Phase 1 2010 Site C Data Collection – Sampling and Analysis Plan

Prepared for

BC Hydro
Site C Fisheries and Aquatics
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ACKNOWLEDGEMENTS

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ACRONYMS

COC – Chain of custody

DL – Detection limit

DUP – Duplicate

DOC – Dissolved organic carbon

GPS – Global Positioning System

HDPE – High density polyethylene

MeHg – Methyl mercury

PCD – Peace Canyon Dam

QA/QC – Quality Assurance / Quality Control

SINLAB – Stable Isotopes in Nature Laboratory (University of New Brunswick)

THg – Total mercury

TOC – Total organic carbon

TSS – Total suspended solids

UTM – Universal Transverse Mercator

EXECUTIVE SUMMARY

Azimuth Consulting Group (Azimuth) was commissioned by BC Hydro to develop a strategy and supporting rationale for addressing the issue of mercury accumulation in aquatic biota related to the proposed Site C development (Azimuth, 2010). The strategy is intended to provide a foundation from which to build a cohesive body of information to support informed management decisions regarding mercury. One of the key issues highlighted in the strategy document was the likely requirement to employ quantitative, predictive mercury models to forecast the magnitude of increases in fish mercury concentrations over the life of the new reservoir.

Azimuth's technical memorandum entitled Mercury Data Review and Planning Considerations (Azimuth, 2010) included a detailed review of existing physical and chemical data on the Peace River to identify data gaps related to specific mercury model input requirements and/or to characterize conditions relevant to better understanding potential mercury dynamics. This Sampling and Analysis Plan (SAP) was developed to provide detailed guidance related to filling the identified data gaps. The basic study design addresses two major objectives: 1) collect all essential input data requirements to run the mechanistic mercury model (if deemed necessary), and 2) use stable isotope analysis of various aquatic species (benthic invertebrates, zooplankton and fish) in the Dinosaur Reservoir (as an analog to the proposed Site C Reservoir) and the mainstem of the Peace River to estimate how trophic structure, which affects mercury accumulation, may change in the future reservoir.

1. INTRODUCTION

Azimuth Consulting Group (Azimuth) was commissioned by BC Hydro to develop a strategy and supporting rationale for addressing the issue of mercury accumulation in aquatic biota related to the proposed Site C development (Azimuth, 2010). The strategy is intended to provide a foundation from which to build a cohesive body of information to support informed management decisions regarding mercury. One of the key issues highlighted in the strategy document was the likely requirement to employ quantitative, predictive mercury models to forecast the magnitude of increases in fish mercury concentrations over the life of the new reservoir.

Azimuth's technical memorandum entitled *Mercury Data Review and Planning Considerations* (Azimuth, 2010) included a detailed review of existing physical and chemical data on the Peace River to identify data gaps related to specific mercury model input requirements and/or to characterize conditions relevant to better understanding potential mercury dynamics. This Sampling and Analysis Plan (SAP) was developed to provide detailed guidance related to filling the identified data gaps.

This document is organized by Section, as follows:

- ***Section 2.0, Monitoring Strategy:*** This section provides a general overview of the sampling program, including the study design and approach taken to collect samples from each of the seven major environmental media listed below.
- ***Section 3.0, Water:*** This section lays out the SAP for collection of water samples for analysis of total and methyl mercury (and ancillary parameters) from various locations from the Peace River and from Dinosaur Reservoir.
- ***Section 4.0, Sediment:*** This section describes the SAP for collection of sediment from depositional areas within the Peace River as well as in Dinosaur Reservoir.
- ***Section 5.0, Benthos:*** Section 5.0 describes collection and preservation procedures for benthic invertebrates from riffle areas in the Peace River and from depositional areas in Dinosaur Reservoir for analysis of total and methyl mercury and for stable carbon and nitrogen isotopes.
- ***Section 6.0, Zooplankton:*** Section 6.0 describes collection and preservation procedures for pelagic zooplankton from the Peace River mainstem and from Dinosaur Reservoir for analysis of total and methyl mercury and for stable carbon and nitrogen isotopes.
- ***Section 7.0, Soil:*** Section 7.0 describes the rationale and methodology used to select discrete habitat types within the flood zone along the 83 km reach of river. Soil chemistry will be used to characterize soil metals and mercury concentrations

within selected habitat types with the greatest likelihood of contributing inorganic mercury to the system.

- ***Section 8.0, Vegetation:*** Although living vegetation typically has very low mercury concentrations, it is important to verify this and to represent mercury concentrations in the dominant, representative vegetation types throughout the proposed reservoir. This section presents the rationale and methodology for vegetation sampling.
- ***Section 9.0, Fish:*** Section 9 describes the method for non-destructive tissue sampling for mercury and stable isotope analysis of certain fish species, and destructive sampling for forage species from the Peace River.

Each Section is structured to provide step-by-step instructions to facilitate collection of environmental media as follows:

1. Specific parameter to be collected
2. Location of sampling station
3. Timing of field collections for each media
4. Detailed sampling procedures
5. Quality assurance / quality control

In addition, a detailed list of '*Equipment Needs*' for the collection of each media type was provided to the field investigation team prior to going into the field to ensure that all of the required equipment was sourced and available prior to embarking on sample collections. These lists are not reported here because of the repetitive nature of many of the requirements.

Note that there are well established protocols for sampling of inorganic mercury and methyl mercury in environmental media. Standard methods, including quality assurance/quality control (QA/QC) procedures must be followed to avoid the risk of inadvertent contamination. Detailed methodologies and QA/QC procedures for the collection of total and methyl mercury and ancillary parameters in water, sediment and soil and total mercury and ancillary parameters in tissues are also provided here.

2. MONITORING STRATEGY

2.1. Background

Mercury accumulation dynamics in the proposed Site C reservoir will depend on baseline physical, chemical and biological conditions and how these change or evolve post-impoundment. Every reservoir is different and it is difficult to predict how changes in ecology or the chemical conditions affect methylation of inorganic mercury and accumulation of methyl mercury through the altered food web. Temporal patterns in mercury accumulation related to reservoir creation have been well-studied (Hall et al., 2005; Bodaly et al., 2004; 2007). In general, there is an initial rapid increase in mercury concentrations in water and biota, peaking about 3 – 5 years after impoundment, followed by a gradual decline in mercury concentrations, returning to background in 20 – 30 years. A principal goal of mercury-related studies for Site C will be predicting how key conditions are likely to change over time in relation to reservoir creation. This information will be used to estimate the magnitude and duration of elevated mercury concentrations in fish, which is an important consideration for humans and piscivorous (fish-eating) wildlife.

Existing reservoirs can serve as analogs, to some extent, for what might be observed in the Site C reservoir. The closest example is Dinosaur Reservoir, because it receives the same water from Williston, has very similar physical/chemical conditions, a similar assemblage of fish, has a low water residence time (i.e., is run-of-the-river) and is just upstream. However, ecological conditions and mercury concentrations observed in Dinosaur would be considered ‘end game’ concentrations, as the reservoir phenomenon would have largely disappeared by now, given the age of Dinosaur Reservoir (30 years).

Food chain structure has a strong influence on contaminant concentrations in predatory fish, particularly for substances that biomagnify (e.g., mercury; Cabana and Rasmussen, 1994; Cabana et al., 1994). Trophic position (i.e., how high an animal is situated in the food web) has traditionally been determined by examining the gut contents of fish, which essentially represent a brief “snap-shot” in time of their diet (e.g., typically on the order of days). Although Mainstream Aquatics will be collecting this information, gut contents do not provide a full picture of diet or where fish acquire energy from the food web during their lifespan. Advances in stable isotope analysis (SIA) over the past two decades have resulted in a powerful time-integrated tool for determining trophic position that is literally based on the premise that “you are what you eat”.

The ratio of stable carbon and nitrogen isotopes has been used to complement one another in the characterization of food webs over a broad range of systems. Together, they provide strong insights into trophic structure and feeding preferences, which are

invaluable in interpreting observed patterns in contaminant uptake and biomagnification (Rasmussen et al., 1990; Cabana and Rasmussen, 1994; Cabana et al., 1994; Atwell et al., 1998; Kidd et al., 1999). The use of stable isotope analyses in this study will help to understand the key factors presently driving mercury dynamics in the Peace River and Dinosaur Reservoir. Ultimately, this will help provide insights into what the new reservoir might eventually resemble. Thus, in addition to sampling for mercury from key biota groups (zooplankton, benthos, fish), it is a simple matter to collect small tissue quantities (<1 g) at the same time and analyse these for stable isotopes. Together, with mercury concentrations, this will provide us with a powerful tool to support predictions of mercury concentrations in biota in Site C and to better understand trophic relationships among fish species in the Peace River, relative to Dinosaur Reservoir.

2.2. Study Design

As part of the mercury strategy development process for Site C (Azimuth, 2010), Azimuth completed a review of previous studies that collected relevant supporting data within the Peace River over the past few years:

- Golder, 2009a. Water Quality, River Sediment, Soil and Vegetation Samples from the Peace River Watershed – 2007. Baseline Data Collection.
- Golder, 2009b. Peace River Watershed Water Quality and Dinosaur Lake Limnology Sampling – 2008.
- Mainstream Aquatics Ltd, 2009. Site C Fisheries Studies Mercury Levels in Peace River Fish Tissue Data Report. June, 2009.
- Terrestrial Ecosystem Mapping (TEM) 2007. Keystone Wildlife Research.

The results of these studies serve as a good foundation and advance our understanding of physical/chemical conditions within the proposed reservoir footprint that relate to mercury. However, a number of data gaps were identified for various components of the terrestrial and aquatic environment. In addition, Reed Harris (Harris Environmental, May 2010 [provided as **Appendix A**]) reviewed the existing information from the perspective of assessing which field data parameters are required as inputs to mechanistic mercury modeling, should this be pursued. For example, in water, actual mercury concentrations are not known because of high detection limits from previous sampling; thus, one of our objectives will be to determine this, as well as collecting certain ancillary parameters (e.g., dissolved organic carbon, pH, anions) in order to provide a full snapshot of chemical conditions at the time of mercury collections. There are other model input parameters, such as biomass of carbon flooded and bathymetry of the new reservoir,

which will be required, but will be addressed elsewhere. Ultimately, these reviews serve as the basis for our sampling strategy targeting specific media, locations and parameters.

The study design is intended to address two major objectives: 1) fulfill all essential data requirements to run the mechanistic mercury model (if necessary); and 2) determine trophic, food-web relationships in Dinosaur Reservoir and in the Peace River upstream of Site C through the use of stable isotopes.

There are seven media types covered in this SAP: water, sediment, soil, vegetation, zooplankton, benthic invertebrates and fish. Sample collection locations for most abiotic parameters (water, sediment, soil) and biotic factors (zooplankton, benthos, vegetation) are presented in **Figure 1**. Soil and vegetation sample collection locations are provided in **Table 1**, which provides UTM coordinates for discrete habitat polygons derived from the TEM information. Fish will be collected from various locations throughout the mainstem of the Peace River and we have not designated specific locations for their collection.

Maps with specific polygons identified for sampling will be provided to field crews and are not included here. Vegetation will be collected opportunistically during soil collections and will be based on professional judgment while in the field. General guidelines are provided here however.

2.2.1. Abiotic Parameters

Abiotic parameters include water, sediment and soil. This section describes the rationale for the location and sample size of abiotic parameters to be collected in summer 2010 from Dinosaur Reservoir and Peace River between Peace Canyon Dam (PCD) and Site C dam (**Appendix A**).

Water – Water residence time within Dinosaur Reservoir discharged from the WAC Bennett dam is about two days. Transit time in the Peace River between PCD and Site C is also relatively short, but could be up to 20 days. Thus we propose to collect samples from Dinosaur Reservoir (two locations), the mainstem of the Peace River (three locations) and three tributary stream locations:

Mainstem:

- PR WQ-1 – Below PCD, upstream of Hudson's Hope, corresponding the Golder (2009a) Peace 1 location.

- PR WA-2 – Upstream of the confluence with Halfway River corresponding to Golder (2009a) Peace 2 location.

- PR WQ-3 – Upstream of the confluence with Moberly River corresponding to Golder (2009a) Peace 3 location.

Tributaries:

- Farrell Creek (FERR-WQ) – To estimate sediment and mercury loading from north shore tributary streams, corresponding to Golder (2009a) Farrell 11A.

- Halfway River (HALF-WQ) – To estimate sediment and mercury loading from the largest north shore tributary stream, corresponding to Golder (2009a) Halfway 9.

- Moberly River (MOB-WQ) – To estimate sediment and mercury loading from the largest south shore tributary stream, corresponding to Golder (2009a) Moberly 7, or downstream of 7 so long as the station is upstream of influence from Peace River.

Sediment – Sediments within the river floodplain consist primarily of sand and gravel and are not expected to contribute significantly to mercury methylation within the new reservoir. Consequently, the number of stations and spatial coverage of sampling stations required to satisfy conditions of the model is relatively small (**Appendix A**). We propose to collect fine sediments from the vicinity of the three mainstem Golder (2009a) Peace River stations, Peace 1, Peace2 and Peace 3 (**Figure 1**), Azimuth station designations PC SED-1, PC SED-2 and PC SED-3. Sediment chemistry is not required from tributary streams (**Appendix A**).

Soil – The major supplier of mercury available to bacteria for methylation in new reservoirs originates from breakdown of newly flooded carbon, a nutrient source. Bacteria incorporate inorganic mercury into organic tissue as methyl mercury. Now in the food web, methyl mercury is accumulated much more quickly than it is eliminated, and so becomes magnified in concentration up the food web. Soils with highly developed organic layers such as peat lands, bogs, wetlands, fens and other moist habitats with well developed soils have the greatest reservoirs of inorganic mercury that are contributed to the environment when flooded. Thus, soil sampling of the floodplain within the proposed reservoir is required to identify and quantify carbon sources. Sampling within the footprint of the new reservoir has been stratified, to dedicate greater effort to habitat polygons from high organic soils, than soils with low organic content. All of the vegetation and soil types / descriptions within habitat polygons were derived from Keystone Wildlife Research (2007) report entitled *Expanded Legend for the Peace River Terrestrial Ecosystem Mapping Project*.

The strategy for sampling soils is as follows:

- Focus on habitat types/polygons, which according to Keystone Wildlife Research (2007) are associated with carbon enriched soils [e.g., step moss peavine (AM), willow horsetail sedge wetland (WH)].
- Distribute sampling across the entire flood zone between PCD and Site C to ensure adequate spatial coverage.
- Establish greater effort (sample frequency) within the two largest habitat classes, Fm02 (cottonwood spruce red-osier dogwood) and SH (currant horsetail).
- Exclude habitats CB (cutbank), GB (gravel bar), RI (river), RZ (road) and those with <1% coverage excepting if BL (lingon berry coltsfoot), BT (Labrador tea sphagnum)
- Include all polygons representing wetlands BL, BT, SE (sedge wetland) and proportional number of polygons for SW (wildrye peavine) and SH
- Polygons that are accessible, either by road or boat.
- Select polygons on Crown or BCH-owned/leased properties if possible and avoid private property.

Table 1 lists the polygon number, map sheet number, UTM coordinate (center of each polygon), area (ha) and vegetation type for each polygon.

2.2.2. Biotic Parameters

Benthic Invertebrates – Benthic invertebrates are an important component of the base of the aquatic food web and are particularly important in rivers. We do not expect there to be large spatial differences in taxonomic composition or mercury concentrations of benthos within the Peace River downstream of PCD, given the relatively short distance and similarity in habitat. Therefore, benthos will be collected from riffle habitats at three locations, the same as for water and sediment, so that mercury data can be paired, between abiotic and biotic components (**Figure 1**). Composite samples of benthos collected from each station (PR-BEN-1, -BEN-2 and -BEN-3) will be divided in half for analysis of total and methyl mercury and for stable isotopes.

In addition, benthic invertebrates will also be collected from three general locations in Dinosaur Reservoir (DINO-BEN-UP; -BEN-MID; -BEN-DOWN). Within each general location, samples will be stratified by depth (i.e., 0 – 5 m, 5 – 10 m and 10 – 15 m; bathymetry is needed to finalize sampling locations) to target discrete depths where isotopic signatures may vary due to reliance on different carbon sources. As with benthos

collected from Peace River, samples will be divided in half for analysis of mercury and isotopes.

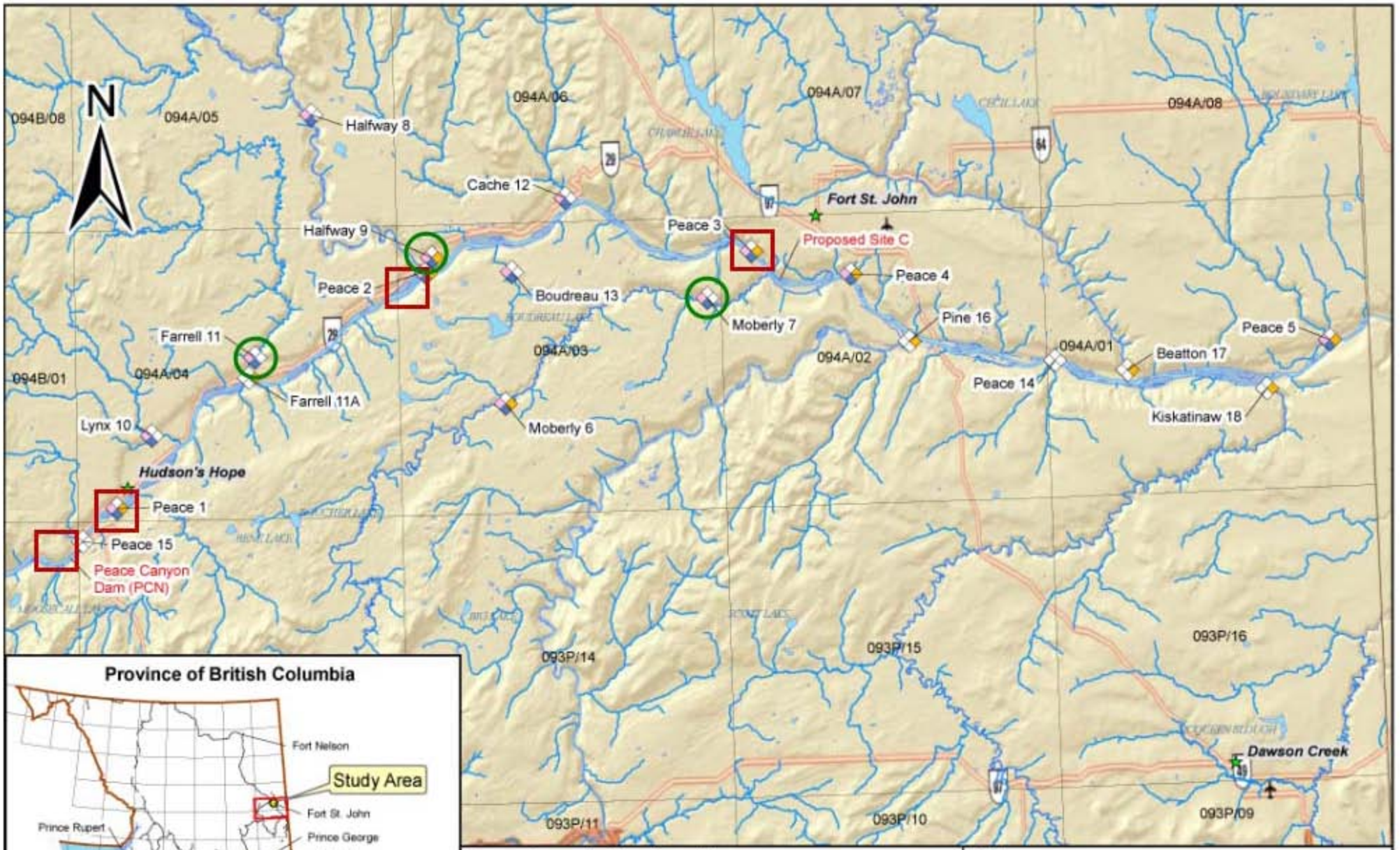
Zooplankton – Pelagic invertebrates are not expected to make up a significant portion of fish diet and therefore may be small contributors to tissue mercury concentrations in fish. However, water leaving Williston Reservoir may contain a sufficient abundance of zooplankton, that when carried through Dinosaur and into the Peace River zooplankter's will be fed on by resident fish and contribute to diet. Zooplankton will be collected from Peace River at the same locations as for abiotic parameters and benthos (PR-ZOOP-1, -ZOOP-2 and -ZOOP-3) (**Figure 1**). Horizontal tows will be conducted from each location in Peace River and the sample divided equally for mercury and stable isotope analysis.

In addition, zooplankton will be sampled from Dinosaur Reservoir (DINO-ZOOP-UP; ZOOP-Mid and –ZOOP-DOWN) at each of the three general locations where benthos will be collected. These samples will be split and analyzed for mercury and stable isotopes.

Fish – Four species representing different levels of the trophic food web will be sampled for total mercury in tissue and stable isotopes. These same species will be collected from the Peace River and from Dinosaur Reservoir. Differences in mercury concentration and stable isotopes will provide insights in to food web structure between the two environments. These fish species are:

- Longnose sucker (*Catostomus catostomus*) a benthic forager that consumes algae and benthic invertebrates.
- Redside shiner (*Richardsonius balteatus*) a common forage species that feeds on insect larvae and zooplankton and is consumed by other fish species.
- Mountain whitefish (*Prosopium williamsoni*), a common benthic feeder that is an important intermediate species in the food web.
- Bull trout (*Salvelinus malma*) an important piscivorous species that is at the top of the food web and also targeted by humans for food.

Comparing mercury concentrations between the two environments, combined with results of stable isotope analyses, will describe mercury dynamics within the Peace River and provide insight into what Peace River might resemble, using Dinosaur Reservoir as a surrogate.


N
094B/08
094A/05
094A/06
094A/07
094A/08
Halfway 8
Cache 12
Halfway 9
Peace 3
Fort St. John
Proposed Site C
Peace 4
Peace 2
Boudreau 13
Moberly 7
Pine 16
Peace 5
Farrell 11
094A/03
094A/02
094A/01
Beatton 17
094B/01
094A/04
Farrell 11A
Peace 14
Lynx 10
Moberly 6
Kiskatinaw 18
Hudson's Hope
Peace 1
Peace 15
Peace Canyon Dam (PCN)
093P/14
093P/15
093P/16
Dawson Creek
093P/11
093P/10
093P/09
Province of British Columbia
Fort Nelson
Study Area
Fort St. John
Prince Rupert
Prince George
Quesnel
Williams Lake
Kamloops
Revelstoke
Merritt
Vernon
Nelson
Kelowna
Port Alberni
Cranbrook
Rossland
Victoria
Vancouver
Penticton
W
E
S
Legend
Golder Sampling
Temperature Data Logger
In-situ Sampling by Calibrated Meter
Not Sampled in 2008
Water Samples
Azimuh Sampling
Water only
Water, Sediment, Benthic Invert., Zooplankton
0 5 10 15
Kilometres
REFERENCE
Base mapping provided by ESRI On-line and Province of British Columbia.
PROJECT
Azimuth Mercury Modeling Study
TITLE
2009 Sample Collection Stations
Golder Associates
Kamloops, BC
FIGURE: 1

3. WATER

3.1. Parameters Collected

Detailed procedures for the collection of the following laboratory analyzed parameters are provided in the sections below:

- Conventional parameters (TSS (DL = 3mg/L), pH, anions, hardness, alkalinity, conductivity)
- Total organic carbon (TOC) and dissolved organic carbon (DOC)
- **Total** mercury (ng/L; DL = 1 ng/L) from **unfiltered** samples, **not** preserved
- **Methyl** mercury (DL = 0.05 ng/L) from **unfiltered** samples, preserved
- **Total** mercury (DL = ng/L) from field **filtered** samples (i.e., dissolved inorganic mercury), **not** preserved
- **Methyl** mercury (DL = 0.05 ng/L) from field **filtered** samples (i.e., dissolved organic mercury), preserved
- Total suspended solids (TSS-low detection; DL = 0.2 mg/L). This analysis is important for calculating particle-bound Hg and MeHg.

In addition to laboratory parameters, temperature (^{o}C), dissolved oxygen (mg/L), pH and conductivity (µS/cm) will be collected in the field. Methods for field collection are also described below.

WATER SAMPLING CHECKLIST				
Parameter*	**Container**	**Field Filter?**	**Preservation/Storage**	**Laboratory**
TSS*, pH, anions, Hardness, Alkalinity, Conductivity	1 L plastic |/	No |/	none / keep cool |/	ALS |/
TOC*	125 mL glass	No	1 vial HCl acid / keep cool	ALS
DOC*	125 mL glass	Yes	1 vial HCl acid / keep cool	ALS
THg-UF*	250 mL glass	No	none / keep cool	ALS
MeHg-UF*	250 mL HDPE plastic	No	1 vial HCl acid / keep cool	ALS
THg-F*	250 mL glass	Yes	none / keep cool	ALS
MeHg-F*	250 mL HDPE plastic	Yes	1 vial HCl acid / keep cool	ALS
TSS-low*	1 L plastic	No	none / keep cool	RTGeosciences

*Ensure that bottles and Chain-of-Custody forms are labeled with these parameter identifiers; UF=unfiltered, F=filtered sample.

3.2. Location

Water will be collected from two stations within the Dinosaur Reservoir, three in the mainstem of the Peace River, and one from each of three major tributary streams (**Figure 1**), at the same locations as Golder (2009a, 2009b). Although is not critical that mainstem sampling locations be situated in the exact locations, it is important that collection locations in the mainstem are not directly influenced by tributary stream input. Similarly, collections in tributary streams should not be influenced by water from the mainstem. All UTM coordinates are in NAD83.

The two Dinosaur Reservoir locations are:

- At the upstream end of the reservoir at 10 U 553327 E 6201221 N
    - Station ID: **DINO-UP-WQ**
- In the approximate middle of the reservoir:10 U 557578 E 6202811 N
    - Station ID: **DINO-MID-WQ**

The three Peace River mainstem locations are:

- Downstream of Peace Canyon Dam and upstream of Hudson's Hope at Peace 1 (Golder, 2009a) at approximately 10 V 5667000 E 6208500 N
    - Station ID: **PR1-WQ**
- Upstream of Halfway River at Peace 2 (Golder, 2009a) at approximately 10 V 593000 E 6229000 N
    - Station ID: **PR2-WQ**
- Upstream of Moberley River at approximately 10 V 626000 E 6233200 N
    - Station ID: **PR3-WQ**

Water will be collected from three major tributary streams to the Peace River. It is important that water is collected from far enough upstream that there is no influence from the Peace River. The locations are:

- Farrell River upstream of the road crossing at Farrell 11 (Golder, 2009a)
    - Station ID: **FER-WQ**
- Halfway River at Halfway 9 (Golder, 2009a) upstream of the road crossing
    - Station ID: **HALF-WQ**
- Moberley River at Moberley 7 (Golder, 2009a) or downstream of this location, if more convenient at approximately 627000 E 6229000 N.
    - Station ID: **MOB-WQ**

3.3. Timing

Water samples will be collected once during spring freshet (early June) and during low flows in late summer (August/September) to characterize freshet inflow from upstream and from tributary flows and base flows. Spring freshet carries large suspended sediment loads that are responsible for transport of particulate-bound inorganic mercury that, depending on where particles are deposited can contribute to mercury methylation. Timing of collections of water should be coordinated with Azimuth, based on discharge from PCD.

3.4. Water Sampling Procedures

3.4.1. Limnology

1. Before and during sampling fill in the requested information on the **field data form** (see **Appendix B**); complete one field data form in its entirety for each sampling station. Forms are made of waterproof paper; print all information on the form using a lead pencil or a write-in-the-rain pen.
2. With the aid of a **GPS unit**, navigate the boat to the sampling station using the UTM coordinates (in NAD 83) provided. Do not allow the anchor to drag through the sampling station. Record the exact UTM coordinates on the field data form.
3. Measure water **depth** at the sampling station using a hand-held depth meter or on board depth sounder. Record this information on the field data form.
4. **Calibrate the YSI** probe prior to going into the field. Lower the YSI probe into the water to just below the water surface level. Measure the pH, temperature (°C), specific conductance (i.e., temperature corrected) (µS/cm) and dissolved oxygen concentration (mg/L) in the water and record on the field data form. Lower the meter to a depth of 1 m and record the field measurements. Allow the concentrations on the meter to stabilize for 10 to 15 seconds before recording the concentrations. Continue recording the field measurements at 1 m depth intervals until you reach the bottom or cord length (at least 10 m). If sampling takes place in an area of high flow, the YSI unit might need to be weighted.

3.4.2. Conventional Parameters

1. Water samples will be collected from just below **surface** from the Peace River and from a depth of **3 m** from Dinosaur Reservoir.
2. Set up the **water pump** in the boat; attach the tubing to the pump using the C-clamps and attach the 12V battery. Attach the **long** tubing to the intake valve, and

the short, **1 meter length** to the output valve. If sampling in current attach the hydro weight (do not use lead) to the end of the 3 meter length of tubing. Lower the 3 meter length of tubing into the water and place the 1 meter length of tubing over the edge of the boat. Run the pump for 2 minutes to flush the sampling device.

3. For each sampling station, fill the required pre-labeled **sampling containers** with water from the 1 meter length of tubing directly from the lake (from 3 m depth) or river (just below surface). After all unfiltered samples have been collected, disconnect the battery from the pump and fix the 45-µm Voss filter onto the end of the discharge hose. Re-connect the pump and allow the water to discharge and flush through the filter for 15 – 20 seconds.
4. Dissolved organic carbon (DOC) samples are to be collected by directing the **filtered water** into the DOC bottles. Flow from the hose can be controlled by pinching the incurrent end of the tube (not the excurrent).
5. For QA/QC samples, remember to use the same filter when collecting equipment blank samples, not a new filter.
6. Add the specified **preservatives** to the appropriate sampling containers (according to the information on the labels and in the table above), seal and mix thoroughly by turning upside down and then upright a number of times. Put in a cooler on ice.
7. Fill out a **chain-of-custody** (COC) (**Appendix C)** form for the water samples being shipped to ALS Environmental. The COC form must be completed carefully and in its entirety to ensure proper analysis. Shipping addresses can be found in **Section 3.7** below.

3.4.3. Mercury

Sampling for **total** and **methyl mercury** follows the same procedures as above with the exception of filling sample containers specific to mercury analyses (i.e., fill one 250 mL glass bottle and one 250 mL plastic bottle per station with unfiltered water, and one 250 mL glass bottle and one 250 mL plastic bottle with filtered water). Keep cool and ship to ALS Vancouver (Burnaby) at the end of each day of sampling. Shipping addresses can be found in **Section 3.7** below and COCs in **Appendix C**.

Note that for the collection of mercury samples, it is important that the samplers follow the '*clean hands / dirty hands'* technique that is described as follows:

- Upon arrival at the sampling site, one member of the two-person sampling team is designated as "dirty hands"; the second member is designated as "clean hands". All operations involving contact with the sample bottle and the transfer of the sample from the sample pumping system to the sample bottle are handled

by the individual designated as “clean hands”. “Dirty hands” is responsible for preparation of the sample pumping system, operation of the pump and for all other activities that do not involve direct contact with the sample or sample container.

- “Dirty hands” deploys the weighted sample line overboard and within a water mass not affected by the presence of the boat or samplers.
- “Dirty hands” activates the pump and times pump running time prior to indicating to “clean hands” that sampling for unfiltered analytes can begin.
- “Clean hands” opens sample bottle and rinses it twice with sample water prior to filling and recapping. If additional unfiltered samples (e.g., for TSS) are to be taken the same procedure is followed for additional bottles.
- “Dirty hands” pinches the sample line on the suction side and installs an in-line filter on the discharge line and then flushes several liters of sample water through the filter at a flow rate held low enough (by pinching the suction line) to avoid excessive back pressure in the filter.
- “Clean hands” opens sample bottle and rinses it twice with sample water prior to filling and recapping. If additional filtered samples (e.g., for other metals, anions) are to be taken the same procedure is followed for additional bottles.
- “Dirty hands” secures the pumping system by returning the weighted sample line and pump to a dedicated plastic bag or clean cooler.
- Water samples are preserved as necessary (i.e., methyl Hg only), re-bagged and placed on ice in a cooler.

3.5. QA/QC

For QA/QC purposes three kinds of samples are required:

- One **field duplicate** is collected per event. All parameters measured in the original sample are measured in the field duplicate (i.e., all parameters listed in table in **Section 3.1**). The sampling station is selected randomly from one of the Peace River stations. Be sure to record the station which was duplicated on the field data sheet.
    - Station ID: **DUP-WQ**
- One **equipment blank** will be acquired per event (collected midway through sampling). To collect an equipment blank, set up the water sampling equipment as if a routine sample was to be collected except that the intake hose is placed into a

4L container of de-ionized water. Pump and discard 4 L of deionized water from the container to flush the pump and tubing. Using the other 4 L DI water container, fill a full set of sample bottles (**Section 3.1**), preserve and treat as other samples, including filtering where necessary. Be sure to record the date and time when sample was taken.

- Station ID: **EB-WQ**

3.6. Storage and Shipping of Water Samples

Samples destined for ALS Environmental (TSS, pH, anions, hardness, alkalinity, conductivity bottles, TOC bottles, DOC bottles, THg & MeHg bottles; filtered and unfiltered):

- Should be kept cool in the field on wet ice
- Kept cool until time of shipping
- Use a separate COC for each of the following: (1) THg samples, (2) MeHg samples, (3) the remainder of parameters
- Shipped with wet ice in a cooler at end of each day, after collection
- Shipped early via an express courier
- Shipped with completed COCs (see **Appendix C**)
- Shipped to the following:

ALS Environmental
100 – 8081 Lougheed Hwy.
Burnaby, BC
V5A 1W9
ATTN: Natasha Markovic
Ph. 604-253-4188

Samples destined for **RT Geosciences** (TSS-low bottles):

- Should be kept cool in the field on wet ice
- Kept cool until time of shipping
- Ship once all the TSS sample bottles are collected
- Shipped with wet ice in a cooler no later than 2-3 days after collection

- Shipped with a completed COC (modify an ALS COC from **Appendix C**; be sure to state “TSS-low” to specify a low detection limit)
- Please notify Ralph Turner of shipment by emailing a notice to rrtgeo@direct.ca
- Shipped to the following:

RT Geosciences Inc.
c/o Squamish Oceanfront Development Corp.
37321 Galbraith Rd.
Squamish, BC
V8B 0A4
ATTN: Ralph Turner
Ph. 604-815-8219

4. SEDIMENT

4.1. Parameters Collected

Detailed procedures for the collection of the following laboratory analyzed parameters are provided in the sections below:

- Grain size and total organic carbon (TOC)
- Total metals and pH
- Total mercury
- Methyl mercury

SEDIMENT SAMPLING CHECKLIST				
Parameter	**Container**	**Field Filter?**	**Preservation/Storage**	**Laboratory**
Grain Size & TOC	125 mL glass	No	none / keep cool	ALS
Total Metals & pH	125 mL glass	No	none / keep cool	ALS
THg & MeHg	125 mL glass	No	none / freeze on dry ice*	ALS

*Freeze immediately on dry ice; dry ice available from Praxair in Fort St. John.

4.2. Location

To adequately characterize sediment chemistry and mercury concentrations, sediment will be collected from at least three locations in the Peace River, three tributaries and three locations in Dinosaur Reservoir. Exact locations for Peace River stations will be determined after additional geomorphic/bathymetric data are available from BCH, but the general locations will be closely associated with the Golder (2009a) water sampling locations (see **Section 3.2**), situated in depositional areas if they can be found. Tributary stations should be located in close proximity to water sampling stations. Locations in Dinosaur Reservoir are co-located with benthos stations (Coordinates are in UTM, NAD 83).

- Peace River Station IDs: **PR-SED-1, SED-2, SED-3**
- Tributary Station IDs: **FER-SED, HALF-SED, MOB-SED**
- Dinosaur Reservoir station **DINO-SED-UP**:10 U 553327 E 6201221 N
- Dinosaur Reservoir station **DINO-SED-MID**:10 U 557578 E 6202811 N
- Dinosaur Reservoir station **DINO-SED-DOWN**: 10 U 561892 E 6203386 N

In Dinosaur Reservoir, sediment will be collected from three depths within the reservoir; between 4 – 5 m; 9 – 10 m, and 14 – 15 m. Benthic invertebrates will be acquired from the same locations. The location within the reservoir is not critical, but the following guidelines should be followed when selecting a station: not too near the intake of PCD in a depositional area; an area with a fairly flat bottom and not too steep; and sediment grain size consists of fine materials (silt/clay).

4.3. Timing

Sediment will be collected only once during August 2010 at the same time as benthic invertebrates are being collected by Golder, ESSA and Limnotek. At this point in time, we are presuming that sediment is being collected by Knight Piesold.

4.4. Sediment Sampling Procedures

Methods for collection of sediment vary depending on water depth and substrate. Methods for deep water (lacustrine) sediment sampling in Dinosaur will differ from sampling of shallow water stream sediments from Peace River.

4.4.1. Dinosaur Reservoir

To collect sediment from Dinosaur Reservoir, a Petite Ponar grab (0.023 m^2) will be used to sample the bottom from a depositional area. As discussed in the Location section, three locations are depth stratified, to target the 5 m contours (i.e., 5 m, 10 m and 15 m). Using a bathymetric map or a depth sounder, select an area with gently sloping bottom between the shoreline and offshore to locate the three stations according to the above criteria. It is important that the slope is not too high or the area situated near the intake to ensure that bottom sediments are stable and have a good benthic community.

Mobilize a boat with appropriate safety equipment and sampling gear (see list below). The field collection procedure is as follows:

1. Before and during sampling fill in the requested information on the **field data form** (see **Appendix B**); complete one field data form in its entirety for each sampling station. Forms are made of waterproof paper; print all information on the form using a lead pencil or a write-in-the-rain pen.
2. With the aid of a GPS unit, **navigate the boat** to the sampling station and record the UTM coordinates (in NAD 83). Approach the station from downstream of the wind direction. In windy conditions, anchor the boat upstream of the station and drift back; it is not necessary to anchor the boat in calm conditions providing the

boat remains within a 50 meter radius of the position. Do not allow the anchor to drag through the sampling station. Record the exact UTM coordinates on the field data form. If the boat cannot be anchored due to wind, drop an anchored buoy overboard to mark the location for sampling. Using the boat engine, keep the boat in one place to allow the Ponar to be sent vertically to the bottom.

3. Measure the **water depth** at the sampling station using a hand-held or electronic depth meter.
4. Begin collecting sediment samples by ensuring that the rope is securely attached to the **Ponar**.
5. Lower the **Ponar** to within 1 meter of the bottom of the lake and then lower very slowly over the last meter and allow the rope to go slack. Raise the Ponar to the edge of the boat and check the grab for **acceptability**. The grab is acceptable if the sample:
    - does not contain large foreign objects;
    - has adequate penetration depth (i.e., 10-15 centimeters);
    - is not overfilled (sediment surface must not be touching the top of the Ponar);
    - did not leak (there is overlying water present in Ponar); and is undisturbed (sediment surface relatively flat).

Once the grab is deemed acceptable, open the Ponar jaws and drop the sample into a stainless steel mixing bowl.

6. Using a clean stainless steel spoon, scoop sediment from the **top layer (3 – 5 cm)** and place into a clean stainless steel mixing bowl. Repeat these steps with 2 more grabs from the same depth (and same location, within a 20 m radius), compositing the 3 grabs.
7. Homogenize the sediment from the 3 grabs in the mixing bowl. Using the spoon, fill two 125 mL jars for chemistry and one 125 mL glass jar for mercury. Appropriately label samples.
8. Put the jars for chemistry on ice and keep cool until they can be shipped. Ship in cooler with ice packs to ALS. Shipping addresses can be found in **Section 4.7** below and COCs in **Appendix C**.
9. Place the jar for mercury onto dry ice and freeze. Keep frozen in a regular freezer until time of shipping. Ship frozen in cooler with dry ice to ALS for analysis of total Hg and methyl Hg. Shipping addresses can be found in **Section 4.7** below and COCs in **Appendix C**.

4.4.2. Peace River

To collect sediment from the Peace River, a Beckson Pump (Guzzler method) will be used to collect fine sediments from the rocky-gravel bottom of the river. This method is generally used in high gradient streams where sediment rarely is deposited more than a few mm in thickness, usually within the hyporheic zone, where grab samplers would be ineffective for collection. The field collection procedure is as follows (adapted from USEPA, 2001):

1. From shore, accessed either by foot from the road or from a boat, locate the sampling station. Record the exact **UTM coordinates** on the field data form. If the boat cannot be anchored due to wind, drop an anchored buoy overboard to mark the location for sampling. Using the boat engine, keep the boat in one place.
2. Measure the **water depth** at the sampling station using a hand-held or electronic depth meter.
3. In waders, install a **square meter frame** (1 m x 1m) over river bottom to be sampled. If bottom substrate is visible through the overlying water, photograph the sampling location with the edges of the frame nearly filling the camera view finder.
4. Use a clean pump to **pump sediment** and water from overlying substrate within the meter frame into one of the pre-cleaned 5 gallon buckets. Short pump strokes reduce the amount of water and maximize the sediment recovered. Move intake end of pump around as sediment is collected to maximize volume of sediment obtained. As much as possible, limit the depth of penetration of the pump tip to the upper 1 – 2 inches of sand, gravel and cobble. Continue pumping until approximately 4 gallons of water/sediment is in the 5 gallon bucket, or the square meter of bottom is swept relatively clean of fine-grained material.
5. After 4 gallons have been pumped, use a clean spoon to completely suspend the sediment. **Stir** for about **15 seconds**.
6. Allow sediment to **settle** for **30 seconds**. All sand in the sample will settle to the bottom of the bucket in this interval.
7. Pour the remaining suspension into a separate pre-cleaned 5 gallon bucket. **Stow** the bucket someplace where it will be moved as little as possible for **30 minutes**.
8. **Measure** the volume of sand remaining in the first bucket and discard. If a more quantitative estimate of the dry weight of the coarse fraction is desired collect a representative aliquot of the sand for determination of percent water.
9. At the end of the 30 minute settling period, carefully **pour off and discard** the as much of the overlying water as possible. Avoid re-suspending or losing any of the sediment that has settled at the bottom of the bucket.

10. Using the spoon, scoop the remaining settled sediment and **fill** two 125 mL jars for chemistry and one 125 mL jar for mercury. Appropriately label samples.
11. If the amount of sediment procured from the first sample is **insufficient**, repeat the above procedure in an adjacent section of the river, then composite each additional grab until sufficient volume is achieved.
10. Put the **125 mL jars for chemistry on ice** and keep cool until they can be shipped. Ship in cooler with ice packs to ALS. Shipping addresses can be found in **Section 4.7** below and COCs in **Appendix C**.
11. Place the **125 mL jar for mercury onto dry ice** and freeze. Keep frozen in a regular freezer until time of shipping. Ship frozen in cooler with dry ice to ALS for analysis of total Hg and methyl Hg. Shipping addresses can be found in **Section 4.7** below and COCs in **Appendix C**.
12. **Clean the bilge pump** – River water should be flushed through the pump at the end of each sampling use, followed by diluted Formula 409 cleaner (or liquinox) and more river water. Flush the pump at the end of each day with reagent water and drain of any water that is not expelled by operating the pump. No other cleaning is needed unless oily sediments are encountered. Store the pump in a clean polyethylene bag.

4.5. QA/QC

Field QA/QC procedures for sediment will focus on limiting cross contamination and generation of appropriate QC samples. QA includes frequent glove changes, rinsing of spoons and confirmation of decontamination effectiveness to control of cross-contamination.

Effectiveness of decontamination procedures will be assessed by collecting one equipment blank midway through the program. Equipment blanks for sediment sampling entail collecting rinse water from Ponar and spoons for analysis of metals and mercury. Ineffective decontamination is indicated in the field by visible suspended matter in rinse water and from laboratory analysis showing higher metal concentrations in equipment rinse water. Station ID: **EB-SED**.

Collect a single duplicate field sediment sample from one of the three Peace River locations. Repeat the above procedures on the same day that the original samples were collected. Station ID: **DUP-SED**.

4.6. Storage and Shipping of Sediment Samples

Samples destined for ALS Environmental (grain size & TOC jars, total metals & pH jars, THg & MeHg jars):

- Should be kept cool in the field on wet ice and until time of shipping; shipped with wet ice in a cooler no later than 5 days after collection
- THg and MeHg jars should be frozen in the field on dry ice, immediately after collection, and kept frozen until time of shipping; shipped on dry ice early in the week via an express courier (to avoid weekend delays & to ensure prompt arrival to laboratory freezer)
- Shipped with a completed COC (see **Appendix C**)
- Shipped to the following:

ALS Environmental
100 – 8081 Lougheed Hwy.
Burnaby, BC
V5A 1W9
ATTN: Natasha Markovic
Ph. 604-253-4188

5. ZOOPLANKTON

Zooplankton are an important component of the food web and consumption of zooplankton by fish will contribute to their energy signature, which can be determined from stable isotope analysis. Mercury concentration also increases in zooplankton post-flooding and documentation of mercury in the zooplankton population in Dinosaur Reservoir and Peace River are important input parameters for mercury modeling (**Appendix A**). Taxonomic composition or biomass estimates are not required.

5.1. Parameters Collected

Detailed procedures for the collection of the following laboratory analyzed parameters are provided in the sections below:

- Total mercury and moisture
- Methyl mercury and moisture
- Carbon and nitrogen stable isotope analysis (SIA)

ZOOPLANKTON SAMPLING CHECKLIST				
Parameter	**Container**	**Field Process?**	**Preservation/Storage**	**Laboratory**
THg & MeHg	6 mL plastic vial (**2 g** ww tissue)	Zoop net tow	none / freeze on dry ice*	Quicksilver
C & N SIA	6 mL plastic vial (**2 g** ww tissue)	Zoop net tow	none / freeze on dry ice*	SINLAB

*Freeze immediately on dry ice; dry ice available from Praxair in Fort St. John.

5.2. Location

Zooplankton will be collected from three stations within the Dinosaur Reservoir and three stations along the mainstem of the Peace River (**Figure 1**) that correspond to the water sampling locations PR WQ-1, PR WQ-2 and PR WQ-3 as per Peace 1, Peace 2 and Peace 3 (Golder, 2009a). In the Peace River, the stations are:

- **PR ZOOP-1, PR ZOOP-2 and PR ZOOP-3**

In Dinosaur Reservoir, zooplankton will be collected from the upper, middle, and downstream ends of the reservoir, at least 1 km upstream from Peace Canyon Dam. The locations are identical to sediment and benthic sampling stations. Coordinates are in UTM, NAD 83. The Dinosaur Reservoir station locations are:

- Dinosaur Reservoir station **DINO-ZOOP-UP**:10 U 553327 E 6201221 N

- Dinosaur Reservoir station **DINO-ZOOP-MID**:10 U 557578 E 6202811 N
- Dinosaur Reservoir station **DINO-ZOOP-DOWN**: 10 U 561892 E 6203386 N

5.3. Timing

Zooplankton are to be collected once during mid- to late August and can be timed to coincide with benthic invertebrate collections.

5.4. Zooplankton Sampling Procedures

Acquisition of zooplankton for mercury and stable isotope analysis will be conducted by dragging a zooplankton net beneath the water surface behind a boat. The procedure is as follows (same for sampling in Dinosaur Reservoir or the Peace River). When sampling in the Peace River, because of water current, it may not be necessary to operate the boat. Instead the net can be held over the side of the boat and allow the current to carry zooplankters into the net. The specific procedure for collecting zooplankton is as follows:

1. Before and during sampling fill in the requested information on the **field data form** (see **Appendix B**); complete one field data form in its entirety for each sampling station. Forms are made of waterproof paper; print all information on the form using a lead pencil or a write-in-the-rain pen.
2. The **zooplankton net** should have an approximate mesh size of **150 µm** (+/- 50 µm), a minimum ring diameter (mouth opening) of 0.3 m and an aspect ratio of 6 – 7x mouth diameter. The net should have a collecting vessel in the cod end with a similar mesh size as the net.
3. Attach a **bridle** to the net with a swivel at the top. Attach a **30-m long rope** or sideline to the swivel, the end of which is held by an operator.
4. **Deploy** the zooplankton net from the side of the boat. If necessary use a small boom. This is to avoid wake from the boat disturbing the zooplankton.
5. Slowly play out the line so that the net is fully submerged, about **0.5 m** below the water surface.
6. Once fully played out, **tow the net** using the boat engine, at a slow speed, no more than 0.5 – 1 m / second. If towing too quickly, the net will rise out of the water. Try to keep the mouth of the net fully submerged. This can be accomplished by towing at a slow depth, or it may be necessary to weigh the net down. This is done by tying a ~**2.5 weight** to the bottom of the net ring, attached with a piece of rope so the weight is suspended a short distance below the ring.

7. Tow the net **horizontally** through the water for about **5 minutes**. Haul the net back into the boat and rinse the net by plunging the net up and down, vertically in the water to wash all zooplankters adhered to the sides of the net into the collecting cup at the cod end.
8. If current velocity is sufficient in the Peace River, **anchor the boat** and allow the current to carry zooplankters into the net.
9. Remove the collecting cup and inspect the **contents**. It is necessary to have at least **3 – 5 g of zooplankton**. Weigh sample to ensure sufficient mass.
10. Transfer one-half of the zooplankton mass using a small stainless steel spoon or similar device, to a labeled **6 mL vial** dedicated to analysis of total and methyl mercury by Quicksilver Scientific. Label with date and collection location PR ZOOP-X (or DINO-ZOOP-xxx). Freeze on dry ice. Transfer to freezer at the end of the day.
11. Transfer the other half of the zooplankton mass to a labeled **6 mL vial** dedicated for analysis of stable isotopes by SINLAB, New Brunswick. Label with date and collection location PR ZOOP-X (or DINO-ZOOP-xxx). Freeze on dry ice. Transfer to freezer at the end of the day.
12. To avoid transference of organisms between stations, thoroughly **rinse the net** at the new station before collecting animals. This is done be hauling the new vertically through the water without the collecting vessel, and by splashing water on the outside of the net to wash away any zooplankters adhered to the net.
13. At the end of the field program **ship frozen zooplankton** samples in a cooler with ice packs to the respective laboratories. Shipping addresses can be found in **Section 5.7** below and COCs in **Appendix C**.

5.5. QA/QC

Collect one duplicate field sample of zooplankton using exactly the same methods and procedures from one of the three Peace River stations. Label as **DUP-ZOOP**. Note on the field collection sheet the location of the duplicate sample.

5.6. Storage and Shipping of Zooplankton Samples

Samples destined for Quicksilver Scientific (THg & MeHg vials):

- Should be frozen in the field on dry ice, immediately after collection
- Kept frozen until time of shipping
- Shipped early in the week via an express courier (to avoid weekend delays & to ensure prompt arrival to laboratory freezer)

- Shipped with a completed COC (see **Appendix C**)
- Shipped to the following:

Quicksilver Scientific
1376 Miners Drive, Suite 101
Lafayette, CO 80026
ATTN: Christopher Shade
Ph. 303-531-0860

Samples destined for SINLAB (C & N SIA vials):

- Should be frozen in the field on dry ice, immediately after collection
- Kept frozen until time of shipping
- Shipped early in the week via an express courier (to avoid weekend delays & to ensure prompt arrival to laboratory freezer)
- Please notify SINLAB of shipment by emailing an electronic copy of the submission form to isotope@unb.ca (see also paper copy in **Appendix C**)
- Shipped to the following:

Stable Isotopes in Nature Laboratory (SINLAB)
Dept. of Biology, University of New Brunswick
P.O. Box 4400
10 Bailey Drive, Room 155 Loring Bailey Hall
Fredericton, NB
E3B 5A3
Ph. 506-453-4967

6. BENTHOS

Benthic invertebrates are a key food chain component of the aquatic food web and an important food group for many fish species including juveniles of piscivorous fish. Concentrations of total and methyl Hg in a composite sample of benthic invertebrates from the Peace River is needed as input parameters to the mercury model (**Appendix A**). Taxonomic composition or abundance estimates are not required. In addition, composite samples of benthos will be collected at the same time as samples for mercury analysis, for stable carbon and nitrogen isotope analyses, to support food chain modeling.

6.1. Parameters Collected

Composite samples of benthic invertebrates will be analyzed for total and methyl mercury and for stable isotopes. Quantitative estimates of taxonomic composition or biomass is not required for mercury modeling (**Appendix A**). However, make note of the general taxonomic composition to Order (e.g., Trichoptera, Ephemeroptera, Chironomidae, etc.) and the rough proportions of each in the sample (e.g., 20% Diptera, 25% Ephemeroptera, etc.).

Detailed procedures for the collection of the following laboratory analyzed parameters are provided in the sections below:

- Total mercury (mg/kg)
- Methyl mercury (mg/kg)
- Carbon and nitrogen stable isotope analysis (SIA)

BENTHOS SAMPLING CHECKLIST				
Parameter	**Container**	**Field Process?**	**Preservation/Storage**	**Laboratory**
THg & MeHg	6 mL plastic vial (**0.5 g** ww tissue)	Sieve; pick out inverts	none / freeze on dry ice*	Quicksilver
C & N SIA	6 mL plastic vial (**0.5 g** ww tissue)	Sieve; pick out inverts	none / freeze on dry ice*	SINLAB

*Freeze immediately on dry ice; dry ice available from Praxair in Fort St. John.

6.2. Location

To adequately characterize mercury concentrations and stable isotopes, benthos will be collected from three locations in the Peace River and three locations in Dinosaur Reservoir. Exact location within Peace River will be determined after additional geomorphic/bathymetric data are available from BCH. Locations in Dinosaur Reservoir

are co-located with sediment stations (Coordinates are in UTM, NAD 83). Collect benthos from the same stations and depths (i.e., 5m, 10m and 15m).

In the Peace River benthos will be collected from the vicinity of water and zooplankton sampling stations that correspond to the Golder (2009a) collection locations as depicted in **Figure 1**.

- Peace River Station IDs: **PR-BEN-1,-BEN-2, and-BEN-3**
- Dinosaur Reservoir station **DINO-BEN-UP**:10 U 553327 E 6201221 N
- Dinosaur Reservoir station **DINO-BEN-MID**:10 U 557578 E 6202811 N
- Dinosaur Reservoir station **DINO-BEN-DOWN**: 10 U 561892 E 6203386 N

6.3. Timing

Benthos will be collected only once during August 2010, timed to coincide with sediment and zooplankton collections.

6.4. Benthos Sampling Procedures

6.4.1. Dinosaur Reservoir

In Dinosaur Reservoir benthos will be collected from three depths within the reservoir; between 4 – 5 m; 9 – 10 m, and 14 – 15 m at the same locations as where sediment is collected using a Petite Ponar grab sampler. The following procedures will be followed, which are the same as for collecting sediment. The field collection procedure is as follows:

1. Before and during sampling fill in the requested information on the **field data form** (see **Appendix B**); complete one field data form in its entirety for each sampling station. Forms are made of waterproof paper; print all information on the form using a lead pencil or a write-in-the-rain pen.
2. With the aid of a GPS unit, **navigate the boat** to the sampling station and record the UTM coordinates (in NAD 83). Approach the station from downstream of the wind direction. In windy conditions, anchor the boat upstream of the station and drift back; it is not necessary to anchor the boat in calm conditions providing the boat remains within a 50 meter radius of the position. Do not allow the anchor to drag through the sampling station. Record the exact UTM coordinates on the field data form.
3. Measure the **water depth** at the sampling station using a hand-held or electronic depth meter.

4. Begin collecting benthos samples by ensuring that the rope is securely attached to the **Ponar**.
5. Lower the **Ponar** to within 1 meter of the bottom of the lake and then lower very slowly over the last meter and allow the rope to go slack. Raise the Ponar to the edge of the boat and check the grab for **acceptability**. The grab is acceptable if the sample:
    - does not contain large foreign objects;
    - has adequate penetration depth (i.e., 10-15 centimeters);
    - is not overfilled (sediment surface must not be touching the top of the Ponar);
    - did not leak (there is overlying water present in Ponar); and is undisturbed (sediment surface relatively flat).
6. Once the grab is deemed acceptable, open the Ponar jaws and drop the sample into the 500 µm sieve bag being held above a plastic bin in the center of the boat that is filled with water.
7. **Sieve** the sample until only the benthic organisms and coarse materials remain. To sieve the sample, gently raise and lower the sieve into the water in the plastic bin and swing side to side. Care must be taken to ensure the benthic organisms are not damaged or crushed. Do not disturb the sample to the point that it is splashing out of the sieve. Do not forcibly push materials through the sieve; gently break apart any small clay balls. Rinse off any pieces of larger plant material or rocks in the sample and discard.
8. Using the tweezers **pick individual** chironomid worms, Trichoptera, Plecoptera and Ephemeroptera larvae and place into a small vial in clean or distilled water and rinse sediment particles from individual animals.
9. Repeat the above procedure until a minimum of **1 g of invertebrate** tissue has been collected.
10. Split the biomass into two vials: 0.5 g for mercury analysis by **Quicksilver** and 0.5 g for analysis of stable isotopes by **SINLAB**.
11. Appropriately label (see above) and freeze the samples in dry ice as soon after collection as practicable.
12. **Ship frozen** in a cooler with ice packs to the appropriate laboratory for analysis of total Hg, methyl Hg and C and N stable isotopes and moisture content. See the chain-of-custody form for correct procedure for completion. Shipping addresses can be found in **Section 6.7** below and COCs in **Appendix C**.

6.4.2. Peace River

In the Peace River we do not expect that the above procedure will work because of the lack of depositional areas with fine sediments. To collect benthic invertebrates in the Peace River, the following procedure should be followed:

1. From shore, accessed either by foot from the road or from a boat, sample **riffle habitats** at low discharge periods, typically in the morning near the PCD and the afternoon farther downstream of PCD. It is important to sample in areas that are permanently wetted, and not from areas that are intermittently wetted and dried because benthos will be rare in these habitats.
2. Once an area is chosen, put on chest waders and with the help on an assistant, use a **kick net** (or similar device) with a 500 – 1000 μm mesh bag to collect benthic invertebrates in the manner described below.
3. Hold the bag tightly against the bottom downstream of the area to be disturbed. Moving upstream of the bag, **kick, dislodge and disturb** the sediment (gravel, sand) to allow the current to drag dislodged organisms into the kick net so they are impinged against the mesh. Continue this procedure at various locations along the shoreline until such time as **1 – 2 g** of organisms has been collected.
4. The bag can be **emptied periodically** so that individual organisms can be picked from the sand/gravel particles that will also be collected while the remaining field crew continue collecting.
5. **Pick individual** organisms from the net contents using stainless steel or plastic tweezers and place into a vial with a small amount of water to rinse sediment particles.
6. Drain the water and divide the organisms in half: placing half of the volume of benthic animals into a 6 mL plastic vial for analysis of total and methyl mercury by **Quicksilver**. Place the other half into a 6 mL vial for analysis of stable isotopes by **SINLAB**.
7. Appropriately label (see above) and freeze the samples in dry ice as soon after collection as practicable.
8. **Ship frozen** in a cooler with ice packs to the appropriate laboratory for analysis of total Hg, methyl Hg and C and N stable isotopes and moisture content. See the chain-of-custody form for correct procedure for completion. Shipping addresses can be found in **Section 6.7** below and COCs in **Appendix C**.
9. Repeat this procedure at the other two stations in the Peace River. See the QA/QC section for instructions about collecting a field duplicate sample from one of the three Peace River stations.

6.5. QA/QC

Field QA/QC procedures for benthos will focus on contamination control and generation of replicates. Frequent glove changes, rinsing of tweezers and biota to eliminate adherence by sediment particles will ensure that there is no interference with mercury analyses.

A single replicate sample of benthos will be randomly collected from one of the three Peace River stations. Note this is a completely independent sample and not a split of one of the original samples. Parameters to match regular stations. Sample ID: **DUP-BEN**.

6.6. Storage and Shipping of Benthos Samples

Samples destined for Quicksilver Scientific (THg & MeHg vials):

- Should be frozen in the field on dry ice, immediately after collection
- Kept frozen until time of shipping
- Shipped early in the week via an express courier (to avoid weekend delays & to ensure prompt arrival to laboratory freezer)
- Shipped with a completed COC (see **Appendix C**)
- Shipped to the following:

Quicksilver Scientific
1376 Miners Drive, Suite 101
Lafayette, CO 80026
ATTN: Christopher Shade
Ph. 303-531-0860

Samples destined for SINLAB (C & N SIA vials):

- Should be frozen in the field on dry ice, immediately after collection
- Kept frozen until time of shipping
- Shipped early in the week via an express courier (to avoid weekend delays & to ensure prompt arrival to laboratory freezer)
- Please notify SINLAB of shipment by emailing an electronic copy of the submission form to isotope@unb.ca (see also paper copy in **Appendix C**)
- Shipped to the following:

Stable Isotopes in Nature Laboratory (SINLAB)
Dept. of Biology, University of New Brunswick
P.O. Box 4400
10 Bailey Drive, Room 155 Loring Bailey Hall
Fredericton, NB
E3B 5A3
Ph. 506-453-4967

7. SOIL

The distribution and behavior of mercury in soils are strong determinants and drivers of methylation potential of new reservoirs, both in terms of the magnitude and duration of elevated methyl mercury concentrations. The area is blanketed with a variety of riparian and upland soils that will be impacted by flooding. An earlier Terrestrial Ecosystem Mapping (TEM) project (Keystone, 2007) provided detailed maps of all habitats within the post-flood footprint. To characterize these soils efficiently, a stratified approach to sampling will maximize collection of the most relevant information and minimize the cost of sampling and analysis. Sampling of soils for mercury has been stratified according to habitat type and depth to separate mineral from organic soils. Mercury is preferentially bound up by carbon in the organic layer and it is critical to analyze this layer separate from the mineral layer that typically has much lower mercury concentrations.

7.1. Parameters Collected

For each sampling location field descriptions of each locale (vegetation), soil profile and sample will be recorded on a field sheet (see **Appendix B**). All soil samples will be analyzed for metals, mercury, methyl mercury, grain size and total organic carbon by ALS Laboratories. Of these, a subset will be analyzed for total metals and a subset only for methyl mercury, because the full suite of metals analysis is not required at all stations. The design is as follows:

- 30 A horizon soils and 10 B horizon soils will be analyzed for total metals, including mercury, as well as TOC and grain size; randomly selected from among all stations (analyzed by ALS).
- 70 A horizon soils and 10 B horizon soils will be analyzed only for total mercury as well as TOC and grain size; randomly selected from among all stations (analyzed by ALS).
- A subset of soil samples (12 samples only) will also be analyzed for methyl mercury (also analyzed by ALS).

These samples must be frozen immediately on dry ice. Sample remaining after filling these containers will be placed in a plastic bag for archive.

Detailed procedures for the collection of the following laboratory analyzed parameters are provided in the sections below:

- Grain size and total organic carbon (TOC)
- Total metals (including mercury) and pH (ALS Vancouver)

- Total and Methyl mercury (mg/kg) (ALS Vancouver)

SOIL SAMPLING CHECKLIST				
Parameter	**Container**	**Field Filter?**	**Preservation/Storage**	**Laboratory**
Grain Size & TOC	125 mL glass	No	none / keep cool	ALS
Total Metals & pH	125 mL glass	No	none / keep cool	ALS
THg & MeHg	125 mL glass	No	none / freeze on dry ice*	ALS

*Freeze immediately on dry ice; dry ice available from Praxair in Fort St. John

7.2. Location

Locations for soil sampling were identified using the TEM maps and associated areas covered by each vegetation type (habitat). Characterization of all habitats is not required as some, like gravel bars (GB), will not affect post-flooding mercury cycling. Habitats of interest in predicting post-flooding mercury cycling include the habitat units designated as: AM, BL, BT, CF, Fm02, SE, SH, SW and WH. Collectively, these habitat units cover 3600 ha of the proposed flooded footprint. Of these Fm02, and SH cover more than 60% of the footprint. Accordingly a proportionally high sampling frequency has been imposed on these habitats. Wetland habitats (BT, SE and WH) rank very high as contributing significantly to post-flooding mercury cycling and thus all examples of these within the flooded footprint have been included in the sampling program. **Textbox 1** provides a complete list of specific polygons, habitat type, areas (ha), numbers (N) of locations within each polygon, land ownership and probable best access for sampling. Field sampling crews will have some flexibility in choosing exact locations within each targeted polygon. The guiding logic in selecting a specific polygon for inclusion in the soil sampling program was based on the following criteria:

- Some sampling in every map reach (11 maps) spanning the distance between PCD and Site C
- Highest sample frequency in two largest habitat classes, Fm02 and SH that collectively comprise more than 50% of flooded habitat
- Exclude habitats Cut banks (CB), Gravel bars (GB), River (RI), Roads (RZ) and those with <1% coverage excepting habitat types BL and BT
- Include all polygons representing wetlands BL, BT, SE and proportional number of polygons for SW and SH
- Accessible by road or boat (this eliminated a few polygons located far up tributary valleys to be flooded)

- Favor Crown or BCH-owned/leased properties and avoid private property during this first sampling effort.

Table 1 below provides information to guide the sampler including map number, polygon number, cover/habitat type, surface area (ha) and access, whether by boat or on foot from the road.

Textbox 1: Habitats of importance to mercury cycling.

Class	Area (ha)	% of Total	# of polygons	Cover descriptions
AM	208	5.8	16	Step moss-Peavine
BL	10.6	0.3	1	Labrador tea- Lingonberry
BT	19.7	0.5	2	Labrador tea-Sphagnum
CF	538	15.0	50	Cultivated field
Fm02	1096	30.5	166	Cottonwood-Spruce-Red osier Dogwood
SE	56.1	1.6	3	Sedge Wetland
SH	1068	29.7	109	Currant-Horsetail
SW	230	6.4	85	Wildrye-Peavine
WH	365	10.2	78	Willow-Horsetail-Sedge Riparian Wetland
Totals	**3591**	**100**	**510**	

Following are definitions of the dominant habitat types selected for soil sampling. These descriptions are paraphrased from the Keystone (2007) report entitled "*Expanded Legend for the Peace River TEM Project*".

AM: SwAt - Step moss: The AM unit typically occurs in submesic to mesic forest on gentle slopes with deep, moderately fine to coarse - textured soil. Nutrient regimes range from poor to rich, and the unit can occur on fluvial, glaciofluvial, morainal or lacustrine parent materials Parent materials were mainly fluvial and glaciolacustrine. The AM was very variable in terms of vegetation, containing a diverse assemblage of plant types.

BL: Labrador tea: Typically submesic to hygric forest on gently sloping sites or depressions with deep, fine to coarse- textured soils. Black spruce forest dominates on gently sloping sites with deep, fine to coarse- textured soils. The seral association normally occurs on morainal or fluvial parent materials with very poor to poor nutrient regimes.

SH: Currant – Horsetail: Typically subhygric to hygric forest on gentle slopes with deep, coarse to fine- textured soils. The SH normally has a medium to very rich nutrient

regime and occurs on lacustrine or fluvial parent materials. In the study area, the SH was typically found on level sites with subhygric to hygric moisture regimes and medium to rich nutrient regimes, on imperfectly to moderately well-drained soils. The SH was found mainly on fluvial parent materials, and was mapped on the lower slopes of the Peace River valley and on the islands in the river. This polygon type represents mature climax forest with large-diameter white spruce and balsam poplar that is excellent habitat for wildlife.

BT: Labrador tea – Sphagnum: Typically a forested organic wetland with deep, peaty soil. The BT unit normally has a poor to very poor nutrient regime and occurs on organic or fluvial parent materials, often on cold sites underlain by permafrost. Habitat of this type is rare in the Peace River Valley but was common along the power line route on the plateau. It was generally found on poorly drained, level to depressional sites (0-12% slope) on organic surficial materials, with subhygric to subhygric moisture regimes and poor to medium nutrient regimes.

Fm02: Cottonwood-Spruce-Red-osier dogwood: Typically a medium bench floodplain found on sandy or gravelly fluvial materials adjacent to streams and rivers. Characterized by an open canopy of *P. balsamifera* with a sparse to well-developed understorey, subject to short flood durations followed by continual subirrigation. This soil type is found on fluvial surficial materials with submesic to hygric moisture regimes and medium to rich nutrient regimes. Plots in this unit were mostly moderately well-drained to well-drained, and located adjacent to the Peace River or its tributaries. Large-diameter balsam poplar are present in its older structural stages.

SE: Sedge Wetland: Typically a sedge wetland (marsh or fen) with a deep to thin peat layer and has a medium to rich nutrient regime; hygric moisture regime. The SE wetland unit was mapped on level to depressional sites on organic surficial materials with subhygric to hygric moisture regimes. Nutrient regimes were generally medium to rich, and sites were poorly to very poorly drained.

SW: Wildrye – Peavine: Typically submesic to mesic forest on gentle slopes with deep, medium to coarse - textured soils. This soil type normally occurs on sites with a poor to medium nutrient regime, and can occur on a variety of parent materials (Delong 1990). In the study area, this unit was usually found on level sites or on mid to upper slopes on cool aspects. This ecosystem was uncommon in the study area.

CF: Cultivated Field: A flat or gently rolling, non-forested open area with current or historic human agricultural practices. Cultivated fields are present extensively on both the north and south sides of the Peace River.

WH: Willow-Horsetail-Sedge: This non-forested polygon unit is described as a riparian wetland on coarse to fine-textured fluvial soils with subhygric to hygric moisture regime.

Table 1. Map number, polygon and location (UTM; 10V) of soil sampling stations and mode of access.

Map #	Polygon	UTM Easting	UTM Northing	Cover Type[1]	Dec_1%	Area (ha)	N/polygon	Owner	Access
1	94A001_165	566712	6207938	WH	50	6.9	1	Crown	Boat
1	94A001_167	567243	6208356	SH	100	23	1	Crown	Boat
1	94A001_197	567258	6208609	Fm02	70	5.1	1	Crown	Boat
2	94A001_336	569752	6211601	WH	70	4.0	1	Crown	Boat
2	94A001_350	570808	6212142	WH	80	7.3	1	Crown	Boat
2	94A001_365	571478	6212674	SH	100	12	1	Crown	Boat
3	94A012_816	577284	6219189	Fm02	100	16	1	Crown	Boat
3	94A012_895	578487	6219601	Fm02	100	14	1	Crown	Boat
3	94A012_925	578807	6219485	SH	100	28	2	Crown	Boat
3	94A012_972	577014	6219647	CF	100	14	1	Own/Lease	Boat
4	94A012_1159	581792	6220278	CF	100	30	2	Own/Lease	Boat
4	94A012_1266	578766	6220739	AM	50	13	1	Own/Lease	Land
4	94A012_1275	583177	6220846	SH	60	35	2	NA	Boat
4	94A012_2226	586276	6223662	SW	100	14	1	Private	Land
4	94A012_2488	586868	6224039	SH	100	13	1	Own/Lease	Boat
5	94A013_2783	590300	6226404	SH	100	95	5	Crown	Boat
5	94A013_2862	589011	6226352	SW	100	10	1	Private	Boat
5	94A013_3077	592177	6228232	SW	40	12	1	Own/Lease	Boat
5	94A023_3286	594602	6229508	SW	100	17	1	Crown	Boat
6	94A023_15018	593341	6233138	Fm02	100	27	2	Crown	Boat
6	94A023_15057	590966	6234261	WH	100	42	2	Crown	Boat
6	94A023_3365	595539	6230080	SH	80	29	2	Crown	Boat
6	94A023_3468	595423	6230663	SH	100	30	2	Crown	Boat
6	94A023_3610	597327	6231250	SH	100	35	2	Crown	Boat
6	94A023_3652	595242	6231331	Fm02	100	18	1	Crown	Boat
6	94A023_3680	597672	6231874	CF	100	52	2	Own/Lease	Boat
6	94A023_3735	595368	6231911	SH	50	85	4	Crown	Boat
6	94A023_3750	596389	6231730	Fm02	100	13	1	NA	Boat
6	94A023_3759	595832	6231783	AM	80	3.6	1	Crown	Boat
7	94A024_4032	603548	6233232	Fm02	100	14	1	NA	Boat
7	94A024_4039	600885	6233237	SH	70	11	1	NA	Boat
7	94A024_4071	601094	6233492	Fm02	60	63	3	NA	Boat
7	94A024_4156	604545	6233808	CF	100	11	1	Own/Lease	Boat
7	94A024_4450	605579	6234809	SE	60	18	1	Own/Lease	Land
7	94A024_4499	605600	6235004	BT	50	7.4	1	NA	Land
7	94A024_4533	606163	6235309	BT	50	12	1	NA	Land
7	94A024_4570	606575	6235649	SE	60	17	1	Own/Lease	Land
7	94A024_4575	607203	6235831	AM	60	17	1	Crown	Land
7	94A024_4588	607199	6236005	SE	80	21	1	NA	Land
7	94A024_4625	607224	6236101	BL	80	11	1	Own/Lease	Land
7	94A024_4742	609868	6237487	CF	100	76	1	Private	Boat
7	94A024_9025	599486	6232766	WH	60	26	1	NA	Boat
8	94A024_4522	608182	6236078	WH	80	66	3	NA	Boat
8	94A024_4658	608468	6236832	Fm02	60	45	2	Crown	Land
8	94A024_4675	608504	6236242	WH	70	3	1	NA	Boat
8	94A024_4682	609058	6236529	WH	40	12	1	NA	Boat
8	94A024_4702	608099	6237027	CF	100	24	1	Own/Lease	Land
8	94A024_4740	611378	6237475	AM	80	20	1	Crown	Boat
8	94A025_4609	613392	6236065	Fm02	100	26	2	NA	Boat
8	94A025_4668	612052	6236506	SW	100	15	1	Crown	Boat
9	94A025_3782	618061	6232218	Fm02	70	70	4	NA	Boat
9	94A025_3854	621630	6232501	Fm02	100	31	1	Crown	Boat
9	94A025_3870	616210	6232900	SH	70	46	2	Crown	Boat
9	94A025_3875	620553	6232439	Fm02	80	19	1	Crown	Boat
9	94A025_3931	622724	6232814	SH	100	26	1	Crown	Boat
9	94A025_3998	616655	6233212	Fm02	80	17	1	NA	Boat
9	94A025_4015	614732	6233727	SW	100	11	1	Crown	Boat
9	94A025_4099	615186	6233752	SH	100	54	3	Crown	Boat
9	94A025_4532	613852	6235510	Fm02	50	15	1	Crown	Boat
10	94A015_20056	623521	6227513	Fm02	100	16	1	Crown	Boat
10	94A015_20139	621683	6228067	SH	100	16	1	Crown	Boat
10	94A016_20072	625361	6227640	Fm02	100	12	1	Crown	Boat
10	94A016_20157	626176	6228272	SH	100	9.1	1	Crown	Boat
10	94A016_3321	627550	6229618	Fm02	100	13	1	Crown	Boat
10	94A016_3347	628069	6229825	SH	100	10	1	Crown	Boat
11	94A016_3428	628509	6230275	Fm02	80	13	1	Crown	Boat
11	94A026_3578	626788	6232268	AM[2]	60	87	4	Crown	Boat
11	94A026_3913	626849	6232540	SW	100	3.3	1	Crown	Boat
11	94A026_4024	624276	6233233	Fm02	50	14	1	Crown	Boat
11	94A026_4906	628702	6231159	SW	60	19	1	Crown	Boat

Notes:
NA = unknown
[1] see text for description of cover types.
[2] cover type designation is uncertain.

7.3. Timing

Soil sampling will be conducted only once, during mid-July 2010.

7.4. Soil Sampling Procedures

On arrival at a sampling location one or more photographs will be taken of the surroundings, including the ground surface, to document the habitat. An additional photograph should also be taken of the soil profile after excavation but before sampling. Include a card with the sample ID and a ruler for scale in these photographs. The step-by-step procedure for soil sampling is as follows:

1. Initiate "position averaging" function on the **GPS unit** and place unit nearby.
2. **Remove** any living vegetation, coarse litter debris, and rocks to expose the top of the soil profile that may or may not include an organic horizon.
3. Use tile **spade**, or serrated knife, to cut a block the width and length of the spade.
4. Carefully use the tile spade inserted on one side to pry the block out of the ground.
5. **Photograph** one face of the block with ruler and station ID in the frame. If soil is highly friable and the block crumbles prior to photography, use the cut soil face to measure and document the profile.
6. **Record** the depth of the organic horizon if present, including depths to any obvious interfaces (e.g., litter, fermentation, humus).
7. Carefully **separate the organic horizon**(s) from the mineral horizon and transfer to mixing bowl.
8. Using a clean pair of gloves break up the organic horizon and homogenize. Pick out and discard rocks, roots and any larger fragments that can be crushed into smaller pieces.
9. Transfer aliquots of the **well-homogenized organic matter** to the pre-labeled 125 mL glass jars. If this station is selected for total and methyl mercury analysis by ALS, transfer an aliquot to the 125 mL jar for mercury.
10. **Repeat** steps 6 through 8 for the mineral horizon. Note that only the uppermost (~5 cm) mineral horizon needs to be sampled.
11. Verify **labeling** of all samples and place in ice chest. Soil destined for total and methyl mercury analysis by ALS is stored on dry ice.

12. Halt position averaging on the GPS and record both the waypoint and the coordinates in UTM format with NAD83 datum.
13. **Record** a brief description of the samples collected including a list of the analyses to be requested.
14. **Decontaminate** all sampling gear using water, dilute detergent, brushes and paper towels.
15. Shipping addresses can be found in **Section 7.7** below and COCs in **Appendix C**.
16. Fill in the appropriate COC carefully to ensure that analyses are conducted for organic carbon and grain size, and / or total metals, or total and methyl mercury.

7.5. QA/QC

Field QA/QC procedures for sediment will focus on limiting cross contamination and generation of appropriate QC samples. QA includes frequent glove changes, rinsing of spoons and confirmation of decontamination effectiveness to control of cross-contamination.

Replicate soil samples should be collected at a rate of 1 to 10 (i.e., 12 in total) and will be composed of splits from the mixing bowl, **not** a second sample from the same station. Station IDs: **DUP-SOIL-xx**.

7.6. Storage and Shipping of Soil Samples

Samples destined for ALS Environmental (grain size & TOC jars, total metals & pH jars, THg & MeHg jars):

- Should be kept cool in the field on wet ice and until time of shipping; shipped with wet ice in a cooler no later than 5 days after collection
- THg and MeHg jars should be frozen in the field on dry ice, immediately after collection, and kept frozen until time of shipping; shipped on dry ice early in the week via an express courier (to avoid weekend delays & to ensure prompt arrival to laboratory freezer)
- Shipped with a completed COC (see **Appendix C**) to the following location:

ALS Environmental
100 – 8081 Lougheed Hwy.
Burnaby, BC
V5A 1W9
ATTN: Natasha Markovic Ph. 604-253-4188

8. VEGETATION

Given the lack of industrial sources of atmospheric mercury in the vicinity of Site C elevated concentrations of mercury in plant tissues along the 83 km reach of river are not expected. However, given the importance of plant material as a source of labile (i.e., readily available) carbon and its role in mercury methylation, a minimum amount of vegetation sampling and analysis will be conducted.

Representative vegetation types of common, abundant species will be collected from dominant habitat types within areas proposed to be inundated. Effort and intensity will be stratified to accurately represent the dominant vegetation types with a focus on those habitats with soils that have abundant carbon stores such as peatlands, bogs, fens, marshes and well-developed humic soils beneath deciduous forests.

8.1. Parameters Collected

Vegetation samples will be analyzed for metals and total Hg. In general, at least one sample of each dominant wetland plant species will be collected (e.g., tamarack, willow, sedge, horsetail, black spruce, sphagnum, step moss).

VEGETATION SAMPLING CHECKLIST			
Parameter	**Container**	**Preservation/Storage**	**Laboratory**
Total Metals (incl. Hg) & Moisture	Ziploc bag (**2 g** wet)	none / keep cool	ALS

8.2. Location

Vegetation samples will be collected at a subset of soil sampling stations representing one or both of the predominant habitat types (Fm02 and SH). See **Table 1** for a list of soil locations. Exact locations will be determined in the field at the discretion of the biologists. Twenty-five (25) vegetation samples will be collected opportunistically, taken from the length of the river, to represent the dominant vegetation types encountered. When a sample is taken, record the polygon number, vegetation type and UTM coordinate of the collection location. The samplers will keep track of the vegetation types collected and polygon locations.

8.3. Timing

Vegetation sampling will be conducted only once, at the same time as soil collections during mid-July 2010.

8.4. Vegetation Sampling Procedures

Samples of grasses, shrubs, and leaves or needles of trees will be collected by gathering the current year's growth (i.e., tips of coniferous trees and leaves). Where possible, sample individual species and do not combine across species. The specific collection procedure is as follows:

1. Before and during sampling fill in the requested information on the **field data form** (see **Appendix B**); complete one field data form in its entirety for each sampling station. Forms are made of waterproof paper; print all information on the form using a lead pencil or a write-in-the-rain pen.
2. Determine the **dominant tree/shrub/grass type** and focus on one or two species and sample these within the flood zone corridor of the area chosen for collection.
3. Determine the **species type(s)** to be collected and focus on these and composite leaves or needles of the same species in separate bags.
4. All vegetation samples should be collected **by hand** using disposable plastic gloves.
5. Fill a single **large Ziploc bag** by wandering over the sampling area while collecting a few fronds, leaves or needles (depending on the species being collected) from many plants or trees to gather a composite.
6. **Refrigerate** samples prior to shipping. Appropriately label the outside of the bag with a felt-tip pen and place a waterproof paper label inside the bag.
7. Seal the **cooler and ship to ALS** with the appropriate chain-of-custody forms which should accompany the shipment. Shipping addresses can be found in **Section 8.7** below and COCs in **Appendix C**.

8.5. QA/QC

Field QA/QC procedures for vegetation include focus on contamination control and generation of replicates. Because vegetation has typically very low mercury concentrations, commonly 10- to 100-fold lower than soil, it is important to maintain strict division of soil and vegetation sampling to avoid cross-contamination. Thus, for sites designated for vegetation sampling, collection of vegetation samples should be done first wearing clean gloves that are changed frequently (e.g., between collection of different vegetation types).

Replicate vegetation samples should be collected at a rate of 1 to 10 (i.e., 3 in total) and will be composed of splits from the composite. Sample IDs: **DUP-VEG-xx**.

8.6. Storage and Shipping of Vegetation Samples

Samples destined for ALS Environmental (plant tissue Ziploc bags):

- Should be kept cool in the field on wet ice
- Kept cool until time of shipping
- Shipped with wet ice in a cooler no later than 5 days after collection
- Shipped with a completed COC (see **Appendix C**)
- Shipped to the following:

ALS Environmental
100 – 8081 Lougheed Hwy.
Burnaby, BC
V5A 1W9
ATTN: Natasha Markovic
Ph. 604-253-4188

9. FISH

9.1. Parameters Collected

Detailed procedures for the collection of the following laboratory analyzed parameters are provided in the sections below:

- Moisture
- Total mercury
- Carbon and nitrogen stable isotope analysis (SIA)

Four fish species are being targeted:

- Longnose sucker (*Catostomus catostomus*) a non-discriminant benthic forager, consuming algae and benthic invertebrates.
- Redside shiner (*Richardsonius balteatus*), a forage species with a mixed invertebrate diet.
- Mountain whitefish (*Prosopium williamsoni*) a benthic feeder and important food chain species
- Bull trout (*Salvelinus confluentus*) a piscivorous predator.

The objectives of the fish collection program in Peace River and Dinosaur Reservoir are two-fold:

1. Describe the relationship between fish mercury, fish size and stable isotopes within discrete size classes of mountain whitefish and bull trout; and
2. Describe the relationship between fish mercury and stable isotopes for adult redside shiner and longnose sucker. Because there is typically no relationship between size and mercury in these species, sampling can be done within a narrow range, targeting adult fish.

Mainstream Aquatics (2009) collected bull trout and mountain whitefish over a wide size range and have adequately characterized the mercury – size relationship for these species and we do not propose to duplicate this effort. However, it is important to characterize stable isotopes for these species to capture changes in dietary shift that may occur during the life of the fish at different sizes. Consequently, we are proposing that 15 fish of each of mountain whitefish and bull trout be captured for stable isotopes and mercury. Bull trout will be sampled using non-destructive techniques, which Mainstream is familiar with and are described below.

Note that a line item in the budget has been set aside for the incidental or targeted collection of lake trout (S. namaycush) that are purportedly abundant and frequently captured from Dinosaur Reservoir in the tail race area below WAC Bennett Dam. These fish should be sampled non-destructively for tissue mercury concentration to document current mercury levels.

For redside shiner and longnose sucker, we only require 10 fish per species be destructively sampled for mercury and stable isotopes, targeting adults only.

Following is a general description of the fish sizes to be targeted for sampling (these numbers are to be collected from each of the Dinosaur Reservoir and Peace River), based on results from Mainstream Aquatics (2009):

- Redside shiner, 10 specimens of adult fish 12 – 15 cm; destructively sampled and filleted for muscle tissue, split between analysis for mercury (ALS) and stable isotopes (SINLAB)
- Longnose sucker, 10 specimens adult fish 12 – 15 cm; destructively sampled and filleted for muscle tissue, split between analysis for mercury (ALS) and stable isotopes (SINLAB)
- Mountain whitefish, 5 specimens each from within the following three size classes: 200 – 250 mm; 300 – 350 mm; and >400 mm; destructively sampled and filleted for muscle tissue, split between analysis for mercury (ALS) and stable isotopes (SINLAB)
- Bull trout 5 specimens each from within the following three size classes: 250 – 300 mm; 400 – 450 mm; and >600 mm; non-destructively sampled, two muscle plugs for mercury analysis (ALS) and one muscle plug for stable isotopes (SINLAB) analysis.

FISH SAMPLING CHECKLIST				
Parameter	**Container**	**Tissue Type**	**Preservation/Storage**	**Laboratory**
THg & moisture	6 mL plastic vial (**2 plugs**)	Biopsy*	none / freeze on dry ice**	ALS
THg & moisture	WhirlPac bag (*minimum* **2 g** ww tissue; ideally **10 g**)	Routine tissue*	none / freeze on dry ice**	ALS
C & N SIA	6 mL plastic vial (**1 plug**)	No	none / freeze on dry ice**	SINLAB

*The same COCs are used for both biopsy and routine tissue analyses at ALS. To select analyses for biopsy, tick the columns with "BSY" (first two columns), see COCs in **Appendix C**.
**Freeze immediately on dry ice; dry ice available from Praxair in Fort St. John.

9.2. Location

Fifty (50) fish are to be collected from the Peace River and 50 from Dinosaur Reservoir: 15 bull trout, 15 mountain whitefish, 10 redside shiner, and 10 longnose sucker from each area. In Peace River, the exact location of fish collections is not critical, so long as fish are captured within the mainstem of the Peace River, between PCD and upstream of Moberly River and away from the mouths of tributary streams.

In Dinosaur Reservoir, fish should be captured from the main body of the reservoir and not from the spillway or upper reservoir between WAC Bennett dam and the main body of the reservoir.

Note that if lake trout are collected from Dinosaur Reservoir, tissue biopsy samples should be collected for mercury and stable isotope analysis. Although not a target species, collect and archive. Advise Azimuth how many fish have been collected and a decision will be made to analyze or not.

9.3. Timing

Time of year is not critical, although attempts should be made to capture fish during an approximately two or three-week period to avoid long holding times for tissues.

9.4. Fish Sampling Procedures

9.4.1. Non-Destructive Tissue Sampling

Bull trout are to be sampled non-destructively, using biopsy tools to extract small tissue quantities (~100 mg) for mercury analysis, following the protocol of Baker et al. (2004) and Environment Canada www.ec.gc.ca/eem/pdf_publications/English/mm_fish_tissue.pdf. When captured, quickly measure for length (mm) to determine the size category into which they fall (see above; size categories are 250 – 300 mm; 400 – 450 mm; and >600 mm). Those fish meeting the required size category are placed into a 20 liter bucket and anaesthetized using clove oil mixed with rubbing alcohol at a rate of 1:10 and then further mixed with water at a rate of 4.4ml per 10 liters.

- Remove anaesthetized fish and measure for fork length (mm) and total weight (g +/- 5 g).
- Place the fish on its right side and remove several scales from the left side just beneath the distal part of the dorsal fin.
- Extract three 50 mg tissue plugs using a 4 mm diameter Miltex biopsy punch and place the plugs on a small plastic board.

- Then, place 'Nexcare Liquid Bandage' into each tissue sampling hole and return the fish to a sampling tub with river or lake water and allow the fish to recover. This antiseptic seal stops any bleeding and facilitates healing.
- Using a clean stainless steel scalpel, cut away the outer skin from the muscle and using forceps, transfer two tissue plugs into a single 6 mL plastic HDPE vial for analysis of mercury by ALS.
- Transfer one tissue plug into a second 6 mL HDPE vial for analysis of stable isotopes by SINLAB.
- Seal and label the vials.
- Freeze the tissue sample on dry ice and transfer to a freezer at the end of the day.
- Release the fish when recovered.

When properly conducted, mortality of fish using biopsy techniques is very low, usually less than 0.5% (Uthe, 1971; Crawford et al., 1977; Mair, 1989). In our own experience in a field trial, biopsied and non-biopsied fish were recaptured with the same frequency several weeks after sampling, indicating that there was no difference in survivorship of biopsied versus non-biopsied fish (Baker et al., 2004). In the current study one biopsied fish was recaptured several weeks after it was initially sampled and the small wound had healed quite well.

Before and during sampling fill in the requested information on the **field data form** (see **Appendix B**); complete one field data form in its entirety for each sampling station. Forms are made of waterproof paper; print all information on the form using a lead pencil or a write-in-the-rain pen.

Shipping addresses can be found in **Section 9.7** below and COCs in **Appendix C**.

9.4.2. Destructive Sampling and Processing

For redside shiner, mountain whitefish, and longnose sucker, destructive tissue sampling methods can be used because of small sample size required and sensitivity of whitefish to handling pressure and small size of shiners. Larger tissue samples can be taken from each fish. For destructive sampling, follow the same procedures for tissue collection except that a 5 – 10 g tissue fillet can be taken from the left side dorsal musculature of the fish and split within HDPE vials or into small Whirl-pac or Ziploc bags for analysis of mercury and stable isotopes. In addition to tissues, the following information should be collected from each fish prior to tissue extraction:

- Length (mm) and weight (g)

- Gender (M or F)
- Maturity (Immature, maturing to spawn current year, ripe, spent, resting)
- Visual inspection and documentation of stomach contents
- Internal and external examination for abnormalities, tumors, growths, parasites.
- Removal of otoliths for ageing of whitefish, pectoral fins for longnose suckers and scale samples from redside shiner. Place into appropriately labeled envelope.

9.5. QA/QC

QA/QC for tissue samples will consist of testing of laboratory duplicates within the laboratory at a rate of 10% and testing of standard reference materials to ensure adequate precision of analysis.

Field duplicate samples will be collected from approximately 10% of fish. Assuming that there are 50 fish collected from Dinosaur Reservoir and Peace River (15 bull trout and15 whitefish; 10 shiner and 10 sucker), duplicate samples will be collected from **5 fish** from **each area**. Where possible, use mortalities from bull trout if there are individuals that do not survive (n=2 or 3). For the rest of the samples, collect a duplicate tissue sample from randomly chosen fish, representing across species. Sample ID: **DUP-PR-FISH-x** or **DUP-DINO-FISH-x**.

9.6. Storage and Shipping of Fish Samples

Samples destined for ALS Environmental (biopsy vials, tissue whirlpac bags):

- Should be frozen in the field on dry ice
- Kept frozen until time of shipping
- Shipped frozen no later than 5 days after collection
- Shipped with a completed COC (see **Appendix C**)
- Shipped to the following:

ALS Environmental
100 – 8081 Lougheed Hwy.
Burnaby, BC
V5A 1W9
ATTN: Natasha Markovic
Ph. 604-253-4188

Samples destined for SINLAB (C & N SIA vials):

- Should be frozen in the field on dry ice, immediately after collection
- Kept frozen until time of shipping
- Shipped early in the week via an express courier (to avoid weekend delays & to ensure prompt arrival to laboratory freezer)
- Please notify SINLAB of shipment by emailing an electronic copy of the submission form to isotope@unb.ca (see also paper copy in **Appendix C**)
- Shipped to the following:

Stable Isotopes in Nature Laboratory (SINLAB)
Dept. of Biology, University of New Brunswick
P.O. Box 4400
10 Bailey Drive, Room 155 Loring Bailey Hall
Fredericton, NB
E3B 5A3
Ph. 506-453-4967

10. REFERENCES

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APPENDICES

APPENDIX A

REVIEW OF DATA REQUIREMENTS FOR MECHANISTIC MODELING OF FISH MERCURY LEVELS IN THE PROPOSED SITE C RESERVOIR, BC; REPORT BY REID HARRIS ENVIRONMENTAL LTD., MAY 14, 2010

Review of Data Requirements for Mechanistic Modeling of Fish Mercury Levels in the Proposed Site C Reservoir, BC

Prepared for Azimuth Consulting Group

Prepared by Reed Harris Environmental Ltd.

May 14, 2010

1 Introduction

BC Hydro has proposed a hydro electric development at Site C, a potential third dam and generating station on the Peace River in northeastern B.C. (Kirk & Consulting and Synovate 2009). Site C would provide approximately 1100 megawatts of generating capacity. The reservoir would be 83 km long (Kirk & Consulting and Synovate 2009) and flood approximately up to 5,300 hectares of riparian and upland soils and vegetation (Azimuth 2010).

Reservoir creation has been well documented to result in increased fish mercury (Hg) concentrations (Bodaly et al., 2007, Jacques Whitford 2006, Schetagne et al., 2003, Bodaly et al. 1997, Canada/Manitoba Governments 1987). Methylmercury (MeHg) concentrations in fish can be high enough to represent a risk to the health of humans and wildlife consuming fish. Azimuth (2010) was retained by BC Hydro to develop a strategy to address the Hg issue for Site C. In connection with the Azimuth study, Reed Harris Environmental Ltd. was retained to carry out the following tasks:

1. Review baseline data reports and Azimuth 2010 Site C Technical Memorandum – Mercury Data Review and Planning Considerations;

2. Identify data requirements as critical input parameters for mechanistic modeling based on review of Task 1 documents;

3. Conduct preliminary simple regression modeling of Peace River baseline conditions; and

4. Prepare Technical Memorandum describing outcome and results of linear modeling.

This technical memorandum describes the results of Tasks 1 and 2, related to data needs and availability for the use of a detailed mechanistic model of mercury cycling and bioaccumulation in reservoirs, known as RESMERC (Harris et al., 2009). Tasks 3 and 4 (regression modeling) are described elsewhere.

2 RESMERC Description

RESMERC is a mass balance model that predicts time-dependent concentrations for three forms of Hg (MeHg, inorganic Hg(II), elemental Hg) in water, sediments, flood zones and a seven level food web (phytoplankton, zooplankton, benthos and up to four fish species) (Figure 1). Fish Hg concentrations tend to increase with age, and are therefore followed in each year class (up to 20 cohorts).

An overview of the major processes involved in the Hg cycle in reservoirs is shown in Figure 1. RESMERC Hg processes include atmospheric deposition, inflows and outflows (surface and groundwater), adsorption/desorption, particulate settling, particle decomposition at the sediment/water interface and within sediments, resuspension, burial, air/water gaseous exchange, industrial point sources, in-situ transformations (e.g. methylation, demethylation, MeHg photodegradation, Hg(II) reduction and oxidation), Hg kinetics in plankton and partitioning in benthos, and MeHg bioaccumulation in fish.

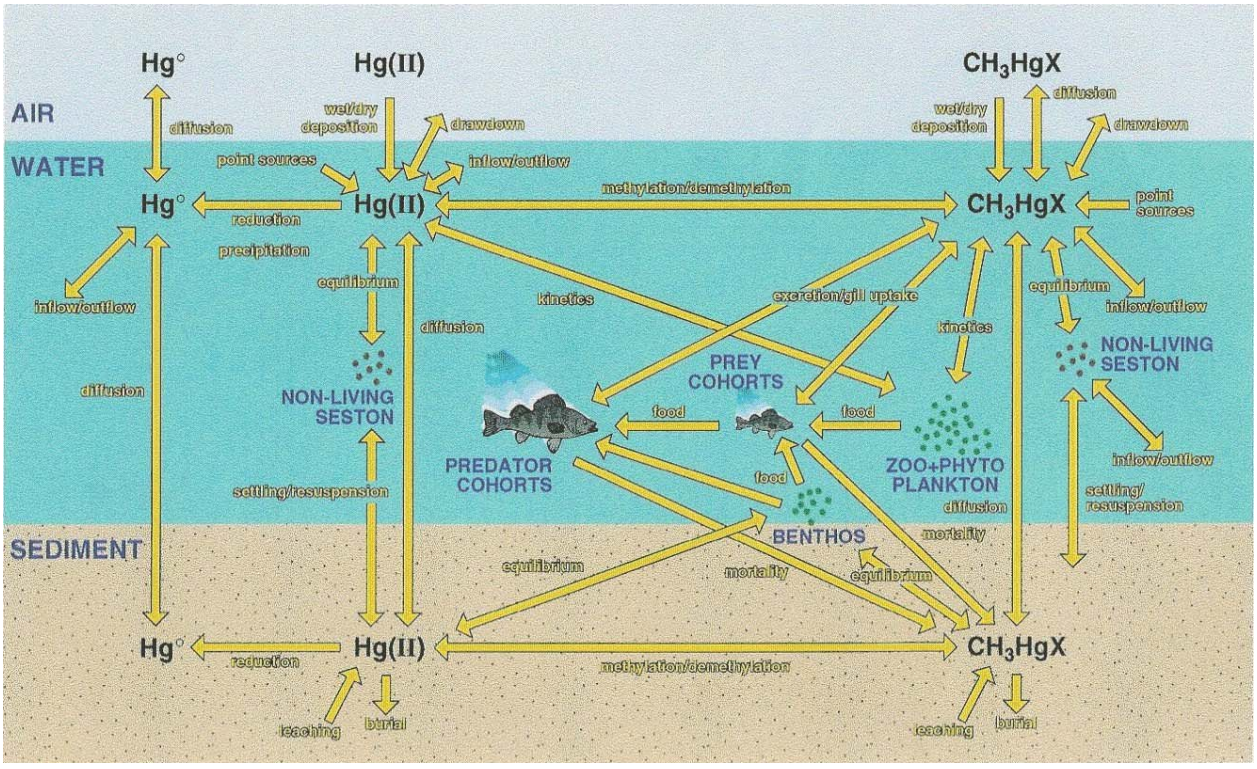

Figure 1. Representation of Hg cycle in RESMERC

While many factors affect fish Hg concentrations in natural lakes, one process takes on special importance in reservoirs: decomposition. Flooding stimulates decomposition and more activity by microbes that convert inorganic Hg(II) into MeHg. Special attention is devoted to these processes in RESMERC. Sediments are divided into a maximum of 5 zones in the model, based on terrain type and elevations set by the user. These zones can include littoral and profundal zones in the original lake, flooded uplands and flooded wetlands. Each sediment zone has two vertical sediments layers.

Developed originally in 1997, RESMERC has been applied to Williston Reservoir, BC (Tetra Tech, 2002), updated and calibrated using results from experimental reservoirs and a natural lake at the Experimental Lakes Area, Ontario, and applied to Notigi Reservoir in Manitoba (Harris et al., 2009).

3 Comments on Azimuth (2010) Report

The following documents were reviewed to assess the extent of existing data in the context of needs for mechanistic mercury modeling:

- Mainstream Aquatics Ltd (2008) Site C Fisheries Studies Mercury Levels In Peace River Fish Tissue – Data Report 2008;
- Golder Associates (2009) Baseline Data Collection - Water Quality, River Sediment, Soil, and Vegetation Samples from the Peace River Watershed - 2007, Report Number: 06-1490-006, May 15, 2009; and
- Azimuth Consulting Group Inc. (2010) Site C Technical Memorandum Mercury Data Review and Planning Considerations. Prepared for BC Hydro. Project No. BCH-09-01. January, 2010.

Overall, the available data and mercury sampling proposed by Azimuth (2010) largely address the data needs for the application of the RESMERC model to Site C. Two related issues that should be clarified to define data needs for modeling are the distance downstream of Site C where mercury is expected to be an issue, and whether MeHg exposure to wildlife will need to be estimated for Site C (this may affect the choice and size of fish species that data are required for).

Specific comments on the Azimuth (2010) report are provided below. Quotes from the report are shown in italics.

Page 7, 3rd paragraph: "*Sediment sampling should take place over a larger area in deeper water in depositional areas.*" It would be useful to have an estimate of the fraction of the existing river bed that is depositional, and areas in the proposed new reservoir that are expected to be depositional. Is an assessment of this type expected at some point?

Page 7, 4th paragraph: "*Mercury concentrations in soils from background, non-mineralized areas range from 0.01 to 0.2 µg/g (e.g., Rasmussen, 1994; Lodenius, 1994; McKeague and Kloosterman, 1974), whereas values for soils from mercury-mineralized areas, such as near the Pinchi fault in BC (Plouffe, 1995), range up to several µg/g. Methyl mercury values typically represent <1% of total mercury concentrations and are higher in soil horizons with high organic content.*" The potential to flood terrain with enriched Hg deposits should be addressed. Can it be determined from geologic maps that this is not the case for Site C. Would limited sampling in the flood zone pick up on this if local Hg deposits existed?

Page 9, 3rd paragraph: "*Based on our understanding of typical metals concentrations in plants, the data seem to be dry weight concentrations when they should be presented as wet weight concentrations, which is typical for tissue*". RESMERC predicts MeHg concentrations in fish and benthos on a wet weight basis, but all other compartments with solids are expressed on a dry weight basis (soil and sediment solids, suspended solids, phytoplankton, zooplankton).

Page 10, 5th paragraph: "*We are also aware that fish might be feeding preferentially from the tailrace area of Peace Canyon G.S. It is well known that fish feeding on higher mercury food sources from an upstream reservoir accumulate mercury to a greater degree than if they were feeding on resident food sources. If a creel census revealed that people were targeting fish in this area, this population of fish should also be sampled."* How far downstream of Site C is mercury a concern? Baseline sampling should be done downstream if this is an issue.

Page 13, 2nd paragraph: Is Hg in wildlife an issue? If so, is baseline work being done to establish key wildlife species and associated Hg levels?

Page 15, 1st paragraph: "*Montgomery et al. (2000) showed that the proportion of methyl mercury in water relative to inorganic mercury was nearly four times higher in reservoirs than in lakes even up to 18 years after reservoir creation*." A good indicator of the long term increased efficiency of methylation would be to monitor the % of THg as MeHg in water and sediments for long periods post-flood. Pre and post flood monitoring should measure MeHg and THg in water in a manner that allows estimates of unfiltered and filtered (ng/L), and particle phase (ng/g) concentrations.

Page: 20 1st paragraph: "*MHMMR mimics the production, destruction and bioaccumulation of methyl mercury in reservoirs in a realistic way using mass balance calculations of elemental, mercuric ion and methyl mercury over time.*" Suggest using "inorganic Hg(II)" rather than mercury ion (MeHg also involves the mercuric ion) and almost none of the Hg in water exists as the free (uncomplexed) Hg^{++} ion.

Page 20, 2nd paragraph: "*Other inputs required include water temperature, hydraulic retention time, thermal stratification, oxygen concentration, pH, dissolved organic carbon concentration, phosphorous and sulphate concentrations…*" Phosphorus is not used directly by RESMERC but is good to know as an indicator of expected suspended solids, sedimentation rates, and fish growth rates, which are model inputs.

Page: 22, bullet list:

- Zooplankton and phytoplankton biomass densities are useful but not essential. It is more important to get overall suspended solids (mg/L).

- Also suggest collecting benthos for MeHg analysis if benthic organisms are an important component of the dietary pathway leading to the fish species of interest. A single campaign in ice free season would suffice, at 2-3 locations. Bulk samples with aggregated benthic species are sufficient (as opposed to individual species). If benthic samples can be collected at sites that also have estimates of MeHg in sediment solids, that would be useful. For post flood conditions, porewater DOC and MeHg data in association with benthic MeHg data would be useful to help calibrate the partitioning of MeHg into benthos in the flood zone. It is not essential that such data be collected in 2010 within the existing river bed.

Page: 25 – General comment: Note that baseline Hg data and relevant site characterization data are expected by regulators for EA studies, independent of modeling. Much of the data needed for modelling is covered by baseline characterization.

Page: 26 – paragraph below bullet list: "*In addition to unfiltered and filtered samples for mercury and methyl mercury analysis, samples should also be collected for analysis of TSS, DOC, pH and anions.*" Include dissolved oxygen profiles (unless you know water column is mixed). If anoxia exists (not expected), measure sulphide.

Page 26, last paragraph: "*In addition to metals and total mercury analysis, each sediment sample should also be analyzed for TOC, moisture and particle size distribution (%sand, %silt, and %clay).*" Porewater DOC, THg and MeHg are also important in the model in flooded areas, but these data cannot be collected pre-flood, and are not essential to measure in pre-flood sediments.

Page 28, 2nd paragraph: "*Soil samples should be analyzed for metals, including total mercury, pH, moisture content, and total and labile organic carbon.*" Consider also analyzing for MeHg in soils - provides initial conditions for detailed model, and regulators want to know how much Hg is present, as a matter of covering the bases.

Page: 29 – 2nd paragraph: General comment: Vegetation biomasses (kg/ha) are probably as or more important than the Hg concentration data, because the surge in decomposition will likely cause more change in methylation rates than the release of Hg. Can we estimate pools of vegetation biomass and carbon (g/m2) in vegetation and soils with the proposed data collection program?

Page 29 – Zooplankton section: "*Zooplankton should be collected from a minimum of two locations in the Peace River and two locations in Dinosaur Reservoir should be collected to determine total mercury concentration and carbon and nitrogen stable isotopes*." Total mercury is not very useful. We need MeHg in zooplankton, on a dry weight basis. Two locations are sufficient.

Page 29 - Benthic section: Same comment as for zooplankton: Benthos Hg analyses should be MeHg. It can't be assumed that most Hg in zooplankton or benthos is MeHg (unlike fish muscle). Two to three locations are sufficient.

Table 1: Table 1 from Azimuth (2010) described data needs for several Hg models, including the RESMERC (MHMMR) model. Table A below presents a similar table that is specific to the RESMERC model, indicating (1) key model inputs, (2) whether data already exist or will be addressed by the Azimuth (2010) proposed sampling program, and (3) additional sampling that should be carried out. Additional comments on Table 1 are provided below.

Regression model comments:

- The Harris and Hutchinson regression model requires total flooded area and total reservoir area, as well as mean annual flow. It does not need volume or residence time, although that would be useful to know, and should be estimated in any case.

Comments on data needs for detailed model:

- RESMERC simulates mercury cycling and bioaccumulation but not water quality or hydrodynamics. Site C conditions will need to be estimated for both pre and post flood conditions to run the detailed model. Table 1 addresses 2010 sampling for pre-flood conditions, but estimates are also needed for post-flood conditions regarding flow regimes, surface water temperature and quality (e.g. oxygen, DOC, pH, sulphate, sulphide if relevant, suspended solids, light penetration), porewater chemistry (DOC, pH, sulphate, sulphide) and trophic conditions (fish growth rates, dietary shifts). These model inputs will need to be estimated for post-flood conditions using external models and/or professional judgment.

- Bathymetry is needed (area vs elevation curve).

- Monthly inflows and outflows (discharges) are needed for detailed modeling. Usually this is available for hydroelectric facilities, at least for the outflow. Surface water elevations vs time are also needed for the reservoir. Inflows can be estimated by difference from a water budget that uses water levels and bathymetric information, discharges and an estimate of evaporation.

- Measure sulphide if anoxia is present.

- Discussions should be held with Drew Bodaly to inquire whether selenium measurements would be useful, and if so to discuss selenium forms, environmental compartments, and frequency.

- There are three types of characterization needed for RESMERC to set up initial conditions upon flooding:

  First, the model can have from 1-3 sediment zones defined by elevations (e.g. littoral/non-depositional, profundal/depositional). We will need to estimate how Site C should be set up in terms of what sediment zones to expect in the reservoir.

  Second, once the sediment zones are defined by elevation, another basic distinction is the fraction of each zone that is wetland or upland.

  Third, within the wetlands and uplands of each sediment zone, soil characterization is needed (Hg levels, Org C fraction, porosity, bulk density, fraction labile C).

  Overall it is possible to have from 1 to 5 different pieces of the overall flood zone to characterize.

- Phytoplankton and zooplankton biomasses are not critical inputs.

- It would be useful to have coincidental data for Hg on solids and dissolved phases, along with pH and DOC, to calibrate existing Hg partitioning. Similarly it would be useful to have coincidental data for MeHg in zooplankton, MeHg dissolved in water, and DOC.

Table A. Data needs for the application of the RESMERC model to Site C.

Model input category	Model input	Status		Comments
		Already available	Should be sampled (S) or estimated (E) in 2010	
Physical	Original waterbody area	Y		
	Flooded wetland area (for each sediment zone)		E	Required if not already planned to be estimated. One to five sediment zones will need to be defined by the modeling and project study team. See additional comments in main text.
	Flooded upland area (for each sediment zone)		E	Required if not already planned to be estimated. One to five sediment zones will need to be defined by the modeling and project study team. See additional comments in main text.
	Bathymetry		S	Required if not already planned to be surveyed. Bathymetric information (area vs elevation) is used by the model to estimate volumes and areas for different compartments.
	Ice cover period	Y		Literature estimates adequate
	Surface water elevations	Y		Assumed available from BC Hydro for future operating scenario
Hydrologic	Monthly discharge	Y		Discharges assumed available from BC Hydro.
	Monthly inflow	?	E	Inflow estimates likely already available from BC Hydro. Needs to be estimated if not, using a simple water mass balance.
	Monthly precipitation	Y		Literature estimates adequate

Model input category	Model input	Status		Comments
		Already available	Should be sampled (S) or estimated (E) in 2010	
Water chemistry	Temperature (vertical, seasonal)	Y	S	2010 temperature data would be useful to provide an indication of peak temperatures in the river.
	Thermocline elevations (if relevant)		S	If stratification is expected in the reservoir, thermocline depths would need to be estimated using external models or professional judgement.
	Oxygen		S	Valuable to sample but not essential if existing data indicate mixing and well-oxygenated conditions exist throughout the river.
	pH	Y	S	
	Surface light exposure	Y	S	Literature estimates sufficient.
	DOC	Y	S	
	Selenium		?	Discuss value of Se data with Drew Bodaly
Water chemistry (continued)	TSS	Y	S	Also needs to be estimated for post-flood conditions (not predicted by RESMERC) using external models or professional judgement.
	Organic Content of TSS		S	
	Sulphate and sulphide (if relevant)	Y	S	Sulphide measurements not needed if water column is oxygenated.
	Chloride	Y	S	

Model input category	Model input	Status		Comments
		Already available	Should be sampled (S) or estimated (E) in 2010	
Soil and sediment characterization (uplands, wetlands, sediments)	Soil porosity, density, horizon depths (for each sediment zone)		S	One to five sediment zones will need to be defined by the modeling and project study team. See additional comments in main text.
	Soil carbon (kg/m2) in flood zones		E	
	Vegetation types in flood zone		E	Estimate with ground surveys and/or GIS
	Vegetation biomasses in flood zone (kg/m2)		E	Estimate with ground surveys and/or GIS
	Flood zone porewater chemistry: DOC, pH, sulphate, sulphide (if relevant)		E	Cannot be sampled pre-flood. Needs to be estimated for post flood conditions (see main text).
Biological	Fish species composition	Y		
	Fish diet		S	Based on literature, gut contents, and/or isotope data.
	Fish growth rates	Y		Based on literature or field data

Model input category	Model input	Status		Comments
		Already available	Should be sampled (S) or estimated (E) in 2010	
Mercury data	Baseline fish THg	Y	S	Sample species relevant to accumulation in species of concern. One sample period during ice free season is sufficient.
	Baseline MeHg in zooplankton and benthos		S	One sample campaign is sufficient, at 2-3 locations.
	Tribuary THg and MeHg (to estimate Hg loads)		Y	At least once in ice free season; High and low flow sample periods would be useful.
	THg concentrations in precipitation	Y		Literature estimates adequate.
	THg and MeHg in soils and sediments		Y	Sufficient samples needed to characterize flood zones
	THg and MeHg in vegetation		Y	Best estimated with site specific data. Could be estimated from literature if regional data exist.
	THg & MeHg in water column (epilimnion/hypolimnion if relevant, unfiltered, filtered and particle phase)		Y	At least once in ice free season; Spring and late summer or fall would be useful.

4 References

Azimuth Consulting Group Inc. (2010) Site C Technical Memorandum Mercury Data Review and Planning Considerations. Prepared for BC Hydro. Project No. BCH-09-01. Jan. 2010

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APPENDIX B

FIELD SAMPLING DATA SHEETS

WATER

SEPARATE DATA SHEETS FOR EACH OF THE FOLLOWING:

1. RESERVOIR SAMPLING

2. MAINSTEM RIVER AND TRIBUTARY SAMPLING

Reservoir Water Sampling - BC Hydro Site C

STATION INFORMATION

Station:
Crew:
Date/ Time:
Weather Observations:

UTM Coordinates: **Easting:** **Waypoint#:**
Northing:
Photo #s:

FIELD MEASUREMENTS

Depth (m)	Temperature	Conductivity	Dissolved Oxygen	pH
units:				
0				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

Total Water Depth:
Field Notes:

Water Chemistry from depth of 3 meters.

River Water Samping - BC Hydro Site C

STATION INFORMATION

Station:
Crew:
Date/ Time:
Weather Observations:

UTM Coordinates: **Easting:** **Waypoint#:**
Northing:
Photo #s:

FIELD MEASUREMENTS

Depth (m)	Temperature	Conductivity	Dissolved Oxygen	pH
units:				

Total Water Depth:
Field Notes:
Water Chemistry from surface.

STATION INFORMATION

Station:
Crew:
Date/ Time:
Weather Observations:

UTM Coordinates: **Easting:** **Waypoint#:**
Northing:
Photo #s:

FIELD MEASUREMENTS

Depth (m)	Temperature	Conductivity	Dissolved Oxygen	pH
units:				

Total Water Depth:
Field Notes:
Water Chemistry from surface.

SEDIMENT

SEPARATE DATA SHEETS FOR EACH OF THE FOLLOWING:

1. RESERVOIR SAMPLING

2. RIVER SAMPLING

STATION INFORMATION

Sample ID: _____

Crew: _____

Date/ Time: _____

Weather Observations (wind/waves): _____

_____

Photo #s: _____

QA/QC Samples Collected at Station? _____

Composite of 3 Petite Ponar grabs per station -
Collecting top 3 - 5 cm layer from each grab, from:

Depth (m)	UTM zone	Easting	Northing	Waypoint #

FIELD NOTES

Sediment Characteristics (Grain size, consistency, colour, odour, biota, sheen/unusual appearance) and Sampling Effort (succesful grabs?):

STATION INFORMATION

Sample ID: _____

Crew: _____

Date/ Time: _____

Weather Observations (wind/waves): _____

_____

Photo #s: _____

QA/QC Samples Collected at Station? _____

Composite of 3 Petite Ponar grabs per station -
Collecting top 3 - 5 cm layer from each grab, from:

Depth (m)	UTM zone	Easting	Northing	Waypoint #

FIELD NOTES

Sediment Characteristics (Grain size, consistency, colour, odour, biota, sheen/unusual appearance) and Sampling Effort (succesful grabs?):

STATION INFORMATION

Sample ID: _____

Crew: _____

Date/ Time: _____

Weather Observations: _____

_____

Photo #s: _____

QA/QC Samples Collected at Station? _____

Collect fine sediments within 1 m x 1 m square frame on river bottom

Compositing at station (i.e., not enough in 1 m^2 frame) Y/N ? _____

Depth (m)	UTM zone	Easting	Northing	Waypoint #

FIELD NOTES

Sediment & River Bed Characteristics (Grain size, consistency, colour, odour, biota, sheen/unusual appearance), and Sampling Effort (succesful grabs?):

STATION INFORMATION

Sample ID: _____

Crew: _____

Date/ Time: _____

Weather Observations: _____

_____

Photo #s: _____

QA/QC Samples Collected at Station? _____

Collect fine sediments within 1 m x 1 m square frame on river bottom

Compositing at station (i.e., not enough in 1 m^2 frame) Y/N ? _____

Depth (m)	UTM zone	Easting	Northing	Waypoint #

FIELD NOTES

Sediment & River Bed Characteristics (Grain size, consistency, colour, odour, biota, sheen/unusual appearance), and Sampling Effort (succesful grabs?):

ZOOPLANKTON

Zooplankton Sampling - BC Hydro Site C

STATION INFORMATION

Sample ID: _____
Crew: _____
Date/ Time: _____
Weather Observations: _____

_____

Photo #s: _____
QA/QC Samples Collected at Station? _____

Horizontal tow with plankton net (150 µm mesh, 0.3 m opening diameter, 3 m length)

Depth (m)	UTM zone	Easting	Northing	Waypoint #

FIELD NOTES

Number of tows needed to collect 3 - 5 g of plankters ? _____
Amount of time spent towing? _____

STATION INFORMATION

Sample ID: _____
Crew: _____
Date/ Time: _____
Weather Observations: _____

_____

Photo #s: _____
QA/QC Samples Collected at Station? _____

Horizontal tow with plankton net (150 µm mesh, 0.3 m opening diameter, 3 m length)

Depth (m)	UTM zone	Easting	Northing	Waypoint #

FIELD NOTES

Number of tows needed to collect 3 - 5 g of plankters ? _____
Amount of time spent towing? _____

BENTHOS

SEPARATE DATA SHEETS FOR EACH OF THE FOLLOWING:

1. RESERVOIR SAMPLING

2. RIVER SAMPLING

STATION INFORMATION

Sample ID: _____

Crew: _____

Date/ Time: _____

Weather Observations: _____

_____

Photo #s: _____

QA/QC Samples Collected at Station? _____

Number of grabs needed to collect 1 g of inverts ? _____

Sieve with 500-µm mesh

Depth (m)	UTM zone	Easting	Northing	Waypoint #

FIELD NOTES

Sediment Characteristics (sand, silt, clay?), Biota Composition (rough estimate of contents) and Sampling Effort (succesful grabs?):

STATION INFORMATION

Sample ID: _____

Crew: _____

Date/ Time: _____

Weather Observations: _____

_____

Photo #s: _____

QA/QC Samples Collected at Station? _____

Number of grabs needed to collect 1 g of inverts ? _____

Sieve with 500-µm mesh

Depth (m)	UTM zone	Easting	Northing	Waypoint #

FIELD NOTES

Sediment Characteristics (sand, silt, clay?), Biota Composition (rough estimate of contents) and Sampling Effort (succesful grabs?):

STATION INFORMATION

Sample ID: _____

Crew: _____

Date/ Time: _____

Weather Observations: _____

_____

Photo #s: _____

QA/QC Samples Collected at Station? _____

Number of kick nets full needed to collect 1 g of inverts ? _____

Depth (m)	UTM zone	Easting	Northing	Waypoint #

FIELD NOTES

Sediment Characteristics (sand, silt, clay?), Biota Composition (rough estimate of contents) and Sampling Effort (succesful grabs?):

STATION INFORMATION

Sample ID: _____

Crew: _____

Date/ Time: _____

Weather Observations: _____

_____

Photo #s: _____

QA/QC Samples Collected at Station? _____

Number of kick nets full needed to collect 1 g of inverts ? _____

Depth (m)	UTM zone	Easting	Northing	Waypoint #

FIELD NOTES

Sediment Characteristics (sand, silt, clay?), Biota Composition (rough estimate of contents) and Sampling Effort (succesful grabs?):

SOIL

Soil Sampling - BC Hydro Site C

STATION INFORMATION

Sample ID: _____

Crew: _____

Date/ Time: _____

Weather Observations: _____

Location: **Easting** _____

Northing _____

Cover Type (category): _____

Photos (at least of ground surface and soil profile) #s: _____

QA/QC Samples Collected at Station? _____

FIELD NOTES

Describe layers observed/sampled:

Depth (cm)/Horizon	Sampled Y/N?	Sample ID
1 -		
2 -		

STATION INFORMATION

Sample ID: _____

Crew: _____

Date/ Time: _____

Weather Observations: _____

Location: **Easting** _____

Northing _____

Cover Type (category): _____

Photos (at least of ground surface and soil profile) #s: _____

QA/QC Samples Collected at Station? _____

FIELD NOTES

Describe layers observed/sampled:

Depth (cm)/Horizon	Sampled Y/N?	Sample ID
1 -		
2 -		

VEGETATION

Vegetation Sampling - BC Hydro Site C

STATION INFORMATION

Sample ID: ______________________

Crew: ______________________

Date/ Time: ______________________

Weather Observations: ______________________

Location: **Easting** ______________________

Northing ______________________

Dominant tree/shrub/grass type: ______________________

Species collected: ______________________

____

Photos #s: ______________________

QA/QC Samples Collected at Station? ______________________

STATION INFORMATION

Sample ID: ______________________

Crew: ______________________

Date/ Time: ______________________

Weather Observations: ______________________

Location: **Easting** ______________________

Northing ______________________

Dominant tree/shrub/grass type: ______________________

Species collected: ______________________

____

Photos #s: ______________________

QA/QC Samples Collected at Station? ______________________

STATION INFORMATION

Sample ID: ______________________

Crew: ______________________

Date/ Time: ______________________

Weather Observations: ______________________

Location: **Easting** ______________________

Northing ______________________

Dominant tree/shrub/grass type: ______________________

Species collected: ______________________

____

Photos #s: ______________________

QA/QC Samples Collected at Station? ______________________

FISH

SEPARATE DATA SHEETS FOR EACH OF THE FOLLOWING:

1. Bull Trout (BLTR) ONLY

2. DETAILED ASSESSMENT (RDSH, LNSC, MNWH)

Fish (BLTR only) Sampling - BC Hydro Site C

STATION INFORMATION

Peace River or Dinosaur Resevoir ?: _____

Approx. Location: _____

Crew: _____

Date/ Time: _____

Weather Observations: _____

Fishing gear used: _____

_____

Photo #s: _____

Collection **Bull Trout -- 15 from Dinosaur Reservoir; 15 from Peace River**

FIELD MEASUREMENTS

Fish Species	Fish Sample ID	Length units:	Weight units:
1 -			
2 -			
3 -			
4 -			
5 -			
6 -			
7 -			
8 -			
9 -			
10 -			
11 -			
12 -			
13 -			
14 -			
15 -			

Field Notes: _____

_____

_____

_____

Fish (detailed) Sampling - BC Hydro Site C

STATION INFORMATION

Peace River or Dinosaur Resevoir ?:

Approx. Location:

Crew:

Date/ Time:

Weather Observations:

Fishing gear used:

Photo #s:

Collection **Redside Shiner -- 10 from Dinosaur Reservoir; 10 from Peace River**

Collection **Longnose Sucker -- 10 from Dinosaur Reservoir; 10 from Peace River**

Collection **Mountain Whitefish -- 15 from Dinosaur Reservoir; 15 from Peace River**

FIELD MEASUREMENTS

Fish Species (Gender & Maturity)	Fish Sample ID	Length units:	Weight units:	Age & Aging Structure (Scale? Pectoral Fin? Otolith?)	Stomach Contents
1 -					
2 -					
3 -					
4 -					
5 -					
6 -					
7 -					
8 -					
9 -					
10 -					
11 -					
12 -					
13 -					
14 -					
15 -					

Field Notes:

APPENDIX C

CHAIN OF CUSTODY FORMS FOR EACH LABORATORY (ELECTRONIC VERSIONS AVAILABLE)

ALS ENVIRONMENTAL

SEPARATE COCS FOR EACH OF THE FOLLOWING:

1. **WATER**
2. **WATER – THg & MeHG ONLY**
3. **SEDIMENT & SOIL**
4. **VEGETATION**
5. **FISH TISSUE**

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Page ____ of ____

Report To		**Report Format / Distribution**				**Service Requested** (Rush for routine analysis subject to availability)	
Company:	Azimuth Consulting Group	☑ Standard	☐ Other			◉ Regular (Default)	
Contact:	Randy Baker	☑ PDF	☑ Excel	☐ Digital	☐ Fax	○ Priority (Specify Date Required → →)	Surcharges apply
Address:	Vancouver	Email 1:	rbaker@azimuthgroup.ca			○ Emergency (1 Business Day) - 100% Surcharge	
		Email 2:				○ For Emergency < 1 Day, ASAP or Weekend - Contact ALS	
Phone:	Fax:					**Analysis Request**	
Invoice To	Same as Report ? ☑ Yes ☐ No	**Client / Project Information**				Please indicate below Filtered, Preserved or both (F, P, F/P)	
Company:		Job #:	BCH-10-01				
Contact:		PO / AFE:					
Address:		LSD:					
Phone:	Fax:	Quote #:	Q24848				
Lab Work Order # (lab use only)		**ALS Contact:**	Natasha MM	**Sampler:**			

Sample #	**Sample Identification** (This description will appear on the report)	**Date** (dd-mmm-yy)	**Time** (hh:mm)	**Sample Type**	TSS	TOC, DOC	Anion Scan	Hardness	Alkalinity	pH, EC							Number of Containers
				Water													
				Water													
				Water													
				Water													
				Water													
				Water													
				Water													
				Water													
				Water													
				Water													
				Water													
				Water													

Special Instructions / Regulations / Hazardous Details

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 provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature: °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES
Environmental Division

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

COC # _____

Page ____ of ____

Report To		**Report Format / Distribution**	**Service Requested** (Rush for routine analysis subject to availability)
Company:	Azimuth Consulting Group	☑ Standard ☐ Other	◉ Regular (Default)
Contact:	Randy Baker	☑ PDF ☑ Excel ☐ Digital ☐ Fax	○ Priority (Specify Date Required → →) Surcharges apply
Address:		Email 1: rbaker@azimuthgroup.ca	○ Emergency (1 Business Day) - 100% Surcharge
		Email 2: mmcconnell@azimuthgroup.ca	○ For Emergency < 1 Day, ASAP or Weekend - Contact ALS
Phone:	604-730-1220 Fax:		**Analysis Request**
Invoice To	Same as Report ? ☑ Yes ☐ No	**Client / Project Information**	Please indicate below Filtered, Preserved or both (F, P, F/P)
Company:		Job #: BCH-10-01	
Contact:		PO / AFE:	
Address:		LSD:	
Phone:	Fax:	Quote #: Q24848	

Lab Work Order # (lab use only) | **ALS Contact:** NMM | **Sampler:**

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	HG-MEHG-TOT-GCAFS-VA	HG-MEHG-DIS-GCAFS-VA	HG-TOT-CVAFS-WP(SUB to	HG-DIS-CVAFS-WP(SUB to									Number of Containers
					P	F/P		F									
				Water													
				Water													
				Water													
				Water													
				Water													
				Water													
				Water													
				Water													
				Water													
				Water													
				Water													
				Water													

Special Instructions / Regulations / Hazardous Details

HG-TOT AND DIS NEEDS TO BE PRESERVED IN WP! See Natasha before logging in these samples!

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

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SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature: °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

ALS Laboratory Group
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Environmental Division

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COC # _____

Page ____ of ____

Report To		**Report Format / Distribution**				**Service Requested** (Rush for routine analysis subject to availability)	
Company:	Azimuth Consulting Group	☑ Standard	☐ Other			◉ Regular (Default)	
Contact:	Randy Baker	☑ PDF	☑ Excel	☐ Digital	☐ Fax	○ Priority (Specify Date Required → →)	Surcharges apply
Address:	Vancouver	Email 1:	rbaker@azimuthgroup.ca			○ Emergency (1 Business Day) - 100% Surcharge	
		Email 2:				○ For Emergency < 1 Day, ASAP or Weekend - Contact ALS	
Phone:	Fax:					**Analysis Request**	
Invoice To	Same as Report ? ☑ Yes ☐ No	**Client / Project Information**				Please indicate below Filtered, Preserved or both (F, P, F/P)	
Company:		Job #:	BCH-10-01				
Contact:		PO / AFE:					
Address:		LSD:					
Phone:	Fax:	Quote #:	Q24848				
Lab Work Order # (lab use only)		**ALS Contact:**	Natasha MM	**Sampler:**			

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	PSA-PIPET+GRAVEL	TOC	Total Metals (& pH) - CCME	CVAFS Hg - CCME	Methyl Mercury by GCAFS								Number of Containers
				Soil													
				Soil													
				Soil													
				Soil													
				Soil													
				Soil													
				Soil													
				Soil													
				Soil													
				Soil													
				Soil													
				Soil													

Special Instructions / Regulations / Hazardous Details

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

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SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature: °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

ALS Laboratory Group
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COC # _____

Page ____ of ____

Report To		**Report Format / Distribution**	**Service Requested** (Rush for routine analysis subject to availability)
Company:	Azimuth Consulting Group	☑ Standard ☐ Other	◉ Regular (Default)
Contact:	Randy Baker	☑ PDF ☑ Excel ☐ Digital ☐ Fax	○ Priority (Specify Date Required → →) Surcharges apply
Address:	Vancouver	Email 1: rbaker@azimuthgroup.ca	○ Emergency (1 Business Day) - 100% Surcharge
		Email 2:	○ For Emergency < 1 Day, ASAP or Weekend - Contact ALS
Phone:	Fax:		**Analysis Request**
Invoice To	Same as Report ? ☑ Yes ☐ No	**Client / Project Information**	Please indicate below Filtered, Preserved or both (F, P, F/P)
Company:		Job #: BCH-10-01	
Contact:		PO / AFE:	
Address:		LSD:	
Phone:	Fax:	Quote #: Q24848	

Lab Work Order # (lab use only)		**ALS Contact:** Natasha MM	**Sampler:**

Sample #	**Sample Identification** (This description will appear on the report)	**Date** (dd-mmm-yy)	**Time** (hh:mm)	**Sample Type**	Total Metals - MS-Dry	Hg-Dry	Moisture										Number of Containers
				Tissue													
				Tissue													
				Tissue													
				Tissue													
				Tissue													
				Tissue													
				Tissue													
				Tissue													
				Tissue													
				Tissue													
				Tissue													
				Tissue													

Special Instructions / Regulations / Hazardous Details

this is VEGETATION Tissue

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 provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature: °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

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COC # _____

Page ____ of ____

Report To		**Report Format / Distribution**				**Service Requested** (Rush for routine analysis subject to availability)
Company:	Azimuth Consulting Group	☑ Standard	☐ Other			◉ Regular (Default)
Contact:	Maggie McConnell	☑ PDF	☑ Excel	☐ Digital	☐ Fax	○ Priority (Specify Date Required → →) Surcharges apply
Address:	Vancouver	Email 1:	mmcconnell@azimuthgroup.ca			○ Emergency (1 Business Day) - 100% Surcharge
		Email 2:	rbaker@azimuthgroup.ca			○ For Emergency < 1 Day, ASAP or Weekend - Contact ALS
Phone:	Fax:					**Analysis Request**
Invoice To	Same as Report ? ☑ Yes ☐ No	**Client / Project Information**				Please indicate below Filtered, Preserved or both (F, P, F/P)
Company:		Job #:	BCH-10-01			
Contact:		PO / AFE:				
Address:		LSD:				
Phone:	Fax:	Quote #:	Q24848			
Lab Work Order # (lab use only)		**ALS Contact:**	Natasha MM	**Sampler:**		

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	AZI100-HG-DRY-BSY-VA	PREP-BSY-DIGEST-VA	Moisture	HG-DRY-CVAFS-VA	PREP-TISS-DIGEST-VA	Number of Containers
				Tissue						
				Tissue						
				Tissue						
				Tissue						
				Tissue						
				Tissue						
				Tissue						
				Tissue						
				Tissue						
				Tissue						
				Tissue						
				Tissue						

Special Instructions / Regulations / Hazardous Details

this is FISH Tissue

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 provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature: °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

QUICKSILVER SCIENTIFIC

QUICKSILVER SCIENTIFIC

Pg1 + Pg3= 45 samples
Pg1 + Pg2 + Pg3=101 samples
Pg1 + Pg2 + Pg2 + Pg3=157 samples
Pg1 + Pg2 + Pg2 + Pg2 + Pg3=213 samples

Project Information
Client Name: Azimuth Consulting
Client Number: 0102
Project Number: 201009

Chain of Custody

Please complete all fields marked by grey boxes.
These can be completed by hand or in MS Word.

CLIENT and PRIMARY CONTACT INFORMATION

Client Name	**Client Shipping Address**
Azimuth Consulting Group	218 – 2902 W. Broadway, Vancouver BC, V6K 2G8
Client E-mail rbaker@azimuthgroup.ca	
Primary Contact Name Randy Baker	
Primary Contact Phone No. 604-730-1220	**Primary Contact Fax No.** 604-739-8511
Primary Contact E-mail (if different than above) _____	

WORK ORDER INFORMATION

Sample Type Choose One	**Additional Sample Information**
Service Required Choose One	**Explain Other Services Required** _____
Sample Kit Tracking Information Number of Coolers _____ Type of Containers Sent Choose One Number of Containers _____	**Refrigerant Used for Shipping** *Samples should arrive to the lab at <4.0°C.* ☐ Wet Ice ☐ Other _____

COLLECTION and PREPARATION INFORMATION

Collector Name	**Samples Prepared By**	**Date Samples Shipped**
_____	_____	_____

SHIPPING and ARRIVAL INFORMATION

Relinquished By	**Date**	**Time**	**Shipped Via**
Relinquished By (Shipper)	**Date**	**Time**	**Received By QS**
Number of Containers Received: _____.		Sample Arrival Temp: _____.°C	

SAMPLE INFORMATION

Client Sample Number	Collection Information			Client Notes		Client Sample Number	Collection Information			Client Notes
	Date	Time	Location				Date	Time	Location	

Project Information
Client Name: Azimuth Consulting
Client Number: 0102
Project Number: 201009

CONTD. Sample Info.

Client Sample Number	Collection Information			Client Notes		Client Sample Number	Collection Information			Client Notes
	Date	Time	Location				Date	Time	Location	

Project Information
Client Name: Azimuth Consulting
Client Number: 0102
Project Number: 201009

CONTD. Sample Info.

Client Sample Number	Collection Information			Client Notes		Client Sample Number	Collection Information			Client Notes
	Date	Time	Location				Date	Time	Location	

ADDITIONAL NOTES

SINLAB

Sample Submission Form

Date	

Client name	Azimuth Consulting Group, Randy Baker

Billing information:	Name on invoice:	Randy Baker
	Billing Address:	Azimuth Consulting Group, 218 - 2902 West Broadway, Vancouver, BC, V6K 2G8, (604) 730-1220
	PO Number or account number	NA

Sample information (number of samples and type)	

please attach an organized sample list with submission and electronically

Pre treatment required	Drying $5/sample	Yes
	Grinding $5/sample	Yes
	Weighing $5/sample	Yes
	Tissue Dissection $50/hr	No
	other	

Do you want samples/trays returned?	If yes, account #:	No thanks

Analysis	CARBON & NITROGEN	Yes
	HYDROGEN	No
	SULFUR (to come)	No

**** Note, an electronic copy of your ID codes must be sent to the lab at: isotope@unb.ca and this form must be completed before your samples will be put into the queue ****

****Note If sending samples from outside of Canada, the client is responsible for all necessary import/export permits****