain elemental impurities which might affect analytical data. High-purity reagents should be used whenever possible. All acids used for this method must be of ultra high-purity grade.
- 7.1.1 Nitric acid, concentrated (sp.gr. 1.41).
- 7.1.2 Nitric acid (1+1) -- Add 500 mL conc. nitric acid to 400 mL of ASTM Type I water and dilute to 1 L.
- 7.1.3 Hydrochloric acid, concentrated (sp.gr. 1.19).
- 7.1.4 Hydrochloric acid (1+1) -- Add 500 mL conc. hydrochloric acid to 400 mL of ASTM Type I water and dilute to 1 L.
- 7.1.5 Hydrochloric acid (1+4) -- Add 200 mL conc. hydrochloric acid to 400 mL of ASTM Type I water and dilute to 1 L.
- 7.2 Reagent water -- For all sample preparation and dilutions, ASTM Type I water (ASTM D1193)⁵ is required. Suitable water may be prepared by passing distilled water through a mixed bed of anion and cation exchange resins.
- 7.3 Refer to the appropriate analytical method for the preparation of standard stock solutions, calibration standards, and quality control solutions.

8.0 SAMPLE COLLECTION, PRESERVATION, AND STORAGE

- 8.1 For determination of total recoverable elements in aqueous samples, the samples must be acid preserved prior to aliquoting for either sample processing or determination by direct spectrochemical analysis. For proper preservation samples are *not* filtered, but acidified with (1+1) nitric acid to pH <2. Preservation may be done at the time of sample collection, however, to avoid the hazards of strong acids in the field, transport restrictions, and possible contamination it is recommended that the samples be returned to the laboratory within two weeks of collection and acid preserved upon receipt in the laboratory. Following acidification, the sample should be mixed and held for 16 hours. (Normally, 3 mL of (1+1) nitric acid per liter of sample is sufficient for most ambient and drinking water samples). The pH of all aqueous samples must be tested immediately prior to withdrawing an aliquot for processing to ensure the sample has been properly preserved. If for some reason such as high alkalinity the sample pH is verified to be >2, more acid must be added and the sample held for 16 hours until verified to be pH <2. If properly acid preserved, the sample can be held up to six months before analysis.

Note: When the nature of the sample is either unknown or is known to be hazardous, acidification should be done in a fume hood. See Section 5.2.

- 8.2 Solid samples require no preservation prior to analysis other than storage at 4°C. There is no established holding time limitation for solid samples.
- 8.3 For aqueous samples, a field blank should be prepared and analyzed as required by the data user. Use the same container and acid as used in sample collection.

9.0 QUALITY CONTROL

- 9.1 Each laboratory determining total recoverable elements is required to operate a formal quality control (QC) program. The minimum requirements of a QC program consist of an initial demonstration of laboratory capability, and the analysis of laboratory reagent blanks, fortified blanks and quality control samples as a continuing check on performance. The laboratory is required to maintain performance records that define the quality of data generated.
- 9.2 Specific instructions on accomplishing the described aspects of the QC program are discussed in the analytical methods (Section 1.3).

10. CALIBRATION AND STANDARDIZATION

- 10.1 Not applicable. Follow instructions given in the analytical method selected.

11.0 PROCEDURE

11.1 Aqueous Sample Preparation -- Total Recoverable Analytes

- 11.1.1 For the determination of total recoverable analytes in aqueous samples, transfer a 100 mL (± 1 mL) aliquot from a well mixed, acid preserved sample to a 250 mL Griffin beaker (Sections 1.2, 1.5, 1.6, 1.7, and 1.8). (When necessary, smaller sample aliquot volumes may be used.)

Note: If the sample contains undissolved solids >1%, a well mixed, acid preserved aliquot containing no more than 1 g particulate material should be cautiously evaporated to near 10 mL and extracted using the acid-mixture procedure described in Sections 11.2.3 through 11.2.8.

- 11.1.2 Add 2 mL (1+1) nitric acid and 1.0 mL of (1+1) hydrochloric acid to the beaker containing the measured volume of sample. Place the beaker on the hot plate for solution evaporation. The hot plate should be located in a fume hood and previously adjusted to provide evaporation at a temperature of approximately but no higher than 85°C. (See the following note.) The beaker should be covered with an elevated watch

glass or other necessary steps should be taken to prevent sample contamination from the fume hood environment.

Note: For proper heating adjust the temperature control of the hot plate such that an uncovered Griffin beaker containing 50 mL of water placed in the center of the hot plate can be maintained at a temperature approximately but no higher than 85°C. (Once the beaker is covered with a watch glass the temperature of the water will rise to approximately 95°C.)

- 11.1.3 Reduce the volume of the sample aliquot to about 20 mL by gentle heating at 85°C. DO NOT BOIL. This step takes about two hours for a 100 mL aliquot with the rate of evaporation rapidly increasing as the sample volume approaches 20 mL. (A spare beaker containing 20 mL of water can be used as a gauge.)
- 11.1.4 Cover the lip of the beaker with a watch glass to reduce additional evaporation and gently reflux the sample for 30 minutes. (Slight boiling may occur, but vigorous boiling must be avoided to prevent loss of the HCl-H₂O azeotrope.)
- 11.1.5 Allow the beaker to cool. Quantitatively transfer the sample solution to a 50 mL volumetric flask, make to volume with reagent water, stopper and mix.
- 11.1.6 Allow any undissolved material to settle overnight, or centrifuge a portion of the prepared sample until clear. (If after centrifuging or standing overnight the sample contains suspended solids that would clog the nebulizer, a portion of the sample may be filtered for their removal prior to analysis. However, care should be exercised to avoid potential contamination from filtration.) The sample is now ready for analysis by either inductively coupled plasma-atomic emission spectrometry or direct aspiration flame and stabilized temperature graphite furnace atomic absorption spectroscopy (Sections 1.3 and 1.4).
- 11.1.7 To ready the sample for analyses by inductively coupled plasma-mass spectrometry (Section 1.3), adjust the chloride concentration by pipetting 20 mL of the prepared solution into a 50 mL volumetric flask, dilute to volume with reagent water and mix. (If the dissolved solids in this solution are >0.2%, additional dilution may be required to prevent clogging of the extraction and/or skimmer cones. Internal standards are added at the time of analysis.)
- 11.1.8 Because the effects of various matrices on the stability of diluted samples cannot be characterized, all analyses should be performed as soon as possible after the completed preparation.

11.2 Solid Sample Preparation -- Total Recoverable Analytes

- 11.2.1 For the determination of total recoverable analytes in solid samples, mix the sample thoroughly and transfer a portion (>20 g) to tared weighing dish, weigh the sample and record the wet weight. (For samples with <35% moisture a 20 g portion is sufficient. For samples with moisture >35% a larger aliquot 50-100 g is required.) Dry the sample to a constant weight at 60°C and record the dry weight for calculation of percent solids (Section 12.1). (The sample is dried at 60°C to prevent the loss of mercury and other possible volatile metallic compounds, to facilitate sieving, and to ready the sample for grinding.)
- 11.2.2 To achieve homogeneity, sieve the dried sample using a 5-mesh polypropylene sieve and grind in a mortar and pestle. (The sieve, mortar and pestle should be cleaned between samples.) From the dried, ground material weigh accurately a representative 1.0 ± 0.01 g aliquot (W) of the sample and transfer to a 250 mL Phillips beaker for acid extraction (Sections 1.5, 1.6, 1.7, and 1.8).
- 11.2.3 To the beaker add 4 mL of (1+1) HNO₃ and 10 mL of (1+4) HCl. Cover the lip of the beaker with a watch glass. Place the beaker on a hot plate for reflux extraction of the analytes. The hot plate should be located in a fume hood and previously adjusted to provide a reflux temperature of approximately 95°C. (See the following note.)
- Note:** For proper heating adjust the temperature control of the hot plate such that an uncovered Griffin beaker containing 50 mL of water placed in the center of the hot plate can be maintained at a temperature approximately but no higher than 85°C. (Once the beaker is covered with a watch glass the temperature of the water will rise to approximately 95°C.) Also, a block digester capable of maintaining a temperature of 95°C and equipped with 250 mL constricted volumetric digestion tubes may be substituted for the hot plate and conical beakers in the extraction step.
- 11.2.4 Heat the sample and gently reflux for 30 minutes. Very slight boiling may occur, however vigorous boiling must be avoided to prevent loss of the HCl-H₂O azeotrope. Some solution evaporation will occur (3-4 mL).
- 11.2.5 Allow the sample to cool and quantitatively transfer the extract to a 100 mL volumetric flask. Dilute to volume with reagent water, stopper and mix.
- 11.2.6 Allow the sample extract solution to stand overnight to separate insoluble material or centrifuge a portion of the sample solution until clear. (If after centrifuging or standing overnight the extract solution contains suspended solids that would clog the nebulizer, a portion of the extract solution may be filtered for their removal prior to analysis. However, care should be exercised to avoid potential contamination

from filtration.) The sample is now ready for analysis by either inductively coupled plasma-atomic emission spectrometry or direct aspiration flame and stabilized temperature graphite furnace atomic absorption spectroscopy (Sections 1.3 and 1.4).

11.2.7 To ready the sample for analyses by inductively coupled plasma-mass spectrometry (Section 1.3), adjust the chloride concentration by pipetting 10 mL of the prepared solution into a 50 mL volumetric flask, dilute to volume with reagent water and mix. (If the dissolved solids in this solution are >0.2%, additional dilution may be required to prevent clogging of the extraction and/or skimmer cones. Internal standards are added at the time of analysis.)

11.2.8 Because the effects of various matrices on the stability of diluted samples cannot be characterized, all analyses should be performed as soon as possible after the completed preparation.

11.3 Sample Analysis -- Use an analytical method listed in Section 1.3.

12.0 DATA ANALYSIS AND CALCULATIONS

12.1 To report percent solids in solid samples (Section 11.2) calculate as follows:

$$\% \text{ solids (S)} = \frac{DW}{WW} \times 10$$

where:

DW = Sample weight (g) dried at 60°C
WW = Sample weight (g) before drying

Note: If the data user, program or laboratory requires that the reported percent solids be determined by drying at 105°C, repeat the procedure given in Section 11.2.1 using a separate portion (>20 g) of the sample and dry to constant weight at 103-105°C.

12.2 Calculation and treatment of determined analyte data are discussed in analytical methods listed in Section 1.3.

13.0 METHOD PERFORMANCE

13.1 Not applicable. Available data included in analytical methods listed in Section 1.3.

14.0 POLLUTION PREVENTION

- 14.1 Pollution prevention encompasses any technique that reduces or eliminates the quantity or toxicity of waste at the point of generation. Numerous opportunities for pollution prevention exist in laboratory operation. The EPA has established a preferred hierarchy of environmental management techniques that places pollution prevention as the management option of first choice. Whenever feasible, laboratory personnel should use pollution prevention techniques to address their waste generation. When wastes cannot be feasibly reduced at the source, the Agency recommends recycling as the next best option.
- 14.2 For information about pollution prevention that may be applicable to laboratories and research institutions, consult "Less is Better: Laboratory Chemical Management for Waste Reduction", available from the American Chemical Society's Department of Government Relations and Science Policy, 1155 16th Street N.W., Washington D.C. 20036, (202)872-4477.

15.0 WASTE MANAGEMENT

- 15.1 The Environmental Protection Agency requires that laboratory waste management practices be conducted consistent with all applicable rules and regulations. The Agency urges laboratories to protect the air, water, and land by minimizing and controlling all releases from hoods and bench operations, complying with the letter and spirit of any sewer discharge permits and regulations, and by complying with all solid and hazardous waste regulations, particularly the hazardous waste identification rules and land disposal restrictions. For further information on waste management consult "The Waste Management Manual for Laboratory Personnel", available from the American Chemical Society at the address listed in the Section 14.2.

16.0 REFERENCES

1. Martin, T.D. and E.R. Martin, "Evaluation of Method 200.2 Sample Preparation Procedure for Spectrochemical Analyses of Total Recoverable Elements", December 1989, U.S. Environmental Protection Agency, Office of Research and Development, Environmental Monitoring Systems Laboratory, Cincinnati, Ohio 45268.
2. "OSHA Safety and Health Standards, General Industry", (29 CFR 1910), Occupational Safety and Health Administration, OSHA 2206, revised January 1976.
3. "Safety in Academic Chemistry Laboratories", American Chemical Society Publication, Committee on Chemical Safety, 3rd Edition, 1979.
4. "Proposed OSHA Safety and Health Standards, Laboratories", Occupational Safety and Health Administration, Federal Register, July 24, 1986.
5. Annual Book of ASTM Standards, Volume 11.01.

1.2.1 Strong Acid Leachable Metals (SALM) in Soil - Prescriptive

Parameters Metals in Soil and Sediment.

Parameter List & EMS Codes This method is applicable to the following parameters:

Parameter	EMS Code	Parameter	EMS Code	Parameter	EMS Code
Aluminum	AL-T	Iron	FE-T	Silver	AG-T
Antimony	SB-T	Lead	PB-T	Sodium	NA-T
Arsenic	AS-T	Lithium	LI-T	Strontium	SR-T
Barium	BA-T	Magnesium	MG-T	Sulfur	S-T
Beryllium	BE-T	Manganese	MN-T	Thallium	TL-T
Boron	B-T	Mercury	HG-T	Thorium	TH-T
Cadmium	CD-T	Molybdenum	MO-T	Tin	SN-T
Calcium	CA-T	Nickel	NI-T	Titanium	TI-T
Chromium	CR-T	Phosphorus	P-T	Uranium	U-T
Cobalt	CO-T	Potassium	K-T	Vanadium	V-T
Copper	CU-T	Selenium	SE-T	Zinc	ZN-T

Other metals may be analyzed by this method if acceptable performance is demonstrated and validated. This method is not suitable for the determination of silica or silicon.

Analytical Method Nitric – Hydrochloric acid digestion, Instrumental analysis.

Introduction This revised method was prepared for BC MOE by the BCELTA to provide improved consistency of results for metals in soil, in support of the Waste Management Act, Contaminated Sites Regulation (CSR). All definitive elements of the method have been prescribed to minimize inter-laboratory variability, particularly for incompletely recovered elements like barium.

The BC CSR includes Water and Soil as matrix types, but Soil is only broadly defined (CSR, section 1). Carter's definition of Soil (Reference: Carter) as being "less than 2 mm" material is used for this method.

This method may also be used for marine and freshwater sediment applications, where sediment is defined as being "less than 63 µm" material. However, by default, laboratories are instructed to apply the method on the "less than 2 mm" fraction, except by special request.

This method uses a mixture of nitric acid, hydrochloric acid, and de-ionized water, with a standardized digestion time and temperature. Laboratories are allowed some flexibility regarding apparatus and heating methods, but variations in acid mixture composition, digestion time, or digestion temperature are not permitted.

Method Summary Samples are dried at ≤ 60°C, sieved, and digested with a mixture of nitric acid, hydrochloric acid, and de-ionized water. Instrumental analysis of sample extracts can be performed by a variety of analytical methods.

This method provides the sample preparation procedure for the analysis of Total Metals, as referenced within the BC CSR. Total Metals does not imply a complete dissolution of silicate materials, as would occur with digestions using perchloric and hydrofluoric acids. The strong acid leach prescribed by this method is intended to dissolve those metals that may be environmentally available. The method achieves

near complete recoveries of some important metals, but many others are only partially recovered (see Table 1 for examples). Metals not dissolved with this method are unlikely to be of environmental consequence.

This method is prescriptive. It must be followed exactly as described. Where minor deviations are permitted, this is indicated in the text. All results must be reported on a dry weight basis.

Method Limitations This method does not dissolve all silicate materials and may result in a partial extraction, depending on the sample matrix, for some metals, including, but not limited to aluminum, barium, beryllium, chromium, strontium, titanium, thallium, and vanadium.

Unpublished studies by some BC laboratories have shown that dissolved antimony and tin may re-sorb to undigested solids over time after the sample extract has been diluted. Once the solids have been removed from the sample extract, antimony and tin are more stable.

This method is suitable for the digestion of samples with silver concentrations of up to 0.5 mg/L in the sample extract after dilution to final volume, which is equivalent to 50 mg/kg in soils, based on a one gram sample size and 100 mL final volume (Reference: US EPA 200.2).

This method is suitable for digesting samples with tin concentrations of up to 100 mg/L in the sample extract after dilution to final volume, which is equivalent to 1% in soils, using a one gram sample size and 100 mL final volume (Reference: US EPA 200.2).

The solubility and stability of barium is limited in the presence of free sulfate using this method (Reference: US EPA 200.2).

Matrix Soil and sediment

Interferences and Precautions The interferences encountered will differ depending on the instrumental method used to analyze the sample extracts. These interferences should be clearly outlined and controlled in the analysis procedure. High concentrations of acids may cause physical interferences with some instrumental techniques.

Sampling, Handling, & Preservation Sampling should be done by qualified personnel. Samples must be collected and stored such that degradation or alteration of the sample is minimized. Collect the sample in a clean polyethylene or glass container, and tightly cap immediately after sampling.

Preservation: **None**

Stability **Holding Time:**
Metals (except Mercury): 180 days
Mercury: 28 days

When tin and antimony analyses are required, the sample extracts must be separated from the undigested solids within 4 hours of diluting to final volume. The decanted or filtered sample extract must be analyzed within 7 days.

Results reported for samples digested beyond holding times must be qualified.

Storage: No requirement for storage temperature. Ambient storage temperature conditions are suitable.

Equipment and Supplies

1. Heating source (e.g. block digester, hotplate, water bath) capable of maintaining a sample extract temperature of $95 \pm 5^\circ\text{C}$.
2. Balance, minimum 3 place.
3. Drying oven (not required).
4. Sieve, 2 mm (ASTM-E11 Sieve No. 10, US Sieve No. 10, Tyler 9 Mesh) or Sieve, 63 μm (ASTM-E11 Sieve No. 230, US Sieve No. 230, Tyler 250 Mesh). It is recommended that a stainless steel screen/sieve with all tin solder be used. Sieves must not be constructed of brass or contain lead solder. Polypropylene or nylon sieves may also be used.
5. Acid dispensers.
6. Vapor refluxing cover to fit digestion vessel (e.g. reflux cover, watch glass etc.).
7. Digestion vessels (e.g. block digester tube, beaker, flask, etc.).
8. Gloves.
9. Spatula.

Reagents

1. Nitric acid (HNO_3) conc. (67 - 70%), reagent grade minimum.
2. Nitric acid (1+1) – add 500 mL concentrated HNO_3 to 400 mL de-ionized water and dilute to 1 L.
3. Hydrochloric acid (HCl) conc. (34 - 37%), reagent grade minimum.
4. Hydrochloric acid (1+1) – add 500 mL concentrated HCl to 400 mL de-ionized water and dilute to 1 L.
5. Water, de-ionized (ASTM Type I or equivalent recommended).

Safety

Nitric and hydrochloric acid must not be premixed; they should be added individually to each sample vessel. Mixtures of nitric and hydrochloric acid must not be stored in closed containers.

Wear appropriate PPE (Personal Protective Equipment) including lab coat, gloves, and safety glasses. Add acids to samples and perform digestions under a fume hood.

Procedure

Samples are prepared and digested using the following procedures:

Sample Homogenization and Sub-Sampling

1. Inspect the sample and record any unusual or significant characteristics (e.g. lead shot pellets, metal turnings, nails, shells, etc).
2. Remove any obviously foreign material such as vegetation.
3. If the sample has separated into visually discrete layers (e.g. aqueous, organic, and sediment phases), the entire sample must be homogenized prior to sub-sampling. The aqueous phase must not be decanted.

Note: Special project requirements may involve alternative procedures such as decanting of the aqueous fraction. Indicate any departures or deviations from the prescribed method with a qualifying statement in the laboratory report.

4. Homogenize the entire sample by vigorous stirring using a spatula. If it is not possible to homogenize the sample in the container it was received in, the sample can be transferred to a larger container prior to homogenization. Clean the spatula and mixing container between samples.
5. Where moisture determination is required, a separate sub-sample must be taken prior to drying and sieving.

Sample Preparation – Drying

1. Dry the sample to a constant weight at a temperature of $\leq 60^{\circ}\text{C}$. Freeze drying is acceptable.

Note: Sample drying temperature must not exceed 60°C to minimize volatilization of analytes such as mercury (Reference: US EPA 200.2).

2. Alternatively, moist or wet samples may be wet-sieved. If a sample is sieved when moist, a moisture determination must be done on the sieved portion (not on the “as received” sample) in order to convert results to dry weight.

Sample Preparation – Sieving

1. Sieve each sample through a 2 mm sieve. By special request, some sediment applications may require the use of a $63\ \mu\text{m}$ sieve. If a $63\ \mu\text{m}$ sieve is used, this must be indicated on the laboratory report. DO NOT pulverize samples to pass through either sieve type. Easily friable materials (dried clay clods, disintegrating rock, etc.) should be disaggregated prior to screening. Where necessary, non-pulverizing disaggregating tools like rolling mills, mortar and pestle, or flail grinders may be used.
2. Where available, it is recommended that a minimum of 25 grams of sample is sieved to ensure representative sub-sampling for the digestion stage.
3. Discard the portion of sample that did not pass through the sieve.
4. Field sampling personnel may pre-screen the samples in the field.

Sample Preparation - Digestion

1. Weigh $1.0 \pm 0.1\ \text{g}$ (dry weight) of sample into a digestion vessel, which must be fitted with a cap that supports open vessel reflux action (e.g. hotblock digestion tube, beaker, or Erlenmeyer flask with watch glass). At minimum, include Method Blanks, Lab Duplicates, and Reference Materials with each batch of samples. Laboratory Control Samples are also recommended. Weights must be recorded using a minimum 3 place balance.

Note: In cases where one gram of sieved sample is not available, perform the analysis as described, and qualify the results (results for poorly recovered metals like Barium may be increased).

2. Add $5 \pm 0.2\ \text{mL}$ de-ionized water, $2.5 \pm 0.2\ \text{mL}$ concentrated HNO_3 , and $2.5 \pm 0.2\ \text{mL}$ concentrated HCl . Alternatively, add $5.0 \pm 0.2\ \text{mL}$ of HNO_3 (1+1) and $5.0 \pm 0.2\ \text{mL}$ of HCl (1+1).
3. Add a reflux cap to the top of the digestion vessel. Swirl acid and sample to mix gently. It is permitted to allow samples to cold digest prior to heating to reduce any potential effervescence from reactive samples.
4. Digest samples for 2 hours ± 15 minutes at a temperature of $95 \pm 5^{\circ}\text{C}$ at atmospheric pressure. A digestion block or waterbath are the preferred methods of heating. The heat for digestion must maintain the sample extract temperature at $95 \pm 5^{\circ}\text{C}$. This refers to the temperature of the sample extract in a digestion vessel covered with a reflux cap, not the temperature setting on the heating source, and not the temperature of an uncovered digestion vessel.

It is recommended that the sample extract temperature be monitored and recorded with each batch.

5. Allow the sample to cool and dilute the entire sample with de-ionized water to the volume required for the analysis. The dilution volume will depend on the analytical method and objectives. Typical final dilution volumes will be 25 mL, 50 mL, or 100 mL. Include all undigested solid material as part of the final diluted volume. Sample extracts should not be stored in glass.
6. When tin and antimony analyses are required, sample extracts must be separated from the undigested solids within 4 hours of diluting to final volume. The decanted or filtered sample extract must be analyzed within 7 days. These steps are necessary to minimize tin and antimony losses due to re-sorption.
7. Analyze the final extract using appropriate analytical methods and report the results on a dry weight basis.
8. Report any anomalies observed during the digestion and analysis.

Quality Control

Summary of QC Requirements		
Method QC Component	Minimum Frequency	Minimum Data Quality Objectives*
Method Blank	1 per batch (max 20 samples)	Less than reported DL
Reference Material	1 per batch (max 20 samples)	70 - 130% of the laboratory's long term mean value (see validation section for additional requirements)
Laboratory Control Sample (recommended)	1 per batch (recommended)	80 - 120% (recommended)
Lab Duplicates	1 per batch (max 20 samples)	≤ 30% RPD for all metals except those indicated below ≤ 40% RPD (Ag, Al, Ba, Hg, K, Mo, Na, Pb, Sn, Sr, Ti)
Field Duplicates	Recommended	None Specified

* Minimum DQOs apply to individual QC samples, not averages, and only at levels above 10x MDL. Laboratories must report qualified data when DQOs are not met.

QC Details

Reference Material requirements: Any suitable RM (including in-house RMs) may be utilized for this method for routine Quality Control purposes, but the RMs listed below under validation requirements are recommended. RMs provide QC data that includes digestion elements of the method and which is representative of method performance for typical samples.

Laboratory Control Sample: Recommended 1 per batch. An LCS for this method is a spiked Method Blank (no blank matrix exists for metals in soils). An LCS has more precisely defined targets than soil RMs, can cover all parameters reported by the method, and allows for better and more precise Quality Control of basic elements of the method (e.g. volumetric precision and controls and instrumental analysis).

Method Validation Requirements

Initial Method Validation requirements as outlined below must be completed before this method may be used to generate results for unknown samples. The method must be re-evaluated periodically (every two years is recommended as a suitable frequency). Prepared validation samples must be analyzed by all instrument methods used for routine analysis.

Demonstration of Accuracy and Precision

Prepare and analyze at least 8 replicates of at least two of the following Certified Reference Materials:

- NRC PACS-2
- CCRMP TILL-1
- CCRMP TILL-3
- SCP Science SS-2

Where the above RMs are utilized for routine QC purposes, re-validations should be conducted using all routine QC data available for the review period.

Accuracy is measured as Percent Recovery versus the Interim Targets outlined in Table 1. For each metal, average accuracy must be within 70-130% of the Interim Targets, for results ≥ 5 times the Reported Detection Limit. Precision must be $<15\%$ RSD for results ≥ 5 times the Reported Detection Limit.

The Interim SALM Targets and DQOs may be re-assessed in the future if RMs become unavailable or if otherwise required.

References

US EPA Method 200.2, Sample Preparation Procedure for Spectrochemical Determination of Total Recoverable Elements, National Exposure Research Laboratory, Office of Water, US EPA, Cincinnati, OH, October 1999.

Soil Sampling and Methods of Analysis, Carter, M.R., editor, for Canadian Society of Soil Science, Lewis Publishers, 1993.

Revision History

- | | |
|--------------|--|
| Nov 6, 2015 | Changed storage temperatures to be consistent with current BC MOE requirements. Removed requirement for minimum one hour cold digestion (not necessary with version 2 of SALM method). Added LCS to QC and Procedure sections (recommended). Removed unnecessary references. |
| July 7, 2009 | Version 2 of BC SALM Method for 2009 BC Lab Manual. Method revised from performance based to prescriptive. All key defining elements of the method are now prescribed. New interim RM targets assigned. |
| Feb 2001 | Version one of BC SALM Method was introduced. Incorporated into Lab Manual November 2002. |

TABLE 1. Interim Target Values for Reference Materials using BC SALM^(a)

Parameter	CCRMP TILL-1 Certified ("Total")	CCRMP TILL-1 SALM Interim Target	CCRMP TILL-3 Certified ("Total")	CCRMP TILL-3 SALM Interim Target	NRC PACS-2 Certified ("Total")	NRC PACS-2 SALM Interim Target	SCP Science SS-2 EPA3050A Digestion Targets	SCP Science SS-2 SALM Interim Target
Aluminum - Al (%)	7.25	1.82	6.45	1.15	6.62	1.75	1.33	1.37
Antimony - Sb (mg/kg)	7.8	6.27	0.9	0.724	11.3	7.3	-	4.16
Arsenic - As (mg/kg)	18	15.4	87	82.1	26.2	23.3	75	88.4
Barium - Ba (mg/kg)	702	80.6	489	40	-	294	215	224
Beryllium - Be (mg/kg)	2.4	0.544	2.0	0.369	1.0	0.408	-	-
Boron - B (mg/kg)	-	-	-	-	-	38.1	-	-
Cadmium - Cd (mg/kg)	< 0.2 ^(b)	-	< 0.2 ^(b)	-	2.11	1.98	-	2.2
Calcium - Ca (%)	1.94	0.332	1.88	0.517	1.96	0.779	11.3	12.3
Chromium - Cr (mg/kg)	65	27.2	123	63.1	90.7	48.1	34	34.6
Cobalt - Co (mg/kg)	18	12.5	15	10.4	11.5	8.75	12	13.1
Copper - Cu (mg/kg)	47	44.9	22	19.8	310	297	191	211
Iron - Fe (%)	4.81	3.33	2.78	2.02	4.09	3.12	2.10	2.53
Lead - Pb (mg/kg)	22	14.4	26	17.3	183	167	126	132
Lithium - Li (mg/kg)	15	-	21	-	32.2	-	14	14.3
Magnesium - Mg (%)	1.30	0.583	1.03	0.609	1.47	0.99	1.11	1.24
Manganese - Mn (mg/kg)	1420	1100	520	315	440	253	457	511
Mercury - Hg (mg/kg)	0.092 ^(b)	0.098	0.107 ^(b)	0.11	3.04	2.88	-	0.33
Molybdenum - Mo (mg/kg)	2	0.738	2	0.619	5.43	4.57	-	2.94
Nickel - Ni (mg/kg)	24	17.4	39	31.7	39.5	31.6	54	63
Phosphorus - P (%)	0.0930	0.0796	0.0490	0.042	0.096	0.0838	0.0752	0.0832
Potassium - K (%)	1.84	0.0619	2.01	0.0965	1.24	0.323	0.342	0.342
Selenium - Se (mg/kg)	-	-	-	-	0.92	-	-	-
Silver - Ag (mg/kg)	0.2 ^(b)	-	1.6 ^(b)	1.75	1.22	-	-	1.1
Sodium - Na (%)	2.01	0.0340	1.96	0.027	3.45	1.86	0.0558	-
Strontium - Sr (mg/kg)	291	11.6	300	20.3	276	68	214	232
Sulfur - S (%)	< 0.05	-	< 0.05	-	1.29	1.22	-	-
Thallium - Tl (mg/kg)	-	-	-	-	0.6 ^(c)	-	-	0.38
Thorium - Th (mg/kg)	5.6	-	4.6	-	-	-	-	-
Tin - Sn (mg/kg)	-	-	-	-	19.8	19.1	-	0.74
Titanium - Ti (%)	0.599	0.0764	0.291	0.0645	0.443	0.09	0.0850	0.0969
Uranium - U (mg/kg)	2.2	-	2.1	-	3 ^(c)	-	-	1.34
Vanadium - V (mg/kg)	99	54.9	62	33.5	133	74.4	34	39.9
Zinc - Zn (mg/kg)	98	67.5	56	40.2	364	337	467	546

(a) Interim Targets from "Report on Results of 2007 Inter-laboratory Study to Re-establish Data Quality Objective for BCMOE Strong Acid Leachable Metals (SALM) in Soil Method, Prepared for the BC Ministry of Environment, JRD Consulting Company, 2007 June 20. Interim Targets for SS-2 RM are single lab values provided to BCLQAAC.

(b) Parameter not listed as "Total". Listed as "Summary of partial extraction elements concentrated HNO₃ – concentrated HCl".

(c) Parameter not certified, provided as informational value.

Methyl Mercury in Sediment

Method:	Methyl mercury in Sediment
Sample Prep:	Wet or Dry. Sieving or grinding as specified by client.
Extraction / Digestion:	Distillation/Ethylation
Separation:	Purge & Trap, GC
Detection:	Cold-vapour atomic fluorescence spectrometry (CVAFS)
Detection limit:	200 mg wet sample: MDL 0.1ng/g and ML 0.4ng/g 50 mg dry sample: MDL 0.4ng/g and ML 1.3ng/g

Reference Method

The analytical methodology used is a modification of the draft EPA Method 1630 for the determination of methyl mercury in aqueous samples. Adaptations have been made to the method for use of distillation based on peer-reviewed, published procedures for the determination of CH₃Hg (Horvat et al 1993) and work completed by the Florida Department of Environmental Protection Bureau of Laboratories (2011).

Sediment samples are first extracted by distillation. The non-volatile methyl mercury in a subsample of the distillate is converted to volatile ethylmethyl mercury and purged with argon, collected on a Tenax adsorbant trap, and then thermally desorbed onto a GC column where the ethylmethyl mercury is separated from several other volatile Hg species. The exiting species are sequentially reduced to Hg⁰ while passing through a pyrolytic furnace and finally they are detected by an atomic fluorescence detector (which is connected to an electronic integrator).

Extraction and Digestion

A subsample of wet or dry sediment is placed in a Teflon distillation vessel. After adding reagent water and an aliquot of KCl/H₂SO₄, the sample is distilled. After distillation, a subsample is adjusted to ~pH 4.9 with a citrate or acetate buffer, a surrogate standard (*n*-propyl Hg) is added, and the solution is ethylated in a closed purge vessel by the addition of sodium tetraethyl borate (NaBEt₄).

Separation

The ethylated subsample is purged under Hg-free UHP Argon flow onto a Tenax trap. Following a brief drying period, the trap is desorbed once again under Hg-free Ar flow. The various ethylated Hg species are swept through the GC column and are thereby separated.

Detection

As the various Hg species leave the column they pass through a pyrolyser, by which they are reduced to Hg⁰ and are now visible to the atomic fluorescence detector (CVAFS: cold-vapour atomic fluorescence spectrometer).

References

US EPA. "Method 1630: Methyl Mercury in Water by Distillation, Aqueous Ethylation, Purge and Trap, and CVAFS," EPA-821-R-01-020, 2001.

Horvat, M., Bloom, N., and Liang, L. 1993. Comparison of distillation with other current isolation methods for the determination of methyl mercury compounds in low level environmental samples. Part 1. Sediments. Anal. Chim. Acta, 281: 135 - 152.

Horvat, M., Liang, L. and Bloom, N., 1993. Comparison of distillation with other current isolation methods for the determination of methyl mercury compounds in low level environmental samples. Part II. Water. Anal. Chim. Acta, 282: 153 - 168.

Liang, L., Horvat, M., and Bloom, N.S., 1994. An improved speciation method for mercury by GC/CVAFS after aqueous phase ethylation and room temperature precollection. Talanta. 41: 371 - 379.

Available Metals in Soil and Sediment using Inductively Coupled Plasma-Mass Spectrometry (ICP-MS)

Introduction

This method is applicable to the determination of metals in soil, sediment and sludge samples. An acid digestion combined with hydrogen peroxide to break down any organo-metallic complexes is used. The resulting solution is analysed for metals by Inductively Coupled Plasma-Mass Spectrometry (ICP-MS). Results are expressed as mg/kg metal in solid sample.

This method is based on USEPA Method SW – 846 Method 3050B Acid Digestion of Sediments, Sludges and Soils, 1996.

Principle

A representative (air dried and sieved), 0.5 g (dry weight) sample aliquot is digested in nitric acid and hydrogen peroxide with a few drops of HCl at the end to aid in dissolution. The sample is then cooled, made up to 50 mL, centrifuged and/or filtered then diluted. The resulting solution is then analysed by ICP/MS.

The most common sample introduction system used on ICP-MS consists of a nebulizer and spray chamber. The nebulizer converts the liquid samples into aerosol. This sample aerosol is carried through the spray chamber and into the injector that is the center channel of the torch and then into the plasma. The plasma ionizes the elements present in the aerosol. The difference between the processes that occur in the flame of AA, or plasma ICP-OES instruments and ICP-MS is that ICP-MS measures the ions themselves and the other techniques measure light instead. These ions then pass through the interface and the ion lens. After being focused by the ion lens, the ions are separated by their mass-to-charge ratio in the mass spectrometer and measured by the detector. Once the detector measures the ions, the computerized data system is used to convert the measured signal intensities into concentrations of each element and generate a report of the results.

Using calibration curves for each element, the amount of each metal present in the digested sample is determined and is used to calculate the metal content of the solid sample.

Measurement

An aliquot of soil is air dried and ground using a mortar and pestle and passed through a #100 sieve. A 0.5 g portion of the dried sieved sample is used for sample digestion and analysis. The following is a list of typically reported metals and standard reporting limits for this analysis. Additional metals can be

Method Summary

Service Beyond Analysis



reported on request. Lower RDL's are available for some metals. Contact your AGAT Representative for additional information.

Element	RDL (mg/kg)	Element	RDL (mg/kg)
Aluminum	10	Lithium	5
Antimony	1	Manganese	2
Arsenic	1	Molybdenum	2
Barium	5	Nickel	2
Beryllium	2	Selenium	1
Boron	2	Silver	0.5
Cadmium	0.3	Strontium	5
Chromium	2	Thallium	0.1
Cobalt	1	Tin	2
Copper	2	Uranium	0.1
Iron	50	Vanadium	2
Lead	0.5	Zinc	5

Quality Control

The ICP-MS is with a series of standards containing all of the metals being reported. The metals concentration determined in each of the digested samples is related to the amount in the original solid sample. Results are expressed as mg/kg of each metal in the solid sample.

The test uses Method Blanks, Calibration Standards, Certified Reference Materials, Sample Spikes and Duplicates in order to ensure method performance.



APPENDIX C: PHOTO LOG



Photo 1: Sample AC147A, black spruce/feathermoss, 14 cm horizon, collected 01/12/2016.



Photo 2: Sample AP126A, black spruce/feathermoss forest, 19 cm horizon, collected 05/12/2016.



Photo 3: Sample BR102A, black spruce/feathermoss forest, 7 cm horizon, collected 05/12/2016.



Photo 4: Sample CS79A, black spruce/feathermoss forest, 15 cm horizon, collected 05/12/2016.



Photo 5: Sample DP52A, black spruce/feathermoss forest, 8 cm horizon, collected 04/12/2016.



Photo 6: Sample DP53A, black spruce/feathermoss forest, 10 cm horizon, collected 04/12/2016.



Photo 7: Sample DY36A, black spruce/feathermoss forest, 10 cm horizon, collected 04/12/2016.



Photo 8: Sample DY47A, black spruce/feathermoss forest, 5 cm horizon, collected on 04/12/2016.



Photo 9: Sample EE40A, black spruce/feathermoss forest, 4 cm horizon, collected 04/12/2016.



Photo 10: Sample EJ19A, black spruce/feathermoss forest, 14 cm horizon, collected 04/12/2016.



Photo 11: Sample EK17A, black spruce/feathermoss forest, 8 cm horizon, collected 04/12/2016.



Photo 12: Sample AX117A, black spruce/lichen woodland, 2 cm horizon, collected 05/12/2016.



Photo 13: Sample BM121A, black spruce/lichen woodland, 8 cm horizon, collected 04.12.2016.



Photo 14: Sample DT41A, black spruce/lichen woodland, 5 cm horizon, collected 04/12/2016.



Photo 15: Sample K153A, black spruce/lichen woodland, 6 cm horizon, collected 01/12/2016.



Photo 16: Sample DQ50A, black spruce/sphagnum woodland, 8 cm horizon, collected 04/12/2016.



Photo 17: Sample AW136A, fir-white spruce forest, 12 cm horizon, collected 05/12/2016.



Photo 18: Sample AX134A, fir-white spruce forest, 5 cm horizon, collected 04/12/2016.



Photo 19: Sample AZ132A, fir-white spruce, 2 cm horizon, collected 04/12/2016.



Photo 20: Sample DV46A, fir-white spruce forest, 5 cm horizon, collected 04/12/2016.



Photo 21: Sample W137A, hardwood forest, 20 cm horizon, collected 03/12/2016.



Photo 22: Sample EK27A, hardwood forest, 9 cm horizon, collected 04/12/16.



Photo 23: Sample AJ139A, mixed wood forest, 5 cm horizon, collected 01/12/2016.



Photo 24: Sample BN117A, mixed wood forest, 6 cm horizon, collected 05/12/2016.



Photo 25: Sample BQ116A, mixed wood forest, 8 cm horizon, collected 05/12/2016.



Photo 26: Sample BV86A, mixed wood forest, 6 cm horizon, collected 05/12/2016.



Photo 27: Sample I159A, mixed wood forest, 8 cm horizon, collected 05/12/2016.



Photo 28: Sample P152A, riparian, 11 cm horizon, collected 05/12/2016.



Photo 29: Sample D153A, riparian, 0 cm horizon, collected 01/12/2016.



Photo 30: Sample DM46A, riparian, 8 cm horizon, collected 05/12/2016.



Photo 31: Sample ER25A, spruce fir/feathermoss forest, 10 cm horizon, collected 04/12/2016.



Photo 32: Samples AW129A, wetland, 3 cm horizon, collected 04/12/2016.



Photo 33: Sample AY130A, wetland, 3 cm horizon, collected 04/12/2016.



Photo 34: Sample BB122A, wetland, 10 cm horizon, collected 04/12/2016.



Photo 35: Sample BF125A, wetland, 30 cm horizon, collected 04/12/2016.



Photo 36: Sample CG83A, wetland, 15 cm horizon, collected 05/12/2016.



Photo 37: Sample DH72A, wetland, 5 cm horizon, collected 05/12/2016.



APPENDIX D: ANALYTICAL RESULTS



AZIMUTH CONSULTING GROUP INC.
ATTN: Randy Baker
218 - 2902 West Broadway
Vancouver BC V6K 2G8

Date Received: 10-MAR-17
Report Date: 17-MAY-17 12:26 (MT)
Version: FINAL

Client Phone: 604-730-1220

Certificate of Analysis

Lab Work Order #: L1900783
Project P.O. #: NOT SUBMITTED
Job Reference: MFC-17-01
C of C Numbers:
Legal Site Desc:

Brent Mack, B.Sc.
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ADDRESS: 8081 Lougheed Hwy, Suite 100, Burnaby, BC V5A 1W9 Canada | Phone: +1 604 253 4188 | Fax: +1 604 253 6700
ALS CANADA LTD Part of the ALS Group An ALS Limited Company

		Sample ID	L1900783-1	L1900783-2	L1900783-3	L1900783-4	L1900783-5
		Description	Soil	Soil	Soil	Soil	Soil
		Sampled Date					
		Sampled Time					
		Client ID	DM 46 A (A)	AP 126 A	DH 72 A	EJ 19 A	BN 117 A
Grouping	Analyte						
SOIL							
Physical Tests	Moisture (%)	41.7	61.6	66.1	67.2	74.9	
	pH (1:2 soil:water) (pH)	5.48	3.37	4.69	3.94	4.49	
Organic / Inorganic Carbon	Total Organic Carbon (%)	5.73	40.1	29.9	44.0	42.5	
Metals	Mercury (Hg) (mg/kg)	0.0190	0.112	0.109	0.160	0.154	

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID Description Sampled Date Sampled Time Client ID		L1900783-6 Soil DM 46 A (B)	L1900783-7 Soil D 153 A	L1900783-8 Soil P 152 A	L1900783-9 Soil CG 83 A	L1900783-10 Soil EE 40 A
Grouping	Analyte					
SOIL						
Physical Tests	Moisture (%)	41.6	8.43	26.5	91.8	58.1
	pH (1:2 soil:water) (pH)	5.61	5.56	6.09	6.57	4.84
Organic / Inorganic Carbon	Total Organic Carbon (%)	8.75	0.365	1.26	33.1	11.1
Metals	Mercury (Hg) (mg/kg)	0.0213	<0.0050	0.0101	0.0470	0.104

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID Description Sampled Date Sampled Time Client ID		L1900783-11 Soil AZ 132 A	L1900783-12 Soil DY 36 A	L1900783-13 Soil BB 122 A	L1900783-14 Soil II 64 A	L1900783-15 Soil AJ 139 A
Grouping	Analyte					
SOIL						
Physical Tests	Moisture (%)	68.9	51.5	60.4	24.9	77.1
	pH (1:2 soil:water) (pH)	3.55	4.02	3.43	4.10	3.74
Organic / Inorganic Carbon	Total Organic Carbon (%)	42.9	12.2	15.3	9.29	39.0
Metals	Mercury (Hg) (mg/kg)	0.130	0.111	0.0505	0.0249	0.0842

		Sample ID	L1900783-16	L1900783-17	L1900783-18	L1900783-19	L1900783-20
		Description	Soil	Soil	Soil	Soil	Soil
		Sampled Date					
		Sampled Time					
		Client ID	N153 A	AW 129 A	CS 79 A	BR 102 A	BQ 116 A
Grouping	Analyte						
SOIL							
Physical Tests	Moisture (%)	36.9	47.6	76.1	45.4	77.5	
	pH (1:2 soil:water) (pH)	4.05	4.41	4.06	3.89	3.48	
Organic / Inorganic Carbon	Total Organic Carbon (%)	6.41	8.87	45.7	42.6	47.9	
Metals	Mercury (Hg) (mg/kg)	0.0382	0.0295	0.151	0.0351	0.185	

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID Description Sampled Date Sampled Time Client ID		L1900783-21 Soil DQ 50 A	L1900783-22 Soil BV 86 A	L1900783-23 Soil AY 130 A	L1900783-24 Soil II 59 A	L1900783-25 Soil AX-134 A
Grouping	Analyte					
SOIL						
Physical Tests	Moisture (%)	88.9	61.7	95.4	45.7	63.5
	pH (1:2 soil:water) (pH)	4.36	4.19	4.06	4.41	4.06
Organic / Inorganic Carbon	Total Organic Carbon (%)	45.7	27.5	42.2	5.71	6.67
Metals	Mercury (Hg) (mg/kg)	0.163	0.127	0.0314	0.0451	0.0456

		Sample ID	L1900783-26	L1900783-27	L1900783-28	L1900783-29	L1900783-30
		Description	Soil	Soil	Soil	Soil	Soil
		Sampled Date					
		Sampled Time					
		Client ID	K 161 A	DV 46 A	K 153 A	K 161 A	DY 47 A
Grouping	Analyte						
SOIL							
Physical Tests	Moisture (%)	42.8	70.8	37.9	59.9	75.6	
	pH (1:2 soil:water) (pH)	4.14	3.46	4.32	3.53	3.68	
Organic / Inorganic Carbon	Total Organic Carbon (%)	3.77	41.8	7.83	18.2	35.9	
Metals	Mercury (Hg) (mg/kg)	0.0231	0.194	0.0383	0.0779	0.189	

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID Description Sampled Date Sampled Time Client ID		L1900783-31 Soil DT 41 A	L1900783-32 Soil AX 117 A	L1900783-33 Soil W 137 A	L1900783-34 Soil AC 147 A	L1900783-35 Soil ER 25 A
Grouping	Analyte					
SOIL						
Physical Tests	Moisture (%)	76.3	67.9	72.2	76.8	74.7
	pH (1:2 soil:water) (pH)	3.84	3.79	3.93	4.41	3.66
Organic / Inorganic Carbon	Total Organic Carbon (%)	47.0	35.6	46.5	26.8	30.3
Metals	Mercury (Hg) (mg/kg)	0.0838	0.138	0.143	0.0942	0.124

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID Description Sampled Date Sampled Time Client ID		L1900783-36 Soil DP 52 A	L1900783-37 Soil BF 125 A	L1900783-38 Soil DP 53 A		
Grouping	Analyte					
SOIL						
Physical Tests	Moisture (%)	92.1	92.3	78.3		
	pH (1:2 soil:water) (pH)	4.48	4.23	3.72		
Organic / Inorganic Carbon	Total Organic Carbon (%)	43.1	42.1	49.3		
Metals	Mercury (Hg) (mg/kg)	0.0951	0.0365	0.102		

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
C-TIC-PCT-SK	Soil	Total Inorganic Carbon in Soil	CSSS (2008) P216-217
A known quantity of acetic acid is consumed by reaction with carbonates in the soil. The pH of the resulting solution is measured and compared against a standard curve relating pH to weight of carbonate.			
C-TOC-CALC-SK	Soil	Total Organic Carbon Calculation	CSSS (2008) 21.2
Total Organic Carbon (TOC) is calculated by the difference between total carbon (TC) and total inorganic carbon. (TIC)			
C-TOT-LECO-SK	Soil	Total Carbon by combustion method	CSSS (2008) 21.2
The sample is ignited in a combustion analyzer where carbon in the reduced CO ₂ gas is determined using a thermal conductivity detector.			
HG-200.2-CVAF-VA	Soil	Mercury in Soil by CVAFS	EPA 200.2/1631E (mod)
Soil samples are digested with nitric and hydrochloric acids, followed by analysis by CVAFS.			
IC-CACO3-CALC-SK	Soil	Inorganic Carbon as CaCO ₃ Equivalent	Calculation
MOISTURE-VA	Soil	Moisture content	CWS for PHC in Soil - Tier 1
This analysis is carried out gravimetrically by drying the sample at 105 C for a minimum of six hours.			
PH-1:2-VA	Soil	pH in Soil (1:2 Soil:Water Extraction)	BC WLAP METHOD: PH, ELECTROMETRIC, SOIL
This analysis is carried out in accordance with procedures described in the pH, Electrometric in Soil and Sediment method - Section B Physical/Inorganic and Misc. Constituents, BC Environmental Laboratory Manual 2007. The procedure involves mixing the dried (at <60°C) and sieved (No. 10 / 2mm) sample with deionized/distilled water at a 1:2 ratio of sediment to water. The pH of the solution is then measured using a standard pH probe.			

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
SK	ALS ENVIRONMENTAL - SASKATOON, SASKATCHEWAN, CANADA
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

mg/kg - milligrams per kilogram based on dry weight of sample.

mg/kg ww - milligrams per kilogram based on wet weight of sample.

mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.

mg/L - milligrams per litre.

< - Less than.

D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).

N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.

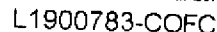
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.



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COC Number: 14 -

Page 1 of 4

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NA-EM-CT26a v09 Final: 04 January 2011

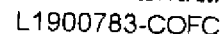
Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.



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COC Number: 14 -

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NA-FM-0326a v02 Front04 January 201

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1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.



Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878



L1900783-COFC

COC Number: 14 -

Page ____ of ____

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Report To		Report Format / Distribution		Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)	
Company:	Azimuth Consulting Group Partnership	Select Report Format:	<input checked="" type="checkbox"/> PDF <input checked="" type="checkbox"/> EXCEL <input type="checkbox"/> EDD (DIGITAL)	R	<input type="checkbox"/> Regular (Standard TAT if received by 3 pm - business days)
Contact:	Randy Baker	Quality Control (QC) Report with Report	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	P	<input type="checkbox"/> Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
Address:	218-2902 W. Broadway Vancouver BC V6K 2G8	<input type="checkbox"/> Criteria on Report - provide details below if box checked		E	<input type="checkbox"/> Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
Phone:	604 730-1220	Select Distribution:	<input type="checkbox"/> EMAIL <input type="checkbox"/> MAIL <input type="checkbox"/> FAX	E2	<input type="checkbox"/> Same day or weekend emergency - contact ALS to confirm TAT and surcharge
		Email 1 or Fax	rbaker@azimuthgroup.ca	Specify Date Required for E2, E or P:	
		Email 2			
Invoice To	Same as Report To <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	Invoice Distribution		Analysis Request	
	Copy of Invoice with Report <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No	Select Invoice Distribution:	<input checked="" type="checkbox"/> EMAIL <input type="checkbox"/> MAIL <input type="checkbox"/> FAX	Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below	
Company:		Email 1 or Fax	rbaker@azimuthgroup.ca		
Contact:		Email 2			
Project Information		Oil and Gas Required Fields (client use)		Number of Containers	
ALS Quote #:	ARCHIVE	Approver ID:	Cost Center:		
Job #:	MFC-17-01	GL Account:	Routing Code:		
PO / AFE:		Activity Code:			
LSD:		Location:			
ALS Lab Work Order # (lab use only)		ALS Contact:	Brent Mack	Sampler:	
ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mm-yy)	Time (hh:mm)	Sample Type	
	BR 102 A CS 79 A			Soil	2
	BR 102 A			soil	2
	BQ 116 A			soil	2
	DQ 50 A			soil	1
	BV 36 A			soil	1
	AY 130 A			soil	1
	II 59 A			soil	1
	AX-134 A			soil	2
	K 161 A			soil	1
	DV 46 A			soil	1
	K 153 A			soil	1
	K 161 A			soil	1
Drinking Water (DW) Samples ¹ (client use)		Special Instructions / Specify Criteria to add on report (client Use)		SAMPLE CONDITION AS RECEIVED (lab use only)	
Are samples taken from a Regulated DW System?	<input type="checkbox"/> Yes <input type="checkbox"/> No	ARCHIVE FOR AZIMUTH		Frozen <input type="checkbox"/> SIF Observations Yes <input type="checkbox"/> No <input type="checkbox"/>	
Are samples for human drinking water use?	<input type="checkbox"/> Yes <input type="checkbox"/> No			Ice packs Yes <input type="checkbox"/> No <input type="checkbox"/> Custody seal intact Yes <input type="checkbox"/> No <input type="checkbox"/>	
				Cooling Initiated <input type="checkbox"/>	
				INITIAL COOLER TEMPERATURES °C	
				FINAL COOLER TEMPERATURES °C	
				10	
SHIPMENT RELEASE (client use)		INITIAL SHIPMENT RECEPTION (lab use only)		FINAL SHIPMENT RECEPTION (lab use only)	
Released by:	Date:	Time:	Received by:	Date:	Time:
				JC	MAR 10 2017 15:05

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HA-754-3325e-v09 Printed January 2014

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1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.



Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878



L1900783-COFC

COC Number: 14 -

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Report To		Report Format / Distribution			Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)															
Company: Azimuth Consulting Group Partnership		Select Report Format: <input checked="" type="checkbox"/> PDF <input checked="" type="checkbox"/> EXCEL <input type="checkbox"/> EDD (DIGITAL)			R <input type="checkbox"/> Regular (Standard TAT if received by 3 pm - business days)															
Contact: Randy Baker		Quality Control (QC) Report with Report <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No			P <input type="checkbox"/> Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT															
Address: 218-2902 W. Broadway Vancouver BC V6K 2G8		Criteria on Report - provide details below if box checked			E <input type="checkbox"/> Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT															
Phone: 604 730-1220		Select Distribution: <input type="checkbox"/> EMAIL <input type="checkbox"/> MAIL <input type="checkbox"/> FAX			E2 <input type="checkbox"/> Same day or weekend emergency - contact ALS to confirm TAT and surcharge															
		Email 1 or Fax rbaker@azimuthgroup.ca			Specify Date Required for E2, E or P:															
		Email 2			Analysis Request															
Invoice To		Invoice Distribution			Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below															
Same as Report To <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No		Select Invoice Distribution: <input checked="" type="checkbox"/> EMAIL <input type="checkbox"/> MAIL <input type="checkbox"/> FAX																		
Copy of Invoice with Report <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No		Email 1 or Fax rbaker@azimuthgroup.ca																		
Company:		Email 2																		
Contact:																				
Project Information		Oil and Gas Required Fields (client use)			Number of Containers															
ALS Quote #: ARCHIVE		Approver ID:																Cost Center:		
Job #: MFC-17-01		GL Account:																Routing Code:		
PO / AFE:		Activity Code:																		
LSD:		Location:																		
ALS Lab Work Order # (lab use only)		ALS Contact: Brent Mack			Sampler:															
ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)			Date (dd-mmm-yy)	Time (hh:mm)	Sample Type														
	DY 47 A					Soil														
	DT 41 A					soil														
	AX 117 A					soil														
	W 137 A					soil														
	AC 147 A					soil														
	ER 25 A					soil														
	DP 52 A					soil														
	BE 125 A					soil														
	DP 53 A					soil														
						soil														
						soil														
						soil														
Drinking Water (DW) Samples¹ (client use)				Special Instructions / Specify Criteria to add on report (client Use)				SAMPLE CONDITION AS RECEIVED (lab use only)												
Are samples taken from a Regulated DW System? <input type="checkbox"/> Yes <input type="checkbox"/> No				ARCHIVE FOR AZIMUTH				Frozen <input type="checkbox"/> SIF Observations Yes <input type="checkbox"/> No <input type="checkbox"/>												
Are samples for human drinking water use? <input type="checkbox"/> Yes <input type="checkbox"/> No								Ice packs Yes <input type="checkbox"/> No <input type="checkbox"/> Custody seal intact Yes <input type="checkbox"/> No <input type="checkbox"/>												
								Cooling Initiated <input type="checkbox"/>												
								INITIAL COOLER TEMPERATURES °C												
								FINAL COOLER TEMPERATURES °C												
								10												
SHIPMENT RELEASE (client use)				INITIAL SHIPMENT RECEPTION (lab use only)				FINAL SHIPMENT RECEPTION (lab use only)												
Released by:		Date:		Time:		Received by:		Date:		Time:		Received by:		Date:		Time:				
												JC		MAR 10 2017		15:05				

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NA-6225a v09 From 04 January 2014

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1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Methyl Mercury Results

Flett Research Ltd.

440 DeSalaberry Ave. Winnipeg, MB R2L 0Y7

Fax/Phone (204) 667-2505

E-mail: flett@flettresearch.ca Webpage: http://www.flettresearch.ca

MVSEDD122016XW1

Page 1 of 1

CLIENT: AGAT Labs - Dartmouth:16x169732

Unit 122-11 Morris Drive

Dartmouth, NS B3B 1M2

Date Received: December 13, 2016

Sampling Date: December 4, 2016 to December 5, 2016

Matrix: Sediment (dry)

Transaction ID: 718

PO/Contract No.:

Date Analysed: December 23, 2016

Analyst(s): Xiang W.

Analytical Method: M10240: Methyl Mercury in Sediment by Distillation, Aqueous Ethylation, Purge and Trap, and CVAFS with Automated Instruments (Version 2)
P:\Methyl Mercury\Method and SOPs\M10240 MeHg in Sediment by Distillation - Automated method.doc

Comments: Samples were freeze dried and ground prior to analysis

Detection Limit: 1.3 ng/g (ML)

MDL= 0.4 ng/g The MDL was determined based on greater than 7 replicates of analytical blanks (98%
For reporting purposes results will be flagged below the ML which is considered a
practical quantitation limit.

Estimated Uncertainty: The estimated uncertainty of this method has been determined to be $\pm 20\%$ at a concentration level of 0.1 and 170 ng/g (95% confidence)

Results authorized by Dr. Robert J. Flett, Chief Scientist

QUALITY DATA		Blanks		pg of MeHg in whole ethylation EPA vial	Gross Peak Area	Mean Ethylation Blank (ng/L)	Equiv. CH Hg Conc. - based on current batch mean weight (0.1205g) of dry sample, ng/g (Sediment)		
			Ethylation blank (H ₂ O+Reagen	0.55	1617	0.01			
			Mean Eth. Blank (last 30 runs)	0.40		0.01			
				Net pg MeHg in whole Ethylation EPA vial	Gross Peak Area				
			Method Blank 1	-0.02	1567	-0.004			
			Method Blank 2	0.27	2417	0.062			
			Method Blank 3	0.15	2067	0.035			
			Mean Method Blank	0.14		0.031			
		Standards		MeHg Standard Added to Ethylation EPA Vial (pg CH ₃ Hg)	Gross Peak Area	Net Corrected MeHg Std Calibration Factor (units / pg)	RSD of MeHg Standard		
			Mean Value			4968	3.7		
Spike Recovery <small>Matrix Spike (MS) and Matrix Spike Duplicate (MSD)</small>	Sample Identification	Sample Type	Gross Peak Area	% CH ₃ Hg Recovery Used for Calculations	Dry Sample Mass (g)	Net CH ₃ Hg as Hg (ng/g-Dry-Wt)	CH ₃ Hg Recovery (%)		
	8083116C (DQ50A)	MS2	1244152	100%	0.116	46	106.3		
	8083116C (DQ50A)	MS2D	1222656	100%	0.121	45	107.8		
	8082971C (AW136A)	MS3	1256408	100%	0.121	46	110.3		
	8082971C (AW136A)	MS3D	1225038	100%	0.121	45	109.5		
	Mean of Recoveries						108.5		
	QC Samples	FRES02 ID1201 (27.4± 3.6 ng/g)		1097121	100%	0.201	24.5	89.3	
		FRES02 ID1201 (27.4± 3.6 ng/g)	Repeat Aliquot	1116683	100%	0.201	24.9	90.9	
Mean of FRES02						24.7	90.1		
Alternate Source Standard (A.S.S.)		A.S.S. - Alfa ID1302 (1000 ng/L)		628456	100%		1072	107.2	
LAB ID	Sampling Details	Sample ID	Date Sampled	Sample Type	Gross Peak Area	% CH ₃ Hg Recovery Used for Calculations	Weighed Dry Sample Mass (g)	Net CH3Hg as Hg (ng/g) Dry Wt. [recovery corrected]	
79121	8082889C	EK17A	December 4, 2016		4975	108.5	0.1100	~ 0.11	
79122	8082969C	CG83A	December 5, 2016		21148	108.5	0.1000	~ 0.76	
79123	8082971C	AW136A	December 5, 2016		3251	108.5	0.1240	~ 0.04	
79124	8082974C	AP126A	December 5, 2016		3676	108.5	0.1210	~ 0.05	
79125	8082979C	P152A	December 5, 2016		4357	108.5	0.1550	~ 0.06	
79126	8082980C	I159A	December 5, 2016		49105	108.5	0.1290	1.41	
79127	8082996C	BM121A	December 4, 2016		5647	108.5	0.1400	~ 0.10	
79128	8083116C	DQ50A	December 4, 2016		8950	108.5	0.1050	~ 0.26	
79129	8083118C	EQ29A	December 4, 2016	DupA1	25607	108.5	0.1150	~ 0.80	
79129	8083118C	EQ29A	December 4, 2016	DupA2	26636	108.5	0.1240	~ 0.78	

* : See 'Comments' section above for discussion.

Q:\Clients A-L\AGAT Labs - Dartmouth\2016\718\Methyl Mercury\MVSEDD122316XW1.xls

~ : Result below the official detection limit for this analyte in this matrix.

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Note: Results relate only to the items tested.

Dup : Duplicate - two subsamples of the same sample carried through the analytical procedure in an identical manner.



CALA
Testing
Accreditation No. A 3306

ISO/IEC 17025:2005 Accredited with the Canadian Association for Laboratory Accreditation

M10200-1 Version 111414

Methyl Mercury Results

Flett Research Ltd.

440 DeSalaberry Ave. Winnipeg, MB R2L 0Y7

Fax/Phone (204) 667-2505

E-mail: flett@flettresearch.ca Webpage: http://www.flettresearch.ca

MVSEDD010417XW1

Page 1 of 1

CLIENT: AGAT Labs - Dartmouth:16x169381

Unit 122-11 Morris Drive
Dartmouth, NS B3B 1M2

Date Received: December 14, 2016

Sampling Date: December 3, 2016

Matrix: Sediment (dry)

Transaction ID: 718

PO/Contract No.:

Date Analysed: January 4, 2017

Analyst(s): Xiang W.

Analytical Method: M10240: Methyl Mercury in Sediment by Distillation, Aqueous Ethylation, Purge and Trap, and CVAFS with Automated Instruments (Version 2)
P:\Methyl Mercury\Method and SOPs\M10240 MeHg in Sediment by Distillation - Automated method.doc

Comments: Samples were freeze-dried and ground at Flett Research prior to analysis

Detection Limit: 1.3 ng/g (ML)

MDL= 0.4 ng/g

The MDL was determined based on greater than 7 replicates of analytical blanks (98% confidence level) and a 50 mg dry sample size.

For reporting purposes results will be flagged below the ML which is considered a practical quantitation limit.

Estimated Uncertainty: The estimated uncertainty of this method has been determined to be $\pm 20\%$ at a concentration level of 0.1 and 170 ng/g (95% confidence)

Uncertainty:

Results authorized by Dr. Robert J. Flett, Chief Scientist

QUALITY DATA

QUALITY DATA		Blanks		pg of MeHg in whole ethylation EPA vial	Gross Peak Area	Mean Ethylation Blank (ng/L)			
			Ethylation blank (H ₂ O+Reagent)	0.75	2398	0.02			
			Mean Eth. Blank (last 30 runs)	0.40		0.02			
				Net pg MeHg in whole Ethylation EPA vial	Gross Peak Area		Equiv. CH Hg Conc. - based on current batch mean weight (0.1255g) of dry sample, ng/g		
			Method Blank 1	-0.13	1977		-0.030		
			Method Blank 2	-0.43	1025		-0.099		
			Method Blank 3	-0.49	832		-0.110		
			Mean Method Blank	-0.35			-0.079		
		Standards		MeHg Standard Added to Ethylation EPA Vial (pg CH ₃ Hg)	Gross Peak Area	Net Corrected MeHg Std Calibration Factor (units / pg)	RSD of MeHg Standard		
			Mean Value			5460	5.6		
		Spike Recovery <small>Matrix Spike (MS) and Matrix Spike Duplicate (MSD)</small>	Sample Identification	Sample Type	Gross Peak Area	% CH ₃ Hg Recovery Used for Calculations	Dry Sample Mass (g)	Net CH ₃ Hg as Hg (ng/g-Dry-Wt)	CH ₃ Hg Recovery (%)
			8079206 (W137A)	MS1	567181	100%	0.110	44	95.0
			8079206 (W137A)	MS1D	566851	100%	0.103	45	92.2
			Mean of Recoveries						93.6
		QC Samples <small>Alternate Source Standard (A.S.S.)</small>	FRES02 ID1201 (27.4± 3.6 ng/g)		1015223	100%	0.160	26.0	95.0
			FRES02 ID1201 (27.4± 3.6 ng/g)	Repeat Aliquot	1017169	100%	0.160	26.1	95.2
			Mean of FRES02					26.1	95.1
			A.S.S. - Alfa ID1302 (1000 ng/L)		349158	100%		1080	108.0
LAB ID	Sampling Details	Sample ID	Date Sampled	Sample Type	Gross Peak Area	% CH ₃ Hg Recovery Used for Calculations	Weighed Dry Sample Mass (g)	Net CH3Hg as Hg (ng/g) Dry Wt. [recovery corrected]	
79257	8079206	W137A	December 3, 2016		6806	93.6	0.1100	~ 0.38	

* : See 'Comments' section above for discussion.

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Note: Results relate only to the items tested.



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M10200-1 Version 111414

CLIENT NAME: AMEC FOSTER WHEELER E&I
133 CROSBIE ROAD
ST. JOHNS, NL A1B4A5
(709) 722-7023

ATTENTION TO: MATT GOSSE

PROJECT: TF13104119.5600

AGAT WORK ORDER: 16X169732

SOIL ANALYSIS REVIEWED BY: James MacDonald, Technical Services Manager

DATE REPORTED: May 31, 2017

PAGES (INCLUDING COVER): 13

VERSION*: 5

Should you require any information regarding this analysis please contact your client services representative at (902) 468-8718

***NOTES**

VERSION 5: Version 5.0 supersedes Version 4.0. Updated report to separate analyses at client request. Issued, May 31, 2017.
Version 2.0 supersedes Version 1.0. Lower RDL for Hg reported. Issued, May 12, 2017.
Partial report for soil data, issued, January 5, 2017.

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.



Certificate of Analysis

AGAT WORK ORDER: 16X169732

PROJECT: TF13104119.5600

11 Morris Drive, Unit 122
Dartmouth, Nova Scotia
CANADA B3B 1M2
TEL (902)468-8718
FAX (902)468-8924
<http://www.agatlabs.com>

CLIENT NAME: AMEC FOSTER WHEELER E&I

ATTENTION TO: MATT GOSSE

SAMPLING SITE:

SAMPLED BY:

Available Metals in Soil

DATE RECEIVED: 2016-12-12

DATE REPORTED: 2017-05-31

		SAMPLE DESCRIPTION:		EK17A	BF125A	DP52A	DY47A	DT41A	DY36A	AY130A	BB122A
		SAMPLE TYPE:		Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
		DATE SAMPLED:		2016-12-04	2016-12-04	2016-12-04	2016-12-04	2016-12-04	2016-12-04	2016-12-04	2016-12-04
Parameter	Unit	G / S	RDL	8082889	8082890	8082892	8082899	8082909	8082910	8082911	8082916
Aluminum	mg/kg		10	1600	406	540	377	910	2510	405	5800
Antimony	mg/kg		1	<1	<1	<1	<1	<1	<1	<1	<1
Arsenic	mg/kg		1	2	2	4	2	2	2	3	3
Barium	mg/kg		5	158	13	53	30	101	54	8	24
Beryllium	mg/kg		2	<2	<2	<2	<2	<2	<2	<2	<2
Boron	mg/kg		2	<2	<2	<2	3	<2	<2	<2	<2
Cadmium	mg/kg		0.3	<0.3	<0.3	<0.3	<0.3	0.3	<0.3	<0.3	<0.3
Chromium	mg/kg		2	3	3	<2	<2	2	7	3	26
Cobalt	mg/kg		1	<1	<1	<1	<1	<1	2	<1	2
Copper	mg/kg		2	7	<2	<2	3	3	3	<2	7
Iron	mg/kg		50	1450	952	1580	344	343	2990	940	14400
Lead	mg/kg		0.5	8.5	2.9	3.7	8.7	20.3	9.2	0.8	4.8
Lithium	mg/kg		5	<5	<5	<5	<5	<5	<5	<5	<5
Manganese	mg/kg		2	15	3	21	280	12	63	17	83
Molybdenum	mg/kg		2	<2	<2	<2	<2	<2	<2	<2	<2
Nickel	mg/kg		2	2	<2	<2	<2	<2	4	<2	8
Selenium	mg/kg		1	<1	<1	<1	<1	<1	<1	<1	<1
Silver	mg/kg		0.5	0.8	<0.5	<0.5	2.2	1.0	<0.5	<0.5	<0.5
Strontium	mg/kg		5	39	22	42	23	28	18	<5	6
Thallium	mg/kg		0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Tin	mg/kg		2	3	4	7	3	3	3	5	<2
Uranium	mg/kg		0.1	0.4	<0.1	<0.1	<0.1	<0.1	0.4	<0.1	1.0
Vanadium	mg/kg		2	7	5	7	3	6	11	10	28
Zinc	mg/kg		5	6	11	11	38	19	15	9	15

Certified By:



AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 16X169732

PROJECT: TF13104119.5600

11 Morris Drive, Unit 122
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CLIENT NAME: AMEC FOSTER WHEELER E&I

ATTENTION TO: MATT GOSSE

SAMPLING SITE:

SAMPLED BY:

Available Metals in Soil

DATE RECEIVED: 2016-12-12

DATE REPORTED: 2017-05-31

SAMPLE DESCRIPTION:				DV46A	AX134A	BR102A	D153A	CS79A	DH72A	CG83A	AW136A
SAMPLE TYPE:				Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
DATE SAMPLED:				2016-12-04	2016-12-04	2016-12-05	2016-12-05	2016-12-05	2016-12-05	2016-12-05	2016-12-05
Parameter	Unit	G / S	RDL	8082928	8082931	8082932	8082933	8082966	8082967	8082969	8082971
Aluminum	mg/kg		10	1310	2280	1970	3520	468	3800	1110	3260
Antimony	mg/kg		1	<1	<1	<1	<1	<1	<1	<1	<1
Arsenic	mg/kg		1	2	2	2	2	2	3	2	2
Barium	mg/kg		5	77	19	68	36	38	112	30	17
Beryllium	mg/kg		2	<2	<2	<2	<2	<2	<2	<2	<2
Boron	mg/kg		2	<2	<2	<2	<2	<2	2	<2	<2
Cadmium	mg/kg		0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Chromium	mg/kg		2	3	6	3	9	<2	20	4	9
Cobalt	mg/kg		1	1	<1	<1	3	<1	4	4	1
Copper	mg/kg		2	2	3	<2	6	<2	12	3	3
Iron	mg/kg		50	1270	2510	901	5040	334	16000	21400	4630
Lead	mg/kg		0.5	11.4	8.2	6.1	1.3	2.3	13.7	1.2	7.2
Lithium	mg/kg		5	<5	<5	<5	<5	<5	<5	<5	<5
Manganese	mg/kg		2	12	16	15	152	34	115	362	36
Molybdenum	mg/kg		2	<2	<2	<2	<2	<2	<2	<2	<2
Nickel	mg/kg		2	3	<2	<2	7	<2	10	3	3
Selenium	mg/kg		1	<1	<1	<1	<1	<1	<1	<1	<1
Silver	mg/kg		0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Strontium	mg/kg		5	27	<5	20	8	18	26	15	5
Thallium	mg/kg		0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Tin	mg/kg		2	3	2	3	3	3	3	3	<2
Uranium	mg/kg		0.1	0.2	0.7	0.4	0.5	<0.1	0.8	<0.1	0.7
Vanadium	mg/kg		2	6	8	5	14	5	23	5	9
Zinc	mg/kg		5	18	<5	11	19	10	17	16	8

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CLIENT NAME: AMEC FOSTER WHEELER E&I

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SAMPLING SITE:

SAMPLED BY:

Available Metals in Soil

DATE RECEIVED: 2016-12-12

DATE REPORTED: 2017-05-31

		SAMPLE DESCRIPTION:		BQ116A	AX117A	AP126A	P152A	I159A	BN117A	BM121A	AW129A
		SAMPLE TYPE:		Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
		DATE SAMPLED:		2016-12-05	2016-12-05	2016-12-05	2016-12-05	2016-12-05	2016-12-05	2016-12-04	2016-12-04
Parameter	Unit	G / S	RDL	8082972	8082973	8082974	8082979	8082980	8082985	8082996	8082997
Aluminum	mg/kg		10	633	1390	2200	8650	16100	748	3290	8600
Antimony	mg/kg		1	<1	<1	<1	<1	<1	<1	<1	<1
Arsenic	mg/kg		1	2	2	2	3	2	1	2	2
Barium	mg/kg		5	77	27	101	97	61	89	74	106
Beryllium	mg/kg		2	<2	<2	<2	<2	<2	<2	<2	<2
Boron	mg/kg		2	<2	<2	<2	3	<2	<2	<2	<2
Cadmium	mg/kg		0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Chromium	mg/kg		2	2	2	6	31	39	<2	3	25
Cobalt	mg/kg		1	<1	<1	2	11	9	<1	<1	8
Copper	mg/kg		2	<2	<2	3	28	12	4	7	14
Iron	mg/kg		50	520	683	2980	17800	45400	818	1950	14400
Lead	mg/kg		0.5	18.6	4.8	10.2	4.9	6.6	9.1	12.0	6.4
Lithium	mg/kg		5	<5	<5	<5	12	9	<5	<5	9
Manganese	mg/kg		2	59	12	69	502	290	380	14	381
Molybdenum	mg/kg		2	<2	<2	<2	<2	<2	<2	<2	<2
Nickel	mg/kg		2	<2	<2	5	23	17	3	3	18
Selenium	mg/kg		1	<1	<1	<1	<1	<1	<1	<1	<1
Silver	mg/kg		0.5	1.3	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Strontium	mg/kg		5	30	7	26	21	7	20	<5	17
Thallium	mg/kg		0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Tin	mg/kg		2	3	3	3	3	<2	3	2	2
Uranium	mg/kg		0.1	<0.1	0.3	0.3	1.8	1.0	0.1	0.3	0.9
Vanadium	mg/kg		2	5	5	11	38	48	4	5	31
Zinc	mg/kg		5	30	7	11	53	49	39	12	51

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AGAT Laboratories

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CLIENT NAME: AMEC FOSTER WHEELER E&I

ATTENTION TO: MATT GOSSE

SAMPLING SITE:

SAMPLED BY:

Available Metals in Soil

DATE RECEIVED: 2016-12-12

DATE REPORTED: 2017-05-31

		SAMPLE DESCRIPTION:		AZ132A	EK27A	ER25A	EJ19A	EE40A	DM46A	DQ50A	EQ29A
		SAMPLE TYPE:		Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
		DATE SAMPLED:		2016-12-04	2016-12-04	2016-12-04	2016-12-04	2016-12-04	2016-12-04	2016-12-04	2016-12-04
Parameter	Unit	G / S	RDL	8083019	8083054	8083081	8083083	8083098	8083115	8083116	8083118
Aluminum	mg/kg		10	2510	1100	842	524	7330	6400	442	282
Antimony	mg/kg		1	<1	<1	<1	<1	<1	<1	<1	<1
Arsenic	mg/kg		1	3	2	2	1	2	2	2	1
Barium	mg/kg		5	136	27	65	71	153	89	15	29
Beryllium	mg/kg		2	<2	<2	<2	<2	<2	<2	<2	<2
Boron	mg/kg		2	<2	<2	<2	<2	<2	<2	<2	<2
Cadmium	mg/kg		0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Chromium	mg/kg		2	3	3	<2	<2	22	19	<2	<2
Cobalt	mg/kg		1	<1	<1	<1	2	10	6	1	<1
Copper	mg/kg		2	<2	2	5	8	17	13	3	3
Iron	mg/kg		50	1180	710	576	514	11600	10900	1730	211
Lead	mg/kg		0.5	17.0	7.9	21.4	11.6	7.7	2.8	9.2	12.4
Lithium	mg/kg		5	<5	<5	<5	<5	8	7	<5	<5
Manganese	mg/kg		2	81	23	18	190	1470	315	30	442
Molybdenum	mg/kg		2	<2	<2	<2	<2	<2	<2	<2	<2
Nickel	mg/kg		2	3	<2	3	3	17	13	2	<2
Selenium	mg/kg		1	<1	<1	<1	<1	<1	<1	<1	<1
Silver	mg/kg		0.5	<0.5	<0.5	<0.5	1.4	<0.5	<0.5	<0.5	<0.5
Strontium	mg/kg		5	42	15	33	55	33	16	56	13
Thallium	mg/kg		0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Tin	mg/kg		2	4	3	4	4	2	3	4	3
Uranium	mg/kg		0.1	0.2	0.5	<0.1	<0.1	0.6	0.7	<0.1	<0.1
Vanadium	mg/kg		2	5	6	5	3	25	25	4	3
Zinc	mg/kg		5	24	6	23	46	57	37	9	31

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Certificate of Analysis

AGAT WORK ORDER: 16X169732

PROJECT: TF13104119.5600

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CLIENT NAME: AMEC FOSTER WHEELER E&I

ATTENTION TO: MATT GOSSE

SAMPLING SITE:

SAMPLED BY:

Available Metals in Soil

DATE RECEIVED: 2016-12-12

DATE REPORTED: 2017-05-31

		SAMPLE DESCRIPTION:		DP53A	BV86A
		SAMPLE TYPE:		Soil	Soil
		DATE SAMPLED:		2016-12-04	2016-12-05
Parameter	Unit	G / S	RDL	8083119	8083120
Aluminum	mg/kg		10	723	2370
Antimony	mg/kg		1	<1	<1
Arsenic	mg/kg		1	2	2
Barium	mg/kg		5	109	38
Beryllium	mg/kg		2	<2	<2
Boron	mg/kg		2	<2	<2
Cadmium	mg/kg		0.3	<0.3	<0.3
Chromium	mg/kg		2	<2	5
Cobalt	mg/kg		1	2	2
Copper	mg/kg		2	2	7
Iron	mg/kg		50	536	2800
Lead	mg/kg		0.5	5.2	6.9
Lithium	mg/kg		5	<5	<5
Manganese	mg/kg		2	91	34
Molybdenum	mg/kg		2	<2	<2
Nickel	mg/kg		2	2	4
Selenium	mg/kg		1	<1	<1
Silver	mg/kg		0.5	<0.5	<0.5
Strontium	mg/kg		5	40	18
Thallium	mg/kg		0.1	<0.1	<0.1
Tin	mg/kg		2	3	3
Uranium	mg/kg		0.1	<0.1	0.6
Vanadium	mg/kg		2	3	8
Zinc	mg/kg		5	26	12

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
8082889-8083120 Results are based on the dry weight of the sample.

Certified By:

Quality Assurance

CLIENT NAME: AMEC FOSTER WHEELER E&I

AGAT WORK ORDER: 16X169732

PROJECT: TF13104119.5600

ATTENTION TO: MATT GOSSE

SAMPLING SITE:

SAMPLED BY:

Soil Analysis															
RPT Date: May 31, 2017			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper

Mercury Analysis in Soil

Mercury	1	8082932	0.053	0.055	NA	< 0.015	83%	70%	130%		70%	130%	77%	70%	130%
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Available Metals in Soil

Aluminum	1215201		8650	8420	2.7%	< 10	106%	80%	120%	102%	80%	120%	92%	70%	130%
Antimony	1215201		< 1	< 1	NA	< 1	89%	80%	120%	108%	80%	120%	91%	70%	130%
Arsenic	1215201		3	3	NA	< 1	98%	80%	120%	95%	80%	120%	91%	70%	130%
Barium	1215201		97	94	3.1%	< 5	94%	80%	120%	93%	80%	120%	94%	70%	130%
Beryllium	1215201		< 2	< 2	NA	< 2	115%	80%	120%	111%	80%	120%	102%	70%	130%
Boron	1215201		3	3	NA	< 2	120%	80%	120%	115%	80%	120%	130%	70%	130%
Cadmium	1215201		< 0.3	< 0.3	NA	< 0.3	98%	80%	120%	100%	80%	120%	92%	70%	130%
Chromium	1215201		31	30	3.3%	< 2	111%	80%	120%	110%	80%	120%	100%	70%	130%
Cobalt	1215201		11	10	9.5%	< 1	108%	80%	120%	107%	80%	120%	102%	70%	130%
Copper	1215201		28	26	7.4%	< 2	105%	80%	120%	109%	80%	120%	104%	70%	130%
Iron	1215201		17800	16700	6.4%	< 50	110%	80%	120%	101%	80%	120%	97%	70%	130%
Lead	1215201		4.86	4.59	5.7%	< 0.5	103%	80%	120%	104%	80%	120%	88%	70%	130%
Lithium	1215201		12	12	NA	< 5	107%	70%	130%	107%	70%	130%	98%	70%	130%
Manganese	1215201		502	476	5.3%	< 2	105%	80%	120%	104%	80%	120%	98%	70%	130%
Molybdenum	1215201		< 2	< 2	NA	< 2	105%	80%	120%	100%	80%	120%	107%	70%	130%
Nickel	1215201		23	23	0.0%	< 2	107%	80%	120%	108%	80%	120%	101%	70%	130%
Selenium	1215201		< 1	< 1	NA	< 1	106%	80%	120%	81%	80%	120%	98%	70%	130%
Silver	1215201		< 0.5	< 0.5	NA	< 0.5	117%	80%	120%	112%	80%	120%	97%	70%	130%
Strontium	1215201		21	21	NA	< 5	97%	80%	120%	96%	80%	120%	111%	70%	130%
Thallium	1215201		< 0.1	< 0.1	NA	< 0.1	112%	80%	120%	99%	80%	120%	91%	70%	130%
Tin	1215201		3	3	NA	< 2	105%	80%	120%	99%	80%	120%	98%	70%	130%
Uranium	1215201		1.8	1.7	5.7%	< 0.1	108%	80%	120%	107%	80%	120%	92%	70%	130%
Vanadium	1215201		38	35	8.2%	< 2	107%	80%	120%	103%	80%	120%	102%	70%	130%
Zinc	1215201		53	51	3.8%	< 5	105%	80%	120%	107%	80%	120%	97%	70%	130%

pH in Soil

pH	1	8083452	8.42	8.62	2.3%	<	98%	80%	120%
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Mercury Analysis in Soil

Mercury	1	8083120	0.065	0.067	NA	< 0.015	115%	70%	130%		70%	130%	103%	70%	130%
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TOC (Soil)

Total Organic Carbon(Walkley-Black Wet Oxidation)	8082889	8082889	30.0	30.4	1.3%	< 0.30	116%	70%	130%				75%	70%	130%
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TOC (Soil)

Total Organic Carbon(Walkley-Black Wet Oxidation)	8082980	8082980	8.97	9.05	0.9%	< 0.30	116%	70%	130%				106%	70%	130%
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Quality Assurance

CLIENT NAME: AMEC FOSTER WHEELER E&I

AGAT WORK ORDER: 16X169732

PROJECT: TF13104119.5600

ATTENTION TO: MATT GOSSE

SAMPLING SITE:

SAMPLED BY:

Soil Analysis (Continued)

RPT Date: May 31, 2017			DUPLICATE			Method Blank	REFERENCE MATERIAL		METHOD BLANK SPIKE			MATRIX SPIKE			
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper

Certified By:



Method Summary

CLIENT NAME: AMEC FOSTER WHEELER E&I

AGAT WORK ORDER: 16X169732

PROJECT: TF13104119.5600

ATTENTION TO: MATT GOSSE

SAMPLING SITE:

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Aluminum	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Antimony	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Arsenic	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Barium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Beryllium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Boron	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Cadmium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Chromium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Cobalt	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Copper	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Iron	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Lead	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP-MS
Lithium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP-MS
Manganese	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Molybdenum	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Nickel	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Selenium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Silver	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Strontium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Thallium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Tin	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Uranium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Vanadium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Zinc	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Mercury	INOR-121-6101 & INOR-121-6107	Based on EPA 245.5 & SM 3112B	CV/AA
Total Organic Carbon(Walkley-Black Wet Oxidation)	INOR-93-6062	Skjemstad & Baldock, 2008 & Walkley & Black 1934	SPECTROPHOTOMETER
pH	INOR-121-6006	modified from Canadian Society of Soil Science p15	pH METER

Method Summary

CLIENT NAME: AMEC FOSTER WHEELER E&I

AGAT WORK ORDER: 16X169732

PROJECT: TF13104119.5600

ATTENTION TO: MATT GOSSE

SAMPLING SITE:

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Water Analysis			
Subcontracted Data			



AGAT

Laboratories

Unit 122 - 11 Morris Dr.
Dartmouth, Nova Scotia
B3B 1M2
http://webearth.agatlabs.com

Phone: 902-468-8718
Fax: 902-468-8924
www.agatlabs.com

Laboratory use only

Arrival Condition: ☐ Good ☐ Poor (complete notes)

Arrival Temperature: 2.2 AGAT Job Number: 162169732

Notes:

Drinking Water Sample (Y/N): _____ Reg. No. _____

Waterworks Number: _____

Report To:

Company: Amec Foster Wheeler
Contact: Matthew Gosse
Address: 133 Crosbie Road

Phone: 722-7023 FAX: 722-7353

PO #: TF13104119.5600

AGAT Quotation: TF13104119.5600

Client Project #: Same (Y/N) - Circle

Invoice to:

Company:

Contact:

Address:

Phone:

Fax:

PO #/Credit Card #:

Report Information

1. Name: Matthew Gosse
Email: matthew.gosse@amecfw.com
2. Name: James McCarthy
Email: james.mccarthy@amecfw.com

Regulatory Requirements (Check):

- ☐ List Guidelines on Report
- ☐ PIRI
- ☐ Tier 1 ☐ Res. ☐ Pol. ☐ Coarse
- ☐ Tier 2 ☐ Com ☐ N/Pol. ☐ Fine
- ☐ Gas ☐ Fuel ☐ Lube
- ☐ COWQ
- ☐ Ind ☐ NSDFOSP
- ☐ Com ☐ HRM 101
- ☐ Res/P ☐ Storm Water
- ☐ Ag ☐ HRM 101
- ☐ FWAL ☐ Waste Water
- ☐ Sediment
- ☐ Other
- ☐ Do Not List Guidelines on Report
- Site Info (check all that apply):

Report Format

- ☐ Single PDF sample per page
- ☐ Multiple PDF samples per page
- ☐ Excel Format
- Included

Turnaround Time (TAT) Business Days

- Regular TAT: ☐ 5 - 7 days
- Rush TAT: ☐ 1 day ☐ 2 days
- ☐ 3 - 4 days
- Date Required: _____
- Time Required: _____

SAMPLE IDENTIFICATION	DATE / TIME SAMPLED	SAMPLE MATRIX	# OF CONTAINERS	COMMENTS - Site, Sample Info, Sample Containment	Field Filtered	Total Organic Carbon	Metals (Total)	Methyl Mercury	Mercury	BOD	pH	TSS	TKN	Anions	Total Phosphorus	Phenols	TPH/BTEX (PIRI) Tier 1	TPH/BTEX-Fractionation Tier 2	VOC	THM	PAH	PCB	Other	Hazardous (Y/N)	Lab Sample #				
EK17A	Dec 4, 16	3	Sc 1																										
BF125A		3																											
DP52A		3																											
DT47A		3																											
DT41A		3																											
DT36A		3																											
AY130A		3																											
BR122A		3																											
DT46A		3																											
AX134A		3																											
BR102A	Dec 5, 16	3																											
D153A		3																											
Sample Relinquished By (print name & sign)					Samples Received By (print name and sign)					Date/Time					Special Instructions					Date/Time					Page				
Matthew Gosse					James McCarthy					10:35 a.m.					Governed by the Terms and Conditions of the agreement No. MTS 016					1					of 3				
Matthew Gosse					James McCarthy					10:35 a.m.					Governed by the Terms and Conditions of the agreement No. MTS 016					1					of 3				



Laboratories

Phone: 902-468-8718
Fax: 902-468-8924
www.agathabs.com

Waterworks Number:

Drinking Water Sample (y/n):

Reg. No.

Laboratory use Only

Arrival Condition:

Arrival Temperature: ~ 6.2

☐ Poor (complete notes)
AGAT Job Number: 66x

~~16x16~~ 16x169732

Report To: Company: Amec Foster Wheeler Contact: Matthew Gosse Address: 133 Crosbie Road		Report Information 1. Name: Matthew Gosse Email: matthew.gosse@amecfw.com 2. Name: James Mccarthy Email: james.mccarthy@amecfw.com	
Phone: 722-7023 FAX: 722-7353 PO #: TF13104119.5600 AGAT Quotation: TF13104119.5600 Client Project #: Same (Y/N) - Circle		Regulatory Requirements (Check): <input type="checkbox"/> List Guidelines on Report <input type="checkbox"/> PIRI <input type="checkbox"/> Tier 1 <input type="checkbox"/> Tier 2 <input type="checkbox"/> Gas <input type="checkbox"/> CCME <input type="checkbox"/> Ind <input type="checkbox"/> Com <input type="checkbox"/> Res/P <input type="checkbox"/> Ag <input type="checkbox"/> FWAL <input type="checkbox"/> Sediment <input type="checkbox"/> Do Not List Guidelines on Report Site Info (check all that apply): <input type="checkbox"/> Pol. <input type="checkbox"/> N/Pol. <input type="checkbox"/> Coarse <input type="checkbox"/> Fine <input type="checkbox"/> Res. <input type="checkbox"/> Com <input type="checkbox"/> Fuel <input type="checkbox"/> Lube <input type="checkbox"/> CDWQ <input type="checkbox"/> MSD-FOSP <input type="checkbox"/> HRM 101 <input type="checkbox"/> Storm Water <input type="checkbox"/> HRM 101 <input type="checkbox"/> Waste Water	
Invoice to: Same (Y/N) - Circle		Report Format <input type="checkbox"/> Single PDF sample per page <input type="checkbox"/> Multiple PDF samples per page <input type="checkbox"/> Excel Format Included Regular TAT: 5 - 7 days Rush TAT: 1 day Date Required: 3 - 4 days Time Required: 2 days	
Phone: _____ Fax: _____ PO#/Credit Card #: _____		Turnaround Time (TAT) Business Days	
SAMPLE IDENTIFICATION		DATE / TIME SAMPLED	
DATE / TIME SAMPLED		SAMPLE MATRIX	
# OF CONTAINERS		COMMENTS - Site/Sample Info, Sample Containment	
Field Filtered/ Preserved		Total Organic Carbon	
Metals (Total)		Methyl Mercury	
Mercury		BOD	
pH		TSS	
TKN		Anions	
Total Phosphorus		Phenols	
TPH/BTEX (PIRI) Tier 1		TPH/BTEX-Fractionation Tier 2	
VOC		THM	
PAH		PCB	
Other		Hazardous (Y/N)	
Lab Sample #			

include P152A for MeHg



AGAT Laboratories

Unit 122 - 11 Morris Dr.
Dartmouth, Nova Scotia
B3B 1M2
Phone: 902-468-8718
Fax: 902-468-8924
www.agatlabs.com
http://webearth.agatlabs.com

Laboratory use Only

Arrival Condition: ☐ Good ☐ Poor (complete notes)

Arrival Temperature: -2.2 AGAT Job Number: 16x169732

Notes:

Drinking Water Sample (Y/N): _____ Reg. No. _____

Waterworks Number: _____

Report To:

Company: Amec Foster Wheeler
Contact: Matthew Gosse
Address: 133 Crosbie Road

Phone: 722-7023 FAX: 722-7353
PO #: TF13104119.5600
AGAT Quotation: TF13104119.5600
Client Project #: Same (Y/N) - Circle

Invoice to:

Company: _____
Contact: _____
Address: _____
Phone: _____ Fax: _____
PO#/Credit Card #: _____

Report Information

1. Name: Matthew Gosse
Email: matthew.gosse@amectw.com
2. Name: James McCarthy
Email: james.mccarthy@amectw.com

Regulatory Requirements (Check):

- ☐ List Guidelines on Report
- ☐ PIRI
- ☐ Tier 1 ☐ Res. ☐ Pol. ☐ Coarse
- ☐ Tier 2 ☐ Com ☐ N/Pol. ☐ Fine
- ☐ Gas ☐ Fuel ☐ Lube
- ☐ CCME ☐ CDWQ ☐ NSD-OSP
- ☐ Ind ☐ Com ☐ HRM 101
- ☐ Res/P ☐ Storm Water
- ☐ Ag ☐ HRM 101
- ☐ FWAL ☐ Waste Water
- ☐ Sediment
- ☐ Other: _____

Report Format

☐ Single PDF sample per page
☒ Multiple PDF samples per page
☐ Excel Format Included

Regular TAT: ☒ 5 - 7 days
Rush TAT: ☐ 1 day ☐ 2 days
☐ 3 - 4 days

Date Required: _____
Time Required: _____

Turnaround Time (TAT) Business Days

SAMPLE IDENTIFICATION	DATE / TIME SAMPLED	SAMPLE MATRIX	# OF CONTAINERS	COMMENTS - Site/Sample Info, Sample Containment	Field Filtered/ Preserved	Total Organic Carbon	Metals (Total)	Methyl Mercury	Mercury	BOD	pH	TSS	TKN	Anions	Total Phosphorus	Phenols	TPH/BTEX (PIRI) Tier 1	TPH/BTEX-Fractionation Tier 2	VOC	THM	PAH	PCB	Other	Hazardous (Y/N)	Lab Sample #
AZ132A	Dec 4, 11	Sci	3																						
ER27A		Sci	2																						
ER25A		Sci	3																						
ES19A		Sci	3																						
EE40A		Sci	3																						
DM46A		Sci	3																						
DR50A		Sci	3																						
EQ29A		Sci	3																						
DP53A		Sci	3																						
BV86A	Dec 5, 11																								

Sample Relinquished By (print name & sign) _____ Date/Time _____
Samples Received By (print name and sign) _____
Sample Relinquished By (print name & sign) _____ Date/Time _____
Matthew Gosse

CLIENT NAME: AMEC FOSTER WHEELER E&I
133 CROSBIE ROAD
ST. JOHNS, NL A1B4A5
(709) 722-7023

ATTENTION TO: MATT GOSSE

PROJECT: TF13104119.5600

AGAT WORK ORDER: 16X169381

SOIL ANALYSIS REVIEWED BY: James MacDonald, Technical Services Manager

DATE REPORTED: May 31, 2017

PAGES (INCLUDING COVER): 5

VERSION*: 5

Should you require any information regarding this analysis please contact your client services representative at (902) 468-8718

***NOTES**

VERSION 5: Version 5.0 supersedes Version 4.0. Updated report to separate analyses at client request. Issued, May 31, 2017.

Version 2.0 supersedes Version 1.0. Lower RDL for Hg reported. Issued, May 12, 2017.

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.



Certificate of Analysis

AGAT WORK ORDER: 16X169381

PROJECT: TF13104119.5600

11 Morris Drive, Unit 122
Dartmouth, Nova Scotia
CANADA B3B 1M2
TEL (902)468-8718
FAX (902)468-8924
<http://www.agatlabs.com>

CLIENT NAME: AMEC FOSTER WHEELER E&I

ATTENTION TO: MATT GOSSE

SAMPLING SITE:

SAMPLED BY:

Available Metals in Soil

DATE RECEIVED: 2016-12-09

DATE REPORTED: 2017-05-31

		SAMPLE DESCRIPTION:		AC147A	AJ139A	I164A	K153A	K161A	N153A	W137A
		SAMPLE TYPE:		Soil	Soil	Soil	Soil	Soil	Soil	Soil
		DATE SAMPLED:		2016-12-01	2016-12-01	2016-12-01	2016-12-01	2016-12-01	2016-12-01	2016-12-03
Parameter	Unit	G / S	RDL	8079180	8079198	8079200	8079202	8079204	8079205	8079206
Aluminum	mg/kg		10	3580	1510	1880	3400	1780	1200	601
Antimony	mg/kg		1	<1	<1	<1	<1	<1	<1	<1
Arsenic	mg/kg		1	3	2	2	2	3	2	2
Barium	mg/kg		5	70	57	20	45	118	47	64
Beryllium	mg/kg		2	<2	<2	<2	<2	<2	<2	<2
Boron	mg/kg		2	3	<2	<2	<2	<2	2	2
Cadmium	mg/kg		0.3	<0.3	<0.3	<0.3	0.4	<0.3	<0.3	<0.3
Chromium	mg/kg		2	7	3	5	4	6	3	2
Cobalt	mg/kg		1	2	<1	<1	1	2	<1	2
Copper	mg/kg		2	6	2	3	4	18	5	5
Iron	mg/kg		50	5290	964	2290	1560	2530	1310	700
Lead	mg/kg		0.5	8.9	6.2	7.4	29.4	26.2	14.0	20.9
Lithium	mg/kg		5	<5	<5	<5	<5	<5	<5	<5
Manganese	mg/kg		2	92	12	18	41	35	65	10
Molybdenum	mg/kg		2	<2	<2	<2	<2	<2	<2	<2
Nickel	mg/kg		2	5	2	<2	2	14	3	3
Selenium	mg/kg		1	<1	<1	<1	<1	<1	<1	<1
Silver	mg/kg		0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Strontium	mg/kg		5	16	10	<5	<5	23	15	63
Thallium	mg/kg		0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Tin	mg/kg		2	2	3	<2	3	3	3	3
Uranium	mg/kg		0.1	0.5	0.2	0.6	<0.1	0.3	0.1	<0.1
Vanadium	mg/kg		2	10	5	8	5	10	6	6
Zinc	mg/kg		5	16	10	<5	18	10	24	22

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
8079180-8079206 Results are based on the dry weight of the sample.

Certified By:

Quality Assurance

CLIENT NAME: AMEC FOSTER WHEELER E&I

AGAT WORK ORDER: 16X169381

PROJECT: TF13104119.5600

ATTENTION TO: MATT GOSSE

SAMPLING SITE:

SAMPLED BY:

Soil Analysis															
RPT Date: May 31, 2017			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper

Available Metals in Soil

Aluminum	1214201		601	583	3.0%	< 10	98%	80%	120%	98%	80%	120%	130%	70%	130%
Antimony	1214201		< 1	< 1	NA	< 1	89%	80%	120%	104%	80%	120%	NA	70%	130%
Arsenic	1214201		2	2	NA	< 1	99%	80%	120%	96%	80%	120%	94%	70%	130%
Barium	1214201		64	64	0.0%	< 5	96%	80%	120%	97%	80%	120%	102%	70%	130%
Beryllium	1214201		< 2	< 2	NA	< 2	107%	80%	120%	110%	80%	120%	102%	70%	130%
Boron	1214201		2	2	NA	< 2	111%	80%	120%	111%	80%	120%	103%	70%	130%
Cadmium	1214201		< 0.3	< 0.3	NA	< 0.3	101%	80%	120%	103%	80%	120%	91%	70%	130%
Chromium	1214201		2	2	NA	< 2	109%	80%	120%	110%	80%	120%	109%	70%	130%
Cobalt	1214201		2	2	NA	< 1	106%	80%	120%	107%	80%	120%	101%	70%	130%
Copper	1214201		5	5	NA	< 2	112%	80%	120%	120%	80%	120%	106%	70%	130%
Iron	1214201		700	682	2.6%	< 50	105%	80%	120%	103%	80%	120%	109%	70%	130%
Lead	1214201		20.9	21.5	2.8%	< 0.5	103%	80%	120%	106%	80%	120%	97%	70%	130%
Manganese	1214201		10	10	0.0%	< 2	103%	80%	120%	104%	80%	120%	109%	70%	130%
Molybdenum	1214201		< 2	< 2	NA	< 2	98%	80%	120%	95%	80%	120%	95%	70%	130%
Nickel	1214201		3	3	NA	< 2	109%	80%	120%	112%	80%	120%	105%	70%	130%
Selenium	1214201		< 1	< 1	NA	< 1	100%	80%	120%	100%	80%	120%	90%	70%	130%
Silver	1214201		< 0.5	< 0.5	NA	< 0.5	109%	80%	120%	107%	80%	120%	100%	70%	130%
Strontium	1214201		63	64	1.6%	< 5	95%	80%	120%	98%	80%	120%	101%	70%	130%
Thallium	1214201		< 0.1	< 0.1	NA	< 0.1	106%	80%	120%	105%	80%	120%	NA	70%	130%
Tin	1214201		3	3	NA	< 2	101%	80%	120%	99%	80%	120%	94%	70%	130%
Uranium	1214201		< 0.1	< 0.1	NA	< 0.1	100%	80%	120%	103%	80%	120%	93%	70%	130%
Vanadium	1214201		6	5	NA	< 2	105%	80%	120%	103%	80%	120%	106%	70%	130%
Zinc	1214201		22	22	NA	< 5	109%	80%	120%	112%	80%	120%	102%	70%	130%

Mercury Analysis in Soil

Mercury	1	8082932	0.053	0.055	NA	< 0.015	83%	70%	130%		70%	130%	77%	70%	130%
---------	---	---------	-------	-------	----	---------	-----	-----	------	--	-----	------	-----	-----	------

pH in Soil

pH	1	8083452	8.42	8.62	2.3%	<	98%	80%	120%						
----	---	---------	------	------	------	---	-----	-----	------	--	--	--	--	--	--

TOC (Soil)

Total Organic Carbon(Walkley-Black Wet Oxidation)	8079180	8079180	44.1	44.7	1.4%	< 0.30	116%	70%	130%				80%	70%	130%
---	---------	---------	------	------	------	--------	------	-----	------	--	--	--	-----	-----	------

Certified By:



Method Summary

CLIENT NAME: AMEC FOSTER WHEELER E&I

AGAT WORK ORDER: 16X169381

PROJECT: TF13104119.5600

ATTENTION TO: MATT GOSSE

SAMPLING SITE:

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Aluminum	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Antimony	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Arsenic	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Barium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Beryllium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Boron	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Cadmium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Chromium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Cobalt	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Copper	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Iron	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Lead	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP-MS
Lithium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP-MS
Manganese	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Molybdenum	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Nickel	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Selenium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Silver	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Strontium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Thallium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Tin	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Uranium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Vanadium	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Zinc	MET-121-6105 & MET-121-6103	EPA SW 846 6020A/3050B & SM 3125	ICP/MS
Mercury	INOR-121-6101 & INOR-121-6107	Based on EPA 245.5 & SM 3112B	CV/AA
Subcontracted Data			
Total Organic Carbon(Walkley-Black Wet Oxidation)	INOR-93-6062	Skjemstad & Baldock, 2008 & Walkley & Black 1934	SPECTROPHOTOMETER
pH	INOR-121-6006	modified from Canadian Society of Soil Science p15	pH METER



Phone: 902-468-8718
Fax: 902-468-8924
www.agatlabs.com

Drinking Water Sample (y/n): _____

Waterworks Number: _____

Reg. No. _____

☐ Other _____

CONCLUSIONS



APPENDIX E: TOTAL CARBON CALCULATIONS

Table E-1: Total Carbon Calculations for the Total Sampled Thickness

Sample Description	Ecotype	Area	Sampled Thickness	TOC (mean/ALS %)	Mass C g C/kg soil	Combined Soil Type Calculation						Calculation for Mineral and Organic					
						density*	Soil Mass		Measured C		Total C	density**	Soil Mass		Measured C		Total C
		ha	(m)	%		(g/cc)	g/cm2	kg soil/ha	g C/ha	t C/ha	t	(g/cc)	g/cm2	kg soil/ha	g C/ha	t C/ha	t
AC147A	Black Spruce/Feathermoss Forest		0.14	26.55	266	0.27	3.80	3.80E+05	1.01E+08	101		0.42	5.93	5.93E+05	1.58E+08	158	
AP126A	Black Spruce/Feathermoss Forest		0.19	40.1	401	0.15	2.81	2.81E+05	1.13E+08	113		0.20	3.78	3.78E+05	1.52E+08	152	
BR102A	Black Spruce/Feathermoss Forest		0.07	42.6	426	0.14	0.95	9.47E+04	4.03E+07	40		0.18	1.24	1.24E+05	5.29E+07	53	
CS79A	Black Spruce/Feathermoss Forest		0.15	45.7	457	0.12	1.84	1.84E+05	8.40E+07	84		0.16	2.33	2.33E+05	1.07E+08	107	
DP52A	Black Spruce/Feathermoss Forest		0.08	44.65	447	0.13	1.01	1.01E+05	4.52E+07	45		0.16	1.30	1.30E+05	5.80E+07	58	
DP53A	Black Spruce/Feathermoss Forest		0.1	49.95	500	0.11	1.09	1.09E+05	5.45E+07	54		0.13	1.33	1.33E+05	6.65E+07	66	
DY36A	Black Spruce/Feathermoss Forest		0.1	28.6	286	0.24	2.45	2.45E+05	6.99E+07	70		0.37	3.73	3.73E+05	1.07E+08	107	
DY47A	Black Spruce/Feathermoss Forest		0.05	35.0	350	0.18	0.91	9.06E+04	3.17E+07	32		0.26	1.29	1.29E+05	4.52E+07	45	
EE40A	Black Spruce/Feathermoss Forest		0.04	11.1	111	0.67	2.69	2.69E+05	2.98E+07	30		0.74	2.96	2.96E+05	3.28E+07	33	
EJ19A	Black Spruce/Feathermoss Forest		0.07	44.0	440	0.13	0.90	9.04E+04	3.98E+07	40		0.17	1.17	1.17E+05	5.14E+07	51	
EK17A	Black Spruce/Feathermoss Forest		0.08	32.9	329	0.20	1.59	1.59E+05	5.23E+07	52		0.29	2.32	2.32E+05	7.63E+07	76	
N153A	Black Spruce/Feathermoss Forest		0.06	6.41	64.1	0.91	5.46	5.46E+05	3.50E+07	35		0.85	5.10	5.10E+05	3.27E+07	33	
		856.26	0.09	34.0	340	0.27	2.12	2.12E+05	5.80E+07	58.0	49671	0.33	2.71	2.71E+05	7.82E+07	78.2	66959
AX117A	Black Spruce/Lichen Woodland		0.02	36.05	361	0.17	0.35	3.46E+04	1.25E+07	12		0.24	0.49	4.88E+04	1.76E+07	18	
BM121A	Black Spruce/Lichen Woodland		0.08	18.4	184	0.43	3.43	3.43E+05	6.31E+07	63		0.72	5.79	5.79E+05	1.07E+08	107	
DT41A	Black Spruce/Lichen Woodland		0.05	47.0	470	0.12	0.59	5.90E+04	2.77E+07	28		0.15	0.74	7.40E+04	3.48E+07	35	
I164A	Black Spruce/Lichen Woodland		0.04	9.29	92.9	0.75	3.02	3.02E+05	2.80E+07	28		0.77	3.06	3.06E+05	2.84E+07	28	
K153A	Black Spruce/Lichen Woodland		0.06	8.835	88.4	0.78	4.66	4.66E+05	4.12E+07	41		0.77	4.65	4.65E+05	4.11E+07	41	
		90.88	0.05	23.9	239	0.45	2.41	2.41E+05	3.45E+07	34.5	3137	0.53	2.95	2.95E+05	4.57E+07	45.7	4152
DQ50A	Black Spruce/Sphagnum Woodland		0.08	45.7	457	0.12	0.98	9.80E+04	4.48E+07	45		0.16	1.25	1.25E+05	5.69E+07	57	
		15.99	0.08	45.7	457	0.12	0.98	9.80E+04	4.48E+07	45	716	0.16	1.25	1.25E+05	5.69E+07	57	910
AW136A	Fir-White Spruce Forest		0.12	14.1	141	0.56	6.68	6.68E+05	9.42E+07	94		0.72	8.60	8.60E+05	1.21E+08	121	
AX134A	Fir-White Spruce Forest		0.05	6.67	66.7	0.89	4.47	4.47E+05	2.98E+07	30		0.84	4.19	4.19E+05	2.80E+07	28	
AZ132A	Fir-White Spruce Forest		0.02	42.9	429	0.13	0.27	2.68E+04	1.15E+07	11		0.17	0.35	3.50E+04	1.50E+07	15	
DV46A	Fir-White Spruce Forest		0.05	44.45	445	0.13	0.64	6.37E+04	2.83E+07	28		0.16	0.82	8.19E+04	3.64E+07	36	
		802.51	0.06	27.0	270	0.43	3.01	3.01E+05	4.10E+07	41.0	32866	0.47	3.49	3.49E+05	5.02E+07	50	40264
EK27A	Hardwood Forest		0.09	24.8	248	0.30	2.68	2.68E+05	6.66E+07	67		0.47	4.26	4.26E+05	1.06E+08	106	
W137A	Hardwood Forest		0.2	46.85	469	0.12	2.37	2.37E+05	1.11E+08	111		0.15	2.98	2.98E+05	1.39E+08	139	
		221.43	0.15	35.8	358	0.21	2.53	2.53E+05	8.88E+07	88.8	19663	0.31	3.62	3.62E+05	1.23E+08	123	27143
AJ139A	Mixedwood Forest		0.05	39.0	390	0.15	0.77	7.70E+04	3.00E+07	30		0.21	1.05	1.05E+05	4.09E+07	41	
BN117A	Mixedwood Forest		0.06	42.5	425	0.14	0.81	8.14E+04	3.46E+07	35		0.18	1.07	1.07E+05	4.54E+07	45	
BQ116A	Mixedwood Forest		0.08	47.9	479	0.12	0.92	9.21E+04	4.41E+07	44		0.14	1.14	1.14E+05	5.48E+07	55	
BV86A	Mixedwood Forest		0.06	28.0	280	0.25	1.51	1.51E+05	4.23E+07	42		0.39	2.32	2.32E+05	6.51E+07	65	
I159A	Mixedwood Forest		0.08	5.71	57.1	0.95	7.62	7.62E+05	4.35E+07	44		0.88	7.06	7.06E+05	4.03E+07	40	
K161A	Mixedwood Forest		0.05	18.2	182	0.43	2.17	2.17E+05	3.95E+07	40		0.73	3.67	3.67E+05	6.68E+07	67	
		695.52	0.06	30.2	302	0.34	2.30	2.30E+05	3.90E+07	39.0	27133	0.42	2.72	2.72E+05	5.22E+07	52	36326
D153A	Riparian		0.2	0.365	3.65	1.36	27.18	2.72E+06	9.92E+06	10		1.56	31.15	3.11E+06	1.14E+07	11	
DM46A	Riparian		0.08	7.24	72.4	0.86	6.89	6.89E+05	4.99E+07	50		0.82	6.54	6.54E+05	4.74E+07	47	
P152A	Riparian		0.11	1.26	12.6	1.28	14.08	1.41E+06	1.77E+07	18		1.36	14.98	1.50E+06	1.89E+07	19	
		655.12	0.13	2.96	29.6	1.17	16.05	1.61E+06	2.59E+07	26	16939	1.25	17.56	1.76E+06	2.59E+07	26	16945
EQ29A	Spruce Fir/Feathermoss Forest		0.15	49.5	495	0.11	1.66	1.66E+05	8.19E+07	82		0.14	2.03	2.03E+05	1.00E+08	100	
ER25A	Spruce Fir/Feathermoss Forest		0.1	33.55	335.5	0.19	1.93	1.93E+05	6.48E+07	65		0.28	2.80	2.80E+05	9.38E+07	94	
		113.49	0.13	41.5	415	0.15	1.79	1.79E+05	7.34E+07	73.4	8325	0.21	2.41	2.41E+05	9.71E+07	97	11017
AW129A	Wetland		0.03	8.87	88.7	0.78	2.33	2.33E+05	2.06E+07	21		0.77	2.32	2.32E+05	2.06E+07	21	
AY130A	Wetland		0.03	42.8	428	0.13	0.40	4.03E+04	1.72E+07	17		0.18	0.53	5.27E+04	2.26E+07	23	
BB122A	Wetland		0.1	15.3	153	0.52	5.17	5.17E+05	7.91E+07	79		0.71	7.12	7.12E+05	1.09E+08	109	
BF125A	Wetland		0.3	41.15	412	0.14	4.27	4.27E+05	1.76E+08	176		0.19	5.68	5.68E+05	2.34E+08	234	
CG83A	Wetland		0.15	33.1	331	0.20	2.96	2.96E+05	9.78E+07	98		0.29	4.30	4.30E+05	1.42E+08	142	
DH72A	Wetland		0.05	29.9	299	0.23	1.15	1.15E+05	3.43E+07	34		0.35	1.73	1.73E+05	5.16E+07	52	
		218.98	0.11	28.5	285	0.33	2.71	2.71E+05	7.08E+07	70.8	15498	0.41	3.61	3.61E+05	9.66E+07	97	21163
Overall Totals		3670.2									173,949						224,879

organic

mineral

TOC >17%

TOC <17%

* density calculated based on Hossain et al, 2015 with combined mineral and organic soil equation.

** density calculated based on Hossain et al, 2015 with organic and mineral soil specific equations.

Table E-2: Total Carbon Calculations for 0-5 cm of Sampled Thickness

Sample Description	Ecotype	Area	Sampled Thickness	Thickness for Calculation	TOC (mean/ALS result)	Mass C	Combined Soil Type Calculation								Calculation for Mineral and Organic							
							density*	Soil Mass		Measured C		Inferred Mineral Soil C***	Measured and Inferred C	Total C	density**	Soil Mass		Measured C		Inferred Mineral Soil C***	Measured and Inferred C	Total C
		ha	(m)	(m)	%	g C/kg soil	(g/cc)	g/cm2	kg soil/ha	g C/ha	t C/ha	t C/ha	t C/ha	t	(g/cc)	g/cm2	kg soil/ha	g C/ha	t C/ha	t C/ha	t C/ha	t
AC147A	Black Spruce/Feathermoss Forest		0.14	0.05	26.55	266	0.27	1.36	1.36E+05	3.61E+07	36.1	0.00	36.1		0.42	2.12	2.12E+05	5.63E+07	56.3	0.00	56.3	
AP126A	Black Spruce/Feathermoss Forest		0.19	0.05	40.1	401	0.15	0.74	7.38E+04	2.96E+07	29.6	0.00	29.6		0.20	0.99	9.95E+04	3.99E+07	39.9	0.00	39.9	
BR102A	Black Spruce/Feathermoss Forest		0.07	0.05	42.6	426	0.14	0.68	6.76E+04	2.88E+07	28.8	0.00	28.8		0.18	0.89	8.87E+04	3.78E+07	37.8	0.00	37.8	
CS79A	Black Spruce/Feathermoss Forest		0.15	0.05	45.7	457	0.12	0.61	6.13E+04	2.80E+07	28.0	0.00	28.0		0.16	0.78	7.78E+04	3.56E+07	35.6	0.00	35.6	
DP52A	Black Spruce/Feathermoss Forest		0.08	0.05	44.65	447	0.13	0.63	6.33E+04	2.82E+07	28.2	0.00	28.2		0.16	0.81	8.12E+04	3.63E+07	36.3	0.00	36.3	
DP53A	Black Spruce/Feathermoss Forest		0.1	0.05	49.95	500	0.11	0.55	5.46E+04	2.72E+07	27.2	0.00	27.2		0.13	0.67	6.66E+04	3.32E+07	33.2	0.00	33.2	
DY36A	Black Spruce/Feathermoss Forest		0.1	0.05	28.6	286	0.24	1.22	1.22E+05	3.50E+07	35.0	0.00	35.0		0.37	1.87	1.87E+05	5.34E+07	53.4	0.00	53.4	
DY47A	Black Spruce/Feathermoss Forest		0.05	0.05	35.0	350	0.18	0.91	9.06E+04	3.17E+07	31.7	0.00	31.7		0.26	1.29	1.29E+05	4.52E+07	45.2	0.00	45.2	
EE40A	Black Spruce/Feathermoss Forest		0.04	0.04	11.1	111	0.67	2.69	2.69E+05	2.98E+07	29.8	0.15	30.0		0.74	2.96	2.96E+05	3.28E+07	32.8	0.15	33.0	
EJ19A	Black Spruce/Feathermoss Forest		0.07	0.05	44.0	440	0.13	0.65	6.46E+04	2.84E+07	28.4	0.00	28.4		0.17	0.83	8.34E+04	3.67E+07	36.7	0.00	36.7	
EK17A	Black Spruce/Feathermoss Forest		0.08	0.05	32.9	329	0.20	0.99	9.94E+04	3.27E+07	32.7	0.00	32.7		0.29	1.45	1.45E+05	4.77E+07	47.7	0.00	47.7	
N153A	Black Spruce/Feathermoss Forest		0.06	0.05	6.41	64.1	0.91	4.55	4.55E+05	2.92E+07	29.2	0.00	29.2		0.85	4.25	4.25E+05	2.72E+07	27.2	0.00	27.2	
		856.26	0.09	0.05	34.0	340	0.27	1.30	1.30E+05	3.04E+07	30.4		30.4	26039	0.33	1.58	1.58E+05	4.02E+07	40.2		40.2	34406
AX117A	Black Spruce/Lichen Woodland		0.02	0.02	36.05	361	0.17	0.35	3.46E+04	1.25E+07	12.5	0.45	12.9		0.24	0.49	4.88E+04	1.76E+07	17.6	0.45	18.0	
BM121A	Black Spruce/Lichen Woodland		0.08	0.05	18.4	184	0.43	2.14	2.14E+05	3.95E+07	39.5	0.00	39.5		0.72	3.62	3.62E+05	6.66E+07	66.6	0.00	66.6	
DT41A	Black Spruce/Lichen Woodland		0.05	0.05	47.0	470	0.12	0.59	5.90E+04	2.77E+07	27.7	0.00	27.7		0.15	0.74	7.40E+04	3.48E+07	34.8	0.00	34.8	
I164A	Black Spruce/Lichen Woodland		0.04	0.04	9.29	92.9	0.75	3.02	3.02E+05	2.80E+07	28.0	0.15	28.2		0.77	3.06	3.06E+05	2.84E+07	28.4	0.15	28.6	
K153A	Black Spruce/Lichen Woodland		0.06	0.05	8.835	88.4	0.78	3.89	3.89E+05	3.43E+07	34.3	0.00	34.3		0.77	3.87	3.87E+05	3.42E+07	34.2	0.00	34.2	
		90.88	0.05	0.04	23.9	239	0.45	2.00	2.00E+05	2.84E+07	28.4		28.5	2593	0.53	2.36	2.36E+05	3.63E+07	36.3		36.4	3312
DQ50A	Black Spruce/Sphagnum Woodland		0.08	0.05	45.7	457	0.12	0.61	6.13E+04	2.80E+07	28.0	0.00	28.0		0.16	0.78	7.78E+04	3.56E+07	35.6	0.00	35.6	
		15.99	0.08	0.05	45.7	457	0.12	0.61	6.13E+04	2.80E+07	28.0		28.0	448	0.16	0.78	7.78E+04	3.56E+07	35.6		35.6	569
AW136A	Fir-White Spruce Forest		0.12	0.05	14.1	141	0.56	2.78	2.78E+05	3.93E+07	39.3	0.00	39.3		0.72	3.58	3.58E+05	5.05E+07	50.5	0.00	50.5	
AX134A	Fir-White Spruce Forest		0.05	0.05	6.67	66.7	0.89	4.47	4.47E+05	2.98E+07	29.8	0.00	29.8		0.84	4.19	4.19E+05	2.80E+07	28.0	0.00	28.0	
AZ132A	Fir-White Spruce Forest		0.02	0.02	42.9	429	0.13	0.27	2.68E+04	1.15E+07	11.5	0.45	11.9		0.17	0.35	3.50E+04	1.50E+07	15.0	0.45	15.5	
DV46A	Fir-White Spruce Forest		0.05	0.05	44.45	445	0.13	0.64	6.37E+04	2.83E+07	28.3	0.00	28.3		0.16	0.82	8.19E+04	3.64E+07	36.4	0.00	36.4	
		802.51	0.06	0.0425	27.0	270	0.43	2.04	2.04E+05	2.72E+07	27.2		27.3	21931	0.47	2.24	2.24E+05	3.25E+07	32.5		32.6	26157
EK27A	Hardwood Forest		0.09	0.05	24.8	248	0.30	1.49	1.49E+05	3.70E+07	37.0	0.00	37.0		0.47	2.37	2.37E+05	5.87E+07	58.7	0.00	58.7	
W137A	Hardwood Forest		0.2	0.05	46.85	469	0.12	0.59	5.92E+04	2.78E+07	27.8	0.00	27.8		0.15	0.74	7.44E+04	3.49E+07	34.9	0.00	34.9	
		221.43	0.15	0.05	35.8	358	0.21	1.04	1.04E+05	3.24E+07	32.4		32.4	7168	0.31	1.56	1.56E+05	4.68E+07	46.8		46.8	10362
AJ139A	Mixedwood Forest		0.05	0.05	39.0	390	0.15	0.77	7.70E+04	3.00E+07	30.0	0.00	30.0		0.21	1.05	1.05E+05	4.09E+07	40.9	0.00	40.9	
BN117A	Mixedwood Forest		0.06	0.05	42.5	425	0.14	0.68	6.78E+04	2.88E+07	28.8	0.00	28.8		0.18	0.89	8.91E+04	3.78E+07	37.8	0.00	37.8	
BQ116A	Mixedwood Forest		0.08	0.05	47.9	479	0.12	0.58	5.75E+04	2.76E+07	27.6	0.00	27.6		0.14	0.72	7.15E+04	3.43E+07	34.3	0.00	34.3	
BV86A	Mixedwood Forest		0.06	0.05	28.0	280	0.25	1.26	1.26E+05	3.53E+07	35.3	0.00	35.3		0.39	1.94	1.94E+05	5.42E+07	54.2	0.00	54.2	
I159A	Mixedwood Forest		0.08	0.05	5.71	57.1	0.95	4.76	4.76E+05	2.72E+07	27.2	0.00	27.2		0.88	4.41	4.41E+05	2.52E+07	25.2	0.00	25.2	
K161A	Mixedwood Forest		0.05	0.05	18.2	182	0.43	2.17	2.17E+05	3.95E+07	39.5	0.00	39.5		0.73	3.67	3.67E+05	6.68E+07	66.8	0.00	66.8	
		695.52	0.06	0.05	30.2	302	0.34	1.70	1.70E+05	3.14E+07	31.4		31.4	21838	0.42	2.11	2.11E+05	4.32E+07	43.2		43.2	30055
D153A	Riparian		0.2	0.05	0.365	3.65	1.36	6.80	6.80E+05	2.48E+06	2.5	0.00	2.5		1.56	7.79	7.79E+05	2.84E+06	2.8	0.00	2.8	
DM46A	Riparian		0.08	0.05	7.24	72.4	0.86	4.31	4.31E+05	3.12E+07	31.2	0.00	31.2		0.82	4.09	4.09E+05	2.96E+07	29.6	0.00	29.6	
P152A	Riparian		0.11	0.05	1.26	12.6	1.28	6.40	6.40E+05	8.06E+06	8.1	0.00	8.1		1.36	6.81	6.81E+05	8.58E+06	8.6	0.00	8.6	
		655.12	0.13	0.05	2.96	29.6	1.17	5.83	5.83E+05	1.39E+07	13.9		13.9	9114	1.25	6.23	6.23E+05	1.37E+07	13.7		13.7	8957
EQ29A	Spruce Fir/Feathermoss Forest		0.15	0.05	49.5	495	0.11	0.55	5.52E+04	2.73E+07	27.3	0.00	27.3		0.14	0.68	6.76E+04	3.35E+07	33.5	0.00	33.5	
ER25A	Spruce Fir/Feathermoss Forest		0.1	0.05	33.55	335.5	0.19	0.97	9.66E+04	3.24E+07	32.4	0.00	32.4		0.28	1.40	1.40E+05	4.69E+07	46.9	0.00	46.9	
		113.49	0.13	0.05	41.5	415	0.15	0.76	7.59E+04	2.99E+07	29.9		29.9	3388	0.21	1.04	1.04E+05	4.02E+07	40.2		40.2	4559
AW129A	Wetland		0.03	0.03	8.87	88.7	0.78	2.33	2.33E+05	2.06E+07	20.6	0.30	20.9		0.77	2.32	2.32E+05	2.06E+07	20.6	0.30	20.9	
AY130A	Wetland		0.03	0.03	42.8	428	0.13	0.40	4.03E+04	1.72E+07	17.2	0.30	17.5		0.18	0.53	5.27E+04	2.26E+07	22.6	0.30	22.9	
BB122A	Wetland		0.1	0.05	15.3	153	0.52	2.59	2.59E+05	3.96E+07	39.6	0.00	39.6		0.71	3.56	3.56E+05	5.45E+07	54.5	0.00	54.5	
BF125A	Wetland		0.3	0.05	41.15	412	0.14	0.71	7.11E+04	2.93E+07	29.3	0.00	29.3		0.19	0.95	9.47E+04	3.90E+07	39.0	0.00	39.0	
CG83A	Wetland		0.15	0.05	33.1	331	0.20	0.99	9.85E+04	3.26E+07	32.6	0.00	32.6		0.29	1.43	1.43E+05	4.74E+07	47.4	0.00	47.4	
DH72A	Wetland		0.05	0.05	29.9	299	0.23	1.15	1.15E+05	3.43E+07	34.3	0.00	34.3		0.35	1.73	1.73E+05	5.16E+07	51.6	0.00	51.6	
		218.98	0.11	0.04	28.5	285	0.33	1.36	1.36E+05	2.89E+07	28.9		29.0	6357	0.41	1.75	1.75E+05	3.93E+07	39.3		39.4	8623
Overall Totals		3670.18												98,875								127,000

organic TOC >17%
mineral TOC <17%

* density calculated based on Hossain et al, 2015 with combined mineral and organic soil equation.

** density calculated based on Hossain et al, 2015 with organic and mineral soil specific equations.

*** Inferred additional carbon in calculation interval assuming mineral soil with 0.5% TOC and density of 1.5 g/cc