ECOLOGICAL RISK ASSESSMENT OF OFF-SITE TERRESTRIAL AND FRESHWATER AQUATIC AREAS NEAR THE BRUNSWICK SMELTER IN BELLEDUNE, NB

FINAL REPORT

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BRUNSWICK SMELTER
A GLENCORE Company

ECOLOGICAL RISK ASSESSMENT OF OFF-SITE AREAS

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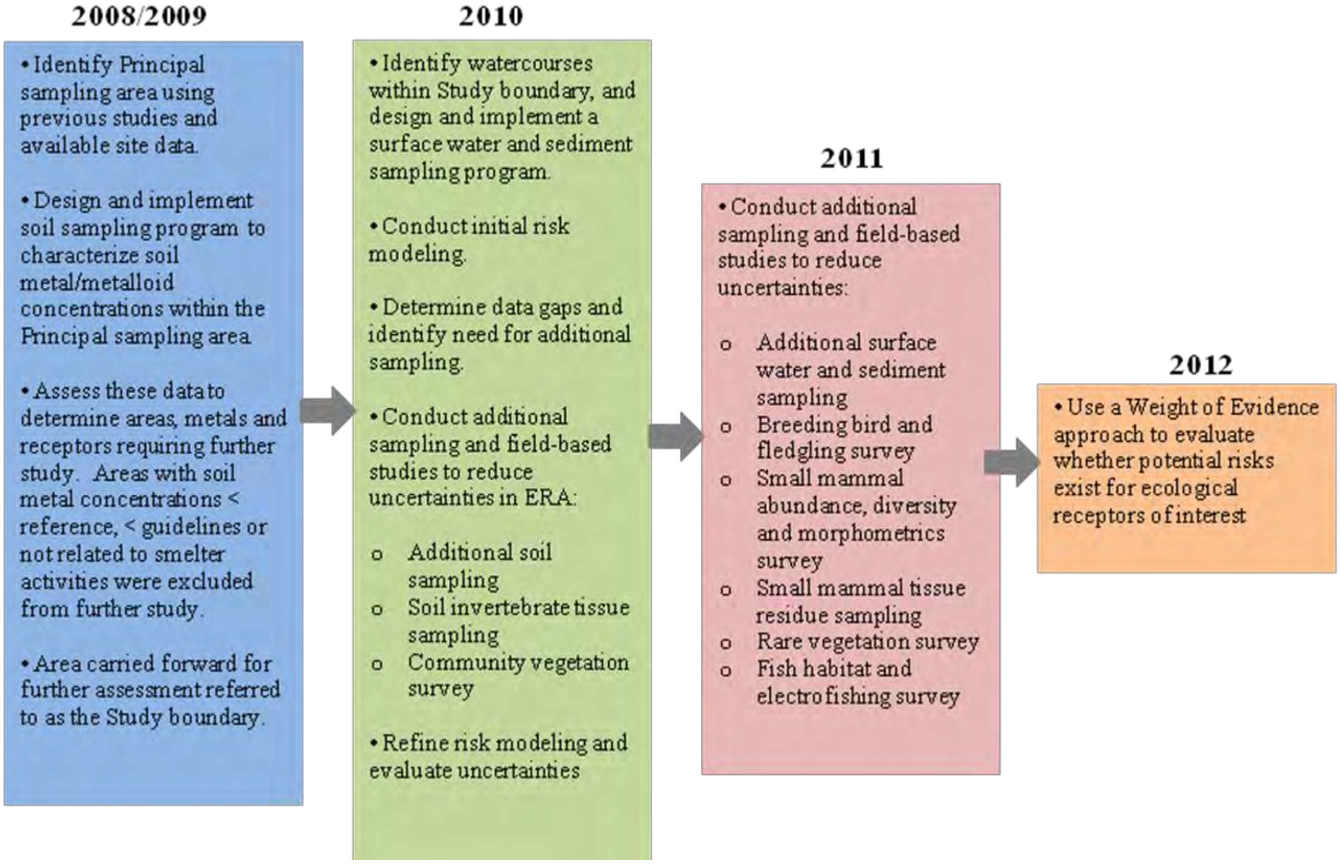
SUMMARY

Glencore has been operating a lead smelter in Belledune, NB, since the mid-1960s. A detailed soil study was previously conducted to investigate the potential for human health risks associated with exposures from facility emissions in residential areas near the facility (*i.e.*, Shore Road Soil Study; Intrinsik Environmental Sciences Inc. *et al.*, 2008). Glencore is now interested in examining the potential for ecological risks to the terrestrial and freshwater aquatic environments adjacent to the facility, associated with current and on-going operations. As such, Glencore commissioned Intrinsik Environmental Sciences Inc. (hereafter referred to as Intrinsik) to conduct an ecological risk assessment (ERA) of off-site terrestrial and freshwater aquatic areas near the smelter.

The study was conducted over 5 years, and involved a team of consultants who conducted field sampling, biological surveys, and risk assessment to evaluate potential risks in the environment associated with releases from the smelter. The timeline and main components of the study are outlined in Figure 1-1.



2008/2009

- Identify Principal sampling area using previous studies and available site data.
- Design and implement soil sampling program to characterize soil metal/metalloid concentrations within the Principal sampling area
- Assess these data to determine areas, metals and receptors requiring further study. Areas with soil metal concentrations < reference, < guidelines or not related to smelter activities were excluded from further study.
- Area carried forward for further assessment referred to as the Study boundary.

2010

- Identify watercourses within Study boundary, and design and implement a surface water and sediment sampling program.
- Conduct initial risk modeling.
- Determine data gaps and identify need for additional sampling.
- Conduct additional sampling and field-based studies to reduce uncertainties in ERA:
    - Additional soil sampling
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    - Fish habitat and electrofishing survey

2012

- Use a Weight of Evidence approach to evaluate whether potential risks exist for ecological receptors of interest

Figure 1-1 Timeline and Flow Diagram of Main Study Components

The risk assessment framework used in this ERA follows the standard risk assessment paradigm comprised of four steps: a qualitative Problem Formulation followed by an Exposure Assessment, Effects Assessment and Risk Characterization.

In this ERA, the key smelter-related sources of COPC are:

- atmospheric deposition of smelter air emissions; and
- fugitive dust emissions from the slag pile.

To determine the Principal sampling area, data gathered in previous studies of the area were considered, including:

- Shore Road Soil Study (Intrinsik Environmental Sciences et. al, 2008);
- The Biodiversity Study (LGL, 2008); and
- Glencore Environmental Monitoring Program (various years).

Wind direction and frequency data, as well as available air dispersion analysis, which combined emissions from all area sources, including Glencore, NB Power, and Canadian Gypsum were also used (Goss Gilroy *et al.*, 2005). Based on data and information from the above mentioned studies, the area within a 7 km radius of the smelter site (called the Principal sampling area) was selected to investigate whether soils in ecological areas surrounding the smelter may be potentially influenced by smelter releases. In addition, an area of crown lands upwind of the smelter was located approximately 21 km due west of the smelter site which served as a suitable reference location. Following initial soil sampling in this 7 km area and reference areas, the area requiring further study in the ERA was determined. The key steps in establishing the Study boundary for the ERA were as follows:

1) Review of previous studies conducted in the Belledune area;
2) Review of 2009 soil study of Glencore and Crown lands within a 7 km radius of the smelter complex (Principal sampling area);
3) Consideration of supporting air dispersion and deposition modelling outcomes; and
4) Consideration of supporting geological data.

The outcomes of each of the steps considered in establishing the Study boundary indicate that the areas requiring further ecological study, in relation to deposition of smelter emissions, are restricted to within a 3 to 4 km radius of the smelter. This area underwent additional sampling to characterize metals levels in soils, soil invertebrates, sediments and surfaces waters, as well as biological field surveys to characterize abundance, diversity and fledgling success of breeding birds, vegetation community diversity and health, small mammals abundance and diversity and tissue organ levels of specific metals, soil nutrient levels, soil invertebrate community abundance and diversity, fish habitat and abundance and diversity.

The chemicals of interest selected for evaluation in the ERA were antimony, arsenic, cadmium, lead, thallium and zinc (in soils), Sulphur dioxide (in air), lead and manganese (in surface waters), and a number of metals in sediments. A conceptual model of key receptors and exposure pathways considered in the risk assessment is outlined in Figure 1-2.

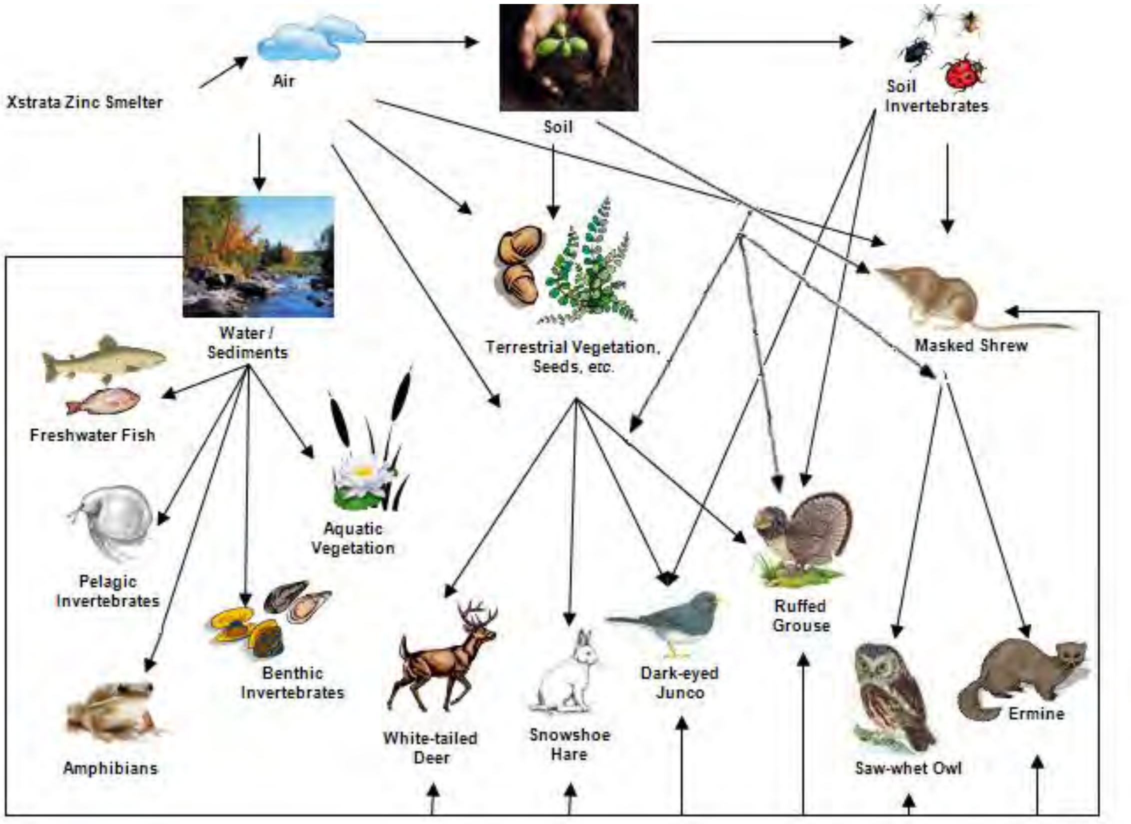

Figure 1-2 Conceptual Model for Terrestrial and Freshwater Aquatic Receptors in the ERA

Using an iterative risk assessment approach, outcomes of sequential risk-based modeling and additional field-based lines of evidence were integrated using a Weight of Evidence approach to draw conclusions with respect to risk to various receptor groups living and foraging in areas south of the smelter. The outcomes of the comprehensive ecological risk assessment on terrestrial and freshwater environments south of the smelter are as follows:

- Risks to vegetation are considered to be low, with the exception of near-field areas immediately South – South-West of the facility, where they are considered moderate. The effects on vegetation South and South-West of the facility are likely related to a number of factors, including site disturbance, soil contamination, possible SO_2 in the near-field, salt spray, nutrient deficiency, amongst others
- Risks to soil invertebrates and soil micro-organisms are considered to be low. Based on the results of the assessment, some individual level effects could be occurring in some

species, but community level effects within the vicinity of the Belledune smelter as a result of smelter operations are considered unlikely.

- Risks to avian species (herbivorous, carnivorous or insectivorous) are considered to be low. Based on the results of the assessment, some individual level effects could be occurring in some species, but population level effects within the vicinity of the Belledune smelter as a result of smelter operations are considered unlikely.
- Risks to herbivorous and carnivorous mammalian species are considered to be negligible, whereas risks to insectivorous small mammals are considered to be low. Based on the results of the assessment, some individual level effects could be occurring in some species, but population level effects within the vicinity of the Belledune smelter as a result of smelter operations are considered unlikely.
- Risks to freshwater aquatic life in Hendry Brook are considered to be negligible to low, whereas risks to freshwater aquatic life in Unnamed Brook are considered to be low for freshwater pelagic species and moderate for benthos, largely due to the influence of the slag storage area in a portion of that brook.
- Based on the available information, risks to sensitive species known to be present on the site (which are limited in number) are likely low (possible effects on some individuals expected, but effects are not considered adverse or measureable). There is considerable uncertainty in this conclusion, but the limited number of sensitive species and limited size of areas with significant contamination suggests that this is likely a reasonable conclusion.

Therefore, based on the outcomes of this study, risks associated with exposures to metals and SO_2 near the Glencore smelter facility are considered to be low to negligible for the terrestrial and freshwater environments. Based on these findings, the uncertainties in this study and the various studies that comprised this work, it is suggested that Glencore conduct a review of their environmental monitoring program, and revise accordingly.

1.0 INTRODUCTION

Glencore (formerly Xstrata Zinc) has been operating a smelter in Belledune, NB, since the mid-1960s. A detailed soil study was previously conducted to investigate the potential for human health risks associated with exposures from facility emissions in residential areas near the facility (*i.e.*, Shore Road Soil Study; Intrinsik Environmental Sciences Inc. *et al.*, 2008). Glencore is now interested in examining the potential for ecological risks to the terrestrial and freshwater aquatic environments adjacent to the facility, associated with current and on-going operations. As such, Glencore commissioned Intrinsik Environmental Sciences Inc. (hereafter referred to as Intrinsik) to conduct an ecological risk assessment (ERA) of off-site terrestrial and freshwater aquatic areas near the smelter.

There have been a number of ERAs conducted in the vicinity of base metal smelters in other parts of Canada, the United States, Europe and Australia (*e.g.,* Beyer and Storm, 1995; Martley *et al.*, 2004; Douay *et al.*, 2009; Fritsch *et al.*, 2010; SARA Group, 2009; Intrinsik Environmental Sciences Inc. *et al*., 2011). Two of the larger Canadian studies include the ERA of the Teck Metals lead / zinc smelter in Trail, B.C. (Intrinsik Environmental Sciences Inc. *et al.*, 2011) and the ERA conducted as part of the Sudbury Soils Study (SARA Group, 2009), which evaluated the potential ecological risks associated with nickel and copper smelting operations in the Sudbury area (Vale Inco and Xstrata Nickel). These previous smelter ERAs have focused on impacts related to atmospheric deposition of smelter sulphur dioxide (SO_2) and metal/metalloid (hereafter collectively referred to as “metals”) emissions. These chemicals are well established as the primary emissions of concern from base metal smelting facilities. Briefly, SO_2 can adversely affect vegetation and can also result in the acidification of soils in the areas surrounding a smelter facility, if emissions are elevated. Metals are primarily emitted in the particulate phase, and deposit onto soils and water bodies. Depending on the properties of the metals, and the properties of the receiving environment, some of these chemicals may accumulate within the environment to levels that may cause direct toxicity to ecological receptors, and/or secondary effects may occur at various trophic levels through food chain transfer.

This Belledune ERA is based on the approaches taken in various other smelter ERAs, as well as existing information from relevant previous studies conducted in the Belledune area, such as the Shore Road Soil Study (Intrinsik Environmental Sciences Inc. *et al.*, 2008) and a biodiversity study conducted by LGL Ltd. (2008). Based on these considerations, a phased approach was developed for this ERA, which included sampling of environmental media (*e.g.*, soil, surface water, sediment and biota) within a defined area, and the application of terrestrial and aquatic ecological risk assessment approaches. The overall approach for this ERA was iterative in nature, wherein the initial data collection and assessment activities focused on a wide area. As the study progressed further data were collected through supplemental studies. This approach allowed for refinement of the risk assessment and subsequent systematic elimination of some metals, ecological receptors and areas identified as not requiring further study. Such an iterative approach has been used in a number of other wide-area ERAs (of smelters, and other industrial facilities) and enables the ERA to focus on the chemicals, receptors, areas and issues that are determined as being of greatest potential concern, and to exclude those that are shown to be of lesser or no concern.

This document provides details of the environmental sampling programs conducted to support the ERA of the Glencore smelter in Belledune, the ERA process that was followed, and the outcomes of the terrestrial and aquatic assessment.

1.1 Site Management and Assessment Goals, Approach and Scope

Before progressing with an ERA, site management goals, the approach to be taken and the scope of the ERA need to be identified. A site management goal is the overall planning objective for a site and is often a statement about the desired condition of an ecosystem or its components within the context of future site use (Azimuth, 2012). The management goal provides direction for the risk assessor and those responsible for the site (e.g., custodian, site owner, etc.). The site management goal for this ERA was to determine whether environmental media (i.e., soil, sediment, water) in the vicinity of the smelter warrant risk management for ecological receptors as a result of smelter operations. The assessment goal of the ERA was to identify whether potential unacceptable ecological risks exist under current conditions.

The approach to this Study was as follows:

- Design a soil sampling program to characterize off-site[1] soil metal / metalloid concentrations in areas where ecological receptors live and forage in the vicinity of the Glencore smelter in Belledune, NB. The initial area sampled is referred to as the "Principal sampling area" (a 7km radius of the smelter).

- Using the soil data collected within the Principal sampling area, determine area(s) requiring further assessment and/or sampling for the ERA. The final spatial area that was deemed to require ERA is referred to throughout this report and its appendices as the "Study boundary".

- Conduct additional sampling in both terrestrial and freshwater environments, as needed. Using these data, conduct a preliminary ERA of off-site terrestrial and freshwater aquatic environments to determine if further study is required for selected metals and receptor groups.

- Conduct additional studies identified above, and using a Weight of Evidence approach, evaluate whether or not potential unacceptable risks exist for ecological receptors of interest.

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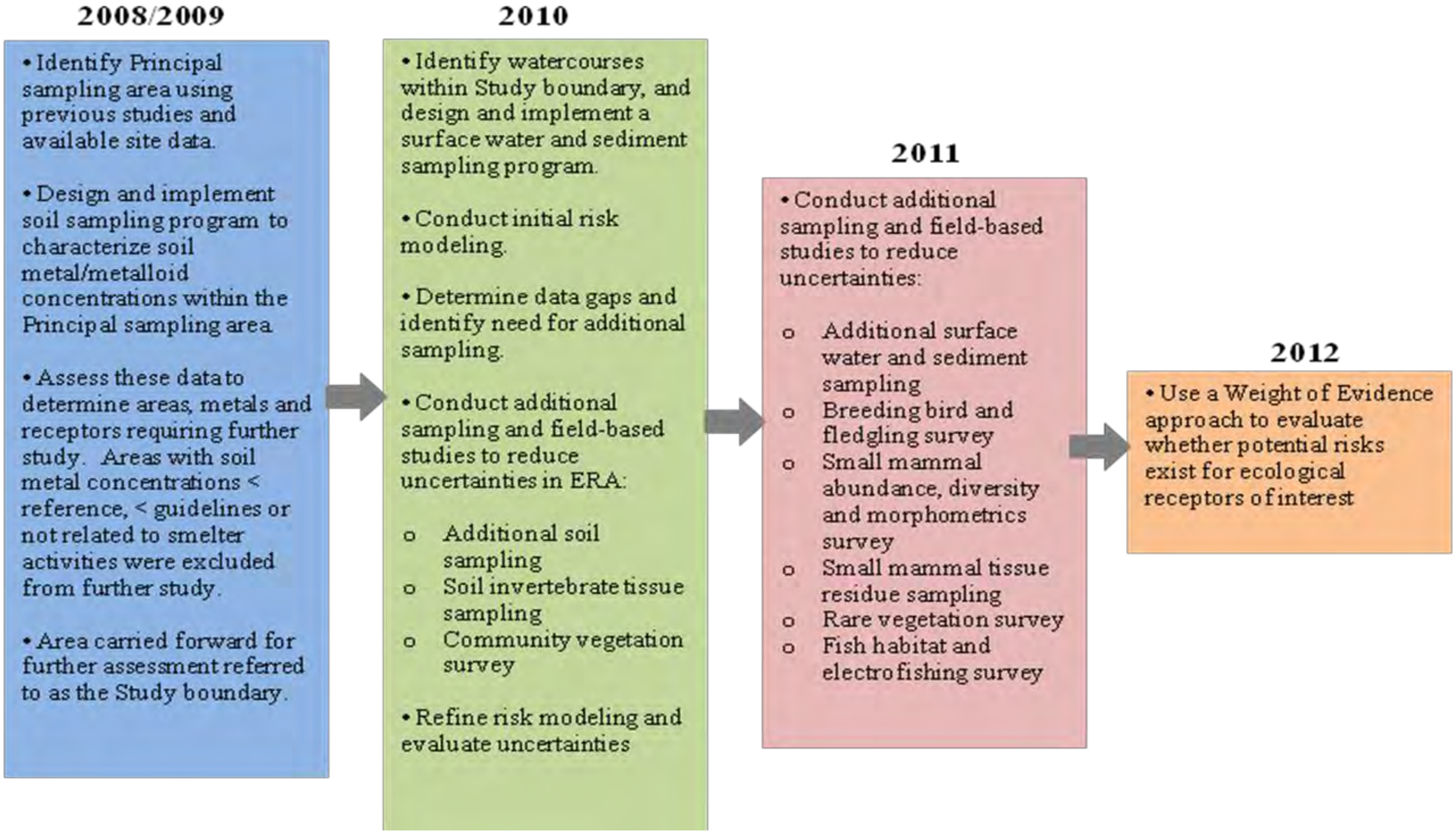
[1] Throughout this document, "off-site" refers to lands that are not currently used for active industrial operations by Glencore.

The scope of the ERA is limited to the off-site terrestrial and freshwater aquatic areas that comprise ecological habitat within the Study boundary. The evaluation of potential exposures and risks to ecological receptors that may occur on residential, commercial, or industrial land use properties, or the marine environment, were not part of the ERA scope.

A flow diagram of the overall study approach including main components is provided in Figure 1-1 with some additional details being provided in Table 1-1.



2008/2009

- Identify Principal sampling area using previous studies and available site data.
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  - Additional soil sampling
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  - Small mammal abundance, diversity and morphometrics survey
  - Small mammal tissue residue sampling
  - Rare vegetation survey
  - Fish habitat and electrofishing survey

2012

- Use a Weight of Evidence approach to evaluate whether potential risks exist for ecological receptors of interest

Figure 1-1 **Timeline and Flow Diagram of Main Study Components**

Table 1-1 ERA Study Components and Timeline

ERA Study Component	Year Study was Conducted	Consultant
Develop study protocol and soil sampling plan	2008 /2009	Intrinsik
Determine principal sampling area	2009	Intrinsik
Collect soil samples	2009	CRA
Analysis of soil chemistry data to determine Study boundary	2010	Intrinsik
Develop surface water, sediment and soil invertebrate sampling protocols and sampling plans	2010	Intrinsik
Collect additional soil data in addition to surface water, sediment and invertebrate samples	2010	CRA
Conduct soil invertebrate survey	2010	LGL
Conduct air dispersion and deposition modeling of smelter emissions	2010	A.J. Chandler Associates
Conduct independent evaluation of metals in natural bedrock in the vicinity of the smelter	2010	S. R. McCutcheon
Evaluation of forest characteristics at soil sampling sites in the vicinity of the smelter	2010	LGL Limited
Conduct vegetation health survey	2010	LGL Limited
Using available data conduct initial ERA	2010	Intrinsik
Determine data gaps and identify need for additional sampling / studies	2010	Intrinsik
Collect additional sediment and surface water data	2011	CRA
Collect additional soil pH data	2011	LGL Limited
Conduct nutrient analysis of soil	2011	FWH Consulting
Conduct breeding bird survey	2011	LGL Limited
Conduct stream habitat survey	2011	R.A. Currie Limited
Conduct rare aquatic vegetation survey	2011	B and B Botanical
Conduct small mammal survey	2011	LGL Limited
Collect small mammals for metals tissue analysis; sample soil to confirm appropriateness of sample locations	2011	LGL Limited
Finalize ERA using all available lines of evidence	2012	Intrinsik

1.2 Organization of Report

This document is organized as follows:

- ERA framework (Section 2.0)
- Problem Formulation (Section 3.0)
- Development and implementation of sampling programs and field studies (Section 4.0)
- Analytical Chemistry Results (Section 5.0)
- Exposure Assessment, Effects Assessment and Risk Characterization (Sections 6.0 to 8.0)
- Results and Discussion (Section 9.0)
- Consideration of Uncertainties, Limitations and Conservative Assumptions in the ERA (Section 10.0)
- Summary of ERA Conclusions (Section 11.0)
- References (Section 12.0)

A series of Appendices are included to provide detailed technical information regarding the assumptions and uncertainties, parameters and methods (including supplementary studies) used in the ERA not presented in the main body of the report. Appendices are as follows:

Appendix A: Soil Sampling Protocol
Appendix B: Technical Memorandum on Soil Sampling Sites Forest Characteristics
Appendix C: Freshwater Aquatic Sampling Protocol and Soil Invertebrate Sampling Protocol
Appendix D: Raw Data
Appendix E: Soil Data Quality Assurance Evaluation
Appendix F: Freshwater and Sediment Data Quality Assurance Evaluation
Appendix G: Identification of Chemicals of Potential Concern for Terrestrial Receptors
Appendix H: Identification of Chemicals of Potential Concern for Aquatic Receptors
Appendix I: Establishment of ERA Spatial Study Boundary
Appendix J: Receptor and Exposure Model Parameters and Assumptions for Terrestrial and Avian Receptors
Appendix K: Vegetation Community Assessment
Appendix L: Breeding Bird Survey
Appendix M: Small Mammal Survey
Appendix N: Rare Vascular Plant Survey
Appendix O: Fish Habitat and Electro-Fishing Survey
Appendix P: Soil Nutrient Analysis
Appendix Q: Limitations, Uncertainties and Conservative Assumptions

2.0 ECOLOGICAL RISK ASSESSMENT FRAMEWORK

This ERA was conducted using widely accepted ERA frameworks, methodologies and guidance published and endorsed by Environment Canada (*e.g.,* Gaudet *et al*., 1994; CCME, 1996), including the recently released Federal Contaminated Sites Action Plan (FCSAP) Ecological Risk Assessment Guidance document (prepared for Environment Canada by Azimuth, 2012) and from the United States Environmental Protection Agency (U.S. EPA, 1998). Consideration was also given to the U.S. EPA (2007a) Framework for Inorganic Metals Risk Assessment; the International Council on Mining and Metals (ICMM, 2007) Metals Environmental Risk Assessment Guidance (MERAG) document; and various chapters in Ecological Risk Assessment (Suter II, 2007).

Ecological risk assessments can involve various levels of detail, complexity and level of effort. The ecological risk assessment framework, as developed by Environment Canada (Gaudet *et al.,* 1994; CCME, 1996) reflects this in its tiered approach to conducting ecological risk assessments. Each successive tier is sequentially more detailed than the previous one, with assessment characteristics ranging from a simple, qualitative and literature-based approach for the first tier (known as the Screening Level Assessment) to complex, predictive and field-based approaches for the second and third tiers (known as the Preliminary Quantitative and Detailed Quantitative Assessments, respectively). While moving from one tier to the next increases the complexity and effort of the assessment, this is typically required only if the results of the previous tier indicate that a more complex and detailed assessment is warranted. More recent ERA guidance endorsed by Environment Canada for use on federally contaminated sites does not categorize risk assessments according to scope or level of detail (*e.g*., screening-level versus detailed quantitative) (Azimuth, 2012). The guidance document reports that the detail of an ERA is dependent on many factors and is assessment specific. As such, rather than specifically "categorize" an ERA, the preference appears to be to focus on getting the various parties involved to agree on the degree of uncertainty (important from the perspective of risk management or decision-making) to be resolved at each iteration if the ERA. Regardless of the terminology, if the ERA scope or level of detail is explicitly stated, using an iterative approach will help address uncertainties and focus the risk assessment on the most critical issues in a time- and cost-efficient manner.

The risk assessment framework used in this ERA is depicted in Figure 2-1 (Azimuth, 2012) and follows the standard risk assessment paradigm comprised of four steps: a qualitative Problem Formulation followed by an Exposure Assessment, Effects Assessment and Risk Characterization. These steps are bounded by iterative feedback from local consultation and discussions. Each of these steps of ERA are briefly described below, and discussed further in Sections 3.0 to 8.0, with the ERA results being presented in Section 9.0.

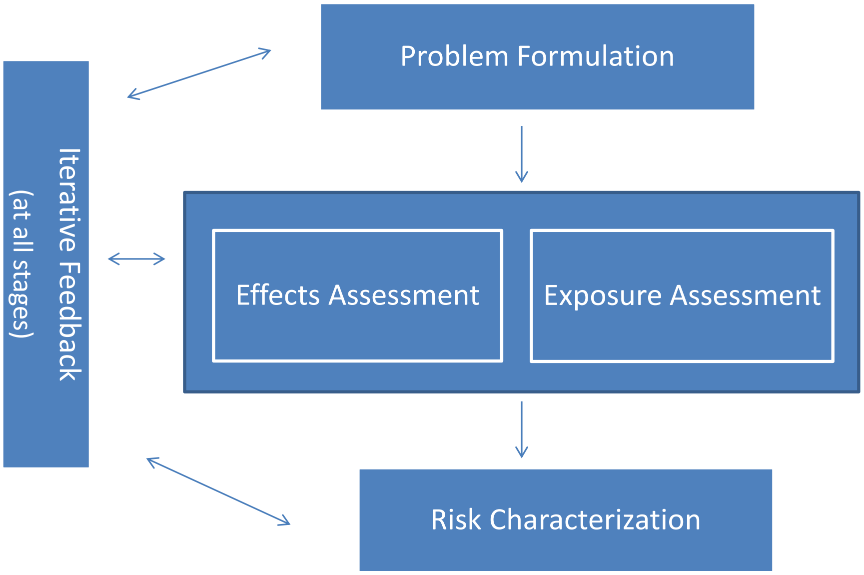

Figure 2-1 Ecological Risk Assessment Steps

Step I: Problem Formulation Step: The problem formulation of an ERA acts as an information-gathering and interpretation step, which serves to plan and focus the approach of the risk assessment on critical areas of concern for the site being evaluated. There are several components to the problem formulation stage including: establishing the objective and level of effort of the ERA, site characterization, selection of reference areas, identification of chemicals of potential concern (COPC), identification of study boundary, identification of receptors, identifying assessment and measurement endpoints; developing lines of evidence (LOE); selection of exposure pathways; and developing a conceptual model.

The outcomes of the problem formulation stage form the basis of the approach taken in the ERA and are provided in Section 3.0. The development and implementation of sampling programs and field studies, and subsequent analytical results, are provided in Sections 4.0 and 5.0, respectively.

Step II: Exposure Assessment: The exposure assessment step of ERA involves estimating the amount of each chemical of concern that is potentially received by each selected ecological receptor. For quantitative assessments, exposures are generally estimated using key receptor characteristics and parameters (*e.g.*, body weight, diet proportions, food intake rates, energy utilization, home ranges, amount of time spent in study area, *etc*.). For more qualitative assessments, exposures are often assumed to be equal to the media in which the receptor occurs (*e.g.*, soil concentrations for soil invertebrates; sediment concentrations for benthic invertebrates). Details of the exposure assessment step are provided in Section 6.0.

Step III: Effects Assessment: In the effects assessment (which may also be referred to as hazard or toxicity assessment), toxicity reference values (TRVs) or other types of toxicity benchmarks are identified for each receptor or receptor group evaluated, for each chemical of potential concern. Toxicity reference values are estimates of an exposure level that is not likely to cause unacceptable adverse effects on growth, reproduction, or survival. Details of the effects assessment are provided in Section 7.0.

Step IV: Risk Characterization: Risk characterization is comprised of several steps which include evaluating / interpreting each LOE; summarizing data for the LOEs; and applying a weight of evidence (WOE) approach to make conclusions on the potential for risk and / or potential magnitude of effect. Uncertainties and limitation of the ERA are to be considered before rendering final risk characterization conclusions. Where required, the risk characterization step, may recommend further actions or study. Risk characterization methods and results are provided in Section 8.0 and 9.0, respectively.

3.0 PROBLEM FORMULATION

3.1 Characterization of the Area

3.1.1 Background Information

The Glencore smelting facility is located on the Baie des Chaleurs in the Village of Belledune, New Brunswick, which is approximately 220 km north of Fredericton and 35 km northwest of Bathurst, NB. Figure 3-1 shows the location of Belledune as well as the smelter and surrounding area. The facility has operated since the mid-1960s. Adjacent to the site is the NB Power Belledune Thermal Generating Station, which opened in the mid-1990s. There was a fertilizer facility located west of the smelter, which was owned and operated by Glencore until it was closed in 1995. In addition, a Canadian Gypsum Company facility has operated in the area since 1996, as has a battery recycling facility, which is owned by Glencore. There is a large, deep water port adjacent to the smelter, offering year-round shipping. The largest employer in the area is Glencore, with NB Power, Chaleur Sawmills and the Port of Belledune also providing significant employment opportunities for local residents.

The population of the Belledune area is approximately 1700. The lands close to the main highway (Highway 134, which is also known as Shore Road) contain much of the residential development in the Belledune area. To the southeast of the smelter is a mixed residential and agricultural area known as Lower Belledune. To the northwest of the smelter is a residential area known as Townsite # 2 (Chaleur Drive) (Figure 3-1), which was formerly a housing neighbourhood for smelter management staff, but properties in this area are now privately owned. Further west of Townsite #2 are additional residential areas, and farmland. Glencore owns a considerable amount of land in the Belledune area, much of which is forested or has limited open field areas (see grayed out areas on Figure 3-1 for lands owned by Glencore).

The non-residential lands in the area are characterized largely by agricultural fields (some of which are no longer actively farmed) and a variety of forested lands, some of which have been actively logged over the last several decades (LGL, 2008). A detailed characterization of the forest habitat in an 8 km zone around the smelter facility was conducted by LGL (2008) in a biodiversity study. Further characterization of the local forest habitat can be found in that report.

The Belledune area is fairly flat, in terms of topography, and winds blow most frequently from the west, with easterly winds being the next most frequent. Winds from the north or south are more infrequent. Based on wind direction, the primary areas influenced by deposition of emissions from the smelter facility are the Baie des Chaleurs (off shore marine area), followed by areas east and west of the facility, with areas immediately south of the smelter also experiencing some deposition (Goss Gilroy *et al.*, 2005).

The Glencore smelter is a relatively small smelting facility (compared to other smelters around the world) which has steadily reduced air emissions over its operating history. For example, sulphur dioxide (SO_2) and total dust emissions in 1978 were reported as 25,000 tonnes/year and 114 tonnes/year, respectively. These levels dropped to 12,000 tonnes/year and 86 tonnes /year, respectively by 2000. Air emissions in 2009 were reported at 8,200 tonnes SO_2/year and 43 tonnes/year of total dust (B. Butler, Glencore, Personal Communication). Stack heights at the Glencore smelter are relatively low (40 m to 70 m; MacRae Environmental Services Inc., 2009) in comparison to other smelters that have stack heights up to 5 times higher than those at the Glencore smelter. Shorter stack heights assist in limiting dispersion of airborne emissions.

There have been a number of environmental studies and soil surveys conducted over the past several years in the Belledune area. These studies include the Belledune Area Health Study (BAHS; Goss Gilroy *et al.*, 2005), the Shore Road Soil Study (Intrinsik Environmental Sciences *et al*, 2008), as well as earlier soil surveys conducted by various environmental consulting firms and the Conservation Council of New Brunswick. In addition, Glencore has an on-going environmental monitoring program (that has occurred since the 1960s) that includes the sampling and analysis of soil, garden soil, forage, air, garden produce, and marine biota. These monitoring data are submitted annually to NB Department of Environment. The Shore Road Soil Study was the largest soil investigation conducted in the area, with the collection and analysis of over 700 soil samples, extending a distance of 23.5 km, from as far northwest as Jacquet River, and as far south-east as Point Verte (Intrinsik Environmental Sciences *et al*, 2008). The focus of the Shore Road Soil Study was to characterize soil metal levels along the predominant residential corridor, which is largely due west and due east of the smelter facility, for the purposes of assessing potential human health risks associated with smelter-related releases into residential areas.

The main smelter-related sources of SO_2 and metals to terrestrial environmental media are stack emissions, and the subsequent deposition of these emissions onto surface environmental media (soil, water, vegetation, *etc*.). Stack emissions, and the dispersion and deposition patterns of such emissions, are dependent on a number of factors including prevailing wind direction and speed, local topography, local meteorology, atmospheric stability, stack heights, air temperatures at the exit points of the stacks, stack and building locations and configurations, and stack velocity. Typically, with most point sources of air emissions, one sees a decrease in soil and other media metals concentrations with increasing distance from the facility, with the highest rates of deposition generally occurring within a few to several kilometers of most facilities, depending upon the factors noted above. Other types of smelter-related chemical releases can also occur, including fugitive releases from wind erosion of slag, concentrate or other stockpiled materials. In Belledune, another known smelter-related source of chemical releases to off-site areas involved the incidental transport of materials containing metals from the use of equipment and vehicles from within the smelter property on various off-site locations, and the historical use of slag as a skid control agent in certain areas in winter months. The Shore Road Soil Study was successful at identifying locations where these incidental releases had occurred in residential and commercial areas.

The smelter is not the only source of metals in the environment within the Belledune area. Other sources of metals include other industrial facilities in the Belledune area (listed previously), natural enrichment of area soils (north-eastern New Brunswick is an active mining area, and there are many locations that are known to have elevated soil metals concentrations in the absence of industrial activity), and other anthropogenic sources such as lead in paint, leaded gasoline, arsenic in pesticides (all of which have now been phased out, but the signature of metals and arsenic in soils does not degrade readily over time).

In this ERA, the key smelter-related sources of COPC are:

- atmospheric deposition of smelter air emissions; and
- fugitive dust emissions from the slag pile.

Much of the incidentally transported materials were restricted to residential areas, were limited in aerial extent, and have been removed through risk management activities related to the outcomes of the Shore Road Soil Study. Therefore, this particular source is not of concern in relation to ecological receptor exposure to COPC and risk.

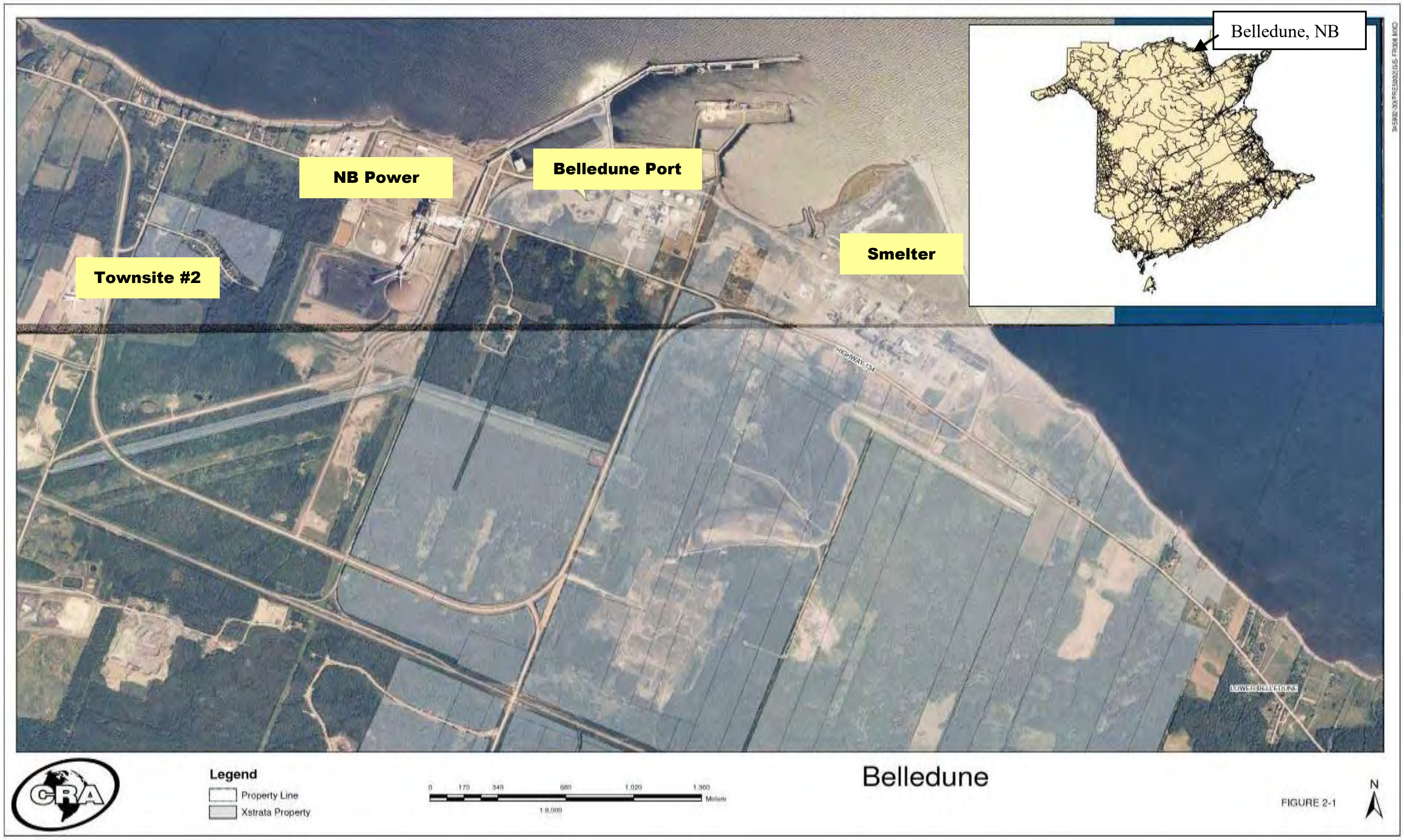

Figure 3-1 Local Setting and the Smelter Facility, Belledune, New Brunswick

3.1.2 Environmental Setting

3.1.2.1 Habitat

The Glencore property extends south of the smelter and contains many naturalized areas including both meadow and forest habitats. The forest community surrounding the smelter is a mix of deciduous and coniferous stands, including mature mixed wood stands with some young mixed and softwood stands and mature softwood and hardwood stands (LGL, 2008; CRA, 2009). The forest community was dominated by hardwoods such as poplar, birch and red maple and conifers such as balsam fir and white cedar (LGL, 2008). Tree heights range from 16 to 20 m, 11to 15 m and 6 to 10 m in the mature stands, and 0 to 5 m in the young stands (CRA, 2009). The area including and surrounding the smelter site was dominated by agricultural land prior to the development of the smelter, and the forest cover which did exist was patchy. The development of the smelter did not likely result in the removal of large areas of forest cover, but impacted farmland to a greater extent (LGL, 2008).

Ferns, moss, regenerating forest, and other plants were observed at the sampling stations on the Glencore property (LGL, 2008). Sphagnum moss blankets the forest floor in many areas and various species of vascular plant are found onsite including: dwarf raspberry (*Rubus pubescens)*, bunchberry (*Cornus Canadensis)*, wild raisin (*Viburnum cassinoides)*, miterwort (*Mitella nuda)*, cinnamon fern (*Osmunda cinnamomea*, bluebead lily (*Clintonium borealis)*, Canada rhododendron(*Rhodora canadensis)*, northern white violet (*Viola macloskeyi)*, pale coral-root(*Corallorhiza trifida),* Labrador tea (*Ledum groenlandicaum),* rose twisted stalk (*Streptopus lanceolatus)*, grass pink (*Calopogon tuberosus)* and rattlesnake fern (*Botrychium virginianum)* found in cedar fens, and jewelweed, fern*,* meadowrue (*Thalictrum pubescens)*, virgin's bower and partridgeberry in the open, wet sections of the site (D. Peck Botanical, 2007). Typical meadows in the area have very little woody vegetation. They are characterized by open, gravelly areas that support exotic grasses, introduced weeds, and seedlings of aspen, willow, and poplar (LGL, 2012c).

Wetlands are predominately found near the coastline albeit limited in number (*i.e.,* comprise approximately two percent of the area) (LGL, 2008). There is a pond adjacent to the slag pile which is a constructed wetland. This wetland is not included in this assessment, as it is monitored as part of the smelters operational discharge. In general, the water flow pattern in the area north of the railway has been impacted by former construction activities and beaver dam flooding in adjacent areas. This had been complicated by the presence of beavers and their dams, with the associated backup of water and with the alteration of the hydrology in the area. In the summer of 2011, a large beaver dam was removed in an attempt to bring water levels back to their natural levels.

Hendry Brook is a good example of a typical brook found in the area. The Belledune shoreline / Hendry Book area was identified by LGL (2008) in their biodiversity study as being an environmentally significant area as a result of the fossil and geology features. Hendry Brook does not have many rocky outcrops, and only one wetland area (beaver pond) was identified (B & B Botanical, 2011). Beyond 25 m on either side of the brook, most of the land has been subjected to farming and hence, a high level of disturbance. Areas to 100 m to either side of Hendry Brook are either old fields or pastures that have become wooded. The mouth of Hendry Brook at the Baie de Chaleur is a gravel beach. Cedar is common along the small flood terraces on either side of the brook (B & B Botanical, 2011).

3.1.2.2 Wildlife

A number of visual observations were made of flora and fauna during the field studies conducted in 2009 and 2010 by the various sampling crews. These included a description of the property where the sample was taken (*e.g*., whether the location was a field, or was forested, *etc.*), and wildlife occurrences (either direct observations, or signs such as scat; browse; tracks, *etc.*). While these data are of an observational nature, and were collected opportunistically while the sampling program was being conducted, they do provide some insight into the species which inhabit the areas under investigation.

The field crews reported seeing a moose (and moose scat) in addition to moose, deer, and black bear tracks within the Principal sampling area. Grouse nesting sites, signs of moose and black bear browsing, and a beaver pond were also observed in the Principal sampling area.

During the small mammal survey, Northern short-tailed shrew (*Blarina brevicauda*), common shrew (*Sorex cinereus*), meadow vole (*Microtus pennsylvanicus*), Southern red-backed vole (*Myodes gapperi*), and deer mouse (*Peromyscus maniculatus*) were captured within 3 km of the smelter (LGL, 2012a). Several specimens of beetles and spiders were collected in the pitfall traps as well as two species of terrestrial salamanders; blue-spotted salamander (*Ambystoma laterale*) and yellow-spotted salamander (*Ambystoma maculatum*). Several additional species of wildlife were observed on site during this survey, including: eastern red-backed salamander (*Plethodon cinereus*), moose (*Alces alces*) tracks and skeletal remains, red squirrel (*Tamiasciurus hudsonicus*), and an American woodcock. In total 70 animal observations were recorded (LGL, 2012a)

A total of 46 bird species were recorded during the June 2011 breeding bird surveys conducted within 3 km of the smelter and in the control areas (LGL, 2012b). There were 14 species found in the control areas that were not found in the exposure areas. Three of these, Wilson's snipe (*Gallinago delicate),* mourning warbler (*Oporornis philadelphia)* and dark-eyed junco (*Junco hyemalis)* were found only in the control meadow plots. The remaining eleven species (yellow-bellied sapsucker (*Sphyrapicus varius),* Northern flicker (*Colaptes auratus),* red-breasted nuthatch (*Sitta Canadensis),* winter wren (*Troglodytes troglodytes),* golden-crowned kinglet (*Regulus satrapa),* brown creeper (*Certhia Americana),* hermit thrush (*Catharus guttatus),* northern parula (*Parula Americana),* blackburnian warbler (*Dendroica fusca),* black-throated green warbler (*Dendroica virens),* and yellow-rumped warbler (*Dendroica coronata*) were only found in control forest plots. Eight species reported within the Study boundary were not found in the control plots: least flycatcher (*Empidonax minimus)*, American crow (*Corvus brachyrhynchos)*, yellow warbler, Canada warbler (*Wilsonia Canadensis),* northern waterthrush (*Seiurus novaboracensis),* rose-breasted grosbeak (*Pheucticus ludovicianus),* chipping sparrow (*Spizella passerine)* and savannah sparrow (*Passerculus sandwichensis).* Canada warbler was the only species at risk observed in this area (ranked Threatened by COSEWIC, SARA Schedule 1)(LGL, 2012b).

3.1.2.3 Sensitive Species

As part of the biodiversity study, LGL (2008) used the ACCDC (Atlantic Canada Conservation Data Centre) databases to identify sensitive species which were observed within 3 km of the smelter. Sensitive species are those that are considered extirpated, threatened, endangered or of special concern. The ACCDC compiled information from the COSEWIC (Committee on the Status of Endangered Wildlife in Canada), Environment Canada Species at Risk and the New Brunswick Department of Natural Resources Species at Risk websites. Northern bog sedge (*Carex gynocrates)*, sheathed sedge (*Carex vaginata)*, round-leaved orchis *(Amerorchis rotundifolia)* and lesser panicled sedge **(***Carex diandra*) were identified within this area; however the last reported observation of some of these species were many years ago (*e.g.,* lesser panicled sedge – 1960; sheathed sedge and northern bog sedge – 2002 and round-leaved orchis – 2007).

In addition to the ACCDC listings, Glencore had a rare terrestrial plant survey in the area surrounding the smelter conducted in 2007 by D. Peck Botanical (2007) and a survey of rare vegetation in the vicinity of Hendry Brook was conducted by B & B Botanical (2011). In the first survey, four rare plant species were found at various locations and in various numbers within the woodlands in the vicinity of the smelter. These four species were: *Amerorchis rotundifolia* (S2), *Corallorhiza maculate* var. *maculata* (S2/S3), *Botrychium minganense* (S2), *Cypripedium reginae* (S2), and are ranked as rare because they grow in unique habitats, and they are uncommon in the province of New Brunswick (D. Peck Botanical, 2007). These four plant species have a rarity ranking of either S2 or S2/S3 as assigned by the Atlantic Canada Conservation Data Centre. A ranking of S2 (Very Rare) indicates that there are only 6 to 20 occurrences of the species and it may be susceptible to extirpation due to some factor of its biology. A ranking of S3 (Rare) indicates that there are 21 to 100 occurrences and the species may be susceptible to extirpation due to large scale disturbances (D. Peck Botanical, 2007).

In the vegetation study conducted within the vicinity of Hendry Brook, 149 species were identified within the lower 2.5 km of the brook and within 100 m on either side. Of these, four rare species were identified: *Humulus lupulus* var. *lupuloides* S1S2 (American Hops); *Spiranthes cernua* S2 (Nodding Ladies Tresses); *Corallorhiza maculata* var. *maculata* S2/S3 (Spotted Coralroot); and *Carex vaginata* S3 (Sheathed Sedge) (B & B Botanical, 2011). These species were ranked rare to very rare (S1-S3) as assigned by the Atlantic Canada Conservation Data Centre. A ranking of S1 (extremely rare) indicates that there are typically 5 or fewer occurrences or very few remaining individuals and it may be especially vulnerable to extirpation. Northern Bog Sedge (*Carex gynocrates*), which was reported by ACCDC was not observed at the previously known site, nor was it observed anywhere along the brook. Areas surveyed around Hendry Brook and 100 m to either side of the brook, were not found to be typical of the rich habitat defined by the other species listed by ACCDC for the area. Most of the land in this area has been subjected to farming and a high level of disturbance. Such areas usually have a low potential for rare species (B & B Botanical, 2011).

Field studies conducted as part of this ERA (See list in Table 1-1) did not report any sensitive small mammals within 3 km of the smelter. The only sensitive avian species reported within 3 km of the smelter was the Canada warbler (LGL, 2012b).

3.1.3 Determination of the Principal Sampling Area

In determining the Principal sampling area, data gathered in previous studies of the area were considered, including:

- Shore Road Soil Study (Intrinsik Environmental Sciences et. al, 2008);
- The Biodiversity Study (LGL, 2008); and
- Glencore Environmental Monitoring Program (various years).

Wind direction and frequency data, as well as available air dispersion analysis, which combined emissions from all area sources, including Glencore, NB Power, and Canadian Gypsum were also used (Goss Gilroy *et al.*, 2005).

Using data from the above mentioned studies as a guide, the area within a 7 km radius of the smelter site (called the Principal sampling area) was conservatively selected to investigate whether soils in ecological areas surrounding the smelter may be potentially influenced by smelter releases. A detailed description of the methods used to select the Principal sampling area and reference areas, the grid established over the sampling area, and the soil sampling methods, are presented in Appendix A.

3.1.4 Soil Sampling In Principal Sampling Area

The overall design of the soil sampling program for the Principal sampling area is presented in Figure 3-2. In total, 61 sampling locations were sampled in July-August of 2009. The coverage or distribution of soil sampling stations for the entire area, based on stations sampled in the previous Shore Road Soil Study (completed in 2008 using a similar soil sampling protocol) and the current 2009 program, is presented in Figure 3-3. Based on Figure 3-3, it is evident that the Belledune area has undergone extensive soil sampling, and both the Shore Road Soil Study and the current Study provide considerable information and understanding of metals levels in soils within the Belledune area. In both studies, the soil sampling programs involved composite shallow soils sampling (0 – 5 cm), with a subset of samples being cored to deeper depths (0 to 5 cm; 5 to 15 cm and 15 to 30 cm). The depth of sampling (0 to 5 cm) was selected as this is an appropriate depth when investigating an atmospheric deposition source (such as smelter emissions). A depth of 0 to 5 cm is also ecologically relevant for soil invertebrates, early emerging vegetation and would be relevant for the soil ingestion pathway for most wildlife receptors. Deeper depths may be of greater relevance for some receptors (such as burrowing small mammals); however it is expected that the focus on the top 5 cm soil layer will provide a conservative estimate of potential exposures. The subset of cored samples (5 to 15 and 15 to 30 cm) was collected in part, to confirm the higher concentrations were in the top 5 cm of soil. The methods used to design the soil sampling program in the current Study, and the soil sampling protocol that was followed are provided in Appendix A. Additional details of the soil sampling program for the Principal sampling area are provided in Section 4.0 with analytical results being provided in Section 5.0.

Sampling of soil within the Principal sampling area was limited by property ownership (*i.e.*, sampling was restricted to Glencore and New Brunswick Department of Natural Resources or Crown owned lands) (See Appendix A; Figure 3-1 for areas contained within the 7 km radius and land ownership). In addition, soils in areas due east and west of the facility had been extensively sampled in the Shore Road Soil Study, and can largely be characterized as residential in terms of land use, in conjunction with agricultural land use. These areas were not re-sampled in this study, since extensive soil data were already available to characterize metals levels in these areas. In addition, the residential parts of these areas would not represent natural habitat for ecological receptors, and these areas are more open, which can limit the sequestering of metals in forest leaf litter (see below). Some other specific sampling locations within the Principal sampling area were also omitted from the soil sampling program. These included all current industrial land use areas owned by Glencore (such as the slag pile, and the main smelter complex site), as well as other privately held industrial lands (*e.g.,* lands owned by NB Power). Other lands held by Glencore are undergoing separate evaluations, and other privately held industrial lands are the responsibility of those land owners, and therefore are not included in this assessment.

Forest canopy cover can influence soil metal concentrations (*e.g*., interception of atmospheric deposition, pulse releases of chemicals retained in foliage during senescence, high organic carbon content of forest floor can sequester certain metals) so candidate sampling stations within the Principal sampling area were reviewed to examine forest type, composition, developmental stage and percent canopy closure (based on GIS mapping conducted for a previous biodiversity study that considered an 8 km radius of the smelter; LGL, 2008). Candidate soil sampling locations were examined by LGL Limited in relation to these forest metrics. The LGL review focused on whether or not the candidate sampling locations were areas that would likely be influenced by canopy cover effects and/or sequestration of metals/metalloids in forest floor soils. The review concluded that such areas were adequately captured in the soil sampling program conducted in 2009, and that the sampling locations provided good coverage of mature forest locations (See Appendix B).

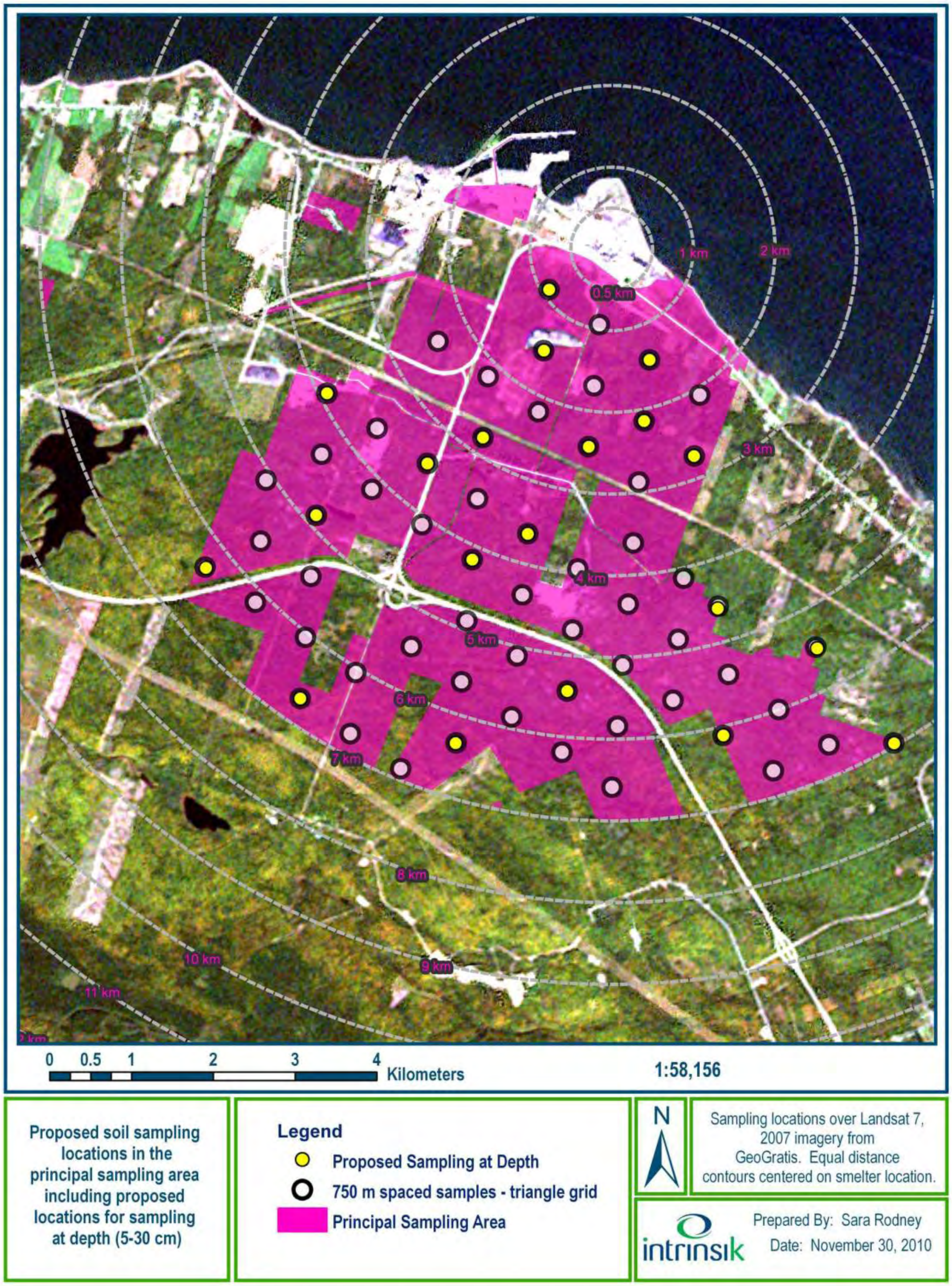

Figure 3-2 Principal Sampling Area for the ERA and 2009 Soil Sampling Locations

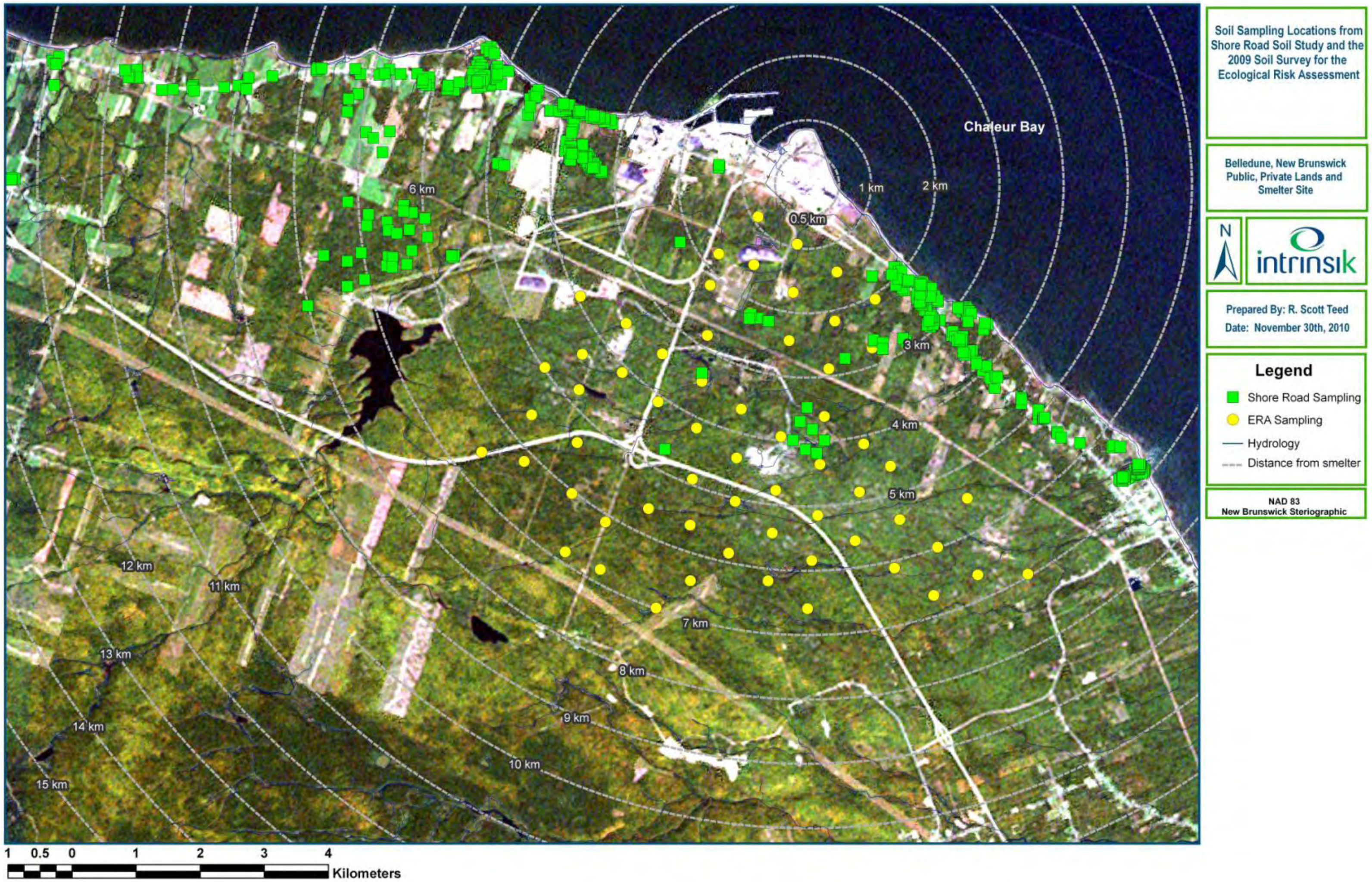

Figure 3-3 Soil Sampling Locations for the Shore Road Soil Study and Belledune ERA (2009 Sampling Locations)

3.2 Identification of Reference Areas

Soil reference areas were identified using the approach discussed in Section 3.2.1. As the study progressed, surface water and sediment samples also were collected. Reference areas for aquatic samples were identified and are discussed in Section 3.2.2. Details of the reference area soil and aquatic sampling methods and results can be found in Sections 4.0 and 5.0, respectively. Reference areas for the biological studies (*e.g.*, breeding bird survey, small mammal survey, vegetation survey) are discussed within these specific reports (See Section 4.2).

3.2.1 Soil Reference Area

The criteria for selecting a soil reference area(s) included: (1) the reference area must occur on crown land to facilitate efficient sampling, (2) the area must occur on land with characteristics similar to those of the Principal sampling area (such as same or similar underlying geology and same or similar ecoregions or ecodistricts[2]), and (3) the reference area must be in a location that is unaffected by smelter emissions or other potential sources of chemicals of potential concern (COPCs), other than those that are naturally occurring. Identification of a potential soil reference area utilized GIS, and available spatial data layers acquired through the New Brunswick Department of Natural Resources and Service New Brunswick (*i.e.*, crown lands of New Brunswick and Ecosite mapping, which contains data regarding the ecological land classifications of New Brunswick).

The most suitable location that was identified for a soil reference area is located approximately 21 km due west of the smelter site (which is also upwind of the prevailing wind direction). The lands in this reference area are owned by the Crown, and comprise the same ecosite as the Principal sampling area (*i.e.*, the Nicolas Denys ecodistrict). Figure 3-4 shows the location of the reference area relative to the Principal sampling area, along with the soil sampling station locations for both areas, and the ecosite boundaries. The soil reference area is approximately 1226 hectares in size.

In the 2009 soil sampling program, a total of 23 soil samples were collected from the reference area. The reference area sampling stations were on undeveloped Crown lands with similar underlying geology (to the extent possible, but recognizing that geological zones in northeastern New Brunswick are inherently patchy and variable), and similar ecoregions and ecosites to that of the Principal sampling area, located 20-30 km west-southwest of the smelter facility (which is also upwind of the prevailing winds in the Belledune area). Reference soil samples were collected using the same protocol that was used for the 2009 Principal sampling area (Appendix A).

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[2] Environment Canada (1995) provides the following definitions:
Ecozone: an area of the earth's surface representative of large and very generalized ecological units characterized by interactive and adjusting abiotic and biotic factors; Ecoregion: a part of a province characterized by distinctive regional ecological factors, including climatic, physiography, vegetation, soil, water, fauna, and land use; and Ecodistrict: a part of an ecoregion characterized by distinctive assemblages of relief, geology, landforms and soils, vegetation, water, fauna, and land use.

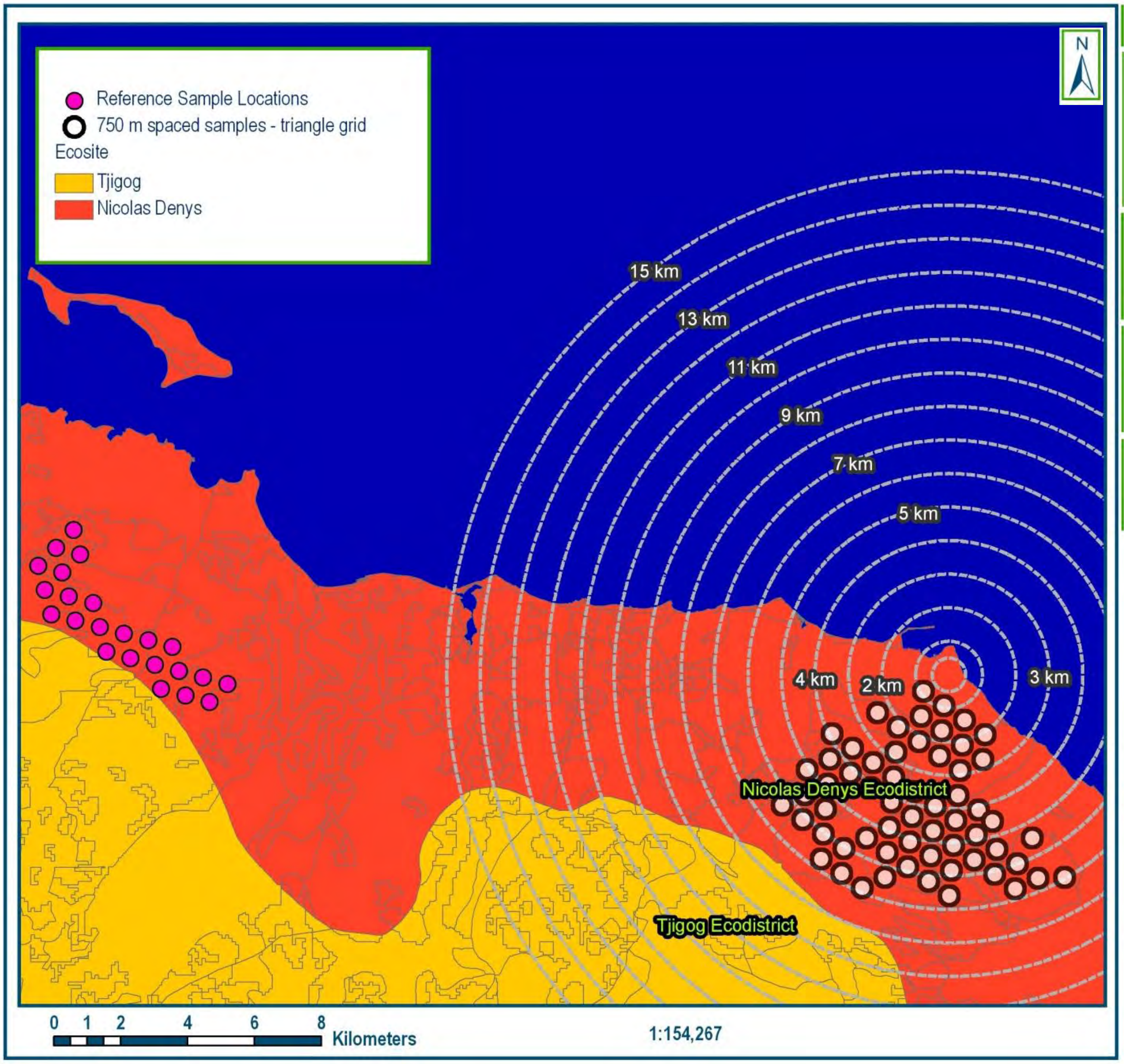

Figure 3-4 Reference Area Sample Locations Relative to the Principal Sampling Area and Local Ecodistricts

3.2.2 *Freshwater Surface Water and Sediment Reference Areas*

As illustrated in Figure 1-1, soil metals levels in the Principal sampling area were evaluated to determine which areas, including freshwater brooks and streams, needed further study. This concept was based on the fact that streams and brooks could be influenced by metals loadings in areas where soils were affected by deposition from either slag or atmospheric emissions from the smelter. Using this approach, it was determined that two brooks near the smelter required further assessment (Hendry Brook and Unnamed Brook), and hence, a reference area for freshwater streams was required. Armstrong Brook (located west of the smelter and near the town of Jacquet River), was selected as a reference stream, based on its distance from the smelter, and its similar size, flow conditions, ecoregion/ecosite, underlying geology, and aquatic habitat to water bodies in the vicinity of the smelter (*i.e.,* Hendry Brook, Unnamed Brook). The field crew visually examined Armstrong Brook (and compared it to Hendry Brook) prior to accepting this stream as an appropriate reference watercourse. Figure 3-5 shows the location of Armstrong Brook, relative to the two streams in the vicinity of the smelter; Hendry Brook and Unnamed Brook (See Section 4.1.3 for details of aquatic sampling program).

Armstrong Brook data were pooled with data from other north-eastern New Brunswick reference streams and brooks that were available to the Study Team to increase the size of the reference area database. These studies used the same sampling protocols, analyses and analytical laboratory as those used for Unnamed, Hendry and Armstrong brooks, and therefore, it was decided to pool the Armstrong Brook data with the reference data from these other locations. This pooling of datasets increased the sample size from 5 to 62 (surface water) and from 5 to 20 (sediment), respectively, and provided more robust datasets of reference water and sediment concentrations for use in the ERA. All of these other stream and brook locations are in wild lands areas that are known to be un-impacted by industrial activities, or other obvious sources of metals. Further details on these additional reference streams and their water and sediment chemistry data are provided in separate reports (*i.e*., Intrinsik Environmental Sciences Inc., 2009; 2011). While it is acknowledged that some of these other streams and brooks may be in areas with different underlying geology, and/or in different ecoregions or ecosites than the water bodies selected within the vicinity of the smelter (*i.e*., Unnamed and Hendry Brooks; See Section 4.1.3), all are considered representative of surface water and sediment concentrations in north-eastern New Brunswick streams and brooks, in the absence of long-term smelter emissions and deposition.

Figure 3-5 **Site and Reference Area Sediment and Surface Water Sampling Locations**

3.3 Identification of Chemicals of Potential Concern (COPCs)

COPC identification was conducted separately for terrestrial receptors and for aquatic freshwater receptors. The selection of the COPCs for both freshwater aquatic and terrestrial receptors involved multiple steps, as described and discussed in Appendices G and H, respectively. Briefly, the identification of COPCs for terrestrial organisms involved a four step process, as follows:

i) Comparisons of soil chemistry data to regulatory environmental soil quality benchmarks and reference area soil chemistry data;
ii) Determining the frequency of exceedance of soil chemistry data over the "final screening benchmark" (described below);
iii) Two sample statistical comparison tests conducted between Principal sampling area and reference area soil chemistry datasets, where deemed necessary; and
iv) Further considerations (where/if deemed necessary), such as: toxicological issues (including availability of ecotoxicity data), COPCs identified in previous studies of the Belledune and surrounding area, smelter feed material chemistry data, smelter stack emissions data, potential non-smelter industrial sources of COPCs, geochemical relationships, statistical relationships, supplementary reference soil chemistry data, local geology, and spatial distribution patterns of soil chemical concentrations.

All chemicals identified as COPCs were carried forward for evaluation in the ERA.

The COPCs selected for evaluation in the terrestrial component of the ERA were:

<u>Soil</u>

- Antimony
- Arsenic
- Cadmium
- Lead
- Thallium
- Zinc

<u>Air</u>

- SO_2: identified as a COPC in air in relation to vegetation effects, not on a formal screening process

The identification of COPCs in surface water involved the following process:

i) Comparisons of total metals surface water data to regulatory water quality benchmarks for the protection of freshwater aquatic life, and to reference area surface water chemistry data; and,
ii) For those metals exceeding total surface water quality benchmarks and reference concentrations, comparisons of surface water chemistry data (expressed as the dissolved

chemical) to regulatory water quality benchmarks for the protection of freshwater aquatic life and to reference area surface water chemistry data.

The identification of COPCs in sediment involved the following process:

i) Comparisons of sediment chemistry data to regulatory sediment quality benchmarks and reference area sediment chemistry data; and,
ii) Two sample statistical comparison tests conducted between Study boundary and reference area sediment chemistry datasets, where necessary.

The COPCs selected for evaluation in the freshwater aquatic component of the ERA were:

Surface Water
- Lead
- Manganese

Sediments
- Barium
- Cadmium
- Iron
- Lead
- Lithium
- Thallium
- Tin
- Vanadium
- Zinc

3.4 Identification of Study Boundary

The spatial delineation for wide area ERAs is typically an iterative process that involves a number of steps to successively refine the extent of the area(s) that require detailed investigation. Such an iterative approach was followed in the current ERA. The key steps in establishing the Study boundary for the ERA were as follows, and each of these steps is described and discussed in Appendix I:

1) Review of previous studies conducted in the Belledune area;
2) Review of 2009 soil study of Glencore and Crown lands within a 7 km radius of the smelter complex (Principal sampling area);
3) Consideration of supporting air dispersion and deposition modeling outcomes; and
4) Consideration of supporting geological data.

The outcomes of each of the steps considered in establishing the Study boundary indicate that the areas requiring further ecological study, in relation to deposition of smelter emissions, are restricted to within a 3 to 4 km radius of the smelter. There is a high degree of confidence in this finding as the outcomes of each step supported the outcomes of other steps (*i.e.*, measured data supported by air dispersion modeling of smelter-related activities and geological patterns in the area). This Study boundary is realistic, well supported by the available studies and data, and will not result in a mathematical "dilution" of the soil data evaluated in the ERA, which could lead to potential underestimation of exposures and risks to small home range receptors. As discussed previously, streams or brooks that were located in the area where soils were influenced by smelter emissions were included in the ERA.

3.5 Identification of Ecological Receptors

For the purposes of ERA, it is not practical, nor necessary, to assess each and every species that may potentially occupy a site. Instead, a selected subset of ecological receptors (also commonly called receptors of concern [ROC] or valued ecosystem components [VEC]) is selected for assessment. Careful consideration is given when selecting receptors and a number of factors are taken into account:

- behavioural and physiological characteristics that would increase the potential for chemical exposure (*e.g.*, diet and habitat preferences, body weights, *etc*.);
- food chain/food web structure in the Study area;
- species abundance and home ranges;
- percentage of time spent within potentially impacted areas and fraction of diet obtained from these areas;
- whether species of interest are resident biota or migratory;
- the availability of biological data describing receptor characteristics and behaviour;
- the physical-chemical and environmental fate/behaviour properties of COPCs (such as persistence and potential to bioaccumulate and/or biomagnify in terrestrial and/or aquatic food webs);
- toxicological properties of COPCs;
- potential presence of rare, threatened or endangered species; and
- professional judgement.

The identification of ecological receptors also typically considers observations of aquatic and/or terrestrial wildlife from current or previous field sampling programs and habitat surveys. Ultimately, receptors should occur within the Study boundary, and have the greatest potential for exposure to COPCs, and/or are the most sensitive to the effects of the COPCs. Thus, the likelihood for occurrence of adverse effects in less exposed or less sensitive receptors would be lower than for the assessed receptors.

Various sources were reviewed to select ecological receptors (of birds and mammals) that could potentially occur within the Study boundary including NatureServe (http://www.natureserve.org/explorer/) and the Birds of North America Databases (http://bna.birds.cornell.edu/bna/). The potential for the species selected to occur within the Study boundary were also discussed with the Chair of the Department of Natural Science and Head of Zoology Section of the NB Museum in Saint John NB (Dr. Donald McAlpine, Research Curator, NB Museum) who felt the list was appropriate. Other sources reviewed to select receptors included the LGL (2008) biodiversity report; a rare plant survey conducted in the vicinity of the smelter (D.

Peck Botanical, 2007); and wildlife observations made by field crews during the 2009 and 2010 sampling programs. Various field studies were conducted for this project after the initial receptor selection occurred (*e.g.*, small mammal survey; bird survey, *etc*.). While not used to select the initial list of receptors evaluated, the species identified in these studies (along with wildlife observations made by field crews in 2010 and 2011) were used to verify the appropriateness of receptors selected. See Section 3.1.2.2 and 3.1.2.3 for a brief discussion of receptor information obtained from previous studies and site observations. The threatened and endangered status of potential receptors was also considered so appropriate surrogates could be selected where required. A discussion of sensitive species (such as threatened and endangered species) is also provided in Section 9.7.

For higher trophic levels organisms, the receptor of concern assessed in an ERA is generally defined at the species level (*e.g*., masked shrew, dark-eyed junco) (Azimuth, 2012). These receptors are conservatively selected to represent other less sensitive species in the shared feeding guild (*e.g*., shrew to represent insectivorous small mammals; heron to represent piscivorous birds). While defined at the species level, potential risks are typically evaluated for terrestrial and avian wildlife at the population level with the exception of sensitive species. Species defined as sensitive are generally evaluated at the individual level. For lower trophic level receptors (*e.g*., terrestrial vegetation, soil organisms, benthic and pelagic aquatic life), it is common practice in an ERA to define and evaluate receptors at the community level (Suter *et al*., 2000; Azimuth, 2012).

The ecological receptor groups selected for evaluation in the ERA are presented in Table 3-1. Surrogate species are provided, where relevant. The potential risk to surrogate species will be used to put potential risks to receptors within a particular group into perspective. Surrogate species were selected for the ERA based on the same set of considerations used to identify ecological receptors (as noted above) and are provided in Table 3-1.

Terrestrial and avian receptors which forage in the aquatic environment (such as those that consume primarily freshwater fish, benthic and/or pelagic invertebrates, and aquatic vegetation) were not specifically evaluated in the ERA. These receptors were excluded from evaluation, based on the outcomes of a preliminary assessment of Hendry Brook and Unnamed Brook surface water and sediment chemistry data (See Section 9.6).

Table 3-1 Ecological Receptors Selected for Evaluation in the ERA

Receptor Group	Include / Exclude	Surrogate Species Receptor Group	Rationale for Selection
Terrestrial vegetation	Include	Not applicable - terrestrial vegetation is assessed as a broad receptor group at the community level	COPCs may enter vegetation from the soil via the roots, and deposition onto foliar surfaces. Terrestrial vegetation is consumed by herbivorous wildlife.
Soil invertebrates and soil micro-organisms	Include	Not applicable – soil invertebrates and microbes are assessed as a broad receptor group at the community level	Soil invertebrates (such as earthworms and arthropods) have a key role in soil development and provide food to many species of wildlife. Soil invertebrates are in constant contact with soil and some species directly consume soil. Thus, these organisms have a high exposure potential to COPCs in soil. Soil micro-organisms are primary consumers of organic matter which convert soil nutrients into forms that are available for uptake by plants and higher trophic level organisms. As such, soil micro-organisms are important to the natural nutrient cycling of soils (Will and Suter II, 1995).
Herbivorous small mammals	Include	Snowshoe hare	Herbivorous small mammals may be exposed to COPCs via consumption of vegetation and soil. The snowshoe hare was selected as a surrogate for this group as it has a relatively small home range and a relatively high exposure potential.
Insectivorous small mammals	Include	Masked shrew	The masked shrew was selected as the surrogate for this group. Masked shrews have a high potential for exposure to chemicals in soils due to their burrowing behaviour, consumption of soil dwelling organisms and their small home range. The shrew may be consumed by carnivorous species.
Carnivorous small mammals	Include	Ermine (short-tailed weasel)	Carnivorous small mammals may be exposed to COPCs via the ingestion of prey items, and incidental soil ingestion. The home ranges of carnivorous small mammals are smaller than the size of the Study boundary, suggesting that foraging could occur entirely within the Study boundary. The ermine was selected as the surrogate for this group.
Herbivorous large mammals	Include	White-tailed deer	While the exposure potential for large herbivorous mammals to COPCs within the Study boundary would be limited, given their

Receptor Group	Include / Exclude	Surrogate Species Receptor Group	Rationale for Selection
			large home range, the white-tailed deer and moose are very common within the Study boundary. Therefore, herbivorous large mammals were included in the assessment. The white-tailed deer was selected as the surrogate for this group as deer tracks were observed within the Principal sampling area and deer have a smaller body weight and home range compared to the moose (making it a more conservative surrogate species).
Carnivorous large mammals	Exclude	Not applicable	Large carnivorous mammals have a limited exposure potential due to their large home ranges. They would be expected to spend considerably less of their time and obtain less of their diet from the Study boundary (particularly in the areas of the site having the highest concentrations) compared to small carnivorous mammals. Therefore, large carnivorous mammals were not included in the assessment. If adverse effects are not predicted to occur in small carnivorous mammals (which incur higher exposures), it can be assumed that adverse effects would not be expected to occur in large carnivorous mammals.
Insectivorous birds	Include	Dark-eyed junco	Insectivorous birds may be exposed to COPCs by consumption of soil invertebrates and by incidental soil ingestion. The dark eyed junco was selected to represent this group since it consumes insects and is a ground foraging species. Ground foraging species would have a higher exposure potential to metals in soils than other bird species due to higher rates of inadvertent soil intake.
Herbivorous birds	Include	Ruffed grouse	Herbivorous birds may be exposed to COPCs via ingestion of vegetation and incidental ingestion of soil. While herbivorous birds are expected to have a lower exposure potential to chemicals in soils than insectivorous birds, the prevalence of these birds in the Study boundary is high; thus, they were included in the assessment. The ruffed grouse was selected as a surrogate for this group.
Carnivorous birds	Include	Northern Saw-whet Owl	Exposure potential for carnivorous birds is typically limited due to their large home ranges. However, this receptor group was selected for evaluation due to the relatively

Receptor Group	Include / Exclude	Surrogate Species Receptor Group	Rationale for Selection
			large size of the Study boundary. The Northern saw-whet owl was selected as a surrogate for this group due to its small size, and relatively small home range, when compared to other raptors. The saw-whet owl is considered a conservative surrogate for other carnivorous birds.
Freshwater aquatic vegetation	Included	Not applicable – freshwater aquatic vegetation is assessed broadly (at the community level) as freshwater aquatic life[a]	Aquatic plant communities such as algae and macrophytes provide food and habitat to fish and other wildlife. They may be exposed to chemicals deposited onto and into area surface waters and sediments.
Freshwater aquatic invertebrates	Included	Not applicable – freshwater invertebrates are assessed broadly (at the community level) as freshwater aquatic life[a]	Aquatic invertebrate communities (pelagic and benthic) provide food to fish and other wildlife and may be exposed to chemicals deposited onto and into area surface waters and sediments.
Freshwater fish	Included	Not applicable – freshwater fish are assessed broadly (at the community level) as freshwater aquatic life[a]	Freshwater fish may be exposed to chemicals deposited onto and released into area surface waters.
Waterfowl	Excluded	See comment	Excluded as a result of low exposure potential (See Section 9 for a qualitative discussion).
Piscivorous wildlife	Excluded	See comment	Excluded as a result of low exposure potential (See Section 9 for a qualitative discussion).
Amphibians	Included (Qualitative assessment)	See comment	While the exposure potential of amphibians is considered to be low (See Section 9), the aquatic stage of life was qualitatively assessed given their small home range. Due to limited toxicity data, the terrestrial stage could not be assessed.
Reptiles	Exclude	See comment	Excluded due to a paucity of toxicity data.
Rare, threatened or endangered species	Include	See comment	Some species of concern have been reported within the Glencore Smelter Site (See LGL, 2008 - Biodiversity Report). Sensitive species observed within the Study boundary have been summarized in Section 3.1.2.3. These species will be considered in the ERA although not specifically assessed.

Notes:

a Freshwater aquatic life includes both pelagic and benthic organisms. Pelagic freshwater aquatic life includes any macrophytes, phytoplankton, invertebrates, fish, and herptiles) that spend all or a major portion of their life stages in the water column. Benthic freshwater aquatic life is largely restricted to sediment-dwelling invertebrate species, as the available regulatory sediment quality benchmarks for inorganic chemicals are based primarily on these types of organisms. While some non-invertebrate aquatic organisms are also in frequent direct contact with sediments (such as aquatic plants, some fish species), these organisms are rarely accounted for in regulatory sediment quality benchmark derivation procedures, or in sediment toxicity studies

3.6 Selection of Assessment and Measurement Endpoints and Lines of Evidence

An assessment endpoint is defined as an explicit expression of what is to be protected, defined by an ecological entity (receptor or receptor group) and by a characteristic[3] (Suter, 1989; U.S. EPA, 1988; Azimuth, 2012). The characteristic is a specific attribute or property for the receptor that is important to protect and which is potentially at risk (*e.g*., abundance, survival). The ecological entity can be defined at different levels of biological organization (Suter II, 2007). For example, the ecological entity can be defined by an ecological species (*e.g*., endangered species such as the Peregrine Falcon), a population (*e.g.,* common loons inhabiting a particular lake) or a community (*e.g*., benthic invertebrate). Effects on assessment endpoints are estimated using measures of effects (U.S. EPA, 2003c).

Assessment endpoints may or may not be directly measurable (U.S. EPA, 1998). For example, presence and abundance of a bird species may be assessed directly if surveys of this bird species have been conducted. If the assessment endpoints are not directly measurable (which is not uncommon due to practical reasons), then other measures, called “measurement endpoints”, may be used to evaluate the risk to the assessment endpoints. Measurement endpoints have been defined as responses to a chemical stressor that can be measured and quantified (Suter II, 1990). The CCME defines measurement endpoints as “the effects on an ecological component that can be measured and described in some quantitative fashion” (CCME, 1996; Gaudet *et al*., 1994).

In terms of what constitutes “sufficient numbers” in relation to the proposed assessment endpoint, it is generally considered by ecological risk assessors that a decrease in an ecological assessment endpoint of less than 20% is acceptable, based on the U.S. Environmental Protection Agency (EPA) practice (Suter II *et al*., 2000). For threatened and endangered species however, a more stringent cut-off value is generally recommended.

The U.S. EPA (1998) identifies three categories of measurement endpoints:

1. Measure of Exposure: a measure of chemical presence and movement in the environment and its contact with the receptor. For example, concentrations of COPCs in soil, sediment, surface water, and / or in wildlife dietary items.

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[3] Wildlife (mammalian and avian) is typically assessed using population-level assessment endpoints, while fish, benthic macroinvertebrates, terrestrial invertebrates and plants are commonly assessed using community-level assessment endpoints. Threatened and endangered species are typically assessed at the individual level (Suter *et al*., 2000).

2. Measure of Effect: a measure that describes a change in a characteristic of a receptor in response to a chemical to which it is exposed. For example, the number of loons in an area; laboratory avian toxicity test data from the literature.

3. Measure of Ecosystem and Receptor Characteristics: measures that influence the behaviour and location of receptors, the distribution of a chemical, and life-history characteristics of the receptor that may affect exposure or response to the chemical. For example, home range and habitat requirements and preferences for the receptor.

A main consideration in the selection of measurement endpoints is how well a measurement endpoint represents an assessment endpoint. The greater the strength of association between the measurement and assessment endpoint, the greater the weight that is given to that measurement endpoint in the overall risk assessment.

Various measurement endpoints were used to assess the receptors evaluated in the ERA, depending upon the availability of data and the level of uncertainty in these data.

Once assessment and measurement endpoints were identified, lines of evidence (LOEs) were developed for each assessment endpoint. The LOE combines exposure and effects information to evaluate risk potential. The LOEs specify exactly how the measurement endpoints will be used to evaluate potential risks. The measurement endpoint is basically the tools used to measure exposure or effects, while the lines of evidence state exactly how those tools will be used to assess risk. Lines can be grouped into 4 main categories (Azimuth, 2012):

- Site-specific toxicological evidence (e.g., amphipod toxicity test; seed germination test conducted with site media);
- Indirect toxicology evidence (e.g., toxicity data from laboratory animal studies; water and soil quality guidelines; available TRVs);
- Site-specific biological evidence (e.g., small mammal trappings; wildlife and vegetation surveys); and
- Indirect biological evidence (e.g., extrapolation of knowledge obtained at other similar sites; literature summary of small mammal tissue concentrations and effects on small mammals at other similar sites).

Specific assessment and measurement endpoints were identified for each of the receptor groups evaluated in the ERA and lines of evidence (LOE) were developed for each assessment endpoint. Assessment and measurement endpoints and LOEs are presented in Table 3-2.

Table 3-2 Assessment Endpoints, Measurement Endpoints and Lines of Evidence

Receptor Group	Assessment Endpoint	Measurement Endpoints	Lines of Evidence
Vegetation	Survival, growth and reproduction of vegetation communities	Concentrations of COPCs in soil (metals) and air (SO_2) and vegetation health-based Soil Quality Guidelines (SQG) and Air Quality Guidelines (AQG) Site-specific plant community survey data (various measures related to community structure, health, etc.) Nutrient soil analysis	Outcomes of the comparison of soil metal and air SO_2 concentrations to SQGs (metals) and AQGs (SO_2) and to reference area concentrations. Comparison of vegetation health within the Study boundary to reference locations. Outcomes of comparisons of nutrient levels within the Study boundary to reference soils and desired nutrient levels in soils in general.
Soil invertebrates and soil microorganisms	Survival and reproduction of soil invertebrate and microorganism communities	Concentrations of COPCs in surface soil and soil microbial and/or invertebrate health-based SQGs Soil invertebrate survey data	Outcomes of the comparison of soil concentrations to SQGs and to reference area concentrations. Results of the soil invertebrate survey within the Study boundary compared to reference locations.
Herbivorous, insectivorous and carnivorous avian species	Survival, growth, reproduction and abundance of populations[1,2]	Food chain modeling Breeding bird and fledgling studies Literature studies discussing effects at other relevant sites	Predicted Exposure Ratios (ER) from food chain modeling (*i.e.*, comparison of estimated COPC exposures via all exposure pathways to Toxicity Reference Values (TRVs). Outcomes of the breeding bird survey and fledgling survey conducted within the Study boundary compared to reference. Consider toxicological / biological information from other studies and extrapolate where applicable to this study.

Receptor Group	Assessment Endpoint	Measurement Endpoints	Lines of Evidence
Herbivorous, insectivorous and carnivorous mammals	Survival, growth, reproduction and abundance of populations[1,2]	Food chain modeling	Predicted Exposure Ratios (ER) from food chain modeling (*i.e.*, comparison of estimated COPC exposures via all exposure pathways to Toxicity Reference Values (TRVs)).
		Small mammal study	Outcomes of the small mammal study (abundance and diversity) conducted within the Study boundary compared to reference.
		Small mammal tissue residue data	Comparison of tissue residue data for small mammals collected on-site to those collected in reference area and to tissue effects literature
		Literature studies discussing effects at other relevant sites.	Consider toxicological / biological information from other studies and extrapolate where applicable to this study.
Freshwater aquatic life	Benthic community survival and reproduction; Survival, growth, reproduction and abundance of fish communities [1,2]	Concentrations of COPCs in surface water and sediment, and sediment and surface water quality guidelines.	Results of comparison of surface water and sediments chemistry data within the Study boundary to relevant guidelines
		Fish habitat survey	Results of fish habitat survey within the Study boundary compared to reference.
		Fish community survey (abundance and diversity as well as age structure)	Results of fish community survey within the Study boundary compared to reference.
		Rare aquatic vegetation survey	Outcomes of rare aquatic vegetation survey.
Amphibians	Survival and reproduction of amphibian communities	Concentrations of COPCs in surface water and sediment and amphibian toxicity data from the scientific literature	Consideration of amphibian toxicity data with respect to Study boundary surface water and sediment chemistry data and anecdotal observations of amphibians from biological surveys conducted within the Study boundary.

Notes:

1 A population is defined by Gotelli (1995) as "a group of plants, animals, or other organisms, all of the same species that live together and reproduce".

2 The abundance of a species could be affected directly (*i.e.,* as a result of direct toxicity of the COPCs on survival, growth or reproduction), or indirectly (*e.g.,* as a result of decreased habitat suitability or reduced prey abundance). The ERA focuses on potential health effects as a result of direct chemical exposures to receptors.

3.7 Selection of Exposure Pathways and Routes

If there are no possible exposure pathways to COPCs, there can be no potential for adverse effects from these chemicals. Therefore, it is important to identify the major exposure pathways for each of the selected receptors.

Exposure of vascular plants to chemicals in soil is controlled by the root distribution in the soil profile, physicochemical characteristics of the soil (which determine the forms of the chemicals and their availability) and by interaction among other chemicals (Suter II, 2007). Exposure to soil invertebrates is determined by depth of burrowing, material ingested, activity patterns, soil characteristics and interaction with other chemicals (Suter II, 2007). For the current ERA, it was assumed that terrestrial plants, soil invertebrates and microorganisms would be exposed to the COPCs in soil via direct soil contact pathways. This would include direct contact with the dermal coverings or integument of invertebrates, direct soil ingestion by invertebrates, and root uptake for plants. Vegetation would also be exposed to COPCs via direct foliar uptake, due to deposition of smelter emissions onto foliar surfaces. There would also be direct foliar exposure to certain gases emitted from the smelter (*i.e.*, SO_2).

Terrestrial and avian wildlife receptors may be potentially exposed to COPCs through soil and surface water ingestion as well as the ingestion of contaminated plant and animal food sources. While some terrestrial and avian species could be exposed to COPCs via the ingestion of fish, other aquatic food resources, and the incidental ingestion of sediments, consumers of aquatic life were deemed as not requiring evaluation in the ERA, due to a limited exposure potential (see Section 9.6 for details).

Dermal exposure to COPCs could also occur in avian and mammalian wildlife but this exposure route is generally considered negligible in most ERAs. The presence of feathers on birds and fur on mammals reduces dermal exposure by limiting the contact of skin with chemicals in environmental media (Sample *et al*., 1997; Sample and Suter II, 1994). In addition, metals do not cross the dermis, and are unlikely to be absorbed through skin (Watters *et al*., 1980). For amphibians, or for chemicals that are readily absorbed dermally (*e.g*., solvents), this exposure pathway may be more relevant.

Inhalation is also considered to be a minor exposure route for mammalian and avian receptors under most circumstances (Gaudet *et al.*, 1994; BC MELP, 1998; Sample and Suter II, 1994; Sample *et al.*, 1997; CCME, 1996). Inhalation exposure to metals/metalloids (which comprise the COPCs in this ERA) is generally assumed to be negligible for birds and mammals because these chemicals have extremely low volatility, and resuspension of fine soil particles is minimized when soils contain vegetation. Also, metals and metalloid inhalation toxicity data are generally lacking for both wildlife and experimental animal species. This makes it difficult to assess ecological risks from this exposure route, especially for birds, but also for mammals where the toxicity endpoint often is not related to the ecological assessment endpoints of concern (*e.g*., lung irritation as opposed to reproduction). While emissions from the smelter would result in the potential for direct inhalation of COPCs from air, data are generally unavailable to assess this pathway (*i.e*., a lack of air toxicity data in addition to a lack of environmental concentrations of metals in air).

Nevertheless, direct inhalation exposure was assessed as a pathway which also included the inhalation of soil dusts. The deposition of air emissions of the COPCs onto vegetation was also estimated and included in the calculations for total exposures of the wildlife receptors that consumed vegetation.

Exposure *via* ingestion was quantitatively evaluated in the ERA for mammalian and avian receptors. This is in agreement with various sources of Canadian and U.S. ecological risk assessment guidance for exposure pathway selection, which consider ingestion to be a major exposure pathway.

The ingestion of surface water as a drinking water source for wildlife within the Study boundary was assumed to occur for all mammalian and avian receptors. This is a conservative assumption as many receptors will not ingest water from local freshwater bodies, but rather, will obtain the majority of their daily water requirements from the ingestion of food, as well as water that condenses on vegetation surfaces, and/or accumulates in puddles. While water contained in food as well as water produced metabolically will decrease the daily drinking water requirements of these receptors, these particular sources of water were not considered in the ERA.

For aquatic life, the main routes and pathways by which these receptors may be potentially exposed to COPCs would include: direct contact of gills and other respiratory surfaces with water and sediments, sediment and water ingestion (including sediment pore water for benthos), and ingestion of aquatic prey species and other food items (*i.e*., detritus, plants, phytoplankton, zooplankton, macroinvertebrate fauna, and fish can all be food items for aquatic organisms depending on the number of trophic levels and aquatic food web structure). Sediment ingestion and pore water ingestion is more prevalent for bottom-dwelling or bottom-feeding species (Schoof, 2003). Aquatic plants are typically exposed to chemicals through root uptake of substances present in sediments and sediment pore water, and surface water uptake. For benthic species, the relative importance of whole sediment versus pore water exposures depends on the individual species, and their feeding and burrowing behaviour. For example, pore water exposure may be insignificant to invertebrates that ingest sediment particles, but may be an important exposure pathway for benthic organisms that burrow, and/or obtain their food by filter feeding.

The specific exposure pathways and routes selected for the receptors that were evaluated in the ERA are provided in Table 3-3.

Table 3-3 Exposure Pathways for Receptors Evaluated in the ERA

Receptor	Exposure Pathways
Terrestrial Vegetation	- direct soil contact and exposure to SO_2 in air
Soil Invertebrates and Soil Microorganisms	- direct soil contact
Snowshoe hare	- incidental soil ingestion - ingestion of terrestrial vegetation - ingestion of water - inhalation air and soil dust
Masked shrew	- incidental soil ingestion - ingestion of terrestrial soil invertebrates - ingestion of water - inhalation air and soil dust
Short tailed weasel (Ermine)	- incidental soil ingestion - ingestion of prey (terrestrial small mammals) - ingestion of water - inhalation air and soil dust
White-tailed deer	- incidental soil ingestion - ingestion of terrestrial vegetation - ingestion of water - inhalation air and soil dust
Saw whet owl	- incidental soil ingestion - ingestion of prey (terrestrial small mammals) - ingestion of water - inhalation air and soil dust
Ruffed grouse	- incidental soil ingestion - ingestion of terrestrial soil invertebrates - ingestion of terrestrial vegetation - ingestion of water - inhalation air and soil dust
Dark-eyed junco	- incidental soil ingestion - ingestion of terrestrial soil invertebrates - ingestion of terrestrial vegetation - ingestion of water - inhalation air and soil dust
Freshwater aquatic life	-direct contact with surface water / pore water / sediment - ingestion of surface water / sediment
Amphibians	- direct contact with surface water / sediments

3.8 Conceptual Model

A conceptual model is a written description and/or a visual representation of the relationships between the source of COPCs, the receiving environment(s), and processes by which receptors may become directly or indirectly exposed to the COPCs (Barnthouse and Brown, 1994). Conceptual models can serve three purposes: 1) clarification of assumptions concerning the situation being assessed; 2) as a communication tool for conveying those assumptions; and 3) providing a basis for organization and completion of the risk assessment (Suter, 1999).

The conceptual model for the ERA is provided in Figure 3-6.

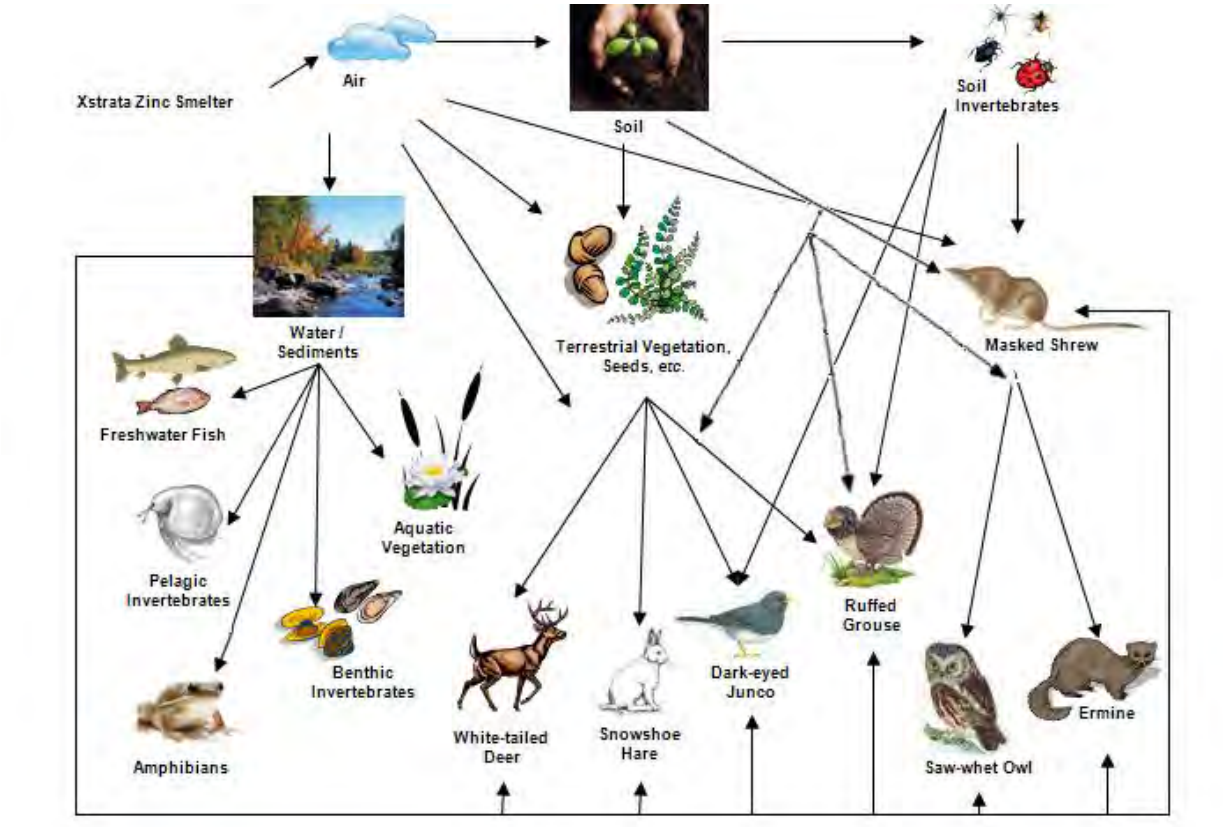


Figure 3-6 Ecological Risk Assessment Conceptual Model Representing the Predominant Exposure Pathways that were Considered

4.0 DEVELOPMENT AND IMPLEMENTATION OF SAMPLING PROGRAMS AND FIELD STUDIES

An iterative study design was developed for the smelter ERA and field work to collected site-specific biological and chemical data was conducted sequentially based on the progression of the study. The initial sampling focused on a wide area (i.e., the Principal sampling area). Using the soil data collected within the Principal sampling area, the media and area(s) requiring further assessment and/or sampling for the ERA were identified (i.e., the Study boundary). Data needs within the Study boundary were further refined based on the preliminary risk estimates and identification of data gaps.

The data collected for this ERA and the associated timeline were included in Table 1-1 (See Section 1.1) and are summarized below in Table 4-1.

Table 4-1 Timeline for Media Sampling and Field Studies

2009	• Collect soil samples in principal sampling area
2010	• Collect additional soil data in addition to surface water and sediment sampling • Conduct invertebrate pitfall trap sampling and tissue analysis • Conduct vegetation health survey
2011	• Collect additional sediment and surface water data • Collect additional soil pH data and nutrient analysis • Conduct breeding bird and fledgling survey • Conduct stream habitat survey • Conduct rare aquatic vegetation survey • Conduct small mammal abundance and diversity survey and tissue analysis

A discussion of the sampling plans and methodology for data collection are found in the following sections. Chemical characterization results are provided in Section 5.0, while biological characterization outcomes have been incorporated into the risk characterization results (See Section 10).

4.1 Chemical Characterization

4.1.1 Soil Sampling and Analysis

The overall design of the soil sampling program for the Principal sampling area was presented in Figure 3-2. In total, 61 sampling locations were sampled in July-August of 2009. The coverage or distribution of soil sampling stations for the entire area, based on stations sampled in the previous Shore Road Soil Study (completed in 2008 using a similar soil sampling protocol) and the current 2009 program, was presented in Figure 3-3. Based on Figure 3-3, it is evident that the Belledune area has undergone extensive soil sampling, and both the Shore Road Soil Study and the current Study provide considerable information and understanding of metals levels in soils within the Belledune area. In both studies, the soil sampling programs involved composite shallow soils sampling (0 – 5 cm), with a subset of samples being cored to deeper depths (0 – 5 cm; 5- 15 cm and 15 – 30 cm). The specific methods used to design the soil sampling program in the current Study, and the specific soil sampling protocol that was followed are provided in Appendix A.

In August of 2010, an additional 17 soil stations were sampled in the areas 0 – 2 km from the smelter facility. The need for this supplementary soil sampling was based on the outcomes of preliminary evaluation of the July-August 2009 soil data. This August 2010 soil sampling event was conducted to refine the initial exposure estimates. These soil samples were collected using the same soil sampling protocol that was used for the 2009 samples, but focused only on the 0-5 cm samples (A layer), since the 2009 data had confirmed that the highest metal concentrations occurred within the top 5 cm of soil. These data were reviewed and screened with the same COPC identification process that had been previously conducted on the 2009 soil chemistry dataset, to confirm the COPCs for the ERA (see Appendix G for details). Figure 4-1 shows the locations of the August 2010 soil sampling stations.

In conjunction with these two sampling events, a total of 23 soil samples were collected from the reference area in 2009, and an additional 4 samples were collected in 2010. The reference area sampling stations were on undeveloped Crown lands with similar underlying geology (to the extent possible, but recognizing that geological zones in northeastern New Brunswick are inherently patchy and variable), and similar ecoregions and ecosites to that of the Study boundary Area, located 20-30 km west-southwest of the smelter facility (which is also upwind of the prevailing winds in the Belledune area). Reference soil samples were collected using the same protocol that was used for the 2009 Principal sampling area (Appendix A). Further information on selection of the reference area was previously provided in Section 3.2.

No deviations to the soil sampling protocol were reported by any of the field crews in either the 2009 or 2010 sampling events (conducted by Conestoga Rovers & Associates, and LGL Ltd., respectively).

All soil samples collected in 2009 and 2010 were prepared and analyzed by Maxxam Analytics in Bedford, NS, with a subset of the 2009 samples undergoing analysis by a second laboratory (RPC Laboratories in Fredericton, NB) for soil data quality control/quality assurance purposes (See Section 5.5 and Appendix E for details). Both Maxxam and RPC are accredited by the Standards Council of Canada for all analyses performed in this project. The preparation of all soil samples followed standard procedures, and involved the selection of the <2 mm size fraction of soils, followed by an available metals digest and analysis by ICP–MS. The acid digest procedure that was applied followed U.S. EPA Method 3050b. Soil pH was also measured in selected soil samples using a pH probe (on a 5:1 DI water extract, based on EPA method 150.1) since soil quality guidelines for some metals (e.g., aluminum, iron) are dependent upon soil pH (e.g., U.S. EPA, 2003 a, b). Selected soil samples were also analyzed for total organic carbon (TOC), following method LEC 203-601-224.

The raw soil chemistry data for both the 2009 and 2010 soil sampling programs are provided in Appendix D. Summary statistics for these soil chemistry data are presented in Section 5.1.

A detailed soil data quality assurance program occurred throughout both the 2009 and 2010 soil sampling and analytical programs. This program is outlined in Appendix A and the methods and outcomes of the detailed soil data quality assurance evaluation are provided in Appendix E (summarized in Section 5.5).

During all soil sampling events, observations were recorded at each station related to animal sightings or signs, extent and type of browse, forest growth, etc. in order to provide an indication of habitat quality, and the degree to which wildlife species forage at or near these locations.

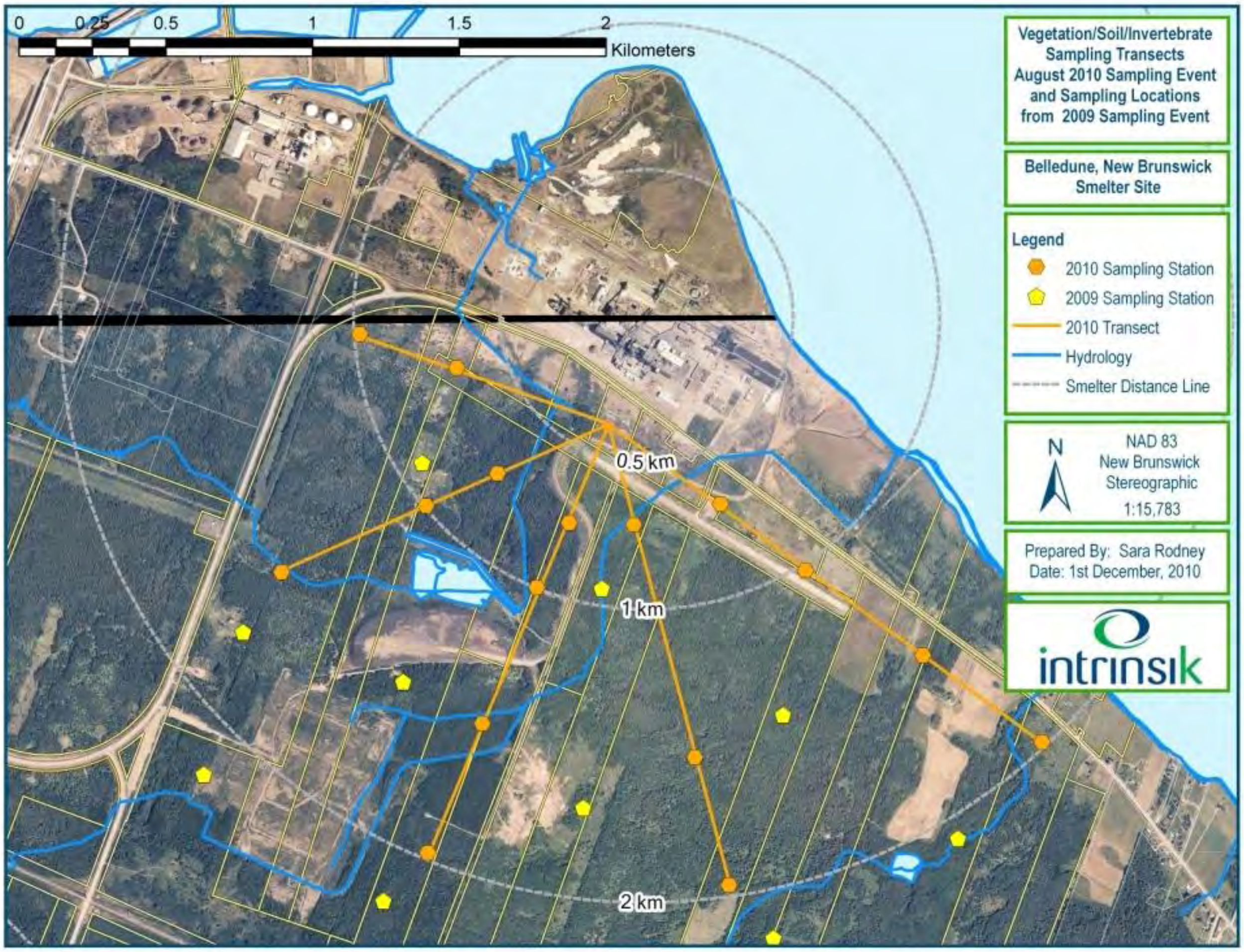


Figure 4-1 2010 Supplemental Soil Sampling Locations in the Areas Surrounding the Glencore Smelter near Belledune, New Brunswick (0-2 km Radius)

Soil nutrient analysis, along with additional metals and paste pH analyses, were conducted in October 2011, using a subset of the sampling stations as those outlined in Figure 4-1. The specific stations included in this sampling were selected based on the outcomes of the vegetation community assessment (LGL, 2012c), which suggested vegetation effects were largely restricted to areas closest to the facility. The nutrient soil stations were (See Figure 4-2):

- Transect 1 (station 1, 2 and 3)
- Transect 2 (station 1, 2 and 3)
- Transect 3 (station 1, 2 and 3)
- Transect 4 (station 1 and 2)

- Transect 5 (station 1 and 2)

In addition to the study area samples, four stations from the reference location (Figure 3-4) were also included in this sampling event. The sampling protocol for this sampling event differed from previous sampling, in that at each location, eight samples from a 0 to 15 cm depth were collected from a 10 x 10 m plot using a stainless steel soil corer. This depth was used in order to evaluate nutrient levels through a relevant depth related to plant growth. The samples were combined in a Zip-Lock freezer bag with all vegetation, moss, sticks, pebbles and rocks removed. Therefore, a total of 19 composite soil samples were obtained and were shipped to FHW Consulting. The samples were submitted to A & L Laboratory in London, Ontario and analyzed for the following parameters: paste pH; organic matter; available nutrients (P, K, Mg, Ca, Na, Fe, Al, Mn, B, Cu, Zn and S).

FHW Consulting (2012) conducted an assessment of nutrient levels in the soil based on the laboratory results, to assist in interpretation of the vegetation effects reported in the vegetation community survey. Details of the nutrient analysis and nutrient analytical results are provided in Appendix P. An interpretation of the nutrient data is incorporated into the risk characterization results (Section 10).

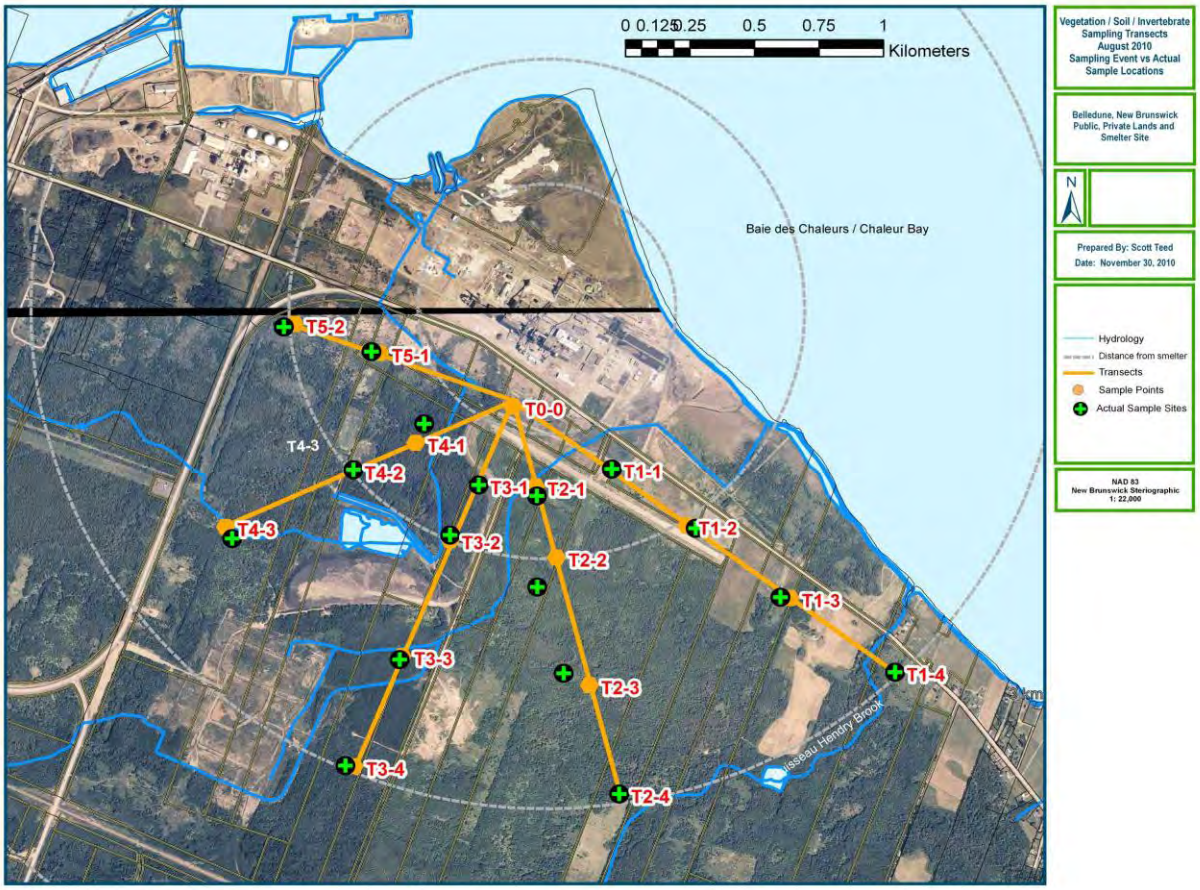


Figure 4-2 Location of LGL Limited Transect Stations

4.1.2 Soil Invertebrate Pit Fall Trap Sampling and Analysis

In the summer of 2010, in conjunction with the supplementary soil sampling and vegetation survey, pitfall traps were set to collect soil invertebrates for tissue analysis. The methods used to set and collect the pitfalls are outlined in Appendix C.

Briefly, the pitfall trap stations were identical to those presented in Figure 4-1 for the 2010 soil sampling stations. Two pitfall traps were set at each of the 17 sampling locations. Each trap, which consisted of an open mason jar, contained distilled water as a trapping fluid, and was left for a 48 hour period, prior to being collected. Upon collection, contents of the two traps at a given station were combined to enable a large enough sample for tissue residue analysis. Samples were placed on ice immediately, and frozen until transported to the laboratory (Maxxam Analytics) for metals analysis. A brief summary of invertebrate abundance and diversity at each station was recorded by the field crew.

Tissue analysis for metals was conducted by Maxxam Analytics using the Metals Tissues MS-Nitric method that is based on Method EPA6020A. Raw analytical results for soil invertebrate metals concentrations are provided in Appendix D. Results of the pitfall trap analysis and sampling results are incorporated into the risk characterization results (Section 9.3).

4.1.3 Freshwater Aquatic Sampling and Analysis

Freshwater surface water and sediment chemistry data were collected in the summer of 2010 and fall of 2011 from two brooks located within the Study boundary; Unnamed Brook and Hendry Brook. The selection of these brooks was based largely on the measured metals levels in soils within the Principal sampling area, which indicated that areas within a 3 km radius of the smelter were more influenced by deposition of emissions than those in more distant areas. This finding was supported by the outcomes of air dispersion and deposition modelling (see Appendix I-1 for details). These two brooks are considered to have the highest likelihood of impacts from smelter activities, relative to other fresh water bodies in the Belledune area, given that they are the closest brooks to the smelter complex and current slag disposal area. There are two additional waterbodies within the Study boundary which currently receive drainage from specific areas related to smelter operations (such as the drainage area associated with the slag pile and the east and west diversion ditches). These receiving environments are routinely monitored and have to meet certain water quality requirements set out for the smelter, as part of the Approval to Operate. Thus, these specific water bodies are not included in the ERA.

Figure 4-5 shows the locations of the water and sediment sampling stations in Unnamed and Hendry Brooks, as well as the reference area, Armstrong Brook, which is located approximately 10 km west of the smelter complex, and upwind of the prevailing wind direction. Further information pertaining to the selection of this brook as a reference watercourse is provided in Section 3.2.2. As the sample size from Armstrong Brook was limited (N=5), and the Study Team supplemented the reference dataset with other available data from streams in north-eastern New Brunswick, from other studies conducted by Intrinsik (Intrinsik, 2009; 2011). These studies used the same sampling protocols, analyses and analytical laboratory as those used for Unnamed, Hendry and Armstrong brooks, and therefore, it was decided to pool the Armstrong Brook data with the reference data from these other locations. This pooling of datasets increased the sample size from 5 to 62 (surface water) and from 5 to 20 (sediment), respectively, and provided more robust datasets of reference water and sediment concentrations for use in the ERA.

All surface water and sediment samples from Unnamed, Hendry and Armstrong brooks were collected by Conestoga Rovers & Associates (CRA) in July, 2010, and September 2011, and were submitted to Maxxam Analytics (Bedford, NS) for chemical analyses. Details of the surface water and sediment sampling and analytical programs and protocols are provided in Appendix C.

Sediment and surface water samples were analyzed by Maxxam Analytics using standard methods. Sediments were digested using an available metals digest (based on U.S. EPA Method 3050b), followed by analysis based on U.S. EPA Method 6020A (ICP-MS metals). Surface waters were analyzed for both total recoverable metals, as well as dissolved metals (based on U.S. EPA Method 6020A). Various general water quality parameters, such as hardness, alkalinity, organic carbon, major ions, etc., were also analyzed according to a number of reference methods (See laboratory certificates of analysis in Appendix D for details). In addition, some water quality parameters were measured in situ during the sampling event (i.e., pH, temperature, conductivity).

All raw 2010 and 2011 analytical data provided to Intrinsik by Maxxam (as well as the associated quality assurance reports) were carefully reviewed by Intrinsik and underwent a data quality assurance evaluation (See Appendix F and Section 5.5). Water and sediment data quality assurance evaluations for the reference water bodies other than Armstrong Brook were conducted in association with other studies, and are not provided in the documentation for the current ERA (but are available within the following documentation: Intrinsik Environmental Sciences Inc., 2009; 2011).

Surface water and sediment chemistry data summaries and raw analytical chemistry data for Hendry Brook, Unnamed Brook, and Armstrong Brook are provided in Appendix D.

During the brook sampling event, observations were recorded at each station related to animal sightings or signs, extent and type of browse, forest growth, etc. in order to provide an indication of habitat quality, and the degree to which wildlife species forage at or near these locations. Information was also recorded on weather conditions, brook width and depth, flow velocity, any observed aquatic life, and sediment conditions (*e.g.,* substrate type/texture, colour, presence of odours, etc.).

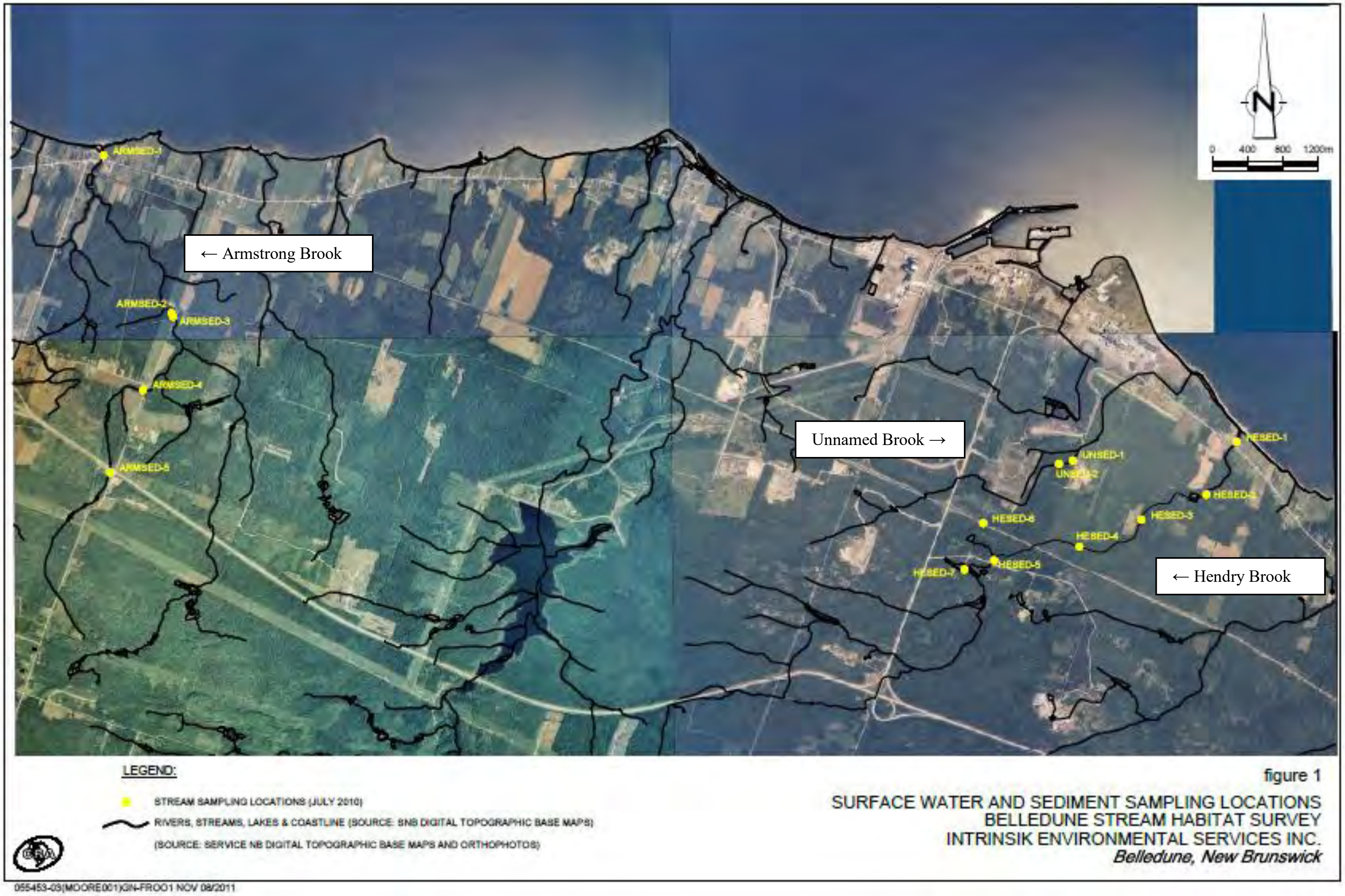


Figure 4-3 Location of Brook Surface Water and Sediment Sampling Locations

4.2 Biological Characterization

4.2.1 Terrestrial Vegetation Survey

A survey of vegetation was undertaken by LGL in August of 2010, within 2 km of the smelter, This survey was conducted using a transect and plot design, with vegetation assessments being conducted along each transect at set distance intervals (0.5 km apart) (See Figure 4-2). The area the survey covered (0 – 2 km) was based on preliminary comparisons of soil metals levels (2009 dataset) to vegetation health guidelines, which indicated that the potential for effects in vegetation was highest in areas closest to the smelter. Vegetation assessments consisted of species abundance and diversity within the canopy and subcanopy, canopy closure at each cardinal point, stand characteristics (size class abundance), standing snags and dead fall densities, ground cover richness and signs of vegetation stress if present. General site observations of community characteristics and vegetation health were gathered while walking along transects between stations. Reference locations approximately 21 km away were also surveyed to provide comparison between areas not directly influenced by smelter emissions. Details of the terrestrial vegetation survey can be found in Appendix K.

4.2.2 Breeding Bird and Fledgling Survey

In response to preliminary food chain modeling, which suggested that ground feeding insectivorous birds may be at risk in areas close to the smelter, a breeding bird survey was conducted during June 27 to 30, 2011 by LGL. This survey focused on abundance, diversity, and breeding evidence, following the protocols outlined in Bird Studies Canada (2006) Breeding Bird Atlas, which recognize three levels of breeding evidence: possible, probable and confirmed. Survey plots were selected near the smelter in areas of potential medium (4 plots) and high exposure (4 plots) relative to a control area (6 plots) which was a 25 km distant from the smelter (same reference area as that used for soil metal characterization). Areas of high and medium exposure were identified by Intrinsik, based on soil metals characterization. Each plot was approximately 200 m by 200 m. Plots in all three exposure areas (i.e., medium, high, control) were established in two habitats: forest (7 plots) and meadow (7 plots). Plots within the Study boundary and in the reference area are shown on Figure 4-6 and Figure 4-7, respectively. Plots K and O are both meadow sites but appear on the image to be forested since both areas have only been cleared since the aerial photograph was taken.

Each plot was surveyed within five hours of sunrise (which occurred at 5:27 a.m. on the survey dates) and approximately 1.5 hours was spent surveying each plot.

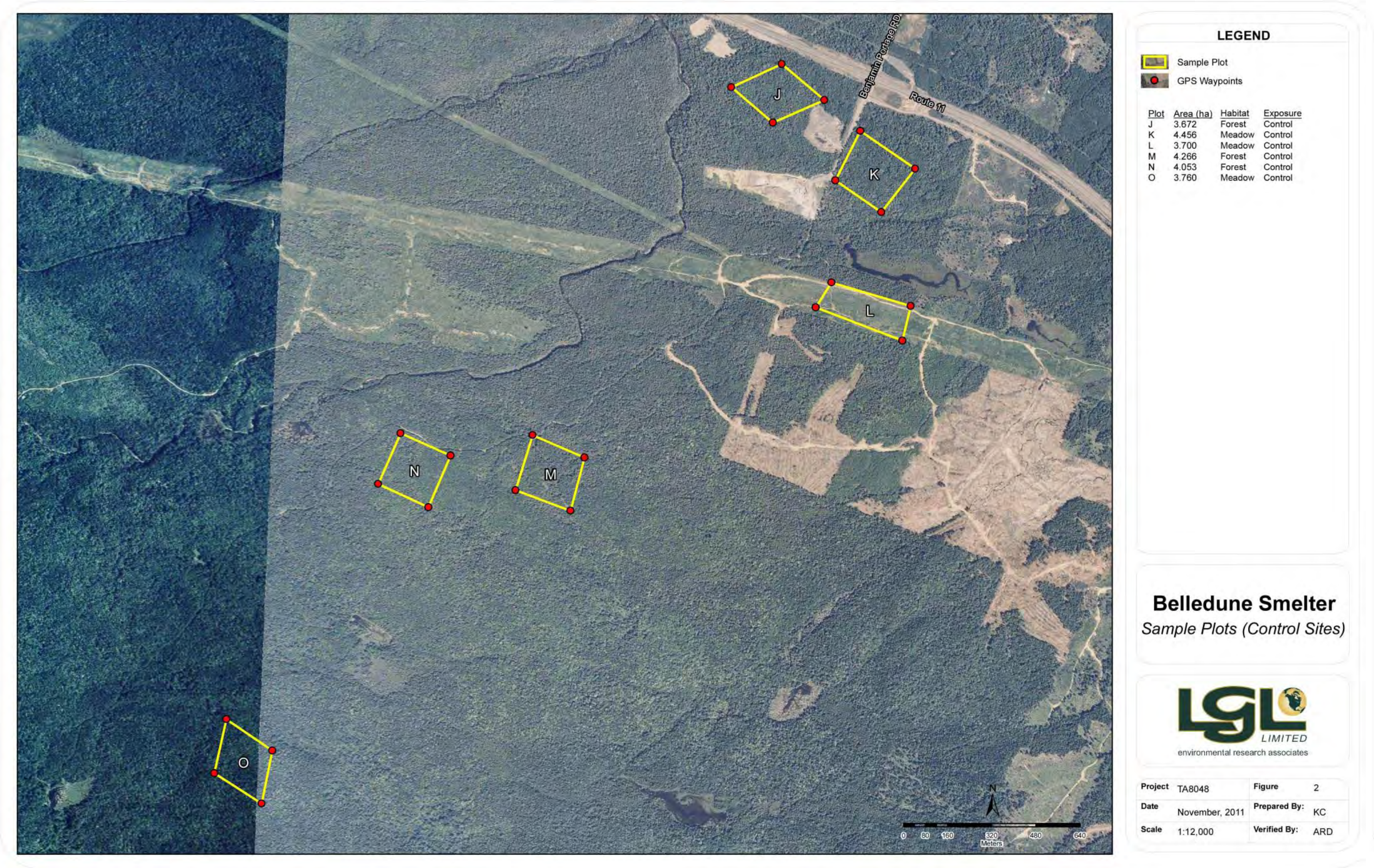
A supplementary fledgling survey was conducted for confirmed breeders from July 20 to 25, 2011, where nests, nestlings and fledglings were targeted for observation. This latter survey was done later in the summer, as nests are easier to find when young are present (due to feeding frequency) and to ensure that later breeders were captured in the survey. Three of the original plots for which breeding birds surveys were conducted (Site E, medium exposure meadow; Site L, control meadow; and Site N control forest) were removed from this component of the study to allow more time to intensively survey the remaining plots for nests and fledglings. These plots were chosen for removal because they were most dissimilar in habitat to the other plots in their categories.

Details of the breeding bird and fledgling surveys can be found in Appendix L. Results of these surveys have been incorporated into the risk characterization results (Section 10.0).

Plot	Area (ha)	Habitat	Exposure
A	1.819	Meadow	High
B	3.981	Forest	High
C	4.358	Forest	Medium
D	4.185	Forest	High
E	2.407	Meadow	Medium
F	2.777	Meadow	High
G	4.009	Forest	Medium
H	3.664	Meadow	Medium

Project	TA8048	Figure	1
Date	November, 2011	Prepared By:	KC
Scale	1:8,000	Verified By:	ARD

Figure 4-4 Bird Survey Plots Within the Study Boundary (LGL, 2012b)



Plot	Area (ha)	Habitat	Exposure
J	3.672	Forest	Control
K	4.456	Meadow	Control
L	3.700	Meadow	Control
M	4.266	Forest	Control
N	4.053	Forest	Control
O	3.760	Meadow	Control

Project	TA8048	**Figure**	2
Date	November, 2011	**Prepared By:**	KC
Scale	1:12,000	**Verified By:**	ARD

Figure 4-5 Reference Area Bird Survey Plots (LGL, 2012b)

4.2.3 Small Mammal Survey

A small mammal survey was conducted by LGL in the fall of 2011. The objective of this study was to collect data on small mammal populations to provide additional lines of evidence for the ERA related to abundance, diversity, morphometrics (*e.g.*, body length, tail length, ear length, *etc*.), and general health and metals loadings in small mammals within the study area to provide further context for risk characterization. A subset of small mammals collected was sent for analysis to determine the level of metals in tissues (liver and kidney). In addition, a limited number of soil samples and soil invertebrates were collected to verify metal levels in small mammal trapping areas and to obtain some information on the types of food available for insectivorous wildlife within the Study boundary.

Small mammal traps were placed in each of the seven plots (5 study area and 2 reference; See Figure 4-8 and 4-9) using a standardized experimental unit that consisted of a 100 m^2 small mammal sampling grid and 5 pitfall cans placed 1.5 m apart from each other 100 m away from the sampling grid to collect soil invertebrates. Small mammal trapping occurred between 17 October and 24 October 2011 (LGL, 2012a; See Appendix M).

A subset of small mammals captured (initially shrews, but due to small number collected, this was expanded to other species), were sacrificed via cervical dislocation between October 18th to 24th (LGL, 2012a). At the end of each field day all collected specimens were transferred to a freezer until necropsies could be performed at the Glencore laboratory on October 25 2011.

Morphometric data were recorded for all specimens and overall condition of body and organs was noted. The kidney and liver of each animal was removed, weighed separately and placed in a Nasco Whirl-Pac®bag. Samples were grouped based on organ type, species and site and each sample bag was labeled accordingly. If not enough tissue was available to satisfy the 1.0 g tissue detection limit then samples were combined based on similar taxon and diet, (i.e. seed-eating rodents livers were grouped together, Deer Mice and Red-backed Voles). Data from multiple sites were combined if the sites were from the same habitat type and of similar metal concentration. Shrew bodies were also used for whole body analysis. Tissues were then placed in a cooler, covered with loose ice and sent for homogenization of tissues and available metals analysis (3050B) at Maxxam Analytics in Bedford, NS. A copy of the LGL (2012a) small mammal report can be found in Appendix M.

The small mammal tissue analyses results are provided in Section 5.4 while results of the small mammal survey are incorporated into the risk characterization results (Section 10.0). Analytical chemistry data for the soil samples which were collected to verify small mammal sampling locations are provided in Appendix D. These soil samples have not been included in the risk assessment modeling as they were collected for the purposes of verifying exposure levels at the small mammal sampling locations.

Figure 4-6 Location of Study Boundary and Reference Area Small Mammal Trapping Sites (Reference sites are approximately 25 km west of the Study sites) (From LGL, 2012a)

Figure 4-7 Distribution of Sampling Sites within the Study Boundary (top) and the Reference Area (bottom) (From LGL, 2012a).

4.2.4 *Fish Habitat and Electro-fishing Survey*

A stream habitat survey was conducted on two brooks within the Study boundary: Hendry Brook (from September 12 and 13, 2011) and Unnamed Brook (from September 20, 2011), in addition to a reference area brook (*i.e.,* Armstrong Brook from September 20 to 21, 2011). The stream habitat surveys were conducted by R.A. Currie Ltd., and the areas examined for each survey are provided in Figures 4-10 and 4-11. A detailed record of habitat features and obstructions observed during the stream survey of each of the brooks may be found in the R.A. Currie (2011) report (See Appendix O). Results of the stream habitat surveys have been incorporated into the aquatic risk characterization results (Section 9.6).

In September 2011, R.A. Currie Ltd. also conducted spot electro fishing in Hendry Brook, Unnamed Brook and Armstrong Brook to gain knowledge concerning the species of fish inhabiting these watercourses (See Appendix O). In addition to recording the types of fish caught, the duration of sampling was noted in order to quantify the catch per unit effort. Spot fishing was conducted in along the areas surveyed for stream habitat (See Figures 4-10 and 4-11). Details of the electro-fishing can be found in Appendix O, while results are incorporated into the risk characterization (Section 9.6).

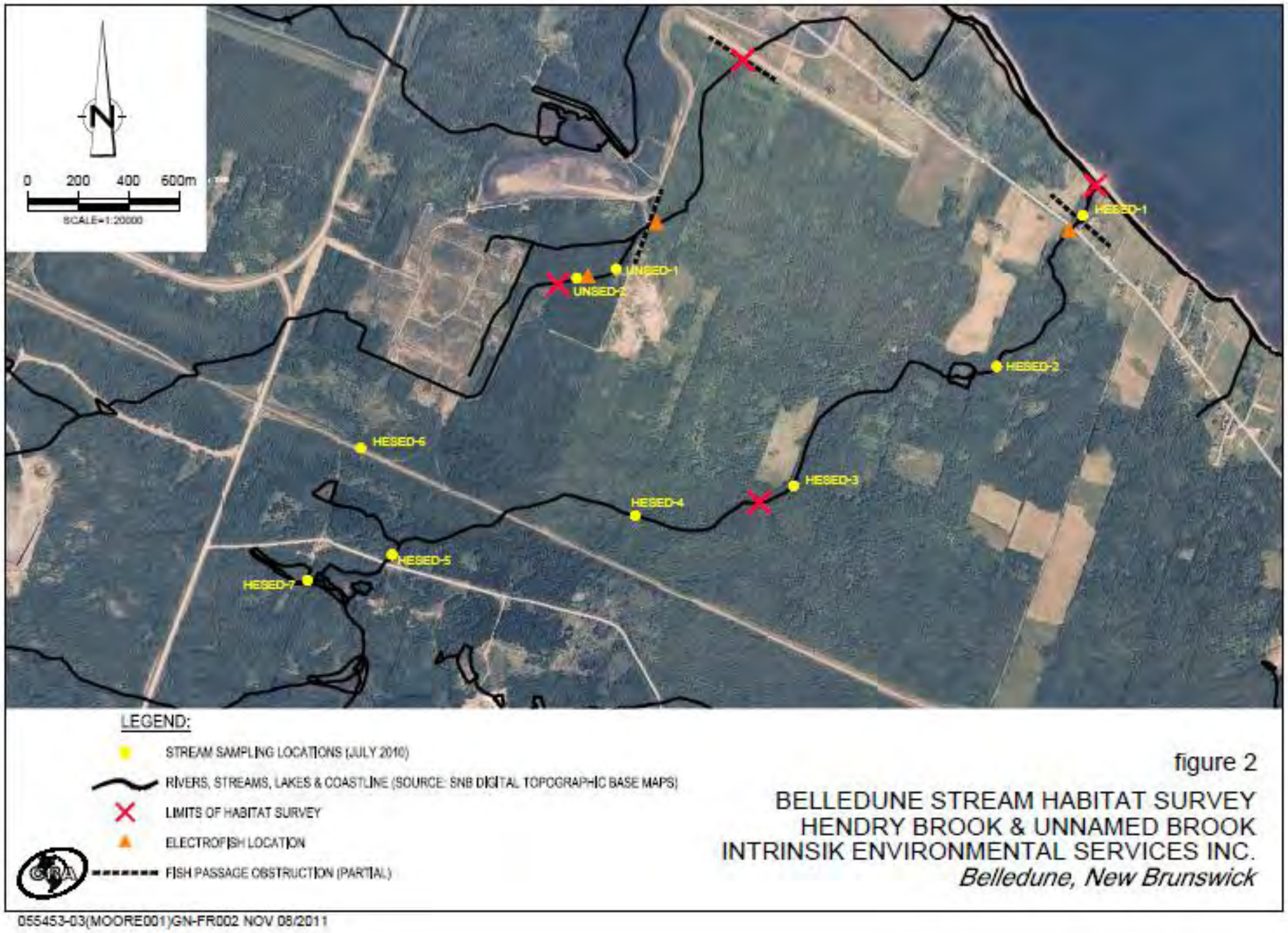


Figure 4-8 Stream Habitat and Electro-Fishing Areas for Hendry and Unnamed Brook

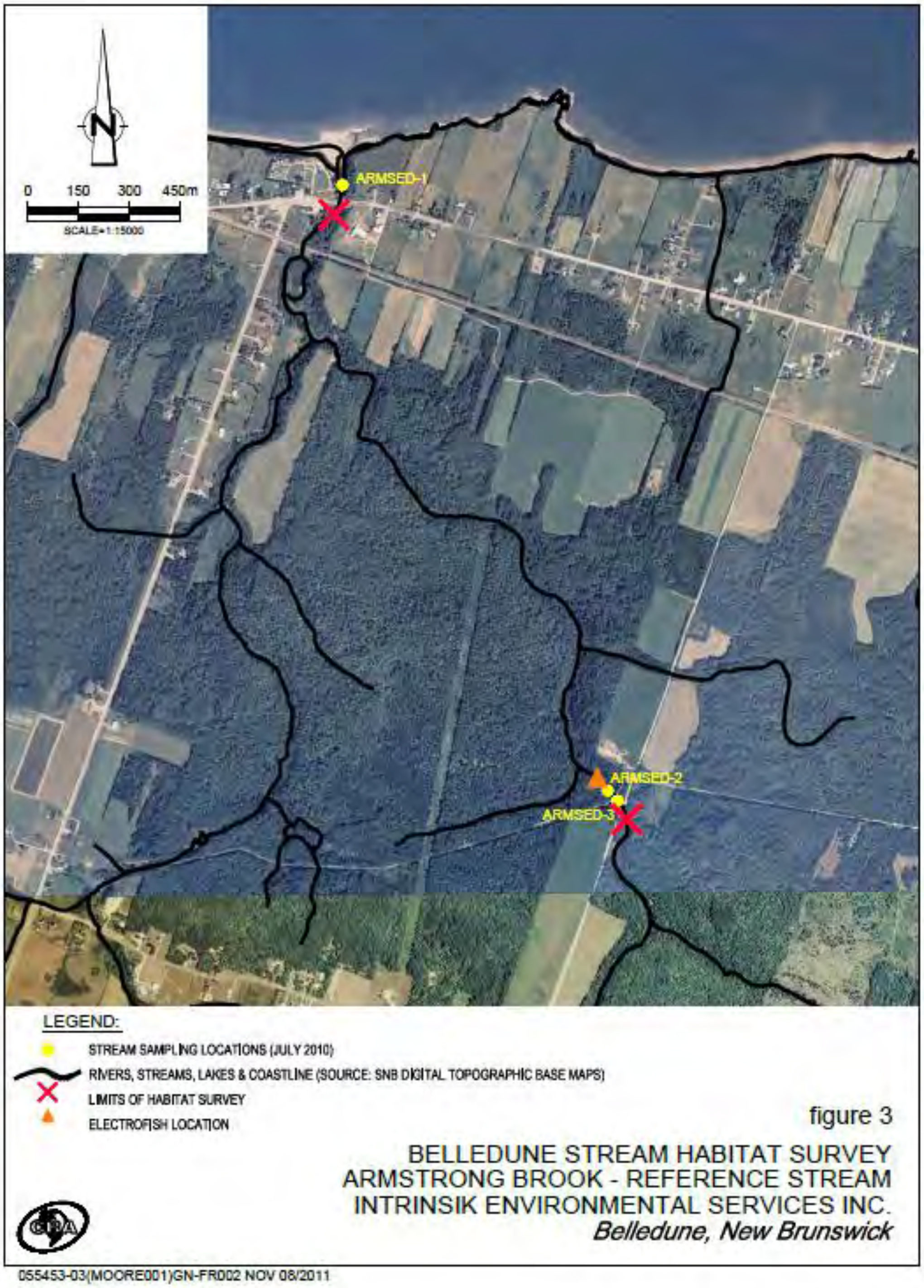


Figure 4-9 Stream Habitat and Electro-Fishing Areas for Armstrong Brook

4.2.5 Rare Plant Survey

As indicated in Section 3.1.2.3, to identify the presence of sensitive vegetation within selected habitats within the Study boundary a survey of rare vegetation in the vicinity of Hendry Brook was conducted by B & B Botanical (2011). In addition, the results of the rare terrestrial plant survey conducted in the area surrounding the smelter for Glencore by D. Peck Botanical (2007) also was used. The rare terrestrial plant survey conducted by D. Peck took place on July 16 and 17, 2007 in six areas of the Glencore woodlands at the Brunswick Smelter property in Belledune, New Brunswick. Both of these studies were considered in the risk characterization for vegetation (Section 9.2).

The survey of rare vegetation in the vicinity of Hendry Brook was conducted by B& B Botanical on August 23 and 24, 2011. The survey focused on the land 100 m along either side of the lower 2.5 km of Hendry Brook, which is just south of the Glencore's Belledune Smelter (B&B Botanical, 2011). Details of the methodology and results of this survey are provided in Appendix N.

The results of both surveys have been incorporated into the risk characterization results (Section 9.2).

5.0 ANALYTICAL CHEMISTRY RESULTS

5.1 Soil Analytical Results

Raw analytical data for the reference area and Study boundary soils are presented in Appendix D. Appendix D also presents summary tables for reference and Study boundary soils for the A layer (0 to 5 cm), B layer (5 to 15 cm) and C layer (15 to 30 cm), for sampling events conducted in 2009 and 2010. Soil pH and TOC data are also provided where applicable. Results of the soil nutrient analysis for samples collected from the reference area and within the Study boundary are presented in the Appendix P.

5.2 Freshwater Aquatic Analytical Results

Raw analytical data and summary tables for reference area stream sediment and surface water chemistry (Armstrong Brook) for 2010 and 2011 are presented in Appendix D. The 2010 and 2011 raw analytical sediment and surface water chemistry data for the two brooks within the Study boundary (*i.e.,* Hendry Brook and Unnamed Brook) are also presented in Appendix D along with summary tables.

5.3 Soil Invertebrate Analytical Results

A summary of metals chemistry data for reference area and Study boundary soil invertebrates are presented in Appendix D in addition to raw invertebrate chemistry data. Invertebrate samples were composites of species caught, and were not depurated prior to sampling and as such, may contain soil inside or adhered to their surface.

Due to low sample weights of invertebrates collected from the 17 sampling stations, samples had to be combined for tissue analysis. This resulted in a total of 6 composite samples from within the Study boundary and 2 within reference.

5.4 Small Mammal Tissue Residue Data

Summary table of reference area and Study boundary small mammal tissue residue data (*i.e.*, whole body, liver and kidney) are presented in Appendix D along with raw analytical data.

5.5 Quality Assurance of Analytical Data

5.5.1 Soil QA/QC Results

Soil chemistry data were collected from various stations in the Belledune area in July and August of 2009, with supplementary soil chemistry data collected in August of 2010, and October of 2011. All soil samples were analyzed by Maxxam Analytics in Bedford, Nova Scotia. To ensure that soil chemistry data used within the ERA are of acceptable quality, a soil data quality assurance evaluation was conducted on the soil chemistry data (Appendix E). This evaluation comprises part of a soil data quality assurance and quality control (QA/QC) program that was conducted concurrently with the soil sampling and analytical programs. The soil data QA/QC program consisted of the following activities:

- Internal laboratory QA/QC procedures and measures (including: QC standards, spiked blanks, method blanks, matrix spikes, certified reference materials (CRMs)).
- Approximately 10% of soil samples were analyzed by the primary lab (*i.e.*, Maxxam Analytics) as laboratory duplicates.
- Approximately 10% of soil samples were submitted to the primary lab (*i.e.*, Maxxam Analytics) as blind field duplicates, and analyzed by the lab as discrete soil samples.
- Approximately 10% of soil samples from the July-August 2009 sampling event were submitted to a secondary laboratory (*i.e.*, RPC Laboratories in Fredericton, NB) for analysis as inter-laboratory duplicates (N=14).
- Of the 14 samples submitted to RPC for inter-laboratory duplicate analysis, three internal laboratory duplicates were analyzed by RPC.

Both the primary and secondary laboratories used in the soil data QA/QC program have internal QA/QC requirements that must be met in order to maintain their accreditations for the analyses performed. Both Maxxam and RPC currently maintain accreditation to ISO/IEC 17025 through the Standards Council of Canada (SCC).

The outcomes of the soil data QA review are summarized as follows, along with suggested actions (if necessary) for situations where the review identified data quality issues that could affect the use of some data for assessment purposes. See Appendix E for further details.

- Maxxam internal laboratory QA/QC procedures for soil samples (QC standards, spiked blanks, method blanks and matrix spikes) produced acceptable outcomes, and none of the instances where QC limits were not met are expected to significantly impact data quality.
- RPC internal laboratory QA/QC procedures (QA/QC blanks) produced acceptable outcomes in that chemical concentrations were less than RDLs with the exceptions of tin (three blank

samples), and aluminum (one blank sample). For tin and aluminum, the measured concentrations in the blanks were only marginally above the RDL for these chemicals. Thus, the measured concentrations of these two metals in blank samples are considered to have a negligible impact on data quality, and likely reflect low level laboratory contamination.

- There was reasonably good agreement between Maxxam's CRM results and the values stipulated in the CRM certificates of analysis, which suggests no apparent issues with respect to chemical recovery, laboratory contamination and overall performance of the laboratory methods in achieving accurate and precise chemical measurements. As such, soil data quality was considered acceptable for ERA purposes, with respect to CRM recovery by Maxxam.

- RPC's performance with CRMs showed a greater frequency of excursions outside the values stipulated in the CRM certificates of analysis, relative to Maxxam's CRM performance.

- Review of the RDLs that were achieved by Maxxam in the soil analyses indicates that typical and acceptable RDLs were achieved for the majority of chemicals in all soil samples. For the samples and chemicals affected by elevated RDLs, there were no issues associated with the achieved RDL for a specific chemical in a given sample being higher than soil quality guidelines. In the laboratory certificates of analysis from Maxxam, elevated RDLs are consistently attributed to matrix interference or sample matrix.

- Review of the RDLs that were achieved in the soil samples analyzed by RPC (N=14) indicates that typical and acceptable RDLs were achieved for all chemicals.

- Comparison of the RPC to the Maxxam typical RDLs revealed some substantial differences across the chemicals measured in soil. However, it is not uncommon for different labs to vary with respect to the RDLs they can typically achieve. Although RPC is able to achieve lower RDLs than Maxxam for all chemicals, there were no major data quality issues identified with Maxxam's RDL performance. As such, the fact that these two labs have different sets of typical RDLs does not have any major impact on soil data quality.

- For all possible chemical comparisons between original soil samples and their corresponding laboratory duplicates that were analyzed by Maxxam, the RPD and ABD DQOs (primary acceptance limits) were met. Thus, it is considered that soil data quality is acceptable with respect to laboratory duplicates.

- For all possible chemical comparisons between original soil samples and their corresponding laboratory duplicates that were analyzed by RPC, the RPD and ABD DQOs (primary acceptance limits) were met. Thus, it is considered that soil data quality is acceptable with respect to internal laboratory duplicates.

- For all possible chemical comparisons between original soil samples and their corresponding field duplicates, as analyzed by Maxxam, the RPD and ABD DQOs (primary acceptance limits) were largely met. There were very few instances where the RPD and/or

ABD DQOs were not met. For all chemicals where these DQOs were not met, concentrations should be flagged as estimates if they are to be used for assessment purposes, unless rejection limits were exceeded, in which case the chemical concentrations in the affected samples should be considered for rejection. Rejection limits were not exceeded for any of the possible comparisons. Overall, it is considered that soil data quality is acceptable with respect to field duplicates.

- The outcome of the evaluation of inter-laboratory duplicates was that all Maxxam (primary laboratory) soil analytical results were considered acceptable for use in the ERA without adjustment.

5.6 Freshwater Surface Water and Sediment QA/QC Results

Sediment and water chemistry data were collected from various stations located in Hendry Brook, Unnamed Brook, and Armstrong Brook in July of 2010 and September, 2011. All water and sediment samples were analyzed by Maxxam Analytics in Bedford, Nova Scotia. To ensure that sediment and water chemistry data used within the ERA are of acceptable quality, a sediment and water data quality assurance (QA) evaluation was conducted (Appendix F). The sediment and water data QA program consisted of the following elements:

- Internal laboratory QA/QC procedures and measures (including: QC standards, spiked blanks, method blanks, matrix spikes).
- Review of reportable detection limits.
- Review of total versus dissolved chemical concentrations in water samples.
- Approximately 10% of sediment and water samples were analyzed by Maxxam Analytics as laboratory duplicates.
- Five sediment and four water samples were submitted to Maxxam Analytics as blind field duplicates and analyzed by the lab as discrete sediment and water samples.

As noted above with respect to the soil chemistry QA/QC results, Maxxam has internal QA/QC requirements that must be met in order to maintain their accreditations for the analyses performed. Maxxam currently maintains accreditation to ISO/IEC 17025 through the Standards Council of Canada (SCC).

The outcomes of the water and sediment data QA evaluation are summarized as follows. While the evaluation identified some issues related to QA/QC measures, the overall conclusion on data quality is that all data collected within the 2010 and 2011 sampling and analytical programs are considered acceptable for use in the current ERA. Any data quality issues that were identified as being potentially significant were considered during the use and interpretation of these data. See Appendix F for further details.

- The majority of chemicals analyzed for in the water and sediment QC standard samples were within QC limits. None of the instances where the QC limits were not met are considered to impact data quality, and there are considered to be no major issues with respect to chemical recovery in water or sediment samples.

- All chemicals analyzed in sediment spiked blank samples and the majority of chemicals analyzed in water spiked blank samples were within the QC limits used by Maxxam Analytics. While there were a few exceptions for the water spiked blank samples, none are considered to significantly impact data quality, and it is considered that there are no major issues apparent with respect to chemical recovery.

- The majority of chemicals analyzed in method blank water and sediment samples are <RDLs. While there were a few exceptions in water method blank samples, none are considered to have a significant impact on data quality (*i.e.*, with respect to laboratory contamination), as the detected concentrations of chemicals in the blanks were either at, or just slightly above the RDL values, in all cases.

- The majority of chemicals analyzed in matrix spike water and sediment samples are within the QC limits used by Maxxam Analytics. While there were some exceptions, none are considered to significantly impact data quality, and there are no major issues apparent with respect to sample matrix interference.

- Review of the RDLs that were achieved in the water and sediment analyses indicates that for the most part, typical and acceptable RDLs were achieved for the majority of samples. In those samples that were affected by elevated RDLs, there were no issues associated with the achieved RDL for a specific sample being higher than sediment or water quality guidelines. Overall, none of the recorded instances of elevated RDLs are considered to adversely affect data quality.

- During the review of total chemical and dissolved chemical water chemistry data, it was noted that dissolved concentrations were occasionally higher than total recoverable concentrations for a number of metals and metalloids, in a number of samples. There are a number of reasons why this can occur (See Appendix F). It is part of Maxxam's internal laboratory data quality assurance procedures to reanalyze all samples where a dissolved result exceeds a total recoverable result for the same chemical in the same parent sample. If reanalysis confirms the original results, Maxxam checks whether the sample was field or lab-filtered (if lab-filtered, Maxxam re-filters and reanalyzes). Given that there were some issues observed with matrix spikes and elevated RDLs in some water samples, it is possible that matrix interference is responsible for some of the instances where a chemical's dissolved concentration was greater than its total recoverable concentration in the same parent sample. Laboratory Certificates of Analysis (Appendix D) do not indicate that any samples were reanalyzed for dissolved chemicals, and consequently, no dissolved analytical results were flagged by Maxxam as being potentially erroneous. Thus, there is no reason to reject any samples where a dissolved chemical concentration was higher than its total recoverable concentration.

- For all possible chemical comparisons between original water and sediment samples and their corresponding laboratory duplicates, the RPD and ABD DQOs (primary acceptance limits) were met. Thus, it is considered that water and sediment data quality is acceptable with respect to laboratory duplicates.

- With respect to sediment field duplicates, of the 91 possible chemical comparisons that could be made between original and field duplicate sediment samples, there were twelve instances wherein the RPD and/or ABD DQOs were not met (12/91 or 13% total RPD and ABD DQO failures). For these instances, the sediment concentrations were flagged as an estimate if they were used for assessment purposes, unless rejection limits were exceeded, in which case the chemical concentrations in the affected samples were considered for rejection. However, no chemical comparisons between original sediment samples and their field duplicates exceeded rejection limits. Overall, it is considered that sediment data quality is acceptable with respect to field duplicates.

- With respect to water field duplicates, of the 154 possible chemical comparisons that could be made between original and field duplicate water samples, there were 23 instances wherein the RPD and/or ABD DQOs were not met (23/154 or 15% total RPD and ABD DQO failures). For all chemicals where these DQOs were not met, concentrations were flagged as estimates if they were used for assessment purposes, unless rejection limits were exceeded, in which case the chemical concentrations in the affected samples were considered for rejection. Rejection limits for RPD and ABD were exceeded in two and four instances, respectively. These instances were closely examined to determine if including the affected samples would adversely impact the data used within the ecological risk assessment (ERA) study. Upon review, it was decided to reanalyze the UNNAMED-SED-2 SURFACE WATER sample for total recoverable and dissolved chemicals, which included lead and cadmium. Another water sample - UNNAMED-SED1-SURFACE WATER, was also submitted for reanalysis, but not for data quality assurance reasons. Rather, this sample was reanalyzed to confirm an apparent elevated total and dissolved lead concentration. Quality assurance evaluation for the reanalyzed samples indicated that data are acceptable for use in the ERA. Although there was poor reproducibility for a number of chemicals in HESED-4 and its field duplicate (QA/QC-1), review of the chemistry data and internal laboratory quality control/assurance information for both samples did not reveal a need for reanalysis of either sample. Rather, it was considered likely that the differences between these two samples reflect sample heterogeneity that is not unexpected in the sampling of flowing surface water.

6.0 EXPOSURE ASSESSMENT

The exposure assessment step of an ERA involves the estimation of the amount of a given chemical(s) received by ecological receptors per unit time.

Exposure can be calculated using quantitative approaches (*e.g.,* where exposures of a specific receptor are estimated using computer models and a variety of receptor input parameters) or can be more qualitative in nature (e.g., where exposures are assumed to equal measured concentrations in environmental media). Estimating exposures using these methods likely overestimates potential exposure as it ignores an organisms' natural barriers to chemical uptake (*i.e.,* bioavailability considerations), and biochemical transformation processes that may occur within cells, tissues and organs, which may reduce the actual dose that reaches a target site within the organism.

The degree of exposure of ecological receptors to chemicals in the environment depends on the interactions of a number of parameters, including:

- The concentrations of chemicals in various environmental media (as determined by the quantities of chemicals entering the environment from various sources, their persistence, fate and behaviour in these media, and the normal ambient, or background concentrations that exist independent of a specific source).
- The physical-chemical characteristics of the chemicals of concern, which affect their environmental fate, transport, behaviour and persistence, and determine the degree or extent by which chemicals can be absorbed into the body of a receptor.
- The influence of site-specific environmental characteristics, such as geology, soil type, topography, hydrology, hydrogeology, local meteorology and climatology, *etc*., on a chemical's fate, transport and behaviour within environmental media.
- The physiological and behavioural characteristics of the receptors (*e.g.,* respiration rate, soils/dusts intake, food ingestion rates, time spent at various activities and in different areas).
- The various exposure pathways for the transfer of the chemicals from the different environmental media to receptors (*e.g.,* ingestion of food items, water, soils/dusts, *etc*.).

For those receptors assessed quantitatively using a food chain modeling approach (*i.e.,* snowshoe hare, masked shrew, ermine, deer, dark-eyed junco, ruffed grouse and saw-whet owl), applicable physiological and behavioral characteristics were identified and used in the exposure modeling (See Appendix J). Receptors assessed using a more qualitative approach (i.e., terrestrial vegetation, soil invertebrates and freshwater aquatic life) were assessed as broad groups of organisms with similar biological and ecological characteristics, and similar exposure potential. Details of the receptor characterization for modeled receptors are provided in Appendix J. This includes the specific parameters used in the exposure modeling for each receptor.

In this ERA, deterministic exposure assessment was conducted using exposure point concentrations (EPCs) of COPCs in environmental media that represent a reasonable upper bound exposure (*i.e.,* the 95th upper confidence limit on the mean or UCLM 95), where possible. Where a UCLM 95 could not be calculated (due to number of non-detectable results, for example), a 95th%ile was used.

Details regarding the exposure modelling inputs for receptors which were quantitatively modelled in the ERA are provided in Appendix J.

6.1 Exposure Scenarios

A key requirement of any ERA is the ability to evaluate changing levels of exposure under a variety of different scenarios. Exposure scenarios describe the situations and conditions in which receptors may be exposed to chemicals of concern in environmental media. In developing an exposure scenario, a variety of factors are considered including: potential for receptor access to specific areas or environmental media; behavioural patterns; home ranges; time spent in contact with environmental media while foraging, nesting, *etc*.; other potential sources of exposure to COPCs; the potential presence of sensitive receptors, *etc*. In general, while many ecological receptors may potentially be subject to the same or similar sets of exposure pathways and environmental concentrations, the magnitude of exposure experienced by a particular receptor *via* those pathways is directly influenced by the behavioural and physiological characteristics of that receptor.

As many of the receptors evaluated have small home ranges, it is highly likely that these receptors could occur predominantly within the Study boundary (*i.e*., 0 to 3 km of the smelter (where surface soil concentrations related to smelter emissions are the highest)), and could obtain most of their diet from this area most of the time. For example, the masked shrew has a home range of approximately 0.0004 km^2 (NatureServe, 2009). The female grouse has been reported to have a home range of 0.04 to 0.12 km^2 in the breeding season (Csuti *et al*., 1997; Rusch *et al*., 2000) and the average year-round home range sizes for the adult female and male snowshoe hares were 0.052 km^2 and 0.067 km^2, respectively (Keith, 1990). During the breeding season, home range size for the junco was reported to ranged from 0.0143 to 0.0389 km^2 (mean = 0.0211) for males (Chandler *et al.*, 1997) and females had a median home range size of 0.022 km^2 (Neudorf *et al.*, 2002). Based on snow tracking, Nyholm (1959) reported an average home range for the short tailed weasel (or ermine) of 0.34 km^2 for males and 0.074 km^2 for females.

The exposures scenarios evaluated included:

- <u>Background[4] (or reference area) conditions</u>: Assessed using the UCLM 95 surface soil concentration for the reference area (or 95% percentile, where a UCLM95 could not be calculated). Surface water data collected within the reference areas were also assessed in this scenario, as were ambient air data that is representative of rural locations in Canada (UCLM 95 concentrations were utilized for both water and air data, where possible).

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[4] All of the chemicals considered in the ERA are found within the normal ambient environment, independent of their presence in emissions from the smelter, either from natural sources or other sources related to human activities. Assessment of a background scenario provides a benchmark of comparison such that the likelihood of potential risks arising from exposures to the chemicals of potential concern in the Study boundary can be directly compared to exposures occurring in a non-impacted area. For the background scenario, the same chemicals, receptors, exposure pathways, and parameters that are assessed in the Study boundary were evaluated.

- Study boundary conditions: Assessed using the UCLM 95 surface soil concentration for sample locations within 0 km to 3 km from the smelter (*i.e.*, the Study boundary), where possible. Surface water data and ambient air monitoring data collected within the Study boundary were also assessed in this scenario (UCLM 95 concentrations were utilized for both water and air data, where possible).

  A total of four sub-scenarios were evaluated within this scenario based on various distances from the Glencore smelter. It should be noted that water and ambient air concentrations were held constant in each sub-scenario as the water and air COPC concentrations were considered equally applicable at any distance from the smelter, within the Study boundary. Only soil concentrations changed based on distance from the smelter site. These Study boundary sub-scenarios were as follows:

    - 0 to 3 km radius from smelter (assessed using UCLM 95 of 2009 soil data collected within the 0 to 3 km radius).
    - 0 to 1 km radius from smelter (assessed using UCLM 95 of 2009 and 2010 soil data collected within the 0 to 1 km radius).
    - 1 to 2 km radius from smelter (assessed using the UCLM 95 of 2009 and 2010 soil data collected within the 1 to 2 km radius).
    - 2 to 3 km radius from smelter (assessed using the UCLM 95 of 2009 soil data collected within the 2 to 3 km radius).

6.2 Calculation of Exposure Point Concentrations for COPCs

Figures 6-1 to 6-6 present the surface soil data for antimony, arsenic, cadmium, lead, thallium and zinc from the 2009 and 2010 sampling programs, within the ERA Study boundary. These data were used to calculate the exposure point concentrations for the various receptors being considered in the ERA. The CCME ecological-based soil quality guidelines, or the detection limit for the metal (when no CCME guideline is available), is used as a benchmark of comparison in these figures, to provide some perspective on where soil levels would be considered elevated, and therefore requiring further assessment, within the Study boundary.

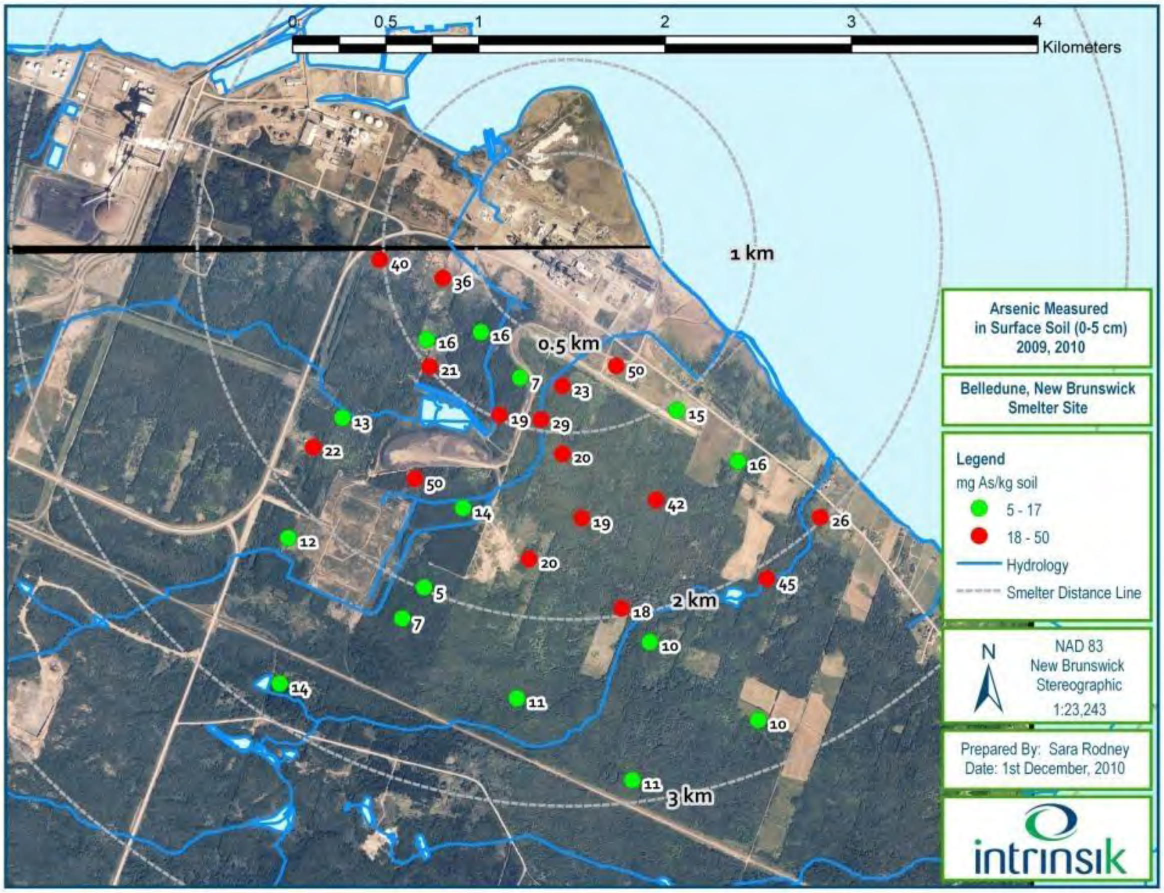

Figure 6-1 Surface Soil Concentrations of Arsenic in the ERA Study Boundary (0 – 3 km from facility)

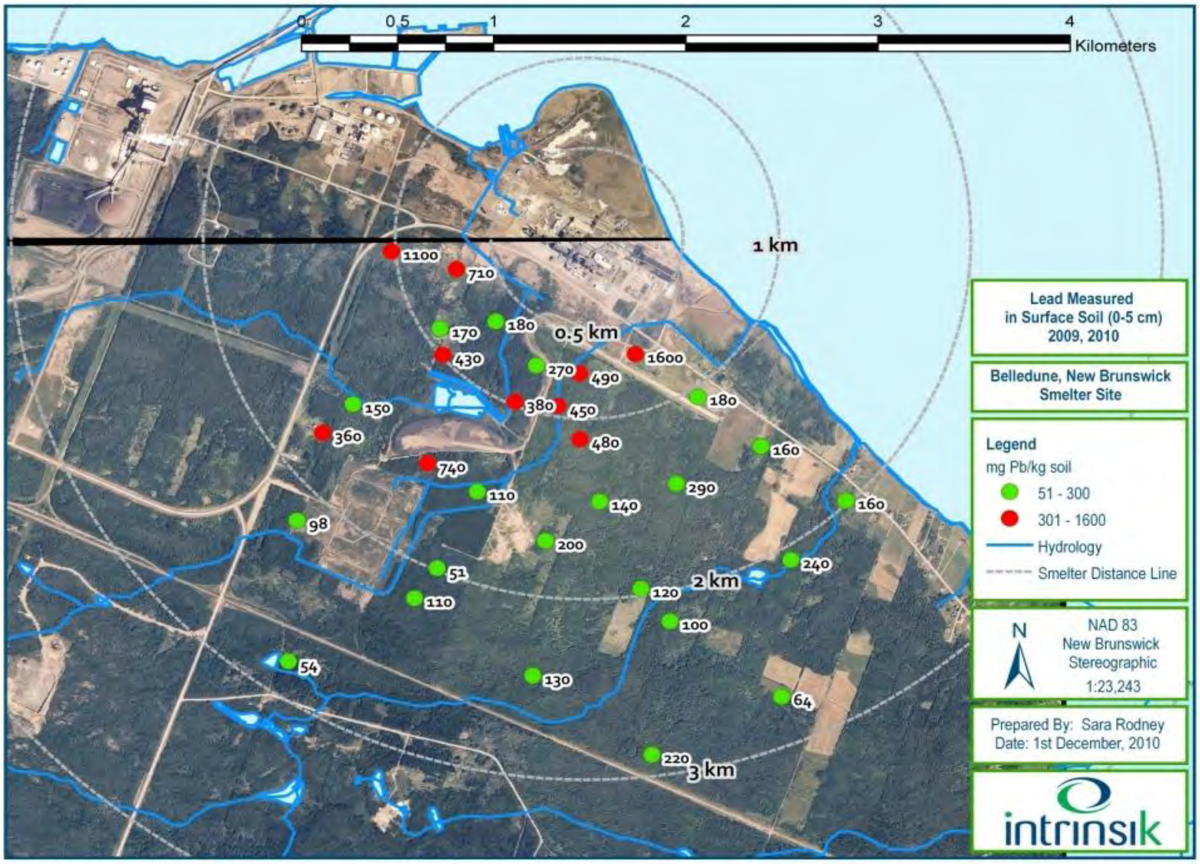

Figure 6-2 Surface Soil Concentrations of Lead in the ERA Study Boundary (0 – 3 km from facility)

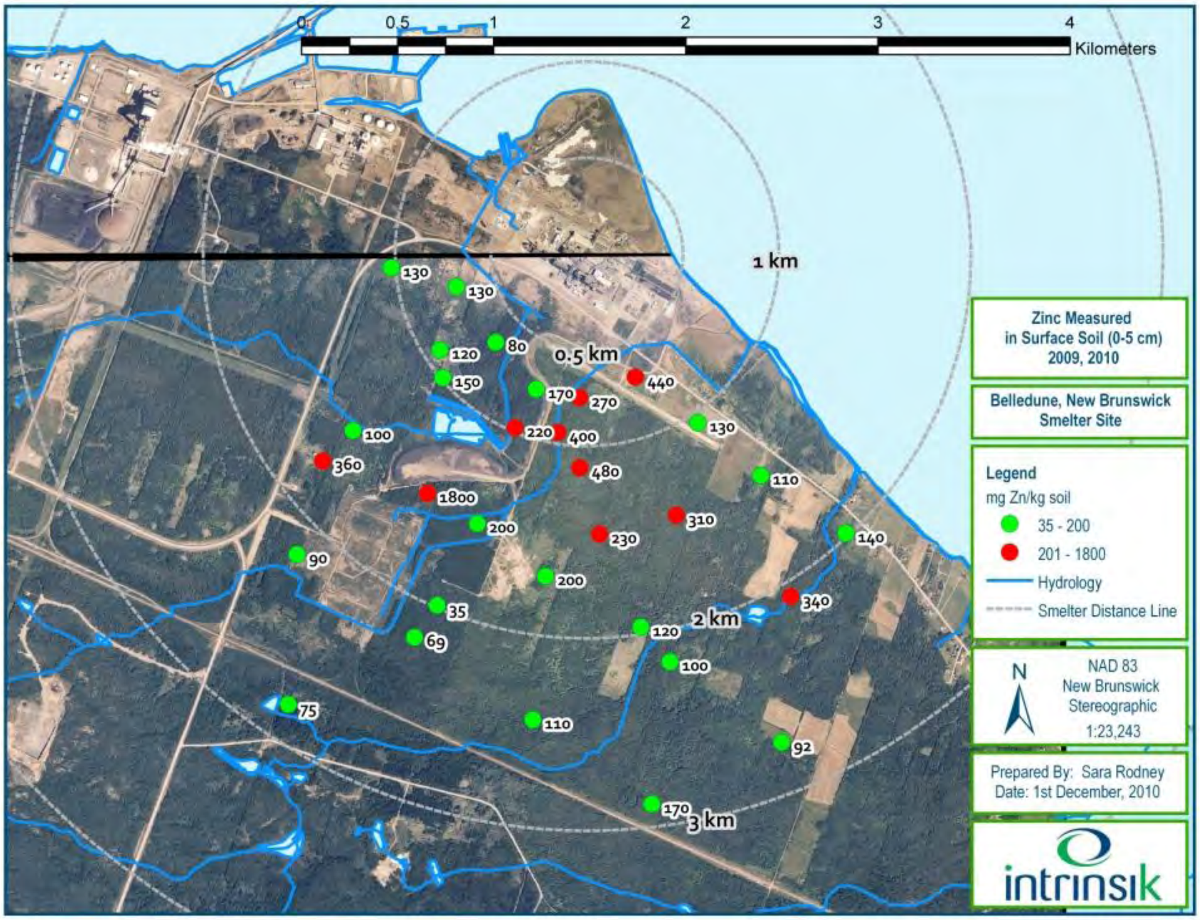

Figure 6-3 Surface Soil Concentrations of Zinc in the ERA Study Boundary (0 – 3 km from facility)

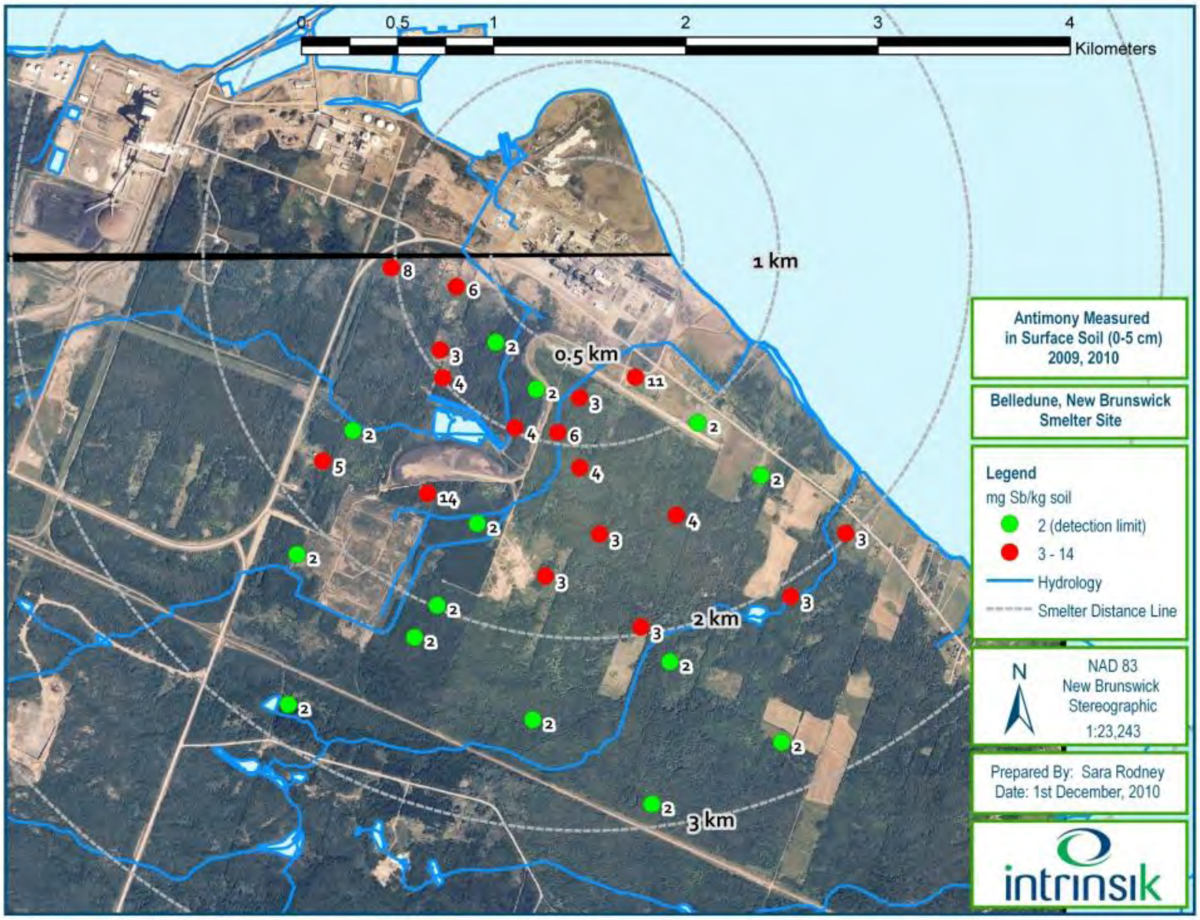

Figure 6-4 Surface Soil Concentrations of Antimony in the ERA Study Boundary (0 – 3 km from facility)

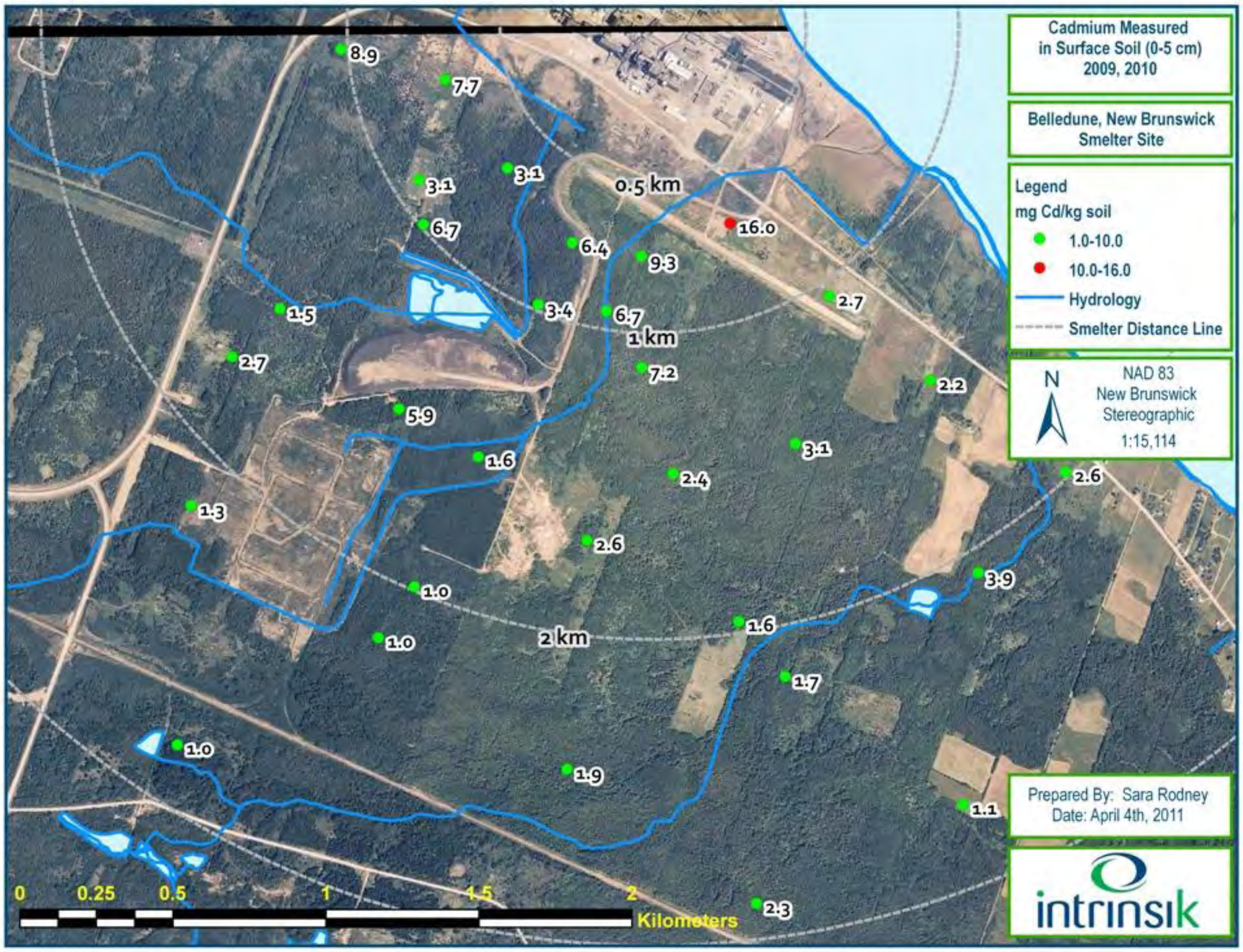

Figure 6-5 Surface Soil Concentrations of Cadmium in the ERA Study Boundary (0 – 3 km from facility)

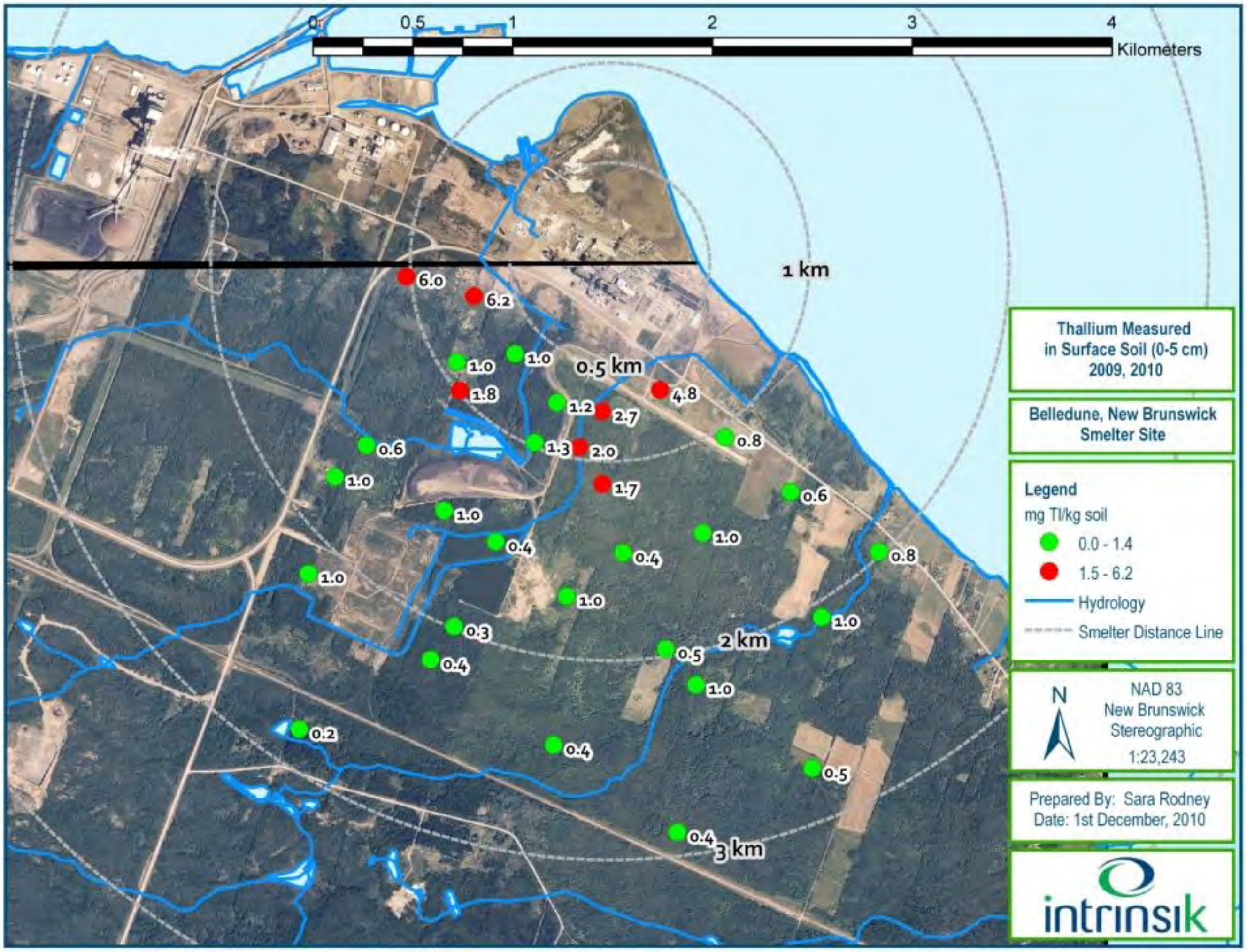

Figure 6-6 Surface Soil Concentrations of Thallium in the ERA Study Boundary (0 – 3 km from facility)

Varying approaches were taken to estimate EPCs for different receptor groups, because of differences in size of the various receptors' home ranges, the differences in habitat availability and utilization, and differences in the quantity of data, and level of ecological risk assessment effort directed at the different receptor groups. Details are provided in the following paragraphs.

Terrestrial vegetation, soil invertebrates and soil microorganisms: 95% upper confidence limit on the mean (UCLM 95) A layer soil concentrations (0-5 cm depth) in the reference area and within the ERA Study boundary were assumed to equal terrestrial vegetation and soil organism exposures. These concentrations were then used for the reference area and soil data comparisons to assess potential risks to vegetation, soil invertebrates and soil microorganisms. Where soil concentrations from 0 to 5 cm, 5 to 15 cm and 15 to 30 cm were available, the depth containing the greatest concentration was used in the assessment which was generally the A layer (0 to 5 cm). For any samples where the B (5 to 15 cm) or C layer (15 to 30 cm) COPC concentrations were highest, those concentrations were used. In all biomes (or ecosystems), the top 30 cm of soil contains most of the root density and as such, the top 30 cm is considered a good default estimate for the depth of plant root exposure to contaminants in soils. This depth is also considered to be reasonable for soil invertebrates and soil microbial communities (Suter II, 2007).

To estimate vegetation exposures to SO_2, ambient air monitoring data in the vicinity of the facility were used (*i.e.,* Chalmers and Boulay ambient air monitors; see location of monitors in Figure 6-7). These two ambient air monitoring stations are the most relevant to the ERA Study Boundary as they are located to the east of the facility and the predominant winds blow from the west. As these monitors are located at the eastern edge of the boundary, they do not capture exposures in the immediate near-field of the facility (Figure 6-7). Data from 2007 to 2009 were obtained from Glencore and reviewed. For the assessment, data from 2007 and 2009 were considered acceptable for use in the assessment, but data from 2008 were not considered, as there were insufficient valid data points available to calculate annual averages (a value of 0.0 $\mu g/m^3$ SO_2 was considered an invalid datum point). The Ontario Air Quality Report (OMOE, 2010) suggests that to create a valid annual average at least 6570 (or 75%) of the hourly ambient air quality measurements of the possible total of 8,760 measurements are valid data. Annual averages and 24-hour average data for the Boulay and Chalmers ambient air monitors were calculated using that data. To calculate the 24-hour averages, the sum of all the readings between midnight and 11:59 pm were calculated and divided by 24. The annual average was calculated by adding the 24-hour averages and dividing them by 365. Within the 2007 and 2009 datasets, any data points with a value of 0.0 $\mu g/m^3$ were assumed to equal 0.1 $\mu g/m^3$ in the average calculations.

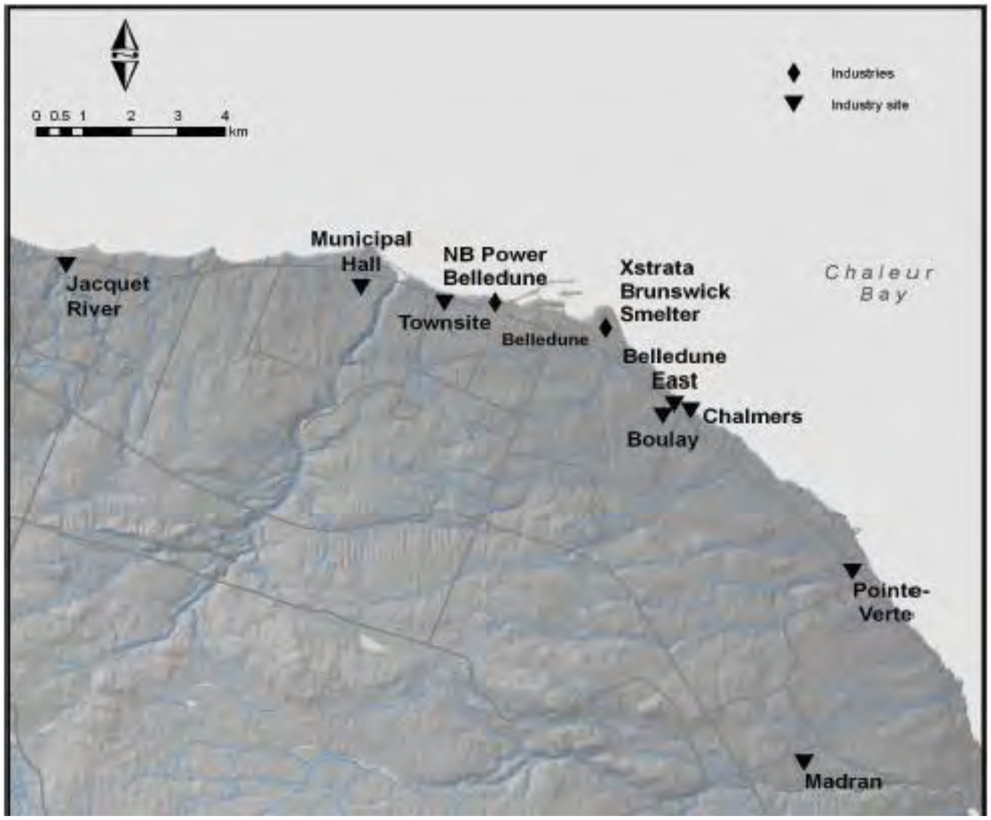

Figure 6-7 Air Quality Monitoring Sites in the Belledune Network (NB DOE 2010)

Mammals and birds: The UCLM 95 A layer soil concentrations in the reference area and within the ERA Study boundary were used to assess exposure via soil ingestion to mammals and birds. Where soil concentrations from 0 to 5 cm, 5 to 15 cm and 15 to 30 cm were available, the depth containing the greatest concentration was used in the assessment (this was generally the A layer). COPC concentrations in food sources, such as vegetation, soil invertebrates and prey (*i.e*., small mammals) were estimated using trophic transfer models and measured soil concentrations (*e.g.,* Sample *et al.,* 1998; U.S. EPA, 2005a). See Appendix J, Attachment J-1 for additional information.

The UCLM 95 surface water concentrations of COPCs within the reference area and ERA Study boundary were used to characterize potential exposures from drinking water. Total recoverable concentrations of COPCs were used over dissolved concentrations as the bioavailability considerations regarding aquatic biota and dissolved versus total recoverable concentrations (See Appendix J for discussion of this topic) are not relevant to the ingestion of water by mammals and birds.

In the ERA Study boundary scenario, UCLM 95 COPC air concentrations from ambient air monitoring data collected in the vicinity of the Glencore smelter (*i.e*., Boulay and Chalmers monitors) were used to estimate COPC air inhalation exposure for mammalian and avian receptors, and to estimate deposition of the COPCs onto vegetation within the Study boundary (See Appendix J, Attachment J-1). For the reference area scenario, local ambient air monitoring data do not exist. Thus, rural ambient air concentrations from National Air Pollution Surveillance (NAPS) Program stations at various locations in Canada from 2005 to 2010 were used as surrogate data for possible background air concentrations of COPCs (data provided by Tom Dann, Environment Canada, Environmental Technology Centre, Personal Communication). For reference area air concentrations of COPCs, it was not possible to calculate a 95th percentile or UCLM 95 (as data were provided in a summarized form, rather than as raw data). Rather, the air exposure point concentration used in the background exposure modelling for the UCLM 95 and 95th percentile were respectively the average of the 90th percentiles and 95th percentiles for each station.

Details regarding the data (including EPCs), assumptions and parameters used in the exposure assessments of mammalian and avian receptors are provided in Appendix J.

Freshwater Aquatic Life: It was assumed that COPC exposures incurred by aquatic life were equal to the measured concentrations within the Study boundary and reference area surface water and sediment samples. This is a common assumption in aquatic ERAs. This is also a conservative assumption that overestimates potential exposure, as it ignores the various factors that influence bioavailability of COPCs, and the biochemical transformation processes that may occur within cells, tissues and organs, which may reduce the actual dose that reaches a target site within the organism. With respect to surface water data, both total recoverable chemical and dissolved chemical water chemistry data were collected. The rationale for collecting both types of data for ERA purposes is described and discussed in Appendix C.

7.0 EFFECTS ASSESSMENT

In the effects assessment (also referred to as the hazard or toxicity assessment), the potential for a chemical to produce an adverse effect on the receptors is examined. The toxicity of a chemical depends on the amount of chemical taken into the body (referred to as the 'dose') and the duration of exposure (*i.e.,* the length of time the receptor is exposed to the chemical). For every chemical, there is a dose and duration of exposure necessary to produce a toxic effect in each receptor (this is referred to as the 'dose-response relationship' of a chemical). In the toxicity assessment, information relating to the dose-response relationships of each chemical is evaluated (usually from laboratory or captive animal studies) in order to determine a chemical dose equivalent to an acceptable exposure level for the receptors selected for evaluation. These values are called toxicity reference values (TRV) and they are species-specific and chemical-specific estimates of an exposure level that is not likely to cause unacceptable adverse effects on growth, reproduction, or survival. The identification of TRVs for each receptor evaluated, for each chemical of potential concern, is the major outcome of the hazard assessment in an ERA.

TRVs can be dose-based (expressed at mg/kg/day) which are usually used to evaluate risks via wildlife ingestion pathways. TRVs can be concentration based which are expressed in mg/unit medium (e.g., mg/L water; mg/kg soil). Concentration based TRVs are generally used for receptors that have direct contact with the exposure medium (e.g., fish in water; vegetation in soil). The third type of TRVs is tissue-based TRVs. These are expressed in units of mg/kg tissue in the exposed receptor (U.S. EPA Region 8, 2011).

7.1 Terrestrial Soil-Dwelling Invertebrates, Microbes and Vegetation Toxicity Reference Values

7.1.1 Soil Toxicity Reference Values

For some terrestrial receptor groups, such as terrestrial plants, terrestrial invertebrates and soil microorganisms, few TRVs exist *per se*. Thus, for these receptor groups, soil quality guidelines and other soil quality benchmarks that considered these types of organisms in their derivation, were used (*e.g*., CCME soil quality guidelines, U.S. EPA Eco-SSLs, Oak Ridge National Laboratory benchmarks, *etc*.). These soil quality guidelines are generally screening level soil contact values, or no effect or 20% effect concentrations of metals, all of which should be protective of assessment endpoints for plants and soil invertebrates. The toxicity data which forms the basis of these guidelines are variable, and sometimes difficult to confirm (due to lack of documentation provided by the regulatory body), and therefore may not be directly applicable to the site-specific nature of this ERA (*e.g*., spinach or lettuce toxicity data may be used to derive a guideline, as opposed to black spruce or poplar). Nonetheless, these guidelines are valid "first-step" preliminary screening tools for the assessment of risk to plants and soil invertebrates.

To evaluate the potential for ecological risks to terrestrial vegetation, soil invertebrates and soil microorganisms, surface soil concentrations within the Study boundary, as well as reference area soil concentrations, were compared to vegetation-specific and soil invertebrate/soil microbial process–specific soil quality guidelines (Table 7-1). Some of these values may differ from the benchmarks used in COPC selection process (See Appendix G), as this process generally used the lowest of the environmental soil quality guidelines derived for various exposure pathways and ecological receptors.

The hierarchies used to select vegetation-specific and soil invertebrate/soil microorganism-specific soil quality guidelines are presented in Table 7-1. CCME guidelines were preferentially used as these guidelines are in current use across Canada. If no CCME guideline was available, a U.S. EPA ecological soil screening level (EcoSSL) was used. If no U.S. EPA ecological soil screening level (EcoSSL) was available, then a Alberta Environment (2009a) Tier 1 remediation guideline was used, followed by soil toxicity benchmarks developed by Oak Ridge National Laboratory (*i.e.*, Efroymson *et al*., 1997a,b). If it was not possible to determine whether the basis of a soil quality benchmark developed by these jurisdictions was plant, invertebrate or microbial effects, then such guidelines were not selected.

The vegetation-specific and soil invertebrate/soil microorganism-specific soil quality guidelines are presented in Table 7-2.

Table 7-1 Hierarchies Used to Select Vegetation-Specific and Soil Invertebrate / Soil Microbial Process- Specific Soil Quality Guidelines

Receptor	Selected 1st	Selected 2nd	Selected 3rd
Vegetation	CCME soil contact guidelines for residential / parkland land use (CCME, 1997; 1999a,b,c,d,e; 2011).	Current U.S. EPA EcoSSLs for plants (http://www.epa.gov/ecotox/ecossl/index.html)	Efroymson *et al*., (1997b); screening benchmarks for terrestrial plants
Soil Invertebrates / Soil Microorganisms	CCME soil contact and nutrient and energy cycling guidelines for residential / parkland land use (used the lower of the 2 guidelines where both were available) (CCME, 1997; 1999a,b,c,d,e; 2011).	Current U.S. EPA EcoSSLs for invertebrates (http://www.epa.gov/ecotox/ecossl/index.html)	Efroymson *et al*., (1997a); screening benchmarks for soil invertebrates, soil microorganisms and microbial processes

Table 7-2 Vegetation and Soil Invertebrate / Soil Microorganism Health-Based Soil Quality Guidelines

COPC	**Vegetation Health-Based Soil Quality Guideline (mg/kg)**	**Soil Invertebrate / Soil Microorganism Health-Based Soil Quality Guidelines (mg/kg)**
Antimony	5[b]	78[d]
Arsenic	17 [a]	60 / 100 [c, e]
Cadmium	10 [a]	140 [d] / 54 [h]
Lead	300 [a]	1700 [d] / 723 [f]
Thallium	1.4 [a]	NGA
Zinc	200 [a]	120 [d] / 100 [g]

a. CCME Soil contact guidelines for Residential / Parkland land use (CCME, 2011 on-line; CCME, 1999a; 1997).

b. Efroymson *et al*. (1997b) screening benchmark for the phytotoxicity of chemicals in soils.

c. CCME Soil contact guidelines for Residential/Parkland land for arsenic, lead and zinc were based on vegetation health end points (CCME, 1999b,c,e). As such, these guidelines were not used. Rather guidelines applicable to soil invertebrates / soil microbial processes were used for comparison purposes where available (e.g., nutrient and energy cycling).

d. U.S. EPA (2005b,e; 2007b) Ecological Soil Screening Level for soil invertebrates. Geometric mean of soil invertebrate toxicity data (EC_{10} and maximum acceptable tolerable concentration MATC) (http://www.epa.gov/ecotox/ecossl/index.html).

e. Efroymson *et al*. (1997a); screening benchmarks for toxicity of chemicals to earthworms / soil microorganisms and soil microbial processes.

f. The CCME (1999a) derived a nutrient and energy cycling guideline for lead of 723 mg/kg (residential / parkland land use). Efroymson *et al*. (1997a) derived a screening benchmark for toxicity to soil micro-organisms and soil microbial processes of 900 mg/kg. The lower of these 2 values (723 mg/kg) was used for comparison purposes.

g. The CCME (1999) derived a nutrient and energy cycling guideline for zinc of 200 mg/kg (residential / parkland land use). Efroymson *et al*. (1997a) derived a screening benchmark for toxicity to soil micro-organisms and soil microbial processes of 100 mg/kg. The lower of these 2 values (100 mg/kg) was used for comparison purposes

h. CCME (1999a) nutrient and energy cycling guideline (residential / parkland land use).

7.1.2 Air Toxicity Reference Values

Sulphur dioxide is emitted from the Glencore smelter and vegetation is the most sensitive receptor group to this COPC. Uptake of SO_2 in vegetation occurs primarily through the stomata, although there is a limited pathway through the cuticle. The rate of uptake is a complicated process; it is highly dependent on the properties of the plant and the external environment. For example, external factors (*e.g.*, humidity, temperature and light intensity) control the opening of the stomata and thereby influence the rate of uptake of SO_2. When the stomata are closed, resistance to gas uptake is very high, and susceptibility to injury is low. Lower plants, which lack a cuticle or stoma (*i.e.,* mosses and lichens), are extremely sensitive to SO_2 when they are metabolically active, as they are continuously exposed to pollutants (WHO, 2000).

Exposures to high concentrations of SO_2, even for short periods, can produce acute injury in the form of foliar necrosis. In the field, however, acute effects are much less important than chronic injury (*e.g.,* reduced growth and yield and increased senescence) caused by long-term exposure to lower concentrations of SO_2 (WHO, 2000). SO_2 exposure can also modify the response of plants to biotic and abiotic stresses, often exacerbating their adverse impacts (WHO, 2000; Adaros *et al*., 1991a,b; Ashmore *et al*., 1988; Mooi, 1984). There is evidence that concurrent exposure to SO_2, and ozone (O_3), and/or nitrogen dioxide (NO_2) at concentrations near their critical levels can produce markedly increased adverse impacts under some circumstances (WHO, 2000). It has also been shown that the interaction of low-temperature stress with low concentrations of SO_2 can lead to increased damage (Makela *et al*., 1987).

To evaluate the potential for effects on terrestrial vegetation as a result of SO_2 emissions from the Glencore facility, SO_2 air monitoring data in the vicinity of the facility (*i.e.,* Chalmers and Boulay ambient air monitors) were reviewed and compared to a variety of air quality guidelines derived to be protective of vegetation. A brief discussion of some of the identified benchmarks is provided in the following paragraphs.

The World Health Organization (WHO) reviewed the effects of SO_2 on vegetation and identified available standards and critical levels (WHO, 2000). However, limited information was provided by the WHO regarding the basis of these values and how they were derived. Regardless, these standards and critical levels have been presented in this ERA given that limited Canadian or American SO_2 air quality guidelines for the protection of vegetation were identified.

The WHO (2000) reported air quality guidelines for SO_2 set by the International Union of Forest Research Organizations (IUFRO) for the protection of trees. While these standards were reported as current IUFRO standards, the WHO recognized that these values have not been revised since the early 1980s (WHO, 2000). The maximum level of SO_2 identified by the IUFRO[5] that allows for full

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[5] The WHO (2000) also reported IUFRO air quality standards for sulphur dioxide that offer "full protection and environmental protection". Environmental protection was indicated to be "protection against erosion and avalanches and to ensure full production in regions of mountains, boreal zones, extreme sites, *etc*.", and as such, was not considered relevant for this assessment.

protection at most sites were reported to be: 50 µg/m^3 (annual average) and 100 µg/m^3 (24-hour average) (Wentzel, 1983). The WHO (2000) also reported sulphur dioxide guidelines set by the European Union (EU) at 40 - 60 µg/m^3 (annual average) and 100-150 µg/m^3 (24 hour) (European Commission, 1980).

In 1992, the United Nations Economic Commission for Europe (UNECE) set annual mean critical levels of 30 µg/m^3 SO_2 for the protection of agricultural crops, 20 µg/m^3 for the protection of forests and natural vegetation, and 10 µg/m^3 for the protection of lichens. A critical level of 15 µg/m^3 was set for natural vegetation and forests in areas of low temperatures (Ashmore and Wilson, 1994). The most recent WHO European annual average guideline identified for SO_2 for the protection of terrestrial vegetation is 10 to 30 µg/m^3 (WHO, 2000).

Limited ambient air quality benchmarks, set to protect against acute effects on vegetation, were identified in the literature reviewed. The Ontario Ministry of the Environment derived a SO_2 air quality criteria benchmark that is protective of both human health and vegetation (OMOE, 2008). The OMOE (2008) criteria are as follows: 55 µg/m^3 SO_2 (annual average); 275 µg/m^3 SO_2 (24-hour average) and 690 µg/m^3 SO_2 (1-hour average). The specific basis of these guidelines and how they were derived were not identified in the supporting documentation from this agency. The U.S. EPA derived a 3-hour average benchmark of 0.50 ppm (1230 µg/m^3) based on protection of acute foliar injury. The FPACAQ (Federal-Provincial Advisory Committee on Air Quality or FPACAQ, 1987) reported an acute toxic effect on forests following exposure to air concentrations of 2470 µg/m^3 SO2 over a 1 hour period and an acute toxic effect in pines at concentrations as low as 78 µg/m^3 over a 1 hour period.

A summary of the SO_2 air quality benchmarks that are protective of vegetation, and which were used in the current assessment are provided in Table 7-3.

Table 7-3 Vegetation Health-Based Air Quality Benchmarks for Sulphur Dioxide (SO2)

	SO_2 Benchmark (µg/m^3)	
Organization	***24-hour***	***Annual Average***
WHO Guideline (2000)	100	30[b]
IUFRO Standard[c]	100[d]	50
EU Standard	100-150	40-60
UNECE Critical Level	NA[a]	30[e] 20 (15)[f] 10[g]
OMOE (2008) [h]	275	55
Alberta Environment	150[i]	30[j]
	Short Term Benchmarks	
OMOE (2008) (1-hour benchmark)[h]	690	
U.S. EPA (2008) (3-hour benchmark)	1430[k]	

Notes:

WHO = World Health Organization; IUFRO = International Union of Forest Research organizations; EU = European Union; UNECE = United Nations Economic Commission for Europe; OMOE = Ontario Ministry of the Environment; NA = not available. All guidelines were obtained from WHO (2000).

a. UNECE (1988) recommended the 24-hour guideline be abandoned due to evidence showing peak concentrations are insignificant when compared with the accumulated dose.
b. This value should not be exceeded as a mean concentration for October to March, inclusive.
c. Maximum level of SO_2 that allows for full production at most sites.
d. The 24-hour average may be exceeded 12 times in a period of 6 months.
e. Annual mean to protect agricultural crops.
f. Annual mean to protect forests and natural vegetation (critical level in areas of low temperature).
g. Annual mean to protect certain lichen species.
h. Limiting effect for guideline is reported to be health (human) and vegetation (OMOE, 2008). Insufficient documentation is provided to determine whether a vegetation-specific guideline would be greater or less than this guideline.
i. Air quality objective basis reported to be begonia, bluegrass, aspen and forests (Alberta Environment, 2009b).
j. Air quality objective basis reported to be natural forests, lichens (Alberta Environment, 2009b).
k. US EPA (2008); 3-hour average of 0.5 ppm for SO_2 based on protection of acute foliar injury. This standard is to be averaged over three hours and not to be exceeded more than once per year. This value was originally derived in 1971. Based on their current review of the available scientific literature, the US EPA decided to retain this value as the secondary standard for SO_2. The U.S. EPA (2008) reported that there is no clear evidence of acute foliar injury at concentrations less than this standard (3-hour average). Three-hour average, given as 0.50 ppm was converted to a value of 1430 µg/m^3 (using a conversion factor of 1 ppm = 2860 µg/m^3; in WHO, 2000). It is conservative to compare the 3-hour guideline to 1-hour average concentrations (as 1-hour average concentration would be greater than 3-hour averages).

7.2 Terrestrial Mammalian and Avian Wildlife Toxicity Reference Values

For terrestrial and avian wildlife receptors that were quantitatively evaluated, toxicity reference values (TRV) were selected. Given the lack of TRVs derived by Canadian regulatory bodies, the mammalian and avian TRVs developed by the U.S. EPA (*i.e.*, from the risk-based ecological soil screening levels or Eco-SSLs) were preferentially chosen for use in this assessment. These TRVs represent a numerical estimate of a no-observable-adverse-effect level (NOAEL) primarily for growth, reproduction and survival endpoints (for details on how these TRVs were developed, please refer to U.S. EPA, 2007c). The U.S. EPA (2007c) specifically defined these TRVs as:

"Doses above which ecologically relevant effects (growth, reproduction or survival) might occur to wildlife species following chronic dietary exposure, and below which it is reasonably expected that such effects will not occur."

The U.S. EPA TRVs are based either on a geometric mean of NOAELs for reproduction and growth effects in a variety of species or, if the geometric mean of NOAELs exceeds the lowest bounded LOAEL, the TRV is based on the highest bounded NOAEL that is lower than the lowest bounded LOAEL. The term "bounded" refers to the fact that there is both a NOAEL and LOAEL from the same study. These TRVs are expected to provide a conservative estimate of potential risks given they are based on a no-effect rather than a low-effect level. Given that these TRVs are NOAEL-based, exceedances over these values do not necessarily indicate the potential for adverse effects. However, they provide an initial starting point for the evaluation of potential risks to receptors.

Where no U.S. EPA TRV was available, other regulatory agency-derived TRVs were selected.

Recently published papers recommend against using NOAELs or LOAELs to derive TRVs (*e.g.*, Allard et al., 2010). Rather, than using results from a single study, a meta-analysis approach is recommended. While it is agreed that using a meta-analysis approach is preferred over one study, data are often limited (or so old the entire data set cannot be accessed), particularly with respect to avian toxicity, and the derivation of TRVs using this approach is often challenging or not possible. While the TRVs were generally derived from one study, consideration has been given to all the available toxicity data and the limitations of the data are recognized.

The TRVs selected for the assessment of terrestrial and mammalian wildlife receptors that underwent quantitative evaluation in the ERA are provided in Table 7-4.

Table 7-4 NOAEL Based Toxicity Reference Values (TRVs) for Terrestrial Mammalian and Avian Ecological Receptors

COPC	Receptor	TRV (mg/kg/day)	Comment	Reference
Antimony	Ruffed grouse Dark-eyed junco Northern saw-whet owl	None available	Potential risks to these receptors will be discussed based on results of other species and available site data.	Not applicable
	Snowshoe Hare Masked shrew Ermine White tailed deer	0.059	Highest bounded NOAEL below the lowest bounded LOAEL reported in EcoSSL document	U.S. EPA, 2005b
Arsenic	Ruffed grouse Dark-eyed junco Northern saw-whet owl	2.24	Lowest reported NOAEL in EcoSSL document for reproduction, growth or survival	U.S. EPA, 2005c
	Snowshoe Hare Masked shrew Ermine White tailed deer	1.04	Highest bounded NOAEL below the lowest bounded LOAEL reported in EcoSSL document	
Cadmium	Dark eyed junco Ruffed grouse Northern saw-whet owl	1.47	Geometric mean of NOAELS for reproduction and growth reported in EcoSSL document	U.S. EPA, 2005d
	Masked shrew Snowshoe hare Ermine White tailed deer	0.77	Highest bounded NOAEL below the lowest bounded LOAEL for reproduction, growth, or survival reported in EcoSSL document	
Lead	Ruffed grouse Dark-eyed junco Northern saw-whet owl	1.63	Highest bounded NOAEL below the lowest bounded LOAEL for reproduction, growth, or survival reported in EcoSSL document	U.S. EPA, 2005e
	Snowshoe Hare Masked shrew Ermine White tailed deer	4.7	Highest bounded NOAEL below the lowest bounded LOAEL for reproduction, growth, or survival reported in EcoSSL document	
Thallium	Dark eyed junco Ruffed grouse Northern saw-whet owl	None available	Potential risks to these receptors will be discussed based on results of other species and available site data.	U.S. Army Centre for Health Promotion and Preventative Medicine, 2007
	Masked shrew Snowshoe hare Ermine White tailed deer	0.015	NOAEL-based TRV derived by the US Army Centre for Health Promotion and Preventative Medicine (2007) based on available data. Low confidence in these TRVs due to limited toxicity data.	
Zinc	Ruffed grouse Dark-eyed junco Northern saw-whet owl	66.1	Geometric mean of NOAELs for reproduction and growth reported in EcoSSL document	U.S. EPA, 2007b
	Snowshoe Hare Masked shrew Ermine White tailed deer	75.4	Geometric mean of NOAELs for reproduction and growth reported in EcoSSL document	

In the event that unacceptable numeric risk is calculated in the risk characterization (i.e., total exposures > NOAEL based TRV; see below), then lowest observed effects-based TRVs were used in a second iteration of calculating numeric risk. Effect or LOAEL-based TRVs were selected using the best available data and one of the following approaches:

- U.S. EPA geometric mean of the bounded LOAELs in the U.S. EPA Eco SSL document databases for each specific COPC. Where possible, toxicity data from the most closely related species taxonomically, or toxicity data from species with a similar gut physiology, were used to derive the effects-based TRV (*e.g.*, rodent data for rodents; ruminant data for ruminants).
    - For mammals: if the toxicity data were from similar species (*e.g.*, rodent data to compare with other rodents, ruminants compared with ruminants) no uncertainty factor was applied to the effects based data to derive the TRV (as recommended by BC MELP, 1998). However, if mammals were not so closely related[6] or if the species had a completely different gut physiology, a 3-fold uncertainty factor was generally applied to the geometric mean of the LOAEL in calculating the TRV.
    - For birds: no uncertainty factor was applied for species differences as data do not generally suggest a large difference in acute chemical sensitivity between birds[7]. Little data exist on the differences in avian chemical sensitivity on a chronic basis.
    - The lowest bounded LOAEL (for growth, reproduction and/or survival) identified in the U.S. EPA Eco SSL documents (and other relevant literature where available). If the chemical form (for the test compound) of the lowest LOAEL was not applicable to this ERA, the lowest LOAEL that is based on a relevant chemical form was selected. Whether an uncertainty factor was applied to the lowest LOAEL was dependent upon a variety of factors including, amount of available toxicity data, potential for differences in species sensitivity, exposure route of study).
    - An EC20 (derived by the U.S. EPA, 2001a).

LOAEL-based TRVs for terrestrial mammalian and avian ecological receptors which had NOAEL-based ERs greater than 1.0 are provided in Table 7-5.

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[6] Although the BC MELP (1998) recommends the application of a 10-fold uncertainty factor if species are not so closely related, they do not define what is meant by “closely related” (Golder Associates, 2006). Others recommend no uncertainty factor be applied when extrapolating between small mammals since they have similar gut physiology, even though they represent herbivores, omnivores and carnivores (A. Fairbrother, U.S. EPA, Personal Communication). As there is no specific national guidance on extrapolation of toxicity data for small mammals, and there are differences in approaches between regulatory agencies, the current ERA considered that if small mammals were not “closely related” (*e.g.*, from the same class but different orders), a 3-fold uncertainty factor was applied to the toxicity data.

[7] For example, although dose-scaling based on body weight is no longer recommended, a scaling factor of 1 was used for many years (that is, the same TRV was used for all birds; for example see Sample *et al*., 1996). As such, no uncertainty factors were applied to the TRVs derived for avian species to account for differences in species sensitivity to the chemical being evaluated. This assumption is based on acute toxicity data and as such there is uncertainty applying this to chronic toxicity data. However, there are limited relevant chronic toxicity data for avian species to determine a better scaling factor.

Table 7-5 LOAEL-Based TRVs for Terrestrial Mammalian and Avian Ecological Receptors which had ER NOAELs Greater than 1.0

COPC	Receptor	TRV (mg/kg/day)	Comment	Reference
Antimony	Masked shrew	0.59	No shrew antimony toxicity data, relevant for TRV derivation, was identified in the literature reviewed. One bounded reproductive LOAEL and 2 bounded growth LOAELs for mammalian species (rodents: rats and mice) were reported in the US EPA Ecological Screening Level for antimony document (U.S. EPA, 2005b). Of the 3 bounded LOAELs reported by the U.S. EPA (2005b), the reproductive LOAEL (based on antimony trichloride) was almost 2 orders of magnitude lower than the two growth LOAELs (based on antimony potassium tartrate). Given the limited toxicity data available for antimony, the lowest LOAEL of 0.59 mg/kg/day was selected as the TRV for the masked shrew. Even though the available antimony toxicity data were based on rodents (*i.e.*, rats and mice) and rodents are from a different taxonomic order than the shrew, no uncertainty factor was applied to the lowest LOAEL to derive the TRV. The study used to derive the TRV (in addition to the other 2 bounded LOAEL studies) were drinking water studies where the bioavailability of the antimony would be greater than in soils and in diet (as is relevant at this site).	U.S. EPA, 2005b

COPC	Receptor	TRV (mg/kg/day)	Comment	Reference
Cadmium	Dark-eyed Junco	2.37	No dark eyed junco cadmium toxicity data were identified in the literature reviewed. Two toxicity studies were identified in the US EPA Eco SSL document for cadmium that reported LOAELS for the starling *(Sturnus vulgaris)*. These LOAELs were for biochemical and pathological endpoints, which are generally not considered as relevant as reproduction, growth and survival in an ERA. However, as the dark eyed junco is a passerine bird, the starling toxicity data were considered in the derivation of the dark eyed junco TRV. Several bounded avian LOAELS were reported in the US EPA EcoSSL document for cadmium (i.e., 5 reproductive studies; 6 growth and 3 survival). Toxicity data were mainly conducted on chicken, duck and quail. The bounded avian reproductive LOAELs ranged from 2.37 to 21.1 mg/kg/day. The bounded growth LOAELs ranged from 7.08 to 37.6 mg/kg/day and survival from 14.3 to 44.6 mg/kg/day. In the starling toxicity studies, LOAELs for biochemical and pathological effects was reported at 7.21 mg/kg/day (Pilastro et al., 1993) and 13.8 mg/kg/day (Congiu et al., 2000). As the lowest LOAEL for biochemical effects in the starling (7.21mg/kg/day) was above the lowest reproductive LOAEL in chickens and ducks (2.37 mg/kg/day), it is likely that reproductive effects in the dark eyed junco would occur at concentrations higher than the lowest reproductive LOAEL reported for chickens and ducks. However, given the limited toxicity data available the lowest bounded reproductive LOAEL of 2.37 mg/kg/day was selected for the junco TRV.	U.S. EPA, 2005d
Cadmium	Masked Shrew	2.28	Limited toxicity effects data were identified in the literature reviewed for the shrew. An unbounded growth LOAEL of 103 mg/kg/day for the common shrew (*Sorex araneus*) was reported by Dodds-Smith et al. (1992) following dietary exposure of cadmium chloride. No other LOAEL data for the shrew was reported in the literature reviewed. The lowest reported bounded LOAEL for reproduction, growth or survival via the food ingestion route (the most relevant exposure route for this assessment; the gavage route would over estimate exposures in the wild and as such, was not selected) was 2.28 mg/kg/day from a study in mice fed cadmium chloride (Sawicka-Kapusta et al., 1994). This value is much lower than the only reported LOAEL for shrew (103 mg/kg/day for effects on growth). This value was selected as the LOAEL-based TRV for the masked shrew. No uncertainty factor was applied to this value as it was the lowest LOAEL identified and was much lower than the one unbounded LOAEL for the shrew identified in the literature reviewed.	US EPA, 2005d

COPC	Receptor	TRV (mg/kg/day)	Comment	Reference
Lead	Ruffed grouse Dark-eyed junco Northern saw-whet owl	9.9	Five bounded reproductive LOAELs for avian species were identified in the U.S. EPA Ecological Screening Level for lead document (U.S. EPA, 2005e). Three of these LOAELs were low (at 1.94; 3.26 and 4.04 mg/kg/day) while the two other LOAELs were much higher (126 and 135 mg/kg/day). All of these LOAELs were derived from dietary studies on chicken or quail by exposing them to lead acetate or lead oxide. The two lowest LOAELs (1.94 and 3.26 mg/kg/day) were from the same study from which the U.S. EPA (2001a) derived an EC20 (Edens and Garlich, 1983). In this study, lead acetate was given to domestic leghorn chicken hens and to Japanese quail hens. The study concluded that quail were more sensitive than chickens. U.S. EPA (2001a) estimated an EC20 of 9.9 mg/kg/d from the chicken reproductive data, because a dose-response model would not fit the quail data. The EC20 of 9.9 mg/kg/day was selected as the LOAEL-based TRV for avian receptors in this assessment. While this EC20 is slightly above the range of the three lowest avian LOAELs for lead reported in the U.S. EPA EcoSSL document (2005e), it is much lower than the 2 LOAELs that reported higher concentrations.	U.S. EPA, 2005e
Lead	Masked shrew	35	No bounded shrew toxicity data were identified in the literature reviewed. An unbounded LOAEL of 61.5 mg/kg/day, for effects on growth and survival following exposure via food in the common shrew (Pankakoski *et al.*, 1994 in U.S. EPA, 2005e) was identified in the literature reviewed. This common shrew study was considered in the masked shrew TRV derivation. Twenty-two bounded reproductive LOAELs for mammalian species were identified in the U.S. EPA Ecological Screening Level for Lead document (U.S. EPA, 2005e). A geometric mean of 106 mg/kg/day was calculated using the 22 reported bounded reproductive LOAELs. Since studies from which the bounded LOAELs were obtained, were conducted with rodents (*i.e.*, 19 rat studies and 3 mice studies), a 3-fold uncertainty factor was applied to the geometric mean to account for differences in species sensitivity to lead (106/3 =35 mg/kg/day) to derive the TRV for the masked shrew (rodents and shrews are all from different taxonomic orders although their gut physiology is similar). While an unbounded LOAEL was identified in the literature reviewed for the shrew (61.5 mg/kg/day; Pankakoski *et al.*, 1994) this study's endpoints were growth and survival. Given this study is unbounded and given the severity of the potential effect (*i.e.*, survival), the derived TRV of 35 mg/kg/day was considered most appropriate to use for the masked shrew TRV.	

COPC	Receptor	TRV (mg/kg/day)	Comment	Reference
Thallium	Ruffed grouse Dark-eyed junco Northern saw-whet owl		No thallium toxicity data.	
	Snowshoe Hare Masked Shrew Ermine White-tailed Deer	0.075	LOAEL-based TRV derived by the U.S. Army Centre for Health Promotion and Preventative Medicine (2007). The Army Centre had low confidence in these TRVs due to a paucity of toxicity data.	U.S. Army Centre for Health Promotion and Preventative Medicine, 2007
Zinc	Dark-eyed junco	77	Six bounded reproductive LOAELs for avian species were reported in the U.S. EPA Ecological Screening Level for Zinc document (U.S. EPA, 2007b). One of these LOAELs was based on a chemical form not relevant to this ERA (*i.e.*, zinc acetate) and this LOAEL was excluded from further consideration. The geometric mean of the five other bounded reproductive LOAELs is 96 mg/kg/day. Given the limited number of bounded reproductive LOAELs and given all of these LOAELs were from dietary exposure of chickens to zinc oxide or zinc sulfate, the lowest bounded LOAEL was selected for assessment. The lowest bounded reproductive LOAEL for zinc identified by the U.S. EPA (2007b) is 76.7 mg/kg/day (rounded to 77 mg/kg/day) (Stevenson *et al*., 1987). No uncertainty factor was applied to this LOAEL to derive the TRV. This LOAEL is less than the U.S. EPA (2001a) EC20 of 135 mg/kg/day derived from a chicken reproduction study (Stahl *et al*., 1990).	U.S. EPA, 2007b

COPC	Receptor	TRV (mg/kg/day)	Comment	Reference
Zinc	Masked Shrew	94.2	No shrew toxicity data, relevant for the derivation of a TRV were derived in the literature reviewed. Six bounded reproductive LOAELs for mammalian species were identified in the U.S. EPA Ecological Screening Level for Zinc document (U.S. EPA, 2007b). There was a wide range in these LOAELs (75.9 mg/kg/day to 4927 mg/kg/day). The geometric mean of the bounded reproductive LOAELs is 745 mg/kg/day. The lowest bounded reproductive LOAEL (75.9 mg/kg/day) was for reproductive effects in cattle (Miller *et al*., 1989). As cattle are ruminants, this LOAEL is not applicable for the shrew (as the shrew is non-ruminant and gut physiology is an important aspect of oral toxicity). The next lowest LOAEL was 82.3 mg/kg/day for reproductive effects in pigs (Hill *et al*., 1983). While pigs are non-ruminant, they are in the same order (*i.e.*, Artiodactyla) as deer, cattle, sheep and goats, which are ruminants. Given the shrew is non-ruminant, pig data were assumed to not be representative of shrew toxicity. The next highest bounded reproductive LOAEL was 452 mg/kg/day (where rats were exposed to zinc oxide in their diet; Ketcheson *et al*., 1969). This value is greater than the U.S. EPA (2001a) EC20 for zinc of 94.2 mg/kg/day based on reproductive effects in rats. The more conservative EC20 of 94.2 mg/kg/day was selected as the LOAEL-based TRV for the masked shrew.	U.S. EPA, 2007b

7.3 Aquatic Life Toxicity Reference Values

In aquatic ERAs, water and sediment quality guideline values and/or other conservative toxicity benchmarks set to be protective of aquatic life, are commonly used as the TRVs.

In this assessment, for pelagic freshwater species, concentrations of COPCs (expressed as total metals) from surface water samples collected within the Study boundary were compared to the current CCME (2007) Freshwater Aquatic Life guidelines, some of which are unchanged from CCREM (1987). If no CCME or CCREM guideline was available for a given COPC, then freshwater aquatic guidelines from the British Columbia Ministry of Environment (2006) and/or other jurisdictions were used, as necessary. The dissolved COPC surface water data from within the Study boundary were compared to U.S. EPA (2011) water quality criteria. If these water quality guidelines were exceeded to a substantial degree and frequency by Study boundary surface water concentrations of COPCs, then aquatic toxicity data from the scientific literature (including species sensitivity distributions presented in U.S. EPA, 2005f and from online toxicity databases, such as the U.S. EPA ECOTOX database (http://cfpub.epa.gov/ecotox/index.html) were compiled and reviewed to provide additional perspective on the potential for adverse effects in pelagic aquatic life from water bodies within the Study boundary.

For benthic species, concentrations of COPCs from sediment samples collected within the Study boundary were compared to the most current freshwater sediment quality guidelines from CCME (2007), MOE (2008) and to the Frequent Effects Concentration (FEC) values from Environnement Canada et ministere du Developpement durable, de l'Environnement et des Parcs du Quebec (2007).

Specific toxicity reference values used in the aquatic ERA are provided in Tables 7-6 and 7-7.

Table 7-6 Freshwater Water Quality Benchmarks

Metals	**Surface Water Quality Benchmarks**	
	Total	**Dissolved**
Lead (Pb)	Hardness-dependent[a]	Hardness-dependent; [CMC: 26.1-252]; [CCC: 1.02-9.82][c]
Manganese (Mn)	Hardness-dependent[b]	NBA

Notes: NBA = no benchmark available.

a. CCME; http://ceqg-rcqe.ccme.ca/. The lead freshwater aquatic life water quality guideline is hardness-dependent. The CCME guideline values for lead at different hardness ranges are as follows: 1 µg/L at hardness of 0-60 mg/L (as $CaCO_3$); 2 µg/L at hardness of 60-120 mg/L (as $CaCO_3$); 4 µg/L at hardness of 120-180 mg/L (as $CaCO_3$); 7 µg/L at hardness of >180 mg/L (as $CaCO_3$). Hardness in Unnamed and Hendry brooks ranges from 44 to 360 mg/L. Thus, the applicable guideline value ranged from 1 to 7 µg/L across Study boundary surface water samples. Only two samples exceeded their respective sample-specific lead water quality guideline values.

b. BC MOE (http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html) acute freshwater water quality guideline. The chronic guideline value from BC MOE is not used as it is only applicable to 5 weekly samples collected over 30 days. The manganese water quality guideline value is hardness-dependent and is estimated using the following equation: Mn WQG (µg/L) = ((0.01102*hardness, in mg/L)+0.54)*1000). Using this equation and the hardness data for each Study boundary surface water sample, the range of sample-specific Mn water quality guideline values was 1025 to 4507 µg/L. Only one sample exceeded its respective sample-specific manganese water quality guideline value.

c. U.S. EPA (2011). Current National Recommended Water Quality Criteria (expressed as dissolved metal in the water column). CMC = criterion maximum concentration. CCC = criterion continuous concentration. The dissolved water quality criteria for lead is hardness-dependent and are estimated using the equations for CMC and CCC provided in U.S. EPA (2011).

Table 7-7 Sediment Quality Benchmarks

Metals	**Freshwater Sediment Quality Benchmarks**		
	SQB – PEL[a]	**SQB – SEL**[b]	**SQB –FEL**[c]
Arsenic	17	33	23
Barium	NBA	NBA	NBA
Cadmium	3.5	10	12
Iron	NBA	40,000	NBA
Lead	91.3	250	150
Lithium	NBA	NBA	NBA
Thallium	NBA	NBA	NBA
Tin	NBA	NBA	NBA
Vanadium	NBA	NBA	NBA
Zinc	315	820	770

Notes: NBA = no benchmark available. SQB = sediment quality benchmark.

a CCME (http://ceqg-rcqe.ccme.ca/?config=ccme&thesite=ceqg&words=&image.x=12&image.y=10). Probable Effect Levels (PELs).

b MOE (2008) Severe Effect Levels (SELs).

c Environnement Canada et Ministere du Developpement durable, de l'Environnement et des Parcs du Quebec (2007) Frequent Effects Levels (FELs).

7.4 Amphibian Toxicity Reference Values

TRVs *per se* are not available for amphibians. In addition, few soil or other environmental quality benchmarks exist specifically for these species. Given the data limitations (which also include a paucity of relevant toxicity data), amphibians were qualitatively assessed in this ERA and as such, no specific TRVs were selected for these receptors.

8.0 RISK CHARACTERIZATION

Risk characterization uses information obtained from the exposure and effects assessment, in addition to other lines of evidence, to estimate the likelihood for adverse ecological effects. It is comprised of many steps, including but not limited to:

- Conduct a relevance check to determine if measurement endpoints are congruent with study objectives (if not, adjust as necessary);
- Interpret/evaluate each Line of Evidence (LOE)
- Prepare and compile data prior to application of the detailed analyses;
- Integrate results using a Weight of Evidence (WOE) framework;
- Integrate ERA Uncertainties; and
- Summarize the overall risk conclusions.

This risk characterization was conducted using a WOE approach (See Figure 8-1), defined in the recent FCSAP ERA guidance document as, "any process used to aggregate information from different lines of scientific evidence to render a conclusion regarding the probability and/or magnitude of harm" (Azimuth, 2012). WOE evaluations can range from best professional judgment to complex quantitative methods (Azimuth, 2012).

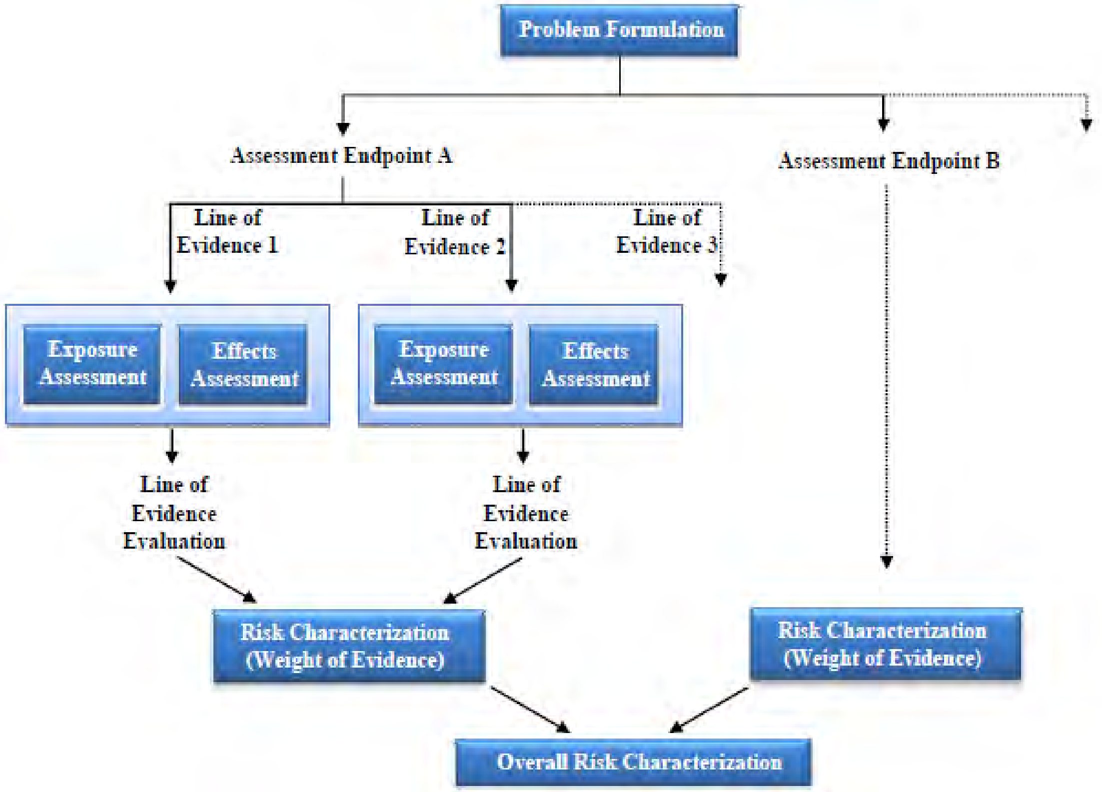

Figure 8-1 A Weight of Evidence Approach to ERA (from Azimuth, 2012)

As discussed in Section 3.6 (Table 3-2), a number of LOE were used in the ERA including:

- Traditional calculation of exposure ratios (ER) (also called Hazard Quotients or HQs) from food chain modelling (*i.e.,* comparison of estimated COPC exposures via all exposure pathways to toxicity reference values (TRVs) (For derivation of ERs See Section 8.1)
- Outcomes of the comparison of surface soil, surface water, sediment and SO_2 air concentrations to relevant TRVs (*i.e.,* health-based soil, water, sediment and air quality benchmarks) for the receptor being evaluated and to reference area concentrations;
- Results of soil invertebrate pitfall trap sampling and analysis;
- Results of vegetation health survey and soil nutrient analysis;
- Outcomes of the small mammal study;
- Results of tissue residue data for small mammals and data obtained from tissue effects literature;
- Outcomes of the breeding bird survey (including identification of possible, probable and confirmed breeding status) and fledgling survey (nest, egg and/or fledgling counts);
- Results of the aquatic habitat survey within Hendry Brook and Unnamed Brook;
- Results of the electrofishing effort in Hendry and Unnamed Brook; and
- Consideration of toxicological / biological information from other studies conducted on smelting and mining sites and extrapolation where applicable to this ERA.

Once all lines of evidence were examined, a final ranking of risk potential was selected for each receptor based on the criteria provided in Table 8-1.

Table 8-1 Definitions of Risk Potential

Receptor	**Risk Potential**			
	Negligible	**Low**	**Moderate**	**High**
Vegetation	No effect on individuals expected	Possible effect on some individuals expected, but effects on communities unlikely	Potential adverse effect on individuals; effect on the local community possible, but a self-sustaining, persistent, local community is expected to remain	Potential adverse effect on, and possible loss of, the local community
Soil invertebrates and soil microorganisms				
Freshwater aquatic life and amphibians				
Freshwater Fish	No effect on individuals expected	Possible effect on some individuals expected, but effects on populations unlikely	Potential adverse effect on individuals; effect on the local population possible, but a self-sustaining, persistent, local population is expected to remain	Potential adverse effect on, and possible loss of, the local population
Herbivorous, insectivorous and carnivorous avian species				
Herbivorous, insectivorous and carnivorous mammals				
Sensitive Species	No effect on individuals expected	Possible effect on some individuals expected, but effects are not considered adverse (e.g., biochemical changes) or measurable	Possible effect on the individual but effects are short-term, reversible and are not expected to affect reproduction or survival	Likely effect on the reproduction or survival of the individual

Notes: Specific assessment and measurements used in determining risk potential are provided in Table 3-2.

Uncertainties and limitations in the assessment are also important factors in the risk characterization, and a discussion of these are presented in Section 10 and Appendix Q.

8.1 Methods to Calculate Exposure Ratios (ERs)

Exposure Ratios (ERs) are often used as the first line of evidence in an ERA. ERs, which are also called HQs (Hazard Quotients), compare the total estimated exposure for each chemical of potential concern, to the appropriate TRV. For all receptors quantitatively modelled in this study, ER values were derived using the following equation:

$$\text{Exposure Ratio (ER)} = \frac{\text{Estimated Exposure}}{\text{TRV}}$$

Consistent with standard ERA practice, a critical ER of 1.0 was selected for this ERA (as all relevant exposure pathways were assessed). If the calculated ER was less than 1.0, no adverse effects were predicted and acceptable risk is the conclusion of the assessment. If the calculated ER exceeded 1.0, it does not necessarily indicate that there were potential unacceptable risks; in these cases the assumptions and data used in the assessment were reviewed in addition to all the other lines of evidence prior to determining whether there was a potential for unacceptable risk for a particular receptor/COPC and whether further assessment was required.

For those receptors that did not undergo quantitative exposure modelling (*i.e.,* terrestrial vegetation, soil invertebrates and microorganisms, freshwater aquatic life), risk characterization was based on the degree and/or frequency of exceedance of measured media concentrations over the identified benchmarks and reference media concentrations in addition to other relevant lines of evidence.

9.0 RESULTS AND DISCUSSION

The risk characterizations of the various receptor groups evaluated are presented in this section for both the reference and Study boundary scenarios. Risk characterization was conducted for each receptor group, using a WOE approach. For all receptor groups, a relevance check was conducted and determined that all measurement endpoints were congruent with study objectives.

As several metals are essential nutrients, there are a number of considerations when interpreting the ERA results which are briefly discussed in Section 9.1. The results of the ERA for vegetation are presented in Section 9.2, while soil invertebrates/soil microorganism results are presented in Section 9.3. In Section 9.4 and 9.5, respectively, results for the avian and terrestrial receptors are provided. Results for the aquatic receptors are presented in Section 9.6 and Section 9.7 provides a discussion of sensitive species.

9.1 Considerations When Interpreting Metals ERA Results

Metals risk assessment is different from the risk assessment of other chemicals, as many metals are essential for the normal development of plants and animals (U.S. EPA, 2007a).

Copper, manganese, molybdenum, nickel and zinc for example, have been reported to be essential minerals for both vegetation and animals (U.S. EPA, 2007a). Arsenic is not considered an essential mineral for higher animals, but some research suggests that in ultra trace amounts, arsenic may offer some beneficial function, at least in some species (NAS, 2005; U.S. EPA, 2007a). Vanadium is beneficial but not known to be essential in animals while antimony and lead are examples of metals considered non-essential and not known to be beneficial (U.S. EPA, 2007a).

In addition, terrestrial and aquatic organisms have evolved mechanisms to regulate both essential and non-essential metals (U.S. EPA, 2007a; Chapman, 2008). For many essential metals, uptake, metabolism and excretion are physiologically regulated such that extreme exposures are generally necessary in order to overwhelm internal compensatory mechanisms and allow toxicity to occur. Furthermore, when taken up within an organism, many metals (essential and non-essential) may bind to proteins, such as metallothionein, or precipitate into insoluble metal-rich granules, and can essentially be detoxified (Campbell *et al.*, 2006).

There are large differences in the accumulation of metals by various plant species, although it is unclear why this is so (Suter, 2007). However, in general, the uptake of metals varies much more among plants than animal species (Suter, 2007).

Populations chronically exposed to elevated metals concentrations often exhibit increased tolerance compared to reference area populations (Klerks and Weis, 1987; Klerks and Levinton, 1993). For example, within a single generation, populations of metal tolerant plants can emerge (Antonovics *et al.*, 1971; U.S. EPA, 2007a). Fairbrother and Kapustka (1997) observed that nutritional requirements of essential minerals in plants are generally one order of magnitude less than the average crustal concentration, while phytotoxic levels are generally one order of magnitude greater. This is thought to be due to physiological acclimation and genetic adaptation (Newman and Clements, 2008). Adaptation is a genetic process, beyond one individual's lifespan, where tolerance is passed (through gene selection) to subsequent generations and may occur without metabolic costs (ICMM, 2007). Heritable genetic adaptations by animals, plants and bacteria can result if concentrations of metals are sufficiently elevated (Chapman, 2008). Acclimation involves a shift in tolerance (or other responses such as an increased reproduction rate) by adjusting physiological or biochemical mechanisms within an individual's lifespan (but does not involve cross-generational changes) and may have metabolic costs associated (ICMM, 2007; Chapman, 2008). Acclimation and adaptation apply to both laboratory populations as well as populations in the field where there was a shift to either higher or lower metal tolerance (ICMM, 2007). Fitness of the individual may improve through adaptation/acclimation processes. However, if adaptation or acclimation to metals has metabolic costs for the population or individual, then fitness can decrease if other metabolic processes or other functions are reduced or compromised (ICMM, 2007). Reduced genetic variation may also be seen in populations that inhabit areas of metals enrichment (ICMM, 2007). For example, in a study from an area having elevated arsenic concentrations (due to natural and anthropogenic sources) in Yellowknife, NWT, arsenobetaine was the primary arsenic species detected in grey jays and spruce grouse (Koch *et al*., 2005). The authors indicated these birds were highly adapted to arsenic compared to other terrestrial organisms since arsenobetaine is not normally found or retained by terrestrial species. The authors reported that adaptation was likely a consequence of the elevated concentrations of arsenic in the Yellowknife area (Koch *et al*., 2005).

Another factor to consider, in interpreting ERA results is bioaccessibility of metals from both soil and food sources. While the application of bioaccessibility data in ERAs is not commonplace, there is growing consensus that the general default assumption that all metals bound to soils are 100% bioavailable is overly conservative. The use of bioaccessibility data for lead and arsenic in ecological risk assessments of waterfowl and mammals has been recently published (*e.g*., Furman *et al*, 2006; Ollson *et al*., 2009; Saunders et al., 2011). Ollson *et al.,* (2009) found that accounting for arsenic bioaccessibility in an ecological risk assessment of deer mice living on mine tailings resulted in an order of magnitude reduction in calculated risks. This study also found that exposure assessment results, when derived based on the bioaccessible-estimated daily intake of arsenic (in soil and vegetation), were not significantly different from results derived based on the actual daily intake, indicating that the incorporation of arsenic soil bioaccessibility data into an ERA provides a more realistic assessment of risk. Similarly, Saunders et al., (2011) found that the bioaccessible fraction of arsenic in soil was significantly less that total arsenic. The authors concluded that the use of site-specific bioaccessibility data in ERAs may result in a more realistic level of conservatism. Furman *et al*. (2006) examined lead bioaccessibility in sediments in the Coeur d'Alene River basin (an area impacted by historical mining and smelting activities), to waterfowl using the basin. Bioaccessibility of lead in sediments using a modified PBET (physiologically based extraction test) technique ranged from 27% to 12%, depending on the area tested. Amendment of sediments with Phosphorus (P) significantly reduced bioaccessibility (to < 1%). These tests were used to assist in the design of remedial planning for this contaminated area.

Bioaccessibility testing was conducted on soils collected in the Shore Road Soil Study for lead and arsenic. Results of these tests were based on the U.S. EPA-accepted method developed by Dr. John Drexler, which includes only a single extraction simulating gastric conditions (as opposed to a bi-phasic extraction simulating both gastric and intestinal conditions). In the Shore Road Soil Study, the results of 21 samples taken in areas affected by atmospheric deposition of smelter emissions indicated an upper estimate of bioaccessibility in soils of 23% for arsenic and 78% for lead in soils (both are UCLM 95 values; Intrinsik Environmental Sciences *et al.*, 2008). While the direct relevance of these estimates to the various species that are being assessed in the current ERA can be debated (Marshall *et al.*, 2010), the available data strongly suggest that the soil bioaccessibility of lead and arsenic will be less than100%. In light of uncertainties related to gastric differences between species and the relevance of the in vitro techniques used in Shore Road to the various receptors in the ERA, the ERA modeling assumed that bioaccessibility was 100%.

All of these factors need to be weighed, along with information on sources of uncertainty and limitations within the ERA, prior to drawing conclusions with respect to potential risks.

9.2 Terrestrial Vegetation

To evaluate the potential for ecological risks to terrestrial vegetation, several lines of evidence (LOE) were used in the WOE approach to characterize risk (See Section 9.2.4) and include:

- Outcomes of the comparison of surface soil metal and air SO_2 concentrations to vegetation health-based soil and air quality guidelines, respectively, and to reference area soil metal and SO_2 air concentrations.
- Results of the vegetation health survey within 2 km of the smelter compared to reference locations, and the rare vegetation surveys in a larger area around the smelter.
- Results of the nutrient analysis of soil samples collected within 2 km of the smelter, relative to reference soils and desired nutrient levels in soils in general.

9.2.1 Comparison to Vegetation Health-Based Guidelines

Surface soil COPC concentrations (*i.e.*, the highest of the A, B or C layers) were compared to vegetation health-based soil quality guidelines and to reference area soil concentrations. Guideline comparisons were conducted for reference areas and the Study boundary scenarios (0 to 3 km, 0 to 1 km, 1 to 2 km and 2 to 3 km). The hierarchies used to select vegetation health-based soil quality guidelines for metals were previously presented in Table 7-1. A summary of the soil chemistry data considered in the ERA in addition to raw analytical soil chemistry data are provided in Appendix D. Results of the guideline comparison for metals and SO_2 are presented in Sections 9.2.1.1 and 9.2.1.2, respectively.

9.2.1.1 Metals

Comparisons of COPC soil concentrations to vegetation health-based soil quality guidelines and reference area COPC soil concentrations are provided in Table 9-1.

Table 9-1 Comparison of Study Boundary Soil Concentrations to Reference Area Soil Concentrations and Vegetation Health-Based Soil Quality Guidelines (2009 dataset; UCLM 95)

COPC	Vegetation Health-Based Soil Quality Guideline (mg/kg)	Reference Area Soil Concentration (mg/kg)	Study Boundary (0 to 3 km) Soil Concentration (mg/kg)
Antimony	5[b]	<2 [c]	8.8 [c]
Arsenic	17 [a]	4.9	30
Cadmium	10 [a]	1.5	3.7
Lead	300 [a]	44	340
Thallium	1.4 [a]	0.34	0.82
Zinc	200 [a]	71	510

Notes: Data collected by CRA in 2009.
Units are in mg/kg. N=14 for Study Boundary and N=23 for Reference (higher of A, B or C layer was used for each sample).
Data rounded to 2 significant figures.
Shaded cell indicates soil concentration was greater than guideline.

a. CCME (2011) Canadian soil quality guidelines on-line; Soil contact guidelines for Residential / Parkland land use (CCME, 1999a,b,c,d,e; 1997).
b. Efroymson *et al*. (1997b) screening benchmark for the phytotoxicity of chemicals in soils.
c. No UCLM could be calculated due to high frequency of RDLs. 95th percentile used instead.

As shown in Table 9-1, antimony, arsenic, lead and zinc UCLM 95 soil concentrations (no UCLM 95 could be calculated for antimony) were greater than the applicable vegetation health-based soil quality guidelines. Cadmium and thallium were below the applicable guidelines. Out of all the samples collected within 0 to 3 km, the samples containing the highest concentration of each COPC was collected either in the vicinity of the slag pile, or directly across from the active smelter property (see Figures 6-1 to 6-6). The presence of these localized “high” samples makes the UCLM soil concentration relatively high compared to the sample values obtained throughout the rest of the Study boundary.

For antimony, 7 of the 14 samples collected were not detected (RDL = 2 mg/kg). Of the 7 detectable samples, only 2 were greater than the antimony guideline of 5 mg/kg (one sample at 6 mg/kg and the other at 14 mg/kg). Although there are a number of soil samples where one or more vegetation health-based soil quality guideline values are exceeded, many vegetation species are able to acclimate and/or adapt to metal concentrations in soil (See Section 9.1). Exceedance of a generic guideline does not necessarily mean that adverse effects have occurred or are occurring in vegetation in the Study boundary, due to the number of factors that will affect the exposure of vegetation to metals in soil (*e.g.*, root distribution in the soil profile, physicochemical characteristics of the soil; and interaction among other chemicals) (Suter, 2007) and the toxicity of the metals to the plants (*e.g.,* adaptation, acclimation) (ICMM, 2007).

Based on a detailed review of the available soil chemistry data, the area with the highest COPC exposure potential for vegetation was found to occur within 2 km of the smelter facility (see Figures 6-1 to 6-6). Given limited samples were collected in 2009 within 2 km of the smelter where concentrations were the greatest and given antimony, arsenic, lead and zinc exceeded the vegetation health-based guidelines, additional soil samples were collected in 2010 to provide a more robust data set to assess potential risks. Soil samples were collected as part of the vegetation health survey conducted by LGL in the areas 0 to 2 km from the smelter in the summer of 2010 (See Section 4.3.1 and Section 9.2.2 for more details and Appendix K for the full report).

The soil datasets for 0 to 3 km from the facility from 2009 and the additional samples from 2010 were combined and re-evaluated against vegetation health guidelines, based on distance from the facility. These comparisons are presented in Table 9-2.

Table 9-2 Study Boundary Soil Concentrations (UCLM 95) at Varying Distances from the Glencore Smelter Compared to Vegetation Health-Based Soil Quality Guidelines (2009 and 2010 dataset)

Chemical	Vegetation Health-Based Soil Quality Guidelines (mg/kg)	Soil Concentration Within Study Boundary (mg/kg)		
		0 to 1km	1 to 2 km	2 to 3 km
Antimony	5[b]	6.3	8.5	2.7[c]
Arsenic	17 [a]	30.7	29.4	34
Cadmium	10 [a]	8.7	3.3	2.6
Lead	300 [a]	803	346	173
Thallium	1.4 [a]	3.8	0.74	0.58
Zinc	200 [a]	314	625	208

Notes:
UCLM = upper confidence limit on the mean.
Data collected by CRA in 2009 and LGL in 2010.
Notes: Units are in mg/kg. N=12 for 0 to 1 km; N = 11 for 1 to 2 km and N = 8 for 2 to 3 km. Data from 0 to 1 km and 1 to 2km included data collected in 2009 and 2010, at 2 to 3km data were only collected in 2009.
Shaded cell indicates soil concentration was greater than guideline.

a. CCME (2011). Canadian soil quality guidelines on-line; Soil contact guidelines for Residential / Parkland land use (CCME, 1999a,b,c,d,e; 1997).
b. Efroymson *et al*. (1997b) screening benchmark for the phytotoxicity of chemicals in soils.
c. No UCLM 95 could be calculated due to the large number of non-detectable sample results. The 95th percentile of soil data are provided instead.

As indicated in Table 9-2, for distances of 2-3 km from the facility, antimony, cadmium, lead and thallium are below the vegetation health-based soil quality guideline, whereas the UCLM 95 of zinc and arsenic exceed their respective guidelines. The maximum concentration of zinc at this distance from the facility (340 mg/kg) was the only sample of the 8 samples collected at 2 to 3 km from the facility that exceeded the zinc guideline. While the maximum measured arsenic concentration in the 2 to 3 km range was 45 mg/kg, the next highest concentration was 14 mg/kg and all other arsenic samples at this distance from the facility were below the arsenic soil quality guideline for vegetation. With the exception of one sample that had elevated arsenic and zinc concentrations, soil concentrations at 2 to 3 km are below soil quality guidelines.

At 0 to 1 km, all of the COPCs (with the exception of cadmium) exceeded their respective vegetation health-based soil quality guidelines. At 1 to 2 km, both thallium and cadmium were below their respective guidelines. One sample collected within the 1 to 2 km radius of the smelter was located adjacent to the slag pile and had a much higher concentration than other samples (i.e., 1800 mg/kg for this sample while the next highest samples was 480 mg/kg; See Figure 6-3). This sample contributed to the higher UCLM 95 in the 1 to 2 km range compared to the 0 to 1 km range for zinc. These guideline comparison results are discussed further along with consideration of the vegetation survey results in Section 9.2.2 and the nutrient analysis results in Section 9.2.3.

9.2.1.2 Sulphur Dioxide (SO_2)

SO_2 air data in the vicinity of the facility were compared to a variety of air quality guidelines derived to be protective of vegetation health. This comparison is provided in Table 9-3. The benchmarks provided in this table were previously discussed in Section 7.1.2 (Table 7-2).

The ambient air monitors are located at the edge of the ERA Study Boundary, and therefore do not capture exposures in the immediate near-field of the facility (Figure 6-7).

Table 9-3 Comparison of Vegetation Health-Based Air Quality Benchmarks for Sulphur Dioxide (SO_2) to Ambient SO_2 Air Concentrations in the Vicinity of the Glencore Smelter

Organization	**SO_2 Benchmark ($\mu g/m^3$)**		**Boulay Ambient Air Concentration ($\mu g/m^3$)[l]**		**Chalmers Ambient Air Concentration ($\mu g/m^3$)[l]**	
Long Term Benchmarks and Concentrations						
	24-Hour	***Annual Average***	***24-Hour (2007/2009)***	***Annual Average (2007/2009)***	***24-Hour (2007/2009)***	***Annual Average (2007/2009)***
WHO Guideline (2000)	100	30[b]	Average 24-hour : 6.5 / 8.5 Max 24-hour: 92.5 / 56.8	6.4 / 8.5	Average 24-hour: 6.7 / 6.5 Max 24-hour: 54.9 / 62.1	6.7 / 6.5
IUFRO Standard[c]	100[d]	50				
EU Standard	100-150	40-60				
UNECE Critical Level	NA[a]	30[e] 20 (15)[f] 10[g]				
OMOE (2008)[h]	275	55				
Alberta Environment	150[i]	30[j]				
Short Term Benchmarks and Concentrations						
	1-Hour		***1-hour***		***1-hour***	
OMOE (2008) (1-hour benchmark)[h]	690		Max 1 – hour: 295 / 394	Not Applicable	Max 1 – hour: 302/ 299	Not Applicable
	3-Hour					
US EPA (2008) (3-hour standard)	1430[m]					

Notes:

WHO = World Health Organization; IUFRO = International Union of Forest Research organizations; EU = European Union; UNECE = United Nations Economic Commission for Europe; OMOE = Ontario Ministry of the Environment; NA = not available.

All guidelines were obtained from WHO (2000).

a. UNECE (1988) recommended the 24-hour guideline be abandoned due to evidence showing peak concentrations are insignificant when compared with the accumulated dose.
b. This value should not be exceeded as a mean concentration for October to March, inclusive.
c. Maximum level of SO_2 that allows for full production at most sites.
d. The 24-hour average may be exceeded 12 times in a period of 6 months.
e. Annual mean to protect agricultural crops.
f. Annual mean to protect forests and natural vegetation (critical level in areas of low temperature).
g. Annual mean to protect certain lichen species.
h. Limiting effect for guideline is reported to be health (human) and vegetation (OMOE, 2008). Insufficient documentation is provided to determine whether a vegetation-specific guideline would be greater or less than this guideline.
i. Air quality objective basis reported to be begonia, bluegrass, aspen and forests (Alberta Environment, 2009b).
j. Air quality objective basis reported to be natural forests, lichens (Alberta Environment, 2009b).
k. There is some uncertainty in the calculation of the 24-hour and annual average data given the presence of 0.0 $\mu g/m^3$ data points in the data set.

l. For average calculations, values of 0.0 were assumed to equal 0.1, the lowest measurable concentration (based on discussions with John Chandler, Pers Comm).

m. US EPA (2008); 3-hour average of 0.5 ppm for SO_2 based on protection of acute foliar injury. This standard is to be averaged over three hours and not to be exceeded more than once per year. This value was originally derived in 1971. Based on their current review of the available scientific literature, the US EPA decided to retain this value as the secondary standard for SO_2. The U.S. EPA (2008) reported that there is no clear evidence of acute foliar injury at concentrations less than this standard (3-hour average). Three-hour average, given as 0.50 ppm was converted to a value of 1430 µg/m^3 (using a conversion factor of 1 ppm = 2860 µg/m^3; in WHO, 2000). It is conservative to compare the 3-hour guideline to 1-hour average concentrations (as 1-hour average concentration would be greater than 3-hour averages).

As shown in Table 9-3, measured ambient SO_2 air concentrations (1-hour, 24-hour and annual average concentrations) are below available benchmarks identified for the potential for acute and chronic effects of SO_2 on vegetation. Based on this comparison, it is unlikely that effects on vegetation would result if off-site sulphur dioxide emissions are similar to those measured at the monitors. However, the Boulay and Chalmers monitors are distant from vegetation in the near-field area and therefore, SO_2 exposures to vegetation in areas closer to the facility are expected to be greater. While there is a reasonable margin of safety between the measured concentrations and guidelines in Table 9-3, additional data were required to conclude whether effects on vegetation could be occurring. To further examine potential risks to vegetation, the terrestrial vegetation survey were considered in conjunction with results of these guideline comparisons.

In addition to direct effects on vegetation, SO_2 has been reported to affect soil pH, in situations where high emission rates are present, which can cause secondary effects on vegetation. Based on the soil pH data collected in the current study (in both 2009 and 2011), soil pH within the Study boundary was similar to that measured in the reference area soils (reference area minimum pH 4.17; maximum pH 6.17; median pH of 4.4 (N=4); Principal sampling area soil pH minimum 4.20; maximum 5.73 and median value of 5.5 (N=6); See Section 5.1). These data suggest there has been minimal acidification beyond that reported in non-exposed areas.

9.2.1.3 Summary of Guideline Comparison

At 0 to 1 km and 1 to 2 km, all of the metals evaluated as COPCs exceeded their respective vegetation health-based soil quality guidelines with the exception of cadmium (which was below guidelines) and thallium which was only exceeded at 0 to 1 km. Sulphur dioxide levels were below vegetation health-based ambient air quality guidelines. Given the distance of the SO_2 monitors from the facility, vegetation in the near-field of the facility may be exposed to higher SO_2 concentrations than those measured at the monitors. However effects on vegetation would not be expected in areas where air concentrations are similar to those measured at the monitors. The pH of soils from the Study boundary and reference areas were generally similar, suggesting minimal acidification beyond that reported in non-exposed areas.

To provide additional perspective on the soil guideline exceedances and in light of uncertainties related to the distance of ambient air monitors to the near-field exposure areas for the SO_2 assessment, a vegetation survey and soil nutrient analysis (conducted within a 2 km radius of the smelter) were undertaken. These are discussed in Sections 9.2.2 and 9.2.3.

9.2.2 Terrestrial Vegetation and Rare Vegetation Surveys

Based on the outcomes of the soil guideline comparisons, a vegetation community assessment was conducted using a transect approach within 2 km of the facility; since this area presented the highest exposure potential (see Table 9-2). This survey was undertaken in August of 2010 (by LGL Consultants; see Section 4.3.1 and Appendix K for more details). In addition, prior to commencing the ERA, Glencore commissioned a rare vascular plant surveys in six areas of the Glencore woodlands in 2007 (D. Peck Botanical, 2007). A more focused rare vascular vegetation survey was conducted in 2011 as part of the ERA to investigate presence of rare vegetation near Hendry Brook, where historical sitings of rare plants had been reported (ACCDC). This survey was conducted within 100 m of either side of the lower 2.5 km of Hendry Brook in August, 2011 (B&B Botanical, 2011; See Appendix N for full report).

In the vegetation survey conducted on the Glencore woodlands in 2007, four rare plant species were found in various locations and numbers (approximately up to 5km from the smelter facility)(D. Peck Botanical, 2007). ACCDC (Atlantic Canada Conservation Data Centre) records for the region of the Glencore woodlands show that fifteen species of rare vascular plants had been previously reported. Of these species, only eight were expected to be found within the habitat typical of the Glencore woodlands. The remaining species being more typical of estuarine habitats and would not be expected to be found in woodland environments (D. Peck Botanical, 2007). Two of the eight species previously identified and expected to be found within the habitat type, were actually found during the vegetation survey. Two additional rare plants were also reported (new sightings for the province). However, 6 of the 8 species previously reported were not found during the survey. While the number of rare vascular plant species in the vicinity of the smelter may appear to have been decreased, the author noted that the data represent a single observation period only. Had additional site visits been conducted at other times during the growing season, additional evidence of other species may have been found (D. Peck Botanical, 2007). It is difficult to confirm whether the absence of previously reported rare plants are a result of exposure to emissions, or changes in habitat (*i.e.,* presence of beaver dams creating wetland areas which used to previously be more dry, *etc*.), or other factors (such as presence of new invasive species, *etc*.).

In the rare vegetation survey conducted in 2011 (B&B Botanical, 2011) a total of 149 species were identified within 100 m of the lower 2.5 km of Hendry Brook and four of these are classified as rare to very rare. The author of this report indicated that the surveyed portion of Hendry Brook and those areas 100 m to either side are in general, not typical of the rich habitat defined by the other species listed by ACCDC for the area. Much the area is either old fields or pastures that have become wooded. While cedar is common along the small flood terraces on either side of the brook, these terraces never approach a richness (calcium induced) required for some of the rarer species. *Corallorhiza maculata* (Spotted Coralroot) thrives in a habitat of disturbance, in this case where the *Picea glauca* (White Spruce) has taken over what was once an old field. *Spiranthes cernua* (Nodding Ladys Tresses) has taken advantage of the recent disturbance of beaver to find a new home. The author reported that Hendry Brook is a good example of a typical brook found in the area.

In summary, based on the outcomes of these surveys, rare plant species are present in the areas near the smelter, and the vegetation found near Hendry brook appear to be fairly typical for that type of habitat. Based on the studies conducted, conclusions related to possible effect of metals levels on the abundance and diversity of rare or endangered species, relative to other nearby areas cannot be drawn.

The results of the community vegetation survey conducted by LGL in 2010 (LGL, 2012c; See Appendix K) found that vegetation in areas south of the smelter is generally healthy and exhibits a diverse assemblage of plants, with possible exception of areas immediately south and southwest of the facility. Communities observed included early successional mixed forest consisting of red maple, trembling aspen and balsam fir; deciduous forest of trembling aspen and birch or red maple; and meadows composed of grasses and wild flowers. In the near-field areas (Transects 5-1, 5-2; See Figure 4-6; Section 4.3.1), the community was highly disturbed and vegetation was found to have reduced growth, dieback, multi-stem growth, and chlorosis. However, the author cited numerous possible contributing factors to these effects (which among other things included smelter-related emissions and dust). Vegetation communities found along Transect 1 varied in composition from other transects, as this area was used for agricultural purposes in the past and contained early successional meadow species including various types of hay. Vegetation was not found to be exhibiting signs of stress. Site disturbance, exposure to smelter-related air emissions (such as SO_2), soil contamination, salt spray (from road and ocean), and/or nutrient deficiency are possible factors that could be contributing to the signs of stress found in the near-field area. Other near-field areas (*e.g.*, Transect Plots 3-1 and 4-1) along with the far field areas, contained early successional forests similar to those found within reference locations and did not exhibit any signs of vegetation stress observed elsewhere within the Study boundary.

9.2.3 Soil Nutrient Analysis

An assessment of nutrient levels in soil collected from site transect stations and reference areas (See Figure 4-2 in Section 4.2.1.2), relative to the vegetation community survey outcomes, was conducted by FHW Consulting (for full report see Appendix P).

The conclusions of the soil nutrient analysis indicated that nutrient levels in the transect stations were generally similar to or higher than the reference site soils partly due to higher pH and presence of organic matter at the site (FWH Consulting, 2012). Nutrient deficiency symptoms were not reported to have been observed in vegetation established at the reference sites in the LGL (2012c) study, and as such, symptoms associated with nutrient deficiencies are not expected in vegetation established at the site transect stations (since these areas had similar or higher soil nutrient levels). FHW Consulting (2012) reported that it is not clear if the higher pH observed in some of the transect stations is related to forest cover (deciduous versus mixed) or to other factors (proximity to the slag heap, historical disturbances *etc*).

Although essential for plant growth, copper and zinc levels in soils were above those of the reference sites and the typical range, particularly along Transect 1 and Transect 5 (see Table 1 and 2 in FWH Consulting, 2012; Appendix P). The vegetation survey conducted by LGL (2012c) reported that signs of vegetation stress were not reported along Transect 1 (which is east of the facility), but were reported near the facility along Transect 5 (see Figure 4-2; specific signs of stress included reduced growth, dieback, multi-stem growth, and chlorosis). Dove-tailing the survey with the nutrient analysis suggests that the vegetation in Transect 1 is not being adversely affected by elevated nutrient metal levels (copper and zinc), but that metal levels in soils, and/or other factors could be contributing factors to the effects noted in vegetation along Transect 5. LGL (2012c) reported a number of possible factors for the effects noted in Transect 5 vegetation, including phytotoxic effect of metals, site disturbance, air emissions, salt spray, *etc*. The phytotoxic effects of metals could be reduced by applying nutrient amendments. Phosphorus could bind with lead, zinc and cadmium thus reducing bioavailability, although high phosphorus levels could potentially increase arsenic bioavailability (U.S. EPA, 2007b).

FHW Consulting, (2012) reported that nitrogen, phosphorus and potassium deficiencies are likely growth limiting, but that this is occurring in both the reference sites and transect stations sampled and might be most severe in areas with low organic matter. Fertilizer amendments would improve nutrient levels and an increase in phosphorus would help reduce lead, zinc and cadmium bioavailability and potential phytotoxicity.

9.2.4 Terrestrial Vegetation Weight of Evidence

The various lines of evidence (LOE) used to assess potential risks to vegetation are identified in Table 9-4 along with the interpretation of each LOE. While the generic soil quality guideline comparisons for a number of the COPCs suggested a potential for adverse effects in vegetation within 2 km of the facility, the site-specific vegetation survey indicated that adverse vegetation effects are limited to areas immediately south of the smelter (*i.e*., south of the highway 148; Shore Road). In addition, the conclusions of the soil nutrient analysis indicated that nutrient levels in the transect stations were generally similar to or higher than the reference site soils. Rare vegetation in the area does not appear to be affected by the metals in soils in the vicinity of the smelter.

The area south of the highway 148 (Shore road) had the highest degree of exceedance over vegetation health soil quality guidelines, and vegetation in these areas was stressed. The alterations in diversity and abundance, as well as indications of stress (such as chlorosis) are likely related to a number of factors, including site disturbance, soil contamination, possible SO_2 exposures in the near-field, salt spray, nutrient deficiency, amongst others. All other areas within the 2 km radius of the facility exhibited healthy vegetation, similar to that observed in reference locations, which indicates that the guideline comparisons yielded overly conservative results.

Given the various LOEs, using a weight of evidence approach and considering the uncertainties and study limitations presented in Section 10.0, the following conclusions for vegetation health can be made:

- Risks to vegetation are considered to be low, with the exception of near-field areas immediately South – South-West of the facility, where they are considered moderate.
- The effects on vegetation South and South-West of the facility are likely related to a number of factors, including site disturbance, soil contamination, possible SO_2 in the near-field, salt spray, nutrient deficiency, amongst others

Table 9-4 Lines of Evidence for Evaluating Terrestrial Vegetation

Soil / Air Chemistry Data Comparisons to Vegetation Health-Based Soil / Air Quality Guideline$_s$ (SQG / AQG)		Soil Nutrient Analysis (FWH Consulting, 2012)	Vegetation Surveys			Potential Risk to Vegetation
2009 – 2010 UCLM 95 Soil Concentration (mg/kg) Comparison to SQG	**SO_2 Air Concentration Comparison and Soil pH**		**LGL, 2012c**	**D. Peck, 2007**	**B&B Botanical, 2011**	
0 to 1km: Sb:6.3 > SQG As:30.7 > SQG Cd:8.7 < SQG Pb:803 > SQG Tl:3.8 >SQG Zn:314 >SQG 1 – 2 km: Sb:8.5 > SQG As:29.4 > SQG Cd:3.3 < SQG Pb:346 > SQG Tl:0.74 <SQG Zn:625 >SQG 2 to 3 km: Sb:2.7< SQG As:34 > SQG Cd:2.6 < SQG Pb:173 < SQG Tl:0.58 <SQG Zn:208 >SQG Frequent exceedance of metal guidelines closer to facility but less so as distance from facility increases. Guideline exceedances suggest that potential effects on vegetation could be occurring in some areas.	1-hour, 24-hour and annual average SO_2 air concentrations at Boulay and Chalmers (2007 / 2009) were < ambient air quality guidelines. Some uncertainty due to location of monitors being some distance from Study boundary. Soil pH data suggest minimal acidification beyond that reported in reference	Soil nutrients are generally similar or higher than reference area soils. Along Transects 1 and 5 Cu and Zn concentrations >reference areas and typical ranges. The author of the field study noted that the vegetation survey results (LGL, 2012c) showed no signs of vegetation stress along Transect 1 but that there were signs of vegetation stress in the near-field areas (Transect 5).	With the exception of near-field areas in the vicinity of Transect 5 (south and south west of facility), signs of vegetation stress were not reported. While vegetation stress was reported along Transect 5 it was not reported in other near field areas (including Transect 1, where the nutrient analysis showed elevated Cu and Zn over reference soils). Stress was hypothesized to be due to many possible contributing factors including phytotoxic effects, emissions and dusts; salt spray; site disturbance.	Some rare species previously seen were not reported, while 2 new rare species were identified. Reduction in previously seen rare species may be due to the limited sampling event. The author of the field study stated it was difficult to confirm whether absences of previously found rare plants are a result of exposure to emissions, or changes in habitat or other factors.	A total of 149 plant species identified within 100 m of the lower 2.5 km of Hendry Brook with four of these classified as rare to very rare. Areas surveyed are generally not typical of the rich habitat defined by the other species listed by ACCDC for the area. The author reported that vegetation near Hendry Brook is typical for brooks found in the area.	Moderate likelihood of some adverse effects to certain vegetation species in areas due south of smelter, where soil metal concentrations are elevated above background and SQG (Transect 5) and SO_2 exposures could be elevated. The potential for effects in other areas is considered negligible. Therefore, the potential for community level effects is considered to be low in areas south of the smelter, with the exception of near-field areas due south- South – west (Transect 5).

SQG = soil quality guideline; AQG = air quality guideline

9.3 Soil Invertebrates and Soil Microorganisms

To evaluate the potential for ecological risks to soil invertebrates and soil microorganisms the following lines of evidence (LOE) were used in the WOE approach to characterize risk (See Section 9.3.3) and include:

- Outcomes of the comparison of surface soil COPC concentrations to soil invertebrate and soil micro-organism health-based soil quality guidelines and to reference area soil concentrations;
- Results of the soil invertebrate pitfall trap sampling and analysis conducted within 2 km of the smelter compared to reference locations.

9.3.1 Comparison to Soil Invertebrate / Soil Micro-organism Health-Based Soil Quality Guidelines

Surface soil COPC concentrations (*i.e.*, the highest of the A, B or C layer) were compared to soil invertebrate and soil micro-organism health-based soil quality guidelines and to reference area soil concentrations (See Table 9-5 to 9-7). Guideline comparisons were conducted for reference areas and for 4 Study boundary scenarios. The Study boundary scenarios consider distance from the smelter and included: 0 to 3 km, 0 to 1 km, 1 to 2 km and 2 to 3 km. The hierarchies used to select the health-based soil quality guidelines for metals were previously presented in Table 7-1. A summary of the soil chemistry data considered in the ERA was previously reported in Section 3.1. Raw analytical soil chemistry data are provided in Appendix C.

Comparisons of the 0 to 3 km COPC soil concentrations to soil organism health-based soil quality guidelines and reference area COPC soil concentrations are provided in Table 9-5.

Table 9-5 Comparison of Study Boundary Soil Concentrations to Reference Area Soil Concentrations and Soil Organism-Based Soil Quality Guidelines (2009 Dataset; UCLM 95)

COPC	Soil Invertebrate / Soil Microorganism Health-Based Soil Quality Guidelines (mg/kg)	Reference Area Soil Concentration (mg/kg)	Study Boundary (0 to 3 km) Soil Concentration (mg/kg)
Antimony	78[b]	<2 [f]	8.8 [f]
Arsenic	60 / 100 [c]	4.9	30
Cadmium	140 [b] / 54 [a]	1.5	3.7
Lead	1700 [b] / 723 [d]	44	340
Thallium	NGA	0.34	0.82
Zinc	120 [b] / 100 [e]	71	510

Notes:
NC = not calculated due to high frequency of RDLs
NGA = no guideline available
Units are in mg/kg. N=14 in Study boundary and N=23 in reference (higher of A, B or C layer was used for each sample).
Data collected by CRA in 2009.
Shaded cell indicates soil concentration was greater than guideline.

a. CCME Soil contact and nutrient and energy cycling guidelines for Residential/Parkland land for arsenic, lead and zinc were based on vegetation health end points (CCME, 1999 a,b,c,e). As such, these guidelines were not used. Rather guidelines applicable to soil invertebrates / soil microbial processes were used for comparison purposes.
b. U.S. EPA (2005b,d,e; 2007b) Ecological Soil Screening Level for soil invertebrates. Geometric mean of soil invertebrate toxicity data (EC_{10} and maximum acceptable tolerable concentration MATC) (http://www.epa.gov/ecotox/ecossl/index.html).
c. Efroymson *et al*. (1997a); screening benchmarks for toxicity of chemicals to earthworms / soil microorganisms and soil microbial processes.
d. The CCME (1999a) derived a nutrient and energy cycling guideline for lead of 723 mg/kg (residential / parkland land use). Efroymson *et al*. (1997a) derived a screening benchmark for toxicity to soil micro-organisms and soil microbial processes of 900 mg/kg. The lower of these 2 values (723 mg/kg) was used for comparison purposes.
e. The CCME (1999a) derived a nutrient and energy cycling guideline for zinc of 200 mg/kg (residential / parkland land use). Efroymson *et al*. (1997a) derived a screening benchmark for toxicity to soil micro-organisms and soil microbial processes of 100 mg/kg. The lower of these 2 values (100 mg/kg) was used for comparison purposes.
f. No UCLM could be calculated due to high frequency of RDLs. 95th percentile used instead.

As shown in Table 9-5, antimony, arsenic, cadmium and lead UCLM 95 soil concentrations were less than the applicable soil invertebrate / soil microbial process guidelines. No soil invertebrate health-based guidelines were identified in the literature reviewed for thallium. Site soil concentrations however, were greater than those found within the reference soils for all metals.

Zinc soil concentrations within 0 to 3 km were greater than the applicable soil invertebrate and soil microbial process guidelines. The sample collected within 0 to 3 km, containing the highest concentration of zinc was collected in the vicinity of the slag pile. The presence of this “high” sample makes the UCLM 95 soil concentration relatively high compared to the sample values obtained throughout the rest of the site.

To provide some additional perspective on the potential effects on soil invertebrates to all of the COPCs evaluated, additional sampling within 0 to 2 km of the facility was conducted in 2010. These data in addition to the data collected in 2009 (which went out to 3 km from the facility) were compared to the invertebrate health-based guidelines. The results of this comparison are presented in Table 9-6.

Table 9-6 UCLM 95 Study Boundary Soil Concentrations at Varying Distances from the Glencore Smelter Compared to Soil Invertebrate Health-Based Soil Quality Guidelines (2009 and 2010 Datasets)

Chemical	Soil Invertebrate / Soil Microorganism Health-Based Soil Quality Guidelines (mg/kg)	Soil Concentration within Study Boundary (mg/kg)		
		0 to 1km	1 to 2 km	2 to 3 km
Antimony	78[b]	6.3	8.5	2.7[f]
Arsenic	60 / 100 [c]	30.7	29.4	34
Cadmium	140 [b] / 54 [a]	8.7	3.3	2.6
Lead	1700 [b] / 723 [d]	803	346	173
Thallium	NGA	3.8	0.74	0.58
Zinc	120 [b] / 100 [e]	314	625	208

Notes:
NGA = no guideline available
UCLM = upper confidence limit on the mean.
Data collected by CRA in 2009 and LGL in 2010.
N=12 at 0 to 1 km; 11 at 1 to 2 km and 8 at 2 to 3 km. Data from 0 to 1 km and 1 to 2km included data collected in 2009 and 2010, at 2 to 3km data were only collected in 2009.
Shaded cell indicates soil concentration was greater than guideline.

a. CCME Soil contact and nutrient and energy cycling guidelines for Residential/Parkland land for arsenic, lead and zinc were based on vegetation health end points (CCME, 1999 b,c,e). As such, these guidelines were not used. Rather guidelines applicable to soil invertebrates / soil microbial processes were used for comparison purposes.
b. U.S. EPA (2005b,d,e; 2007b) Ecological Soil Screening Level for soil invertebrates. Geometric mean of soil invertebrate toxicity data (EC_{10} and maximum acceptable tolerable concentration MATC) (http://www.epa.gov/ecotox/ecossl/index.html).
c. Efroymson *et al*. (1997a); screening benchmarks for toxicity of chemicals to earthworms / soil microorganisms and soil microbial processes.
d. The CCME (1999a) derived a nutrient and energy cycling guideline for lead of 723 mg/kg (residential / parkland land use). Efroymson *et al*. (1997a) derived a screening benchmark for toxicity to soil micro-organisms and soil microbial processes of 900 mg/kg. The lower of these 2 values (723 mg/kg) was used for comparison purposes.
e. The CCME (1999a) derived a nutrient and energy cycling guideline for zinc of 200 mg/kg (residential / parkland land use). Efroymson *et al*. (1997a) derived a screening benchmark for toxicity to soil micro-organisms and soil microbial processes of 100 mg/kg. The lower of these 2 values (100 mg/kg) was used for comparison purposes.
f. No UCLM could be calculated due to the large number of non-detectable sample results. The 95th percentile of soil data are provided instead.

Similar to the UCLM 95 for the 0 to 3 km soil samples, the UCLM 95 of soil samples of antimony, arsenic and cadmium at the 0 to 1 km, 1 to 2 km and 2 to 3km are less than the soil invertebrate / soil microbial health based soil quality guidelines. No soil invertebrate / soil microbial health based guideline was available for thallium and there was a paucity of invertebrate toxicity data from the literature reviewed.

The UCLM 95 of lead exceeded the soil microbial health based soil quality guideline but not the soil invertebrate guideline at 0 to 1 km, but not at other distances. Of the 12 samples analyzed for lead at 0 to 1 km, only 2 were greater than 723 mg/kg (1100 mg/kg and 1600 mg/kg, respectively; see Figure 6-2). This indicates that in most areas sampled, lead is less than the soil invertebrate / soil microorganism guidelines.

The UCLM 95 zinc soil concentrations at 0 to 1 km, 1 to 2 km and 2 to 3 km exceeded both the soil invertebrate and soil microorganism health-based guidelines. For zinc, 10 of 12 and 11 of 12 samples at 0 to 1 km; 7 of 11 and 9 of 11 samples at 1 to 2 km and 2 of 8 and 3 of 8 samples at 2 to 3km exceeded the soil invertebrate and soil microbial health-based guidelines, respectively. One sample collected within the 1 to 2 km radius of the smelter was located adjacent to the slag pile and had a much higher concentration than other samples (i.e., 1800 mg/kg for this sample while the next highest samples was 480 mg/kg; See Figure 6-3). This sample contributed to the higher UCLM 95 in the 1 to 2 km range compared to the 0 to 1 km range for zinc.

Similar to vegetation, soil pH levels may affect soil invertebrates and soil microbial processes. As previously discussed in Section 9.2.1.2, pH data collected within the vicinity of the Smelter suggest there has been minimal acidification beyond that reported in non-exposed areas.

9.3.1.1 Summary of Guideline Comparison

The comparison of soil data to soil quality guidelines derived to be protective of soil invertebrates and soil micro-organisms revealed exceedances of zinc at all distances sampled (i.e., 0 to 1 km; 1 to 2 km and 2 to 3 km). The UCLM 95 lead concentration exceeded the soil micro-organism guideline at 0 to 1 km by approximately 11% and was not exceeded at other distances. Measured lead concentrations were below the soil invertebrate guideline. While there are a number of soil samples where one or more soil organism-based soil quality guidelines are exceeded, mainly for zinc, the exceedances were generally low (lead was < 2-fold; zinc ranged from 2 to 3-fold at to 1 km and 2 to 3 km and 6-fold at 1 to 2 km, but this was due in part to one very high sample. No guidelines were identified for thallium and there was a paucity of thallium toxicity data for soil invertebrates and soil micro-organisms which remains an uncertainty in the assessment. Many soil organisms are able to acclimate and/or adapt to soil metal concentrations, and there are a variety of other factors that will affect the exposure of soil organisms to metals in soil (e.g., burrowing depth, types of food/materials ingested, activity patterns, physicochemical characteristics of the soil, soil bioaccessibility and interactions among other chemicals) (Suter, 2007).

The pH of soils from the Study boundary and reference areas were generally similar, suggesting minimal acidification beyond those reported in non-exposed areas.

To provide additional perspective on potential effects to terrestrial invertebrates, a limited invertebrate sampling program was done using pitfall traps in areas 0 to 2 km from the facility. This sampling was done in conjunction with the soil sampling conducted in the summer of 2010. The protocol used to conduct the invertebrate sampling is provided in Appendix C. The results of this sampling are presented in Table 9-7 and Figure 9-1 and discussed in Section 9.3.2.

9.3.2 Soil Invertebrate Pit Fall Trap Sampling and Analysis

Soil invertebrate pitfall trap sampling and analysis was conducted by LGL in 2010. Invertebrates from 10 taxonomic groups were captured and identified in the pitfall traps located within 0 to 2 km from the facility. The greatest numbers of invertebrates were capture in the area 1.5 km from the facility with a mean of 18 individuals / trap (See Table 9-7), followed by the 2 km area (17 / trap), the 1 km area (14.3/ trap), the reference location (11.3 / trap), and the 0.5 km area (8 / trap) (See

Table 9-7). Within the Study boundary (0 to 2 km), *Coleoptera* and *Arachnida* were the most numerous invertebrates captured (consisting of beetle, mites, and spiders). In the reference area, *Coleoptera* (beetles) were the most numerous invertebrate, followed by *Orthoptera* (crickets and grasshoppers).

Table 9-7 Invertebrates Captured in the Pitfall Traps Located within the Study Boundary and within Reference Areas (data provided by LGL, 2012a)

	Invertebrate Taxa	***Hymenoptera***	***Orthoptera***	***Coleoptera***	***Lepidoptera***	***Diptera***	***Gastropoda***	***Arachnida***	***Chilopoda***	***Oligochaeta***	***Elliplura***	**Total**
	Station											
0.75 km	**T1-1**		1	5		2		2	1	1		12
	T2-1[1]			2		1						3
	T3-1[1]	1		1			2	4				8
	T4-1	2		1					1	1	1	6
	T5-1	4	2	1		1		2			1	11
	Total	7	3	10		4	2	8	2	2	2	40
	Mean	1.4	0.6	2		0.8	0.4	1.6	0.4	0.4	0.4	8
1 km	**T1-2**	3	1	4			2	10	1	2		23
	T2-2[1]											
	T3-2	1		1				2				4
	T4-2	19						2		1	4	26
	T5-2			1				3				4
	Total	23	1	6			2	17	1	3	4	57
	Mean	5.75	0.25	1.5			0.5	4.25	0.25	0.75	1	14.3
1.5 km	**T1-3**	2		8		1	1	4		3		19
	T2-3[1]			2			1	3				6
	T3-3	1		27				10				38
	T4-3	3						6				9
	Total	6		37		1	2	23		3		72
	Mean	1.5		9.25		0.25	0.5	5.75		0.75		18
2 km	**T1-4**	17		1			2	8	1	1		30
	T2-4			8				4				12
	T3-4[1]	5		1				3				9
	Total	22		10			2	15	1	1		51
	Mean	7.33		3.33			0.67	5	0.33	0.33		17
Reference[2]	**BS-Ref-1**	1		2	1		1				2	7
	BS-Ref-2	4		4								8
	BS-Ref-3	2	1	6				4			3	16

	Invertebrate Taxa	***Hymenoptera***	***Orthoptera***	***Coleoptera***	***Lepidoptera***	***Diptera***	***Gastropoda***	***Arachnida***	***Chilopoda***	***Oligochaeta***	***Elliplura***	**Total**
	Station											
	BS-Ref-4	1	10	3								14
	Total	8	11	15	1		1	4			5	45
	Mean	2	2.75	3.75	0.25		0.25	1			1.25	11.25

Notes:

1 Of the 2 traps (*i.e.*, glass jars) set at each sampling station, one jar was dug up and emptied at station T2-1; T2-3; T3-1 and T3-4, most likely by bear; both of the glass jars were dug up at T2-2. As all traps at station T2-2 were destroyed, the mean was calculated by dividing the total number of invertebrates by 4.

2 Eggs (N=15) were also found in the reference area trap.

The data provided in Table 9-7 show that in general, there are a larger number of individual invertebrates observed further away (1 km onward) from the smelter, than in areas closer to the smelter (0.75 km) or reference. While soil concentrations of COPCs are greater closer to the smelter, habitat may also being playing a role in the outcomes of this observational study (*e.g.,* in some more areas closer to the facility where industrial activity occurred, the soil may be more compacted and not an attractive habitat to the invertebrates).

Figure 9-1 shows the number of taxa and the average number of invertebrates found in each area. As previously indicated, there was a general trend of increased number of invertebrates captured with increased distance from the facility (see solid line on Figure 9-1), but reference numbers are only slightly higher than those near the facility. The bar graphs on Figure 9-1 show that closer to the smelter (0.75 and 1 km); diversity was somewhat greater than in stations further from the facility (1.5 km and 2 km) and from reference. Only a basic analysis can be done due to the limited data collected and a number of factors that could not be controlled for.

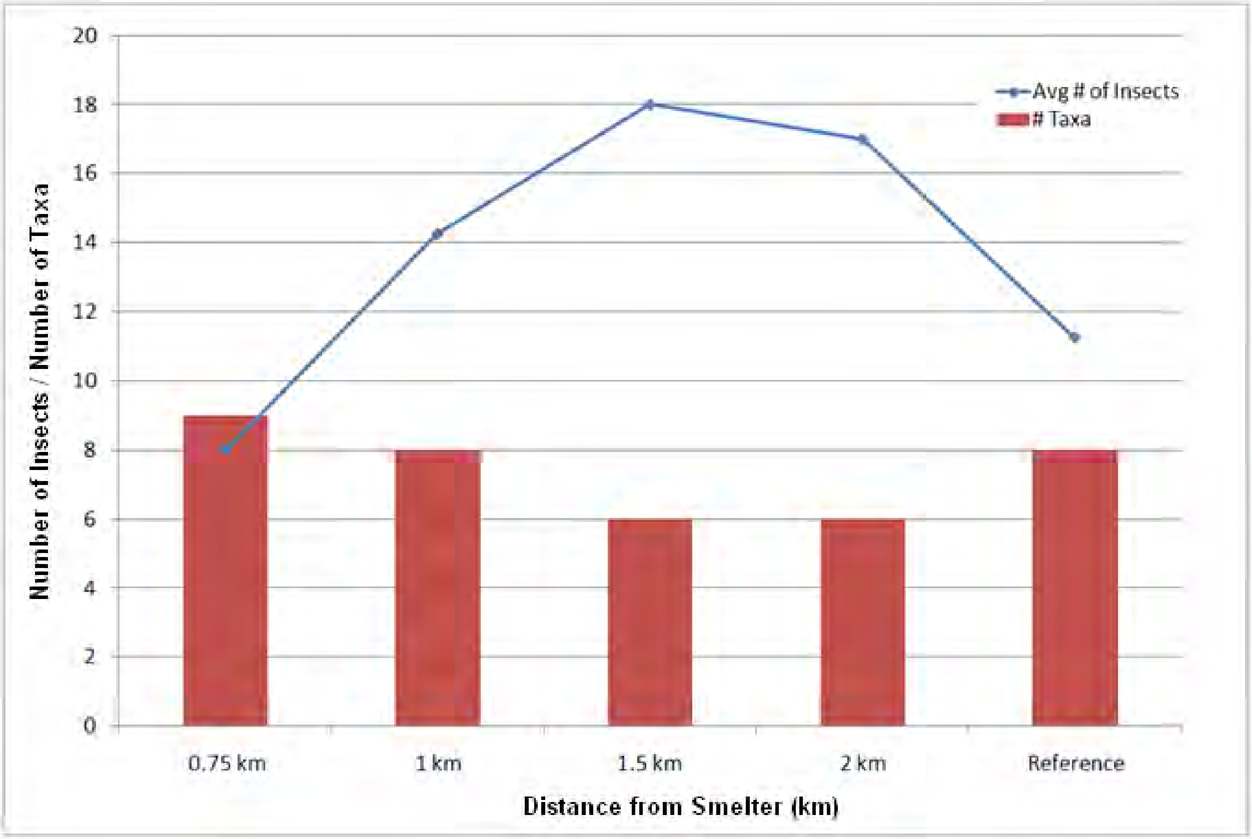

Figure 9-1 Number of Taxa and Average Number of Invertebrates Found within the Study Boundary and in the Reference Areas

Based on the data available, there appears to be fewer numbers of individual invertebrates in areas closer to the smelter (0.75 km) and reference, compared to distances further away (1 km and onward), on an average basis. The number of taxa however was highest in areas closest to the facility.

9.3.3 Soil Invertebrate and Soil Micro-organism Weight of Evidence

The lines of evidence (LOE) used to assess potential risks to soil invertebrates and soil micro-organisms along with the interpretation of each LOE are presented in Table 9-8. Given the various LOEs, using a weight of evidence approach and considering the uncertainties and study limitations presented in Section 10.0, the following conclusions for soil invertebrates and soil micro-organism health can be made:

- Risks to soil invertebrates and soil micro-organisms are considered to be low. Based on the results of the assessment, some individual level effects could be occurring in some species, but community level effects within the vicinity of the Belledune smelter as a result of smelter operations are considered unlikely.

In some areas in close proximity to the smelter (i.e., near the slag pile and in the near-field areas immediately south of the smelter) effects on individual species in some areas could be occurring. Effects however are likely subtle and difficult to distinguish from what would be expected due to natural variability associated with varying habitats, *etc*.

Table 9-8 Lines of Evidence for Evaluating Soil Invertebrates and Soil Micro-Organisms

Soil Chemistry Data Comparisons to Soil Invertebrate and Soil Micro-Organism Health-Based Soil Quality Guidelines (SQG)		**Invertebrate Pitfall Trap and Analysis (CRA, 2010)**	**Potential Risk to Soil Invertebrates and Soil Micro-Organisms**
2009 – 2010 UCLM 95 Soil Concentration (mg/kg)	**Soil pH**	**LGL, 2012c**	
0 to 1km: Sb:6.3 < SQG As:30.7 < SQG Cd:8.7 < SQG Pb:803 > SQG Tl: no guideline available Zn:314 >SQG 1 – 2 km: Sb:8.5 < SQG As:29.4 < SQG Cd:3.3 < SQG Pb:346 < SQG Tl: no guideline available Zn:625 >SQG 2 to 3 km: Sb:2.7< SQG As:34 < SQG Cd:2.6 < SQG Pb:173 < SQG Tl: no guideline available Zn:314 >SQG Frequent exceedance over soil invertebrate and soil microbial guidelines for zinc at all distances and for lead at 0 to 1 km for soil micro-organisms only. No other metals were found to be elevated over soil invertebrate or microbial screening level guidelines. No guidelines available for thallium.	Data suggest minimal acidification beyond that reported in reference	Based on the data available, there appears to be fewer numbers of individual invertebrates in areas closer to the smelter (0.75 km) and in reference compared to distances further away (1 km and onward), on an average basis. The number of taxa however was highest in areas closest to the facility.	Some effects to certain soil invertebrate species could be occurring in some areas where concentrations are elevated, such as areas closer to the facility (i.e., near the slag pile and in the near-field areas immediately south of the smelter), but effects are likely subtle and difficult to distinguish from what would be expected due to natural variability associated with varying habitats, *etc*. Community level effects are considered unlikely.

Note: SQG = soil quality guideline

9.4 Avian Species

To evaluate the potential for ecological risks to avian species, the following lines of evidence (LOE) were used in the WOE approach to characterize risk (See Section 9.4.4):

- Predicted Exposure Ratio (ER) values from food chain modeling (*i.e.*, comparison of estimated COPC exposures via all exposure pathways to Toxicity Reference Values (TRVs)).
- Outcomes of the breeding bird survey (including identification of possible, probable and confirmed breeding status) and fledgling survey (nest, egg and/or fledgling counts) conducted within the Study boundary compared to reference.
- Consider toxicological / biological information from other studies and extrapolate where applicable to this study.

9.4.1 Exposure Ratios

Exposure Ratios (ERs) for avian receptors (*i.e.,* dark eyed junco, ruffed grouse and northern saw-whet owl) were initially calculated using no-effects based TRVs (i.e., ER_{NOAEL}; See Section 8.0). If the ER_{NOAEL} exceeded the critical value of 1.0, receptors were remodeled using an effects-based TRV to derive an effects-based ER (*i.e.,* ER_{LOAEL}). The ERs were calculated using the 95th upper confidence limit on the mean soil concentration (UCLM 95) to represent general exposures throughout the site (*i.e.*, 0 to 3 km; 2009 and 2010 soil data).

Limited avian toxicity data were identified in the literature reviewed for antimony and thallium and as such, no quantitative modeling could be conducted for the selected receptors for these COPCs. A qualitative discussion of potential risks associated with antimony and thallium in birds is provided in Section 9.4.1.1 ER values for avian receptors for remaining COPCs are provided in Section 9.4.1.2.

9.4.1.1 Consideration of Chemicals with Limited Avian Toxicity Data

Antimony

No antimony TRV was identified in the literature reviewed for avian species, and there is a paucity of antimony toxicity data to evaluate this metal in birds. This remains an uncertainty in the assessment. However, the mobility of antimony in food chains has been reported to be low (Ainsworth et al., 1990). Given this and based on the data available on the concentrations of other chemicals on-site and their toxicity, antimony is unlikely to be driving potential risks. To provide some perspective on potential antimony risks, further examination of the concentrations of antimony in the data collected is useful.

A total of 31 samples were collected in the 0 to 3 km range in 2009 and 2010 analyzed for antimony (See Figure 6-4). In 2009 14 samples were collected and in 7 of these samples, antimony was not detected at the reported detection limit (RDL) of 2 mg/kg. Three of the 14 samples collected in 2009 had concentrations just above the RDL at 3 mg/kg, indicating most samples were either not detected or present at concentrations close to the RDL. The remaining antimony soil samples collected in 2009 had concentrations of 4, 5, 6 and 14 mg/kg respectively. When considered spatially, sample concentrations beyond 2 km were not detected (with the exception of one sample collected slightly beyond 2 km which had a concentration of 3 mg/kg). Antimony was not detected in any of the reference soil samples at an RDL of 2 mg/kg. Therefore by about 2 km, antimony concentrations in soil are virtually no different from background levels.

In 2010 an additional 17 soil samples were collected within 0 to 2 km of the smelter facility and analyzed for antimony. Of these samples, 10 were collected within 0 to 1 km of the facility and 7 were within 1 to 2 km of the facility. Sample concentrations ranged from <2 to 11 mg/kg at 0 to 1 km and <2 to 3 mg/kg at 1 to 2 mg/kg.

The highest sample collected in the 1 to 2 km range (2009 and 2010 data) was a sample collected in 2009 with a concentration of 14 mg/kg (0 – 5 cm depth; Figure 7-4). This sample was collected relatively close to the slag pile. The average soil concentration within 1 to 2 km was 3.9 mg/kg; however if the 14 mg/kg sample is excluded the average would be 2.9 mg/kg which is similar to concentrations in the reference area. Therefore, antimony concentrations in the 1 to 2 km range are similar to reference, with the exception being areas that are in the general vicinity of the slag pile.

At 0 to 1 km, the average soil concentration of the 2009 and 2010 data was 4.6 mg/kg. Given the home range size of avian species, the low mobility of antimony in food chains and given that antimony concentrations are basically within range of reference area concentrations (with the exception of concentrations within 0 to 1 km of the facility and in the vicinity of the slag pile), population level effects on avian species as a result of antimony soil concentrations are considered unlikely. While antimony exposures to avian species would be greater if they feed in areas closer to the facility and near the slag pile (as soil concentrations are greater in these areas), the portion of their diet coming from areas having the greatest antimony concentrations is likely small.

Thallium

No thallium TRV was identified in the literature reviewed for avian species. In addition, there was a paucity of thallium toxicity data to evaluate this metal in birds. This remains an uncertainty in the assessment.

Insectivorous ground feeding avian receptors would be expected to have greater exposures to thallium than herbivorous birds. Soil to insect and vegetation uptake factors for berries and browse have been reported to be 0.0086 and 0.004, respectively (US EPA, 2005a; Baes *et al*., 1984) compared to 0.22 for invertebrates (US EPA, 1999). Invertebrate thallium concentrations in 6 samples collected within 2 km of the smelter ranged from 0.213 to 3.85 mg/kg while reference area concentrations ranged from <0.04 to 0.111 (N=2). Based on these data, receptors ingesting soil invertebrates from the site may incur exposures to thallium that would be higher than in reference areas. Whether these exposure levels have the potential to result in adverse effects in avian wildlife is not currently known, based on the lack of toxicity data.

Top predator risks (*e.g.,* owl) are likely low, due to the size of their home range. Avian species with smaller home ranges could obtain a higher percentage of their diet from within 0 to 2 km of the smelter. However, given the size of the area and the available habitat, it is unlikely that a large number of bird species would obtain a large portion of their diet from areas closest to the smelter, thereby limiting the potential for significant risks at the population level.

Given the lack of toxicity data, the potential effects as a result of thallium exposures are considered as part of the weight of evidence discussion for birds See Section 9.4.5.

9.4.1.2 Risk Characterization Results

The NOAEL-based ERs for avian receptors (*i.e.*, dark eyed junco, ruffed grouse and northern saw-whet owl) for the Study boundary as well as the reference area are provided in Table 9-9 and discussed in this section. Where ERs exceed 1.0, cells in the table are shaded.

Table 9-9 Reference and Study Boundary (0 to 3 km) NOAEL-Based Exposure Ratios (ER_{NOAEL})

Chemical	Reference ER_{NOAEL} [1]	Study Boundary (0 to 3 km) ER_{NOAEL} [1]
	UCLM 95 [2]	UCLM 95 [2]
Dark Eyed Junco		
Arsenic	0.17	0.56
Cadmium	1.2	3.3
Lead	2.3	14
Zinc	0.86	1.9
Ruffed Grouse		
Arsenic	0.045	0.17
Cadmium	0.067	0.16
Lead	0.35	2.5
Zinc	0.082	0.27
Saw Whet Owl		
Arsenic	0.033	0.12
Cadmium	0.10	0.20
Lead	0.82	3.2
Zinc	0.31	0.42

Notes:
NOAEL = no observable adverse effect level; UCLM = upper confidence limit on the mean.
ERs have been rounded to two significant figures.
Shading indicates ER greater than critical value of 1.

1. Predicted ER values are based on UCLM (upper confidence limit on the mean) soil concentrations. To estimate exposures from food items, the maximum measured tissue concentration was used (*i.e.*, for non-woody vegetation or grasses and for small mammals). Food item tissue concentrations were estimated from soil concentrations and uptake factors. See Appendix J for additional information.
2. Model input values were calculated using the 95% UCLM of soil data and where adequate data were available, the 95% UCLM of other media.

ER_{NOAEL} for each of the receptors were greater than the critical ER_{NOAEL} value of 1.0 using EPCs based on the UCLM 95 for one or more of the COPCs. ER_{NOAEL} for the junco (*i.e.*, cadmium, lead) and owl (*i.e.*, lead) also exceeded the critical ER values in the reference area; however, the reference area ER_{NOAEL} were lower than those obtained for the Study boundary.

As soil data collected in 2009 and 2010 indicated that soil concentrations were generally higher in areas closer to the Glencore smelter, all receptors were re-modelled at distances 0 to 1 km, 1 to 2 km and 2 to 3 km from the smelter, using the expanded soil database (2009 and 2010 datasets combined). This was to enable an evaluation of potential risks to species (particularly those with a small home range) that foraging almost exclusively near the smelter. The resulting ERs are provided in Table 9-10. Where ER_{NOAEL} values exceed 1.0, cells in the table are shaded.

Table 9-10 Study Boundary NOAEL-Based Exposure Ratios (ER_{NOAEL})

Chemical	0 to 1km ER_{NOAEL} [1] UCLM 95 [2]	1 to 2 km ER_{NOAEL} [1] UCLM 95 [2]	2 to 3 km ER_{NOAEL} [1] UCLM 95 [2]
Dark Eyed Junco			
Arsenic	0.58	0.56	0.63
Cadmium	4.8	2.3	1.9
Lead	28	14	7.9
Zinc	1.5	2.0	1.3
Ruffed Grouse			
Arsenic	0.17	0.17	0.18
Cadmium	0.23	0.12	0.10
Lead	4.9	2.5	1.6
Thallium	NA	NA	NA
Saw Whet Owl			
Arsenic	0.13	0.12	0.14
Cadmium	0.26	0.15	0.13
Lead	6.4	3.3	2.0
Zinc	0.38	0.44	0.35

Notes:
NOAEL = no observable adverse effect level; UCLM = upper confidence limit on the mean.
ERs have been rounded to two significant figures.
Shading indicates ER values greater than critical value of 1.

1. Predicted ER values are based on UCLM (upper confidence limit on the mean) soil concentrations. Food item tissue concentrations were estimated from soil concentrations and uptake factors. See Appendix J for additional information.
2. Model input values were calculated using the 95th UCLM of soil data and where adequate data were available the 95th UCLM of other media.

ER_{NOAEL} for the dark eyed junco (*i.e.*, cadmium, lead, zinc), ruffed grouse (i.e., lead) and saw whet owl (*i.e.*, lead) exceeded the critical ER at 0 to 1 km, 1 to 2 km and 2 to 3 km. As a result of this, exposure ratios were then calculated using LOAEL-based TRVs, to estimate the likelihood for adverse effects in these surrogate species. This was only conducted for COPCs that had a critical ER_{NOAEL} value greater than 1.0, as those metals where ER_{NOAEL} were less than 1.0 were not considered to merit further assessment. Resulting ER_{LOAELs} for the receptors and applicable COPCs are provided in Table 9-11.

Table 9-11 Study Boundary LOAEL-Based Exposure Ratios (ER_{LOAEL})

Chemical	0 to 1km ER_{LOAEL} [1] UCLM 95 [2]	1 to 2 km ER_{LOAEL} [1] UCLM 95 [2]	2 to 3 km ER_{LOAEL} [1] UCLM 95 [2]
Dark Eyed Junco			
Cadmium	3.0	1.4	1.2
Lead	4.7	2.3	1.3
Zinc	1.3	1.7	1.1
Ruffed Grouse			
Lead	0.81	0.41	0.26
Saw Whet Owl			
Lead	1.0	0.54	0.33

Notes:
LOAEL = lowest observable adverse effect level; UCLM = upper confidence limit on the mean.
ERs have been rounded to two significant figures.
Shading indicates ER greater than critical value of 1.

1. Predicted ER values are based on UCLM (upper confidence limit on the mean) soil concentrations. Food item tissue concentrations were estimated from soil concentrations and uptake factors. See Appendix J for additional information.
2. Model input values were calculated using the 95th UCLM of soil data and where adequate data were available the 95% UCLM of other media.

The effects-based ER_{LOAEL} for the ruffed grouse and saw whet owl did not exceed the critical value of 1.0 for lead. As such, these species and receptor groups were not considered to merit further assessment. While the owl ER was 1.0 and the grouse ER was approaching 1.0 (0.81 at 0 to 1 km), these receptors were also not considered to require additional assessment given the conservative assumptions used in the exposure modeling (*e.g.,* receptors were assumed to live and feed within the 0 to 1 km radius of the site for their entire life; bioavailability of lead from soil and other media were assumed to be 100%).

The dark eyed junco ER for cadmium, lead and zinc exceeded the critical ER_{LOAEL} value of 1.0 at all modelled distances from the smelter (See Table 9-11). Some perspectives on the dark eyed junco ER are provided in the following paragraphs.

TRVs

The LOAEL-based lead TRV selected for the junco was the U.S. EPA (2001) EC20 which was based on chicken reproductive data. This EC20 is slightly greater than the range of the three lowest avian LOAELs for lead reported in the U.S. EPA EcoSSL document (2005e), but is much lower than the 2 LOAELs that reported higher concentrations. While there is uncertainty in this TRV, the laboratory studies from which the LOAELs were derived would be expected to have higher lead bioavailability than that which would occur in the field.

For cadmium, lowest bounded reproductive LOAEL of 2.37 mg/kg/day identified in the US EPA (2005d) Eco SSL document for cadmium was selected for the junco TRV. No dark eyed junco cadmium toxicity data were identified in the literature reviewed, however two starling (*Sturnus vulgaris*) toxicity studies were identified (US EPA, 2005d). These LOAELs were based on biochemical and pathological endpoints, which are not considered to be as relevant as reproduction, growth and survival in an ERA. Nevertheless the starling toxicity data were considered in the assessment of the dark eyed junco as both the starling and junco are passerine birds. In addition, the starling, like the junco generally eats invertebrate when available, but also eats certain fruits, berries, grains and seeds (Cabe, 1993). Several bounded avian LOAELS were reported in the US EPA EcoSSL document for cadmium (*i.e*., 5 reproductive studies; 6 growth and 3 survival mainly conducted on chicken, duck and quail). The bounded avian reproductive LOAELs ranged from 2.37 to 21.1 mg/kg/day. The bounded growth LOAELs ranged from 7.08 to 37.6 mg/kg/day and survival from 14.3 to 44.6 mg/kg/day.

In the starling toxicity studies, LOAELs for biochemical and pathological effects were reported at 7.21 mg/kg/day (Pilastro et al., 1993) and 13.8 mg/kg/day (Congiu et al., 2000), respectively. As the lowest LOAEL for biochemical effects in the starling (7.21mg/kg/day) was above the lowest reproductive LOAEL in chickens and ducks (2.37 mg/kg/day), it is likely that reproductive effects in the dark eyed junco would occur at concentrations higher than the lowest reproductive LOAEL reported for chickens and ducks. If this is the case, the resulting ER values for the junco may be over-estimated.

For zinc, the lowest bounded reproductive LOAEL for zinc of 77 mg/kg/day identified by the U.S. EPA (2007b) was selected as the LOAEL-based TRV for the junco. This LOAEL is less than the US EPA (2001a) EC20 of 135 mg/kg/day derived from a chicken reproduction study (Stahl *et al*., 1990). The selected LOAEL is also less than the geometric mean of the bounded reproductive LOAELs (with the exception of one zinc acetate study which was not included in the calculation as the chemical form is not relevant for this site) provided in the U.S. EPA (2007b) EcoSSL document of 96 mg/kg/day. If either the geometric mean of the bounded reproductive LOAELs or the U.S. EPA (2001a) EC20 were selected as the LOAEL-based TRV, the UCLM 95 ER_{LOAEL} values for the junco would not be greater than the critical value of 1.0 at 2 to 3 km or at 1 to 2 km (with the exception of the area of highest concentrations in the vicinity of the slag pile). There is no ideal avian TRV for zinc as there is uncertainty in the available toxicity data since almost all studies have been conducted on chickens. However, when compared to the available toxicity data, zinc would on average not be expected to have elevated ER_{LOAEL} values at 2 to 3 km or 1 to 2 km (except in the vicinity of the slag pile).

Home Range

To provide additional perspective on the ER_{LOAEL}, one can consider home range size. While the junco has a relatively small home range during breeding season (1.43 to 3.89 ha; Chandler *et al.*, 1997), this receptor's diet would still be obtained from a variety of areas across the Study boundary and not only in the areas having the highest soil concentrations.

Diet

In the exposure modeling, the ingestion of soil invertebrates was the greatest contributor to total cadmium, lead and zinc exposures of the junco. Soil invertebrates represented 60% of the junco diet (Martin *et al.,* 1951) while soil ingestion was assumed to be 9.3% (based on wild turkey; Beyer *et al.*, 1994). Ingestion of cadmium in soil invertebrates accounted for approximately 94% of exposure to the junco with soil and browse each being 3%. For lead, exposures from the ingestion of soil invertebrates accounted for approximately 55% in areas near the facility, while soil accounted for 40% and seeds 5%. Zinc exposures were also driven by soil invertebrate ingestion (81% to 57%) with seeds (12% to 13%) and soil (7% to 11%) being more minor contributors.

Soil invertebrate tissue concentrations were estimated using soil concentrations and uptake models (for more information, refer to Appendix J). Soil invertebrate tissue samples were also collected at 0 to 1 km (N=3) and 1 to 2 km (N=3) from the facility and in reference areas, albeit sample numbers were small (due to the low sample weights, samples from the different sampling stations needed to be combined, resulting in 3 composite samples from 0 to 1 km and 3 composite samples from 1 to 2 km). These measured metal tissue residue data from these invertebrates are presented in Appendix D.

The measured concentrations in the soil invertebrates were highly variable. The means of the measured COPC soil invertebrate tissue concentrations were compared to the mean modelled values (See Table 9-12 and Appendix Q). The uncertainty associated with these data is high due to the limited sample size and as such conclusions with respect to how representative the predicted values are compared to the actual tissue concentrations cannot be made.

Table 9-12 Comparison of Mean Measured to Predicted Soil Invertebrate Concentrations (mg/kg dry weight)

Chemical	0 to 1 km		1 to 2 km	
	Mean Measured [1]	Predicted (Mean)[3]	Mean Measured [2]	Predicted (Mean) [3]
Antimony	0.89	4.6	0.85	3.9
Arsenic	16	2.3	8.0	2.2
Cadmium	29.9	38	30.2	17.2
Lead	217	128	46	64
Thallium	1.69	0.55	0.509	0.14
Zinc	756	507	482	572

Notes:
UCLM95 = 95% upper confidence level on the mean.
Soil invertebrates collected by LGL and analyzed by Maxxam.
1 N=3
2 N=3
3 Soil invertebrate tissue concentrations were estimated using site soil data and uptake models (See Appendix J for more details).

9.4.2 Breeding Bird and Fledgling Survey

A breeding bird survey was conducted between June 27 to 30, 2011 by LGL, for the purposes of collecting data on the abundance and diversity of birds in the area, and breeding success, relative to distant control areas. Survey plots were selected near the smelter in areas of potential medium (4 plots) and high exposure (4 plots) relative to a control area (6 plots) 25 km distant from the smelter. In addition, surveys specifically designed for confirmed breeders were conducted from July 20 to 25, 2011, where nests, nestlings and fledglings were the target of observers. A summary of the breeding bird and fledgling survey results are presented below with the full study being found in Appendix L.

Breeding Activity / Breeding Success

Very little difference in metrics of breeding success were observed between the Belledune Smelter study plots, including the high and medium metal exposure areas, and the control area. Evidence of successful breeding was observed throughout the control and exposure areas. The number of confirmed and probable breeding species was similar across the exposure levels for each habitat type. The average number of breeding territories found in each of the exposure levels was close to the overall average; 18.7 in the control plots, 15.0 in the medium exposure level plots and 17.0 in the high exposure level plots (See Appendix L). In meadow habitats two plots that were dissimilar to the others selected (higher shrub cover) may have biased the data, resulting in higher numbers of territories in control and high exposure plots than in medium exposure plots. The number of confirmed, probable and possible breeding species was consistent across the exposure levels for each habitat type.

Species Richness

With respect to species richness, control forest plots had somewhat higher species richness than that found within the Study plots evaluated. In forests, 14.3 species per plot were reported in control areas while 11.0 and 12.0 species per plot were reported for medium and high exposure areas, respectively. In meadow plots there was no clear trend with 9, 6.5 and 9.5 species / plot being reported for control, medium and high exposure areas (LGL, 2012b).

Species Composition

A total of 46 species were recorded during the surveys within the Study boundary and control areas (See Appendix L). There were 14 species found in the control areas that were not found in the exposure areas. Three of these, Wilson's Snipe, Mourning Warbler and Dark-eyed Junco were found only in the control meadow plots. The remaining eleven species (Yellow-bellied Sapsucker, Northern Flicker, Red-breasted Nuthatch, Winter Wren, Golden-crowned Kinglet, Brown Creeper, Hermit Thrush, Northern Parula, Blackburnian Warbler, Black-throated Green Warbler and Yellow-rumped Warbler) were only found in control forest plots. Eight species reported within the Study boundary plots were not found in the control plots: Least Flycatcher, American Crow, Yellow Warbler, Canada Warbler, Northern Waterthrush, Rose-breasted Grosbeak, Chipping Sparrow and Savannah Sparrow. Canada Warbler was the only species at risk that was observed in this study (ranked Threatened by COSEWIC, SARA Schedule 1); it was found in a medium exposure forest site.

Twelve of the species recorded feed primarily on terrestrial invertebrates during the breeding season. These species are Ruffed Grouse, Wilson's Snipe, Winter Wren, Ovenbird, Northern Waterthrush, Common Yellowthroat, Lincoln's Sparrow, Song Sparrow, Chipping Sparrow, White-throated Sparrow and Dark-eyed Junco. Wilson's Snipe, Winter Wren and Dark-eyed Junco were found only in the Control Area, while Northern Waterthrush, Chipping Sparrow and Savannah Sparrow were not found in the Control Area. The remaining six species were found both in the high and medium exposure plots and in the control plots. See Appendix L for a complete list of species observed along with a description of their feeding and nesting requirements.

Fledgling Survey

Surveys for eggs, nestlings and fledglings were conducted to determine whether species breeding in areas of high or medium exposure were able to successfully raise young. Fledglings were found as often in forests (11 fledglings) as in meadows (10 fledglings). There was little difference in the number of fledglings between habitat types and exposure levels, with the exception of medium exposure meadows in which no fledglings were found. The fledglings of 13 species were observed (American Robin, Hermit Thrush, Swainson's Thrush, Northern Parula, Black-throated Blue Warbler, Chestnut-sided Warbler, Bay-breasted Warbler, Magnolia Warbler, American Redstart, Ovenbird, Common Yellowthroat, Song Sparrow and White-throated Sparrow). These species are primarily insectivores in the breeding season, though the American Robin and the two thrushes have a variable diet that includes many seeds and fruits as well. The most commonly found species (three individuals of each) were American Robin, Common Yellowthroat and White-throated Sparrow.

While the survey effort and sample size was too low to calculate any quantitative measure of nesting success, the results did confirm that birds are able to fledge young in all exposure levels. In the forest habitat, there was no clear difference in the number of fledglings between the control and the medium and high exposure areas. Fledglings were observed in control and high exposure plots in the meadow category.

Bird Survey and Fledgling Results

The results of this study indicate that birds are establishing breeding territories in areas near the Belledune smelter with medium and high soil metals concentrations at similar densities to unaffected (*i.e*., control) areas. While the elevated soil metals concentrations within 2 km of the smelter are potential sources of exposure for birds nesting in those areas, based on observations made during the 2011 breeding season, birds near the smelter were successful in nesting, egg-laying and fledging young in numbers similar to those recorded in distant control areas. While there are some uncertainties in the findings of this study, related to habitat differences and observation duration periods, the data collected to date do not suggest the presence of significant concerns for breeding avifauna in areas near the smelter.

There were two primary limitations of the breeding bird study in discerning differences between control and exposure areas; level of effort and habitat differences. The authors of the breeding bird study indicated that while the level of effort may have been too low to provide conclusive quantitative evidence and habitat differences make interpretation a challenge, the study was able to provide strong qualitative and limited quantitative evidence of breeding throughout the Study boundary (LGL, 2012b).

9.4.3 Relevant Literature

A review of recently published literature on impacts to birds from contaminated soils was conducted to provide additional perspective on potential risks to avian species. The literature reviewed supports the risk modeling results which estimated higher ER values for ground-feeding insectivorous species (*i.e*., the junco) compared to carnivorous (*i.e*., saw-whet owl) or herbivorous (*i.e.,* ruffed grouse) avian species. Resident and migratory ground feeding insectivorous avian species were reported to have higher exposures than birds that forage above ground or primarily on foliage due to the importance of soil ingestion to total exposure (Hansen, 2011; Roux and Marra, 2007).

In a large multi-year study of lead in avian species as a result of historical mining and smelting activity in the Coeur D'Alene river basin in northern Idaho, blood lead levels of avian species were collected and ingesta examined (Hansen *et al*., 2011). Study results found that soil ingestion rates in songbirds were approximately 20% in robins, 17% in song sparrows and 0.7% in Swainson's thrushes. Analysis of ingesta indicated that soil accounted for almost all of the songbird's exposure to lead. When soil ingestion rates were lower, however; other sources of lead became more significant to total lead exposures. The authors reported that blood concentrations in ground-feeding songbirds tend to be greater than those reported for raptors as a result of the lower soil exposures in raptors compared to ground-feeders (Hansen *et al*., 2011).

Sample *et al.* (2011) derived preliminary remedial goals (PRG) for lead for a variety of avian songbirds in the Coeur D'Alene river basin. The lowest PRG derived at 490 mg/kg in soil based on subclinical effects due to lead in blood of the American robin. The authors define subclinical effects as "measureable physiological responses that are not sufficient to cause severe biological impairment", based on Pain (1996). Other PRGs for subclinical effects in the song sparrow and Swainsons thrush ranged from 2500 – 2700 mg/kg. Clinical effect PRGs for all three species ranged from 2700 – 5000 mg/kg. Based on the lowest PRG and its similarity to other PRGs developed for the Coeur D'Alene basin, the US EPA made a risk management decision that a site specific PRG of 530 mg/kg lead in soil would be protective of songbirds in the Coeur D'Alene Basin. While this PRG is a site-specific value, it does provide some perspective on the potential risk associated with levels of lead in soil in the vicinity of the Belledune Smelter. Of the 31 soil samples collected within 3 km of the Belledune smelter in 2009 and 2010, only 4 of them exceed the Coeur D'Alene site-specific PRG value of 530 mg/kg (one sample near the slag pile and the other 3 within 1 km of the smelter). Given the size of the area with soil lead levels above this PRG value, the potential for subclinical effects in ground feeding insectivores as a result of lead exposures is considered to be low.

9.4.4 Avian Receptor Weight of Evidence

The various LOE used to assess potential risks to avian receptors are identified in Table 9-13 along with the interpretation of each LOE. The ER_{LOAELs} values for the grouse and owl were at or below the critical ER value of 1.0. Junco ER_{LOAEL} values for Pb, Cd and Zn exceeded the critical ER value at 0 to 1 km, 1 to 2 km and 2 to 3 km from the smelter. The lower ER values for the grouse and owl are in agreement with other studies which found lower exposures to herbivorous and carnivorous avian species compared to ground feeding insectivores, due in part to the higher soil exposure of ground feeders (e.g., Hansen et al., 2011).

The ER results for the junco indicate that insectivorous avian species may potentially be at risk (more so in areas near to the smelter and in the vicinity of the slag pile). These ER values were calculated using a variety of conservative assumptions and likely over-estimated junco exposures to metals (e.g., exposure modeling used the UCLM 95 which is an upper bound estimate of soil concentrations; bioavailability in soil and diet was assumed to be 100%).

Although the junco ER values were elevated, several insectivorous ground feeders were found within the Study boundary during the bird survey. These species included: Ovenbird, Lincoln's Sparrow, Song Sparrow, Savannah Sparrow, White-throated Sparrow. While no juncos were found within the Study boundary but were found within one of the control areas (i.e., a control meadow), this may be due more to habitat preferences than soil metal levels. Juncos prefer open-forest habitats or cut-over areas and many of the forest and meadow plots may have been either too dense or too open for them (Rising and Beadle 1996). Results of the fledgling survey indicate that the ground feeding species (in addition to other species) are capable of producing young in these exposure areas.

The results of the breeding bird survey indicate that birds are establishing breeding territories in areas near the Belledune smelter with medium and high soil metals concentrations at similar density to unaffected (*i.e.*, control) areas. While there are some uncertainties in the findings of this study, related to habitat differences and observation duration periods, the data collected to date do not suggest the presence of significant concerns for breeding avifauna in areas near the smelter.

Of the 31 soil samples collected within 3 km of the smelter only 4 samples are more elevated than the site specific soil PRG of 530 mg/kg derived for Coeur D'Alene basin by US EPA (Sample et al., 2011), which is based on subclinical effects. Given the size of the Study boundary, avian home ranges, and the limited area exceeding a recently derived site-specific PRG from another site, the potential for subclinical effects in avian species as a result of metals in soils is considered to be low.

Given the outcomes of the various LOEs and considering the uncertainties and study limitations presented in Section 10.0, the following conclusions for the health of avian species can be made:

- Risks to avian species (herbivorous, carnivorous or insectivorous) are considered to be low. Based on the results of the assessment, some individual level effects could be occurring in some species, but population level effects within the vicinity of the Belledune smelter as a result of smelter operations are considered unlikely.

Table 9-13 Lines of Evidence for Evaluating Avian Receptors

ER Values for Receptors	Breeding Bird and Fledgling Survey Outcomes (LGL, 2012b)				Literature	Potential Risks to Avian Receptors
	Species Richness	Species Composition	Breeding Activity / Breeding Success	Fledgling Survey		
Junco: Pb, Cd and Zn >critical ER value indicating potential risks to ground-feeding insectivores mainly within 2 km of smelter Owl: all COPCs < critical ER value Grouse: all COPCs < critical ER value Thallium and antimony could not be modeled due to a lack of toxicity data	Control forest plots somewhat higher than Study boundary, no clear trend in meadow plots. Species per plot: Forests: Control = 14.3 Medium = 11.0 High = 12.0 Meadow: Control = 9 Medium = 6.5 High = 9.5	46 species recorded within the Study boundary and control areas. Of these: 14 were only recorded in control areas; 8 were only recorded in Study boundary. Canada Warbler only species at risk observed (ranked Threatened by COSEWIC, SARA Schedule 1), which was found in medium exposure forest	Number of confirmed and probable breeding species was similar across the exposure levels for each habitat type. Average breeding territories similar for all exposure levels: Control = 18.7 Medium = 15.0 High = 17.0	Birds are able to fledge young in all exposure levels. No clear difference in number of fledglings between exposure areas in forest habitat. In meadow habitat fledglings were observed in control and high exposure plots.	Pb exposures generally higher in ground feeding insectivores compared to herbivores and carnivores due in part to higher soil exposures. Site specific soil PRG of 530 mg/kg derived for Coeur D'Alene basin by US EPA (Sample et al., 2011). Of the 31 soil samples collected within 3 km of the smelter 4 would exceed PRG. Given the size of the Study boundary, avian home ranges, and that only a few samples exceeded PRG, potential for subclinical effects as a result of lead exposures would be low.	Risks to avain species are considered to be low. Population level effects on avian receptors are considered unlikely

9.5 Mammalian Receptors

To evaluate the potential for ecological risks to mammalian species, the following LOE were used in the WOE approach to characterize risk (See Section 9.5.5):

- Predicted Exposure Ratios (ER) from food chain modeling (*i.e.*, comparison of estimated COPC exposures via all exposure pathways to TRVs);
- Outcomes of the small mammal study (abundance and diversity) conducted within the Study boundary compared to reference area;
- Comparison of tissue residue data for small mammals collected within the Study boundary to those collected in reference area and to tissue effects literature; and
- Consideration of toxicological / biological information from other studies and extrapolation where applicable to this ERA.

9.5.1 Exposure Ratios

The NOAEL-based ERs for mammalian receptors (*i.e.*, masked shrew, snowshoe hare, short-tailed weasel and white-tailed deer) for the Study boundary and reference area are provided in Table 9-14 and discussed in this section. Where ERs exceed 1.0, cells in the table are shaded. The ERs were calculated using the 95th upper confidence limit on the mean soil concentration (UCLM 95) to represent general exposures throughout the Study boundary (*i.e.*, 0 to 3 km; 2009 and 2010 soil data).

Within the Study boundary, ER_{NOAELs} for the masked shrew were greater than the critical ER_{NOAEL} value of 1.0 for all COPCs except arsenic (*i.e.,* antimony, cadmium, lead, thallium and zinc)(Table 9-14). ERs in the reference area also exceeded the critical ER value for antimony, cadmium and thallium, but to a lesser degree.

For the snowshoe hare and short-tailed weasel only the ER_{NOAEL} for thallium exceeded the critical value of 1.0 while there were no ER_{NOAEL} exceedances of the critical value in the reference area for these receptors.

There were no ER_{NOAEL} exceedances of the critical value of 1.0 for the white-tailed deer within the Study boundary or reference area.

Like the assessment of avian species, risk for all mammalian receptors was re-modelled at distances 0 to 1 km, 1 to 2 km and 2 to 3 km from the smelter, using the expanded soil database (2009 and 2010 datasets combined)(Table 9-15). Evaluating varying distances from the smelter allows for an evaluation of the soil concentrations that are generally higher in areas closer to the smelter, which in turn enables an evaluation of potential risks to species (particularly those with a small home range) that may forage almost exclusively closer to the smelter. The resulting ERs are provided in Table 9-15. Where ER_{NOAELs} exceed 1.0, cells in the table are shaded.

Table 9-14 Reference and Study Boundary (0 to 3 km) NOAEL-Based Exposure Ratios (ER_{NOAEL})

Chemical	Reference ER_{NOAEL} [1]	Study Boundary ER_{NOAEL} [1]
	UCLM 95 [2]	UCLM 95 [2]
Masked Shrew		
Antimony	6.5	29
Arsenic	0.23	0.65
Cadmium	2.8	7.6
Lead	0.74	3.9
Thallium	1.1	8.0
Zinc	0.86	1.7
Snowshoe Hare		
Antimony	0.21	0.81
Arsenic	0.048	0.18
Cadmium	0.058	0.13
Lead	0.057	0.41
Thallium	0.09	1.2
Zinc	0.038	0.12
Short Tailed Weasel (Ermine)		
Antimony	0.16	0.68
Arsenic	0.027	0.11
Cadmium	0.082	0.16
Lead	0.12	0.46
Thallium	0.33	3.0
Zinc	0.12	0.15
White Tailed Deer		
Antimony	0.094	0.33
Arsenic	0.022	0.08
Cadmium	0.036	0.081
Lead	0.025	0.17
Thallium	0.028	0.55
Zinc	0.024	0.074

Notes:
NOAEL = no-observable-adverse-effect level; UCLM = upper confidence limit on the mean.
ER values have been rounded to two significant figures.
Shading indicates ER values greater than critical value of 1.0.

1. Predicted ER values are based on UCLM (upper confidence limit on the mean) soil concentrations. To estimate exposures from food items, the maximum measured tissue concentration was used (*i.e.*, for non-woody vegetation or grasses and for small mammals). Food item tissue concentrations were estimated from soil concentrations and uptake factors. See Appendix J for additional information.
2. Model input values were calculated using the 95% UCLM of soil data and where adequate data were available, the 95% UCLM of other media.

Table 9-15 Study Boundary NOAEL-Based Exposure Ratios (ER_{NOAEL})

Chemical	0 to 1km ER_{NOAEL} [1]	1 to 2 km ER_{NOAEL} [1]	2 to 3 km ER_{NOAEL} [1]
	UCLM 95 [2]	UCLM 95 [2]	UCLM 95 [2]
Masked Shrew			
Antimony	20	28	8.7
Arsenic	0.67	0.65	0.73
Cadmium	11	5.2	4.3
Lead	8.1	4.0	2.3
Thallium	12	2.3	2.0
Zinc	1.4	1.8	1.2
Snowshoe Hare			
Antimony	0.60	0.78	0.30
Arsenic	0.18	0.18	0.20
Cadmium	0.18	0.10	0.091
Lead	0.77	0.41	0.27
Thallium	1.5	0.77	0.74
Zinc	0.092	0.14	0.072
Short Tailed Weasel (Ermine)			
Antimony	0.49	0.65	0.22
Arsenic	0.11	0.11	0.12
Cadmium	0.21	0.12	0.11
Lead	0.87	0.47	0.29
Thallium	4.2	1.3	1.2
Zinc	0.14	0.16	0.13
White Tailed Deer			
Antimony	0.25	0.32	0.14
Arsenic	0.082	0.080	0.086
Cadmium	0.10	0.064	0.057
Lead	0.27	0.17	0.13
Thallium	0.62	0.44	0.44
Zinc	0.057	0.084	0.045

Notes:
NOAEL = no-observable-adverse-effect level; UCLM = upper confidence limit on the mean.
ER values have been rounded to two significant figures.
Shading indicates ER values greater than critical value of 1.0.

3. Predicted ER values are based on UCLM (upper confidence limit on the mean) soil concentrations. Food item tissue concentrations were estimated from soil concentrations and uptake factors. See Appendix J for additional information.
4. Model input values were calculated using the 95th UCLM of soil data and where adequate data were available the 95th UCLM of other media.

ER_{NOAELs} for the masked shrew (*i.e.*, antimony, cadmium, lead, thallium and zinc) and ermine (*i.e.,* thallium) exceeded the critical ER at 0 to 1km, 1 to 2 km and 2 to 3 km. The snowshoe hare ER_{NOAEL} for thallium was also exceeded but only at the 0 to 1 km distance. ER_{NOAELs} for the white tailed deer at 0 to 1 km, 1 to 2 km and 2 to 3 km are below the critical ER value of 1.0 (See Table 9-14) indicating exposures to this species to the identified COPCs are below those likely to cause effects. Based on these results, it is unlikely that exposures exceeding effect levels in other herbivorous large mammalian receptors with similar or larger home ranges would occur.

As a result of this, exposure ratios were then calculated using effects-based TRVs (*i.e.*, LOAEL-based TRVs) to estimate the likelihood for adverse effects in these species. This was only conducted for COPCs that had a critical ER_{NOAEL} greater than 1.0. Resulting Study boundary ER_{LOAELs} for the receptors and applicable COPCs are provided in Table 9-16. The shrew was the only receptor with ER_{NOAELs} which were >1.0 in reference (*i.e.,* antimony, cadmium and thallium). Reference area shrew ER_{LOAELs} were calculated for these COPCs, and were below the critical value of 1.0 (0.65, 0.92 and 0.21 for antimony, cadmium and thallium, respectively), and therefore are not shown in Table 9-16.

Table 9-16 Study Boundary LOAEL-Based Exposure Ratios (ER_{LOAEL})

Chemical	**0 to 1km ER_{LOAEL} ^{1}**	**1 to 2 km ER_{LOAEL} ^{1}**	**2 to 3 km ER_{LOAEL} ^{1}**
	UCLM 95 ^{2}	**UCLM 95 ^{2}**	**UCLM 95 ^{2}**
Masked Shrew			
Antimony	2.0	2.8	0.87
Cadmium	3.6	1.8	1.5
Lead	1.1	0.54	0.31
Thallium	2.4	0.47	0.41
Zinc	1.1	1.4	0.99
Snowshoe Hare			
Thallium	0.29	0.15	0.15
Ermine			
Thallium	0.84	0.26	0.24

Notes:
LOAEL = lowest observable adverse effect level; UCLM = upper confidence limit on the mean.
ER values have been rounded to two significant figures.
Shading indicates ER values greater than critical value of 1.0.

3. Predicted ER values are based on UCLM (upper confidence limit on the mean) soil concentrations. Food item tissue concentrations were estimated from soil concentrations and uptake factors. See Appendix J for additional information.
4. Model input values were calculated using the 95th UCLM of soil data and where adequate data were available the 95% UCLM of other media.

The effects-based ER_{LOAELs} for the snowshoe hare and ermine did not exceed the critical value of 1.0 (Table 9-16). As such, these species and receptor groups do not require further assessment. Based on the ER_{LOAELs} for these species and the data and assumptions used in this assessment, it is unlikely that exposures exceeding effect levels in other herbivorous and carnivorous mammalian species would occur. Large carnivorous and herbivorous mammals would be expected to have lower exposure potentials to the COPCs than the small herbivorous mammal (*i.e.*, snowshoe hare) and small mammalian carnivore (*i.e.,* ermine) modeled in this study, since larger mammalian receptors have bigger home ranges, and therefore lower exposure potential. Given that the areas with the highest soil concentration are small and generally closest to the facility, the larger the animals home range, the lower the percentage of the diet that will come from the areas having the highest metal concentrations.

The ER_{LOAELs} for the masked shrew varied based on distance from the Glencore smelter. ER_{LOAELs} for cadmium, lead and thallium were greatest at the 0 to 1 km distance and decreased as the distance from the facility increased (See Table 9-16). For antimony and zinc, ER_{LOAELs} at 0 to 1 km were slightly less than the 1 to 2 km. However this is due to one sample with elevated concentrations relative to the other samples collected at a distance of 1 to 2 km from the smelter.

This sample was collected in the vicinity of the slag pile and as such, it is not surprising that this sample had higher metals concentrations (see Figures 6-3 and 6-4).

All ER_{LOAELs} for the masked shrew at 2 to 3 km, with the exception of cadmium, were below the critical value of 1.0 indicating that beyond 2 km, exposures are generally less than effect levels. At 0 to 1 km the ER_{LOAELs} for all COPCs exceed the critical value of 1.0 with ER_{LOAELs} ranging from 1.1 to 3.6. At 1 to 2 km, antimony, cadmium and zinc are elevated over the critical ER with values of 2.8, 1.8 and 1.4, respectively (See Table 9-16).

Exposures to the shrew were mainly due to ingestion of soil invertebrates, which accounted for 72% to 99% of total exposures, followed by soil and dust ingestion, which accounted for 2% to 24% of total exposure (See Table 9-17). While some invertebrates collected within the Study boundary were analyzed for metals, the sample size was small (N=6). As such, conclusions regarding how representative the predicted invertebrate tissue concentrations are to measured values cannot be made. While there is uncertainty in the predicted invertebrate tissue concentrations, bioavailability of the COPCs in the diet and soil was conservatively assumed to be 100% in the exposure modeling, and actual exposures would be expected to be less than that assumed. In addition, exposures to soil (and invertebrates) were estimated using the top 5 cm soil data (where soil concentrations were greatest). Shrews (and other species) can burrow to deeper depths then 5 cm and would not always be exposed to surface soils where metal concentrations were greatest. As such, it is likely exposures to insectivorous small mammals have been overestimated.

Table 9-17 Relative Contributions to Overall Exposure for Shrew [1]

	Soil Ingestion (%)	Soil, Dust, Air Inhalation (%)	Invertebrate Ingestion (%)
Antimony	3	0	97
Arsenic	24	3	72
Cadmium	1	0	99
Lead	12	1	87
Thallium	12	2	86
Zinc	2	0	98

1 Based on modeling for 0 to 1 km UCLM 95 soil concentrations
Note: Numbers may not always add to 100% due to rounding

To identify whether there are potential risks to the shrew and other insectivorous small mammals to the COPCs, it is also useful to consider the basis of the effects-based TRVs.

No shrew antimony toxicity data, relevant for TRV derivation, was identified in the literature reviewed. One bounded reproductive LOAEL and 2 bounded growth LOAELs for mammalian species (rodents: rats and mice) were reported in the US EPA Ecological Screening Level for antimony document (U.S. EPA, 2005b). The antimony TRV used to assess the shrew was based on the lowest bounded LOAEL reported by the US EPA (2005b) of 0.59 mg/kg/day. This study was based on antimony trichloride and was almost 2 orders of magnitude lower than the two growth LOAELs (based on antimony potassium tartrate). Even though the available antimony toxicity data were based on rodents (*i.e.*, rats and mice) and rodents are from a different taxonomic order than the shrew, no uncertainty factor was applied to the lowest LOAEL to derive the TRV given the limited toxicity data available for the shrew and given all three studies identified were drinking water studies where the bioavailability of the antimony would be greater than in soils and in diet (as is relevant at this site). Using a TRV based on drinking water studies and chemical species more available than what would be expected on-site, it is likely that the antimony TRV may have overestimated potential risks to the shrew.

Given there was only a slight exceedance of the antimony ER_{LOAELs} at 0 to 1 km and 1 to 2 km (2.0 and 2.8, respectively). These ER_{LOAELs} were calculated assuming the antimony concentrations in the soil invertebrates equaled soil antimony concentrations. The available tissue data for soil invertebrates, while limited, suggests that predicted tissue concentrations are much less than the measured concentrations (*i.e.,* mean measured concentrations at 0 to 1 km and 1 to 2 km were 0.89 mg/kg and 0.85 mg/kg, respectively while mean predicted concentrations at these distances were 4.6 mg/kg and 3.9 mg/kg, respectively; See Table 9-12 and Appendix D). In addition antimony was not detected in small mammal kidney, liver or whole body within the Study boundary indicating that antimony does not readily accumulate (See Section 9.5.3). Antimony exposures and risks have likely been overestimated. As such, antimony exposures were not considered to represent a potential risk to shrew, and therefore did not require further assessment.

Whether exposures of the shrew to cadmium, lead, thallium and zinc were over / under estimated was less clear (See Table 9-12). For cadmium, predicted mean tissue concentrations at 0 to 1 km overestimated measured tissue concentrations (38 mg/kg predicted versus 29.9 mg/kg measured); however at 1 to 2 km this opposite was true (17.2 mg/kg predicted versus 30.2 measured). The reverse occurred for lead with 0 to 1 km predicted mean concentrations being less than mean measured concentrations (128 mg/kg predicted versus 271 measured) and 1 to 2 km predicted mean concentrations being more than mean measured concentrations (64 mg/kg predicted versus 46 mg/kg measured). Zinc was over predicted at the 0 to 1 km distance (507 mg/kg predicted; 756 mg/kg measured) but under predicted at 1 to 2 km (572 predicted; 482 measured). Given the small number of invertebrate samples, the results are generally variable. Since the soil invertebrate species composition varied from sample to sample, and the invertebrates were not depurated (i.e., the measured values include soil that could be contained within the invertebrates gut, or adhered to the surface), these factors play a large role in the variability within the data, in addition to the small sample sizes. These factors all contribute to uncertainties in the application of the data to characterization of risk.

The LOAEL-based cadmium TRV was based on the lowest reported bounded LOAEL for reproduction, growth or survival (from well over 40 studies) via the food ingestion route in the US EPA Eco SSL documentation for cadmium (U.S. EPA, 2005d). This TRV was 2.3 mg/kg/day and it was from a study in mice fed cadmium chloride (Sawicka-Kapusta et al., 1994). While one study conducted on common shrew (*Sorex araneus*) was identified in the literature reviewed (*i.e*., Dodds-Smith *et al*., 1992), it was not used to derive the shrew TRV. In this study, effects on growth were reported at 103 mg/kg/day but no other doses were tested limiting the usefulness of this study to derive a TRV. If the shrew LOAEL of 103 mg/kg/day is representative of where effects on the shrew may occur, using the effects-based TRV of 2.3 mg/kg/day in the modeling may have resulted in overly conservative ERs.

The shrew effects-based TRV of 35 mg/kg/day for lead was based on a bounded LOAEL for effects on rabbit survival (106 mg/kg/day) and by applying a 3-fold uncertainty factor to account for differences in the shrew and rabbit (See Table 7-5). While an unbounded LOAEL was identified in the literature reviewed for the shrew (61.5 mg/kg/day; Pankakoski *et al*., 1994) this study's endpoints were growth and survival. Given the Pankakoski *et al*. (1994) study is unbounded and given the severity of the potential effect (*i.e*., effects on survival), the selected TRV of 35 mg/kg/day (selected from the twenty-two bounded reproductive LOAELs for mammalian species) was considered most appropriate to use for the masked shrew TRV. Given the shrew study was unbounded and no other shrew toxicity data were identified in the literature reviewed, there is uncertainty in whether the selected TRV would be overestimating or underestimating potential risks to the shrew.

The LOAEL-based TRV for thallium of 0.075 mg/kg/day used in the exposure modeling was derived by the U.S. Army Centre for Health Promotion and Preventative Medicine (2007). The Army Centre had low confidence in these TRVs due to a paucity of toxicity data and as such, there is uncertainty with the estimated hazard of thallium exposures. As such there is uncertainty in whether the selected TRV would be overestimating or underestimating potential risks to the shrew.

The shrew effects-based TRV of 94.2 mg/kg/day for zinc was based on an EC20 for reproductive effects in rats as a result of exposure to zinc carbonate, which is a highly available form of zinc (US EPA, 2001a). Six bounded reproductive LOAELs for mammalian species were identified for zinc which ranged from 75.9 mg/kg/day to 4927 mg/kg/day (US EPA, 2007b). The lowest bounded reproductive LOAEL (75.9 mg/kg/day) was from a cattle study (Miller *et al*., 1989) which would not be considered a relevant surrogate for the shrew due to major differences in physiology (See Table 8-4). Similarly the next lowest LOAEL of 82.3 mg/kg/day, based on reproductive effects in pigs (Hill *et al*., 1983). While pigs are non-ruminant, they are in the same order (*i.e*., Artiodactyla) as deer, cattle, sheep and goats which are ruminants, so this study was not considered relevant. The next highest bounded reproductive LOAEL was 452 mg/kg/day (where rats were exposed to zinc oxide in their diet; Ketcheson *et al*., 1969). This LOAEL is greater than the EC20 of 94 mg/kg/day (US EPA, 2001a) so the EC20 was conservatively selected as the LOAEL-based TRV for the masked shrew. Given the lack of shrew toxicity data, there is uncertainty as to whether the selected TRV is overly conservative for the shrew. However, the form of metal used in to derive the EC20 (zinc carbonate) would be more bioavailable than the form of zinc which would be expected to be found within the Belledune area (*i.e*., zinc oxides, sulphates, chlorides, *etc*.), and as such, selecting a TRV based on zinc carbonate likely overestimated potential risks.

9.5.1.1 Summary of Exposure Ratios

In summary, ER_{LOAELs} for herbivorous small and large mammals and carnivorous small mammals are less than the critical ER indicating exposures are less than those associated with adverse effects. Some shrew ER_{LOAELs} were greater than the critical ER of 1.0. These ERs were derived using effects-based TRVs which were generally selected from toxicity data for other species since there is a paucity of shrew and other insectivorous small mammal toxicity data.

Exposures however, have likely been overestimated since bioavailability of the COPCs in the diet and soil was conservatively assumed to be 100% in the exposure modeling. Actual exposure of shrew to COPC is expected to be less. Exposures to soil (and invertebrates) were estimated using the top 5 cm soil data (where soil concentrations were greatest). Shrews can burrow to deeper depths then 5 cm and as such, would not always be exposed to surface soils where metal concentrations were greatest. In addition, the area within the Study boundary where metal concentrations are elevated is small, therefore limiting the potential for exposures to shrew populations. However, the measured invertebrate tissue data indicate that in some areas within 0 to 1 km of the smelter, predicted invertebrate tissue concentrations of lead may have been underestimated (while at 1 to 2 km invertebrate concentrations were over estimated but ER values were still below the critical value of 1.0). As such, the possibility of potential adverse health effects on individual shrews in areas within 0 to 1 km of the facility exposed to lead cannot be ruled out based on the ER approach alone.

9.5.2 Small Mammal Study

An additional LOE to support the ERA is the site-specific small mammal study. The objective of the small mammal survey was to collect data on small mammal populations to provide additional support for the ERA related to abundance, diversity, morphometrics (*e.g.*, body length, tail length, ear length, *etc*.), and general health and metals loadings in small mammals within the Study boundary and reference areas. The small mammal survey was conducted by LGL in the fall of 2011 and the full report can be found in Appendix M. Small mammal metrics from within the Study boundary were compared to those at the reference areas.

The small mammal survey results provided a preliminary indication of the distribution and occurrence of small mammals in the Study boundary. Small mammals found within the Study boundary included shrew (*i.e.,* northern short-tailed, common shrew), vole (*i.e.*, meadow, red-backed), deer mice and red squirrel (See Appendix M for full list of species and numbers observed). In the reference area, species reported included the common shrew, red-backed vole and deer mouse. The data available were insufficient to determine whether differences were related to trapping duration, the time of year, habitat suitability, or metal levels in soils (LGL, 2012a). The authors however, reported that that the data collected to date do not suggest impacts to diversity of small mammal populations, given the largest number of species was associated with a survey location within the Study boundary where metals in soils were considered “high” (LGL, 2012a).

No masked shrews were caught in traps during the small mammal survey within the Study boundary. This may be due to habitat, trapping methods or duration or time of year. Metal levels in soil or food may not be a factor, as no masked shrews were caught in the reference area either. Common shrews however; were found within the Study boundary and in the reference area, while northern short-tailed shrews were found but only within the Study boundary.

There were no apparent differences in body length, tail length, ear length, *etc*. reported between the Study boundary survey sites, where morphometric comparisons were possible. In addition, all animals captured appeared to be in good health with no observed abnormalities or obvious signs of malnourishment. In addition, the authors of the report indicated that the age class and sex specific data when pooled, suggested that the populations of the meadow vole and deer mouse were viable (LGL, 2012a). More data would however reduce the uncertainty in this conclusion given the data were limited.

The authors of the small mammal survey report concluded that based on the data collected, there appears to be little difference in species richness, diversity, relative abundance, or morphometrics between animals inhabiting the Study boundary and reference areas (LGL, 2012a). Given the sample size, they indicated that the strength of the evidence is limited and additional data collection would strengthen conclusions.

9.5.3 Comparison of Tissue Residue Data

One other LOE used in the risk characterization was small mammal tissue analyses for all metals (provided in Appendix D and Tables 9-18 to 9-20). During the small mammal survey, a select number of animals were sacrificed in order to collect organs (liver and/or kidney) for metals analysis (for details see LGL, 2012a; Appendix M). Due to small tissue mass, organs frequently were required to be composited. In addition, where animal body size was small, whole bodies were collected and submitted for analysis. Within the Study boundary, composite samples analyzed for metals included 2 kidney, 6 liver and 4 whole body. In reference, composite samples included 2 liver, 1 kidney and 1 whole body. A comparison of metal levels in the kidney, liver and whole body from within the Study boundary and reference areas are provided in Tables 9-17 to 9-19, respectively.

Antimony

Results indicate that antimony was not detected in small mammal kidney, liver or whole body within the Study boundary or in reference areas, indicating that antimony does not readily accumulate (Tables 9-18 to 9-20).

Arsenic

Whole body arsenic tissue concentration in small mammals ranged from 0.91 to 2.81 mg/kg wet weight within the Study boundary and was less than the detection limit in the reference area (<0.5 mg/kg)(Table 9-20). Arsenic was not detected in kidney samples collected from small mammals in either the Study boundary or reference areas (Table 9-18). Based on the available data, arsenic does not appear to accumulate in this tissue at concentrations above detection limits. Similarly, arsenic does not appear to be significantly accumulating in liver as 5 of the 6 liver samples obtained from small mammals within the Study boundary did not have detectable concentrations of arsenic (Table 9-18). Arsenic was not detected in reference area samples. Based on the available data, arsenic does not appear to be accumulating in critical organs, but was found in measureable concentrations in whole bodies, which could be related to ingesta within the gut.

Cadmium

Small mammal whole body cadmium concentrations within the Study boundary ranged from 0.885 mg/kg wet weight to 2.89 mg/kg wet weight while a whole body cadmium concentration in the reference area of 0.275 mg/kg wet weight was reported (Table 9-20). Cadmium in Study boundary kidneys was 5.06 and 9.28 mg/kg while liver cadmium tissue concentrations ranged from <0.1 to 23.5 mg/kg (Tables 9-18 and 9-19). While 3 of the 6 composite liver tissue samples were similar to reference, 3 were greater (and 2 of these 3 samples were much greater)(Table 9-19). Similarly, the reference area kidney cadmium concentration was lower than concentrations in the 2 samples obtained within the Study boundary (Table 9-18).

Given that the kidney is the primary organ in which cadmium damage/functional changes occur, and that kidneys are the organ which accumulates the highest cadmium concentration, the kidney is considered the critical organ in chronic mammalian cadmium toxicity studies (Beyer and Meador, 2011). These authors report a critical level for serious effects in wild small mammals of 100 mg/kg wet weight in whole kidney. Critical levels for serious nephrotoxicity of 30 to 60 mg/kg wet weight were also reported by the authors. To evaluate whether kidney cadmium concentrations could pose potential adverse effects in small mammals, cadmium concentrations in the kidney from the Study boundary were compared to tissue effect levels reported in the literature (Table 9-21). The range in critical kidney tissue concentrations identified in the literature reviewed was 29 to 100 mg/kg ww. The maximum kidney tissue concentration reported within the Study boundary was 9.28 mg/kg ww which was well below the identified critical tissue concentrations. These comparisons suggest a low potential for cadmium-related nephrotoxicity in small mammals within the study area, based on the available data.

Lead

Lead concentrations in small mammal kidney, liver and whole body were greater in samples from within the Study boundary compared to reference with the exception of one sample which was slightly below reference (See Tables 9-18 to 9-20). Based on the available data, lead appears to be accumulating more in tissues of small mammals collected from within the Study boundary compared to those in reference.

To examine whether these tissue concentrations pose the potential for adverse effects, lead concentrations in small mammal kidney and liver from within the Study boundary were compared to tissue effect levels reported in the literature (See Table 9-22). Reported tissue effect levels identified in the literature reviewed ranged from 2.3 to 56 mg/kg wet weight in the kidney and 1.3 to 4.8 mg/kg wet weight in the liver (Table 9-22). Of the 2 study area kidney samples, both were greater than the reported tissue effect levels while the reference area sample was less than reported effect levels. As for the livers, 2 of the 6 samples were greater than the lower end of the effects range (*i.e.*, 1.3 mg/kg wet weight) at 3.27 and 6.45 mg/kg while only one of these samples exceeded the upper range of reported tissue effect levels at 6.45 mg/kg. Based on the available data, the potential for adverse effects in some shrew and other small insectivorous small mammals in the Study boundary to be adversely affected by lead tissue concentrations cannot be ruled out.

Thallium

Thallium concentrations in whole bodies, livers and kidneys of mammals collected from within the Study boundary were higher than thallium in all samples collected from the reference area (Tables 9-18 to 9-20). Based on the available data, thallium appears to be accumulating more in tissues of small mammals collected from within the Study boundary compared to those in reference.

There is a paucity of thallium toxicity data for mammals, and as such, the no definitive conclusions could be made with respect to thallium in small mammal tissues and possible effects.

Zinc

Zinc was detected in all whole body, liver and kidney samples from site and reference areas. While sample size is limited, zinc concentrations in livers and kidneys collected from within the study are similar to those from the reference areas (Tables 9-18 and 9-19). Reference area and Study boundary whole body zinc concentrations were also similar (Table 9-20). Zinc is an essential nutrient and is regulated by mammals (NRC, 2005). The US Department of the Interior (1998), reported that diagnostic levels for toxicity in any animal are not well established for zinc since zinc tissue concentrations are generally homeostatically regulated. They reported a toxicity threshold for zinc in small mammals to be >88 mg/kg wet weight (converted from 274 mg/kg dry weight[8]) in kidney and >149 mg/kg wet weight (converted from 465 mg/kg [1]) in liver (Talmage and Walton, 1991; US Department of the Interior, 1998). Liver and kidney zinc tissue concentrations from within the Study boundary were a maximum of 39.4 mg/kg and 26.8 mg/kg wet weight, respectively which are well below the reported toxicity thresholds.

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[8] Dry weight values converted to wet weight using the following equation:
Tissue concentration dw * (1-% moisture) = wet weight. Percent moisture content was assumed to be 68% in liver and kidney based on a prey water content of 68% reported by Suter et al. (2000). While no site-specific prey moisture content was available, this percent moisture value was supported well by percent moisture values in the Yukon Country Food survey conducted in 2000. In this study, mean percent moisture content in arctic ground squirrel livers were reported to be 69.8 (N=7); 64.1 (N=2); 69.8 (N=5) and 70.2 (N=7) and in arctic ground squirrel kidneys: 32.8 (N=6); 71.5 (N=2); 69.9 (N=5) and 74.3 (N=2).

Table 9-18 Metal Concentrations in Kidney of Small Mammals Collected from Study Boundary and Reference Areas in 2011

	Study Boundary (mg/kg wet weight)		Reference (mg/kg wet weight)
	Deer mouse – Vole	Vole - Deer mouse	Vole - Deer mouse
Metals	A-F-PEMA-MIPE KIDNEY	G-B-MYGA-PEMA KIDNEY	FOR REF-MYGA-PEMA KIDNEY
Antimony (Sb)	<0.5	<0.5	<0.5
Arsenic (As)	<0.5	<0.5	<0.5
Cadmium (Cd)	5.06	9.28	3.09
Lead (Pb)	14.1	7.11	1.02
Thallium (Tl)	3.73	1.12	0.058
Zinc (Zn)	21.0	26.8	23.3

Notes:
BLBR = northern short tailed shrew; MIPE = meadow vole; PEMA = deer mouse; MYGA = southern red backed vole

Table 9-19 Metal Concentrations in Liver of Small Mammals Collected from Study Boundary and Reference Areas in 2011

	Study Boundary(mg/kg wet weight)						Reference (mg/kg wet weight)	
	Meadow vole	Deer mouse	N. Short tailed shrew	Deer mouse	S. Red backed vole	Vole- Deer mouse	Deer mouse	S. Red backed vole
Metals	A-MIPE-LIVER	F-PEMA-LIVER	F-BLBR-LIVER	A-PEMA-LIVER	G-MYGA-LIVER	B-MYGA-PEMA LIVER	FOR REF-PEMA-LIVER	FOR REF-MYGA-LIVER
Antimony (Sb)	<0.5	<1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Arsenic (As)	<0.5	<1.0	0.82	<0.5	<0.5	<0.5	<0.5	<0.5
Cadmium (Cd)	1.44	<0.1	23.5	1.28	9.18	5.05	0.180	1.16
Lead (Pb)	3.27	<0.36	6.45	0.82	1.29	0.86	<0.18	0.39
Thallium (Tl)	1.43	0.081	1.32	0.270	0.155	0.220	<0.02	<0.02
Zinc (Zn)	25.7	16.5	39.4	19.1	25.5	24.6	19.5	21.4

Notes:
BLBR = northern short tailed shrew; MIPE = meadow vole; PEMA = deer mouse; MYGA = southern red backed vole

Table 9-20 Metal Concentrations in Small Mammal Whole Body Collected from Study Boundary and Reference Areas in 2011

Metals	Whole Body Reference (mg/kg wet weight)	Whole Body Study Boundary (mg/kg wet weight)			
	REF-SOCI-BODY	F-SOCI-Bodies	F-BLBR-Bodies	A-SOCI-Bodies	D-SOCI-Bodies
Antimony (Sb)	<0.5	<0.5	<0.5	<0.5	<0.5
Arsenic (As)	<0.5	0.91	2.81	1.08	1.06
Cadmium (Cd)	0.275	2.89	0.885	2.65	2.41
Lead (Pb)	5.67	27.3	18.5	30.8	23.9
Thallium (Tl)	0.098	1.56	1.40	4.11	1.24
Zinc (Zn)	33.0	36.7	35.2	31.3	32.5

Notes:
BLBR = northern short tailed shrew
SOCI = common shrew

Table 9-21 Critical Effects Levels Reported in the Literature for Cadmium in Liver in Various Small Mammals

Species	**Organ Concentration (mg/kg dw / mg/kg ww)**	**Critical Effect**	**Reference**
Small mammals	119 mg/kg dw (30 µg/g ww; converted by Ma, 1991 assuming a dry matter content of 25.3%)	Sub-clinical symptoms (Chmielnicka et al., 1989)	Ma et al., 1991 Dry matter content from (Ma, 1987)
Rats	350 mg/kg dw (100 mg/kg ww)[1]	Renal dysfunction (Based on several studies including Tohyama, et al., 1987; Liu et al., 1998; Mitsumori et al., 1998; Noel et al., 2004).	Beyer and Meador, 2011
Laboratory rats and mice	105 to 210 mg/kg dw (30 to 60 mg/kg ww)[1]	Proteinuria (Prigge, 1978); changes in urinary excretion of trace elements (Chmielnicka et al., 1989); cell necrosis and degenerative changes in proximal tubules (Itokawa et al., 1978; Aughey et al., 1984)	Beyer and Meador, 2011
Mice	110 – 260 mg/kg dw (31 to 74 mg/kg ww)[2]	Severe tissue damage, changes in proximal tubules including cell necrosis, nuclear pyknosis and mitochondrial swelling, although the animals appeared “outwardly healthy” (Nicholas et al., 1983)	Beyer and Meador, 2011
Mammalian wildlife	100 – 120 mg/kg dw (29 to 34 mg/kg ww)[2]	Values reported to be critical threshold for wildlife (Ma et al., 1991; Shore and Douben, 1994)	Beyer and Meador, 2011

Notes:

1. Wet and dry weight values provided by the author.
2. Converted using a conversion factor of 3.5 which was used by Beyer and Meador (2011) to convert from dry to wet weight (dw/3.5 = ww).

Table 9-22 Critical Effects Levels Reported in the Literature for Lead in Liver and Kidney in Various Small Mammals

Species	Organ Concentration (mg/kg dw) / (mg/kg ww)	Critical Effect	Reference
Lead in Liver			
Bank vole	5 / 1.3	Kidney damage	Ma, 1989
Wood mice	12 / 3	Kidney damage	Roberts et al., 1978
Shrew	19 / 4.8	Weight loss, death	Pankakoski et al., 1994
Shrew	16 / 4	Kidney damage	Ma, 1989
Lead in Kidney			
Not provided	>15 / 2.3 >80 / 12	Kidney damage Weight loss, death	Beyer and Meador, 2011
Small mammals	25 / 3.8	Considered to be diagnostic of lead intoxication in mammals (↑ kidney to body weight ratios)	Ma, 1989; Ma et al., 1991
Bank vole	16 / 2.4	Kidney damage	Ma, 1989
Wood mice	47 / 7.2	Kidney damage	Roberts et al., 1978
Shrew	225 / 56	Weight loss, death	Pankakoski et al., 1994
Shrew	270 / 42	Kidney damage	Ma, 1989
Shrew	280 / 43	Kidney damage	Beyer et al., 1985
Rat	30 / 4.6	Kidney damage	Goyer et al., 1970
Rat	120 / 19	Body weight loss	Goyer et al., 1970

Notes:

[1] Tissue effects levels were generally taken from the book Environmental Contaminants in Biota (Beyer and Meador, 2011). For lead, the authors indicated that for sake of standardization, concentrations reported as wet weight were also given as dry weight using a factor of 6.5 for kidney and 4.0 for liver (Ma, 1994). To be consistent, these conversion factors were applied when conversions factors were not provided for other studies. So tissue effects data could be compared to tissue data from the site, both wet and dry weight values are provided.

9.5.4 Other Studies

As a final LOE a review of recently published literature on heavy metal exposure to small mammals from contaminated soils was conducted to provide additional perspective on potential risks to these species. Results of previous studies indicate that small mammals living in areas with high concentrations of metals in soil typically contain elevated levels of metals in body tissues (Johnson and Roberts, 1978; Ma *et al*., 1991; Schwarz, 2003). However, abundance, diversity and tissue sampling conducted in these studies show little evidence of impact to small mammal populations from elevated metal concentrations (Marquez *et al.* 2007, Sanchez-Chardi et al., 2007; Ollson, 2009); suggesting that small mammals living in contaminated areas tend to show high tolerance to metal pollution (Ma, 1987; Schwarz, 2003).

Schwarz (2003) examined the relationship between metals exposure and survival, abundance and reproduction of deer mice (*Peromyscus maniculatus*) and (*Microtus pennsylvanicus*) inhabiting the former Anaconda copper smelter in Montana. In this study deer mice and voles were obtained from naturally vegetated (6 plots) and remediated (4 plots) areas which had varying levels of As, Cd, Cu, Pb and Zn (the COPCs for the Anaconda site). Sampling plots were selected based on arsenic soil concentrations and categorized as High (>1000 mg/kg), Medium (100 to 1000 mg/kg) or Low (<100 mg/kg). At the high exposure sites lead and zinc ranged from about 700 mg/kg to >1000 mg/kg. Deer mice (N = 121) and meadow vole (N = 52) tissues (*i.e*., liver, kidney, blood and carcass; number of samples of deer mice varied for each tissue) were analyzed for As Cd, Cu, Pb and Zn. Using mark-recapture techniques and sample collection, comparisons of population and community parameters (e.g., species diversity, rodent biomass, abundance, survival, reproduction) and As, Cd, Pb, Cu, and Zn in tissue, soil, and stomach contents) were made. Results of the study indicated that deer mice and meadow voles from the study plots were being exposed to COPCs and / or had tissue concentrations greater than those established as toxicity thresholds in the literature (Schwarz, 2003). However, deer mice and meadow vole populations on the remediated plots did not appear to be adversely affected by the levels of COPCs. Similarly, Marques *et al*. 2007 evaluated the physiological and biochemical effects of continued heavy metal exposure in great white-toothed shrews at an abandoned lead/zinc mining site in Southern Portugal. The shrews from the lead / zinc mining site had significantly higher concentrations of hepatic cadmium (9.29 microg/g dw) and zinc (1.56 microg/g dw) than in reference shrews (1.18 microg/g dw cadmium and 0.343 micorg/g dw zinc). No significant changes on haematological or enzymatic parameters in site shrews were reported, when compared to control animals. The results indicated that while shrews appear to be good bioaccumulators of toxic heavy metals, they are very tolerant to their effects, revealing a long-term adaptation to polluted environments (Marques *et al.* 2007).

Deer mice living in mine tailings areas (average soil As = 1740 mg/kg) and mine forest areas (average soil As = 392g/kg) in Yellowknife, NT had average concentrations of As in carcass, liver and kidney of 4.4 mg/kg ww, 1.9 mg/kg ww and 2.1 mg/kg ww, respectively in mine tailings areas and 5.1 mg/kg ww, 2.1 mg/kg ww and 2.5 mg/kg ww, respectively in mine forests (Ollson *et al.*, 2009). The mean background As soil concentration was 104 mg/kg, while carcass, liver and kidney average concentrations were 0.20 mg/kg ww, 0.16 mg/kg and 0.05 mg/kg ww, respectively. Based on estimated daily intake calculations, Ollson et al. (2009) reported that deer mice in the mine tailings habitat should have been experiencing adverse health effects. However, all animals appeared to be in good health and no differences were found in liver /body mass between the mine tailings and background sites. Sanchez-Chardi et al. (2007) found elevated levels of lead and cadmium in small mammals surrounding an abandoned pyrite site in Portugal; however, acute poisoning effects were not observed.

Similarly, little evidence of biological accumulation of antimony in grassland food chains was found in a study conducted on small mammals (*i.e.,* rabbit - *Oryctolagus*; short-tailed field vole – *Microtus agrestis* and common shrew – *Sorex aranetus*) in the vicinity of an antimony smelter in north-England.

9.5.5 Mammalian Receptor Weight of Evidence

The various LOE used to assess potential risks to mammalian receptors are identified in Table 9-23 along with the interpretation of each LOE.

ER_{LOAELs} for herbivorous small and large mammals and carnivorous small mammals are less than the critical ER indicating exposures are less than those associated with adverse effects. Some shrew ER_{LOAELs} were greater than the critical ER of 1.0; however these ER values likely overestimated potential risks due to the conservative assumptions in exposure modeling (*e.g.*, assumed 100% bioavailability; used top 5 soil concentrations only to estimate exposures).

Little difference was reported in species richness, diversity, relative abundance, or morphometrics between animals inhabiting the Study boundary and reference areas, based on available data (LGL, 2012a). Tissue metal concentrations were either not detected or below tissue residue toxicity levels with the exception of lead.

Given the various LOEs, using a weight of evidence approach and considering the uncertainties and study limitations presented in Section 10.0, the following conclusions for the health of mammalian species can be made:

- Risks to herbivorous and carnivorous mammalian species are considered to be negligible, whereas risks to insectivorous small mammals are considered to be low. Based on the results of the assessment, some individual level effects could be occurring in some species, but population level effects within the vicinity of the Belledune smelter as a result of smelter operations are considered unlikely.

Table 9-23 Lines of Evidence for Evaluating Mammalian Receptors

ER Values for Receptors	**Small Mammal Survey Outcomes and Tissue Residue Levels (LGL, 2012c)**		**Literature**	**Potential Risks to Mammalian Receptors**
	Small Mammal Survey	**Tissue Residues**		
Masked Shrew: Sb, As, Cd, Pb, Tl and Zn >critical ER value indicating potential risks to ground-feeding insectivores mainly within 2 km of smelter Snowshoe-Hare: all COPCs < critical ER value White-tailed Deer: all COPCs < critical ER value Ermine: all COPCs < critical ER value	Little difference was reported in species richness, diversity, relative abundance, or morphometrics between animals inhabiting the Study boundary and reference areas, based on available data (LGL, 2012a).	Antimony and arsenic do not appear to be accumulating in small mammals in the vicinity of the smelter. While cadmium was detected in tissues of small mammals, concentrations were below tissue residue toxicity levels. Lead in some liver and kidney samples collected within the Study boundary exceeded tissue residue toxicity levels, suggesting a potential for effects. Thallium was greater in Study boundary samples than reference areas samples, but no tissue residue levels for thallium were identified. Zinc was found in all analyzed tissues in both the Study boundary and reference areas samples; however, tissue concentrations in these areas were similar.	Results of studies identified in the literature reviewed, indicate that while small mammals may accumulate metals in their tissues, there is little evidence of impact to small mammal populations suggesting small mammals living on contaminated sites (e.g., arsenic concentrations >1000 mg/kg and Pb concentrations >700 mg/kg; Schwarz, 2003; Ollson et al., 2009) tend to be tolerant of metal pollution.	Population level effects on mammalian herbivorous and carnivorous receptors are considered to be unlikely Risks for mammalian insectivorous receptors are considered to be low.

9.6 Freshwater Aquatic Receptors

To evaluate the potential for ecological risks to aquatic receptors, several lines of evidence (LOE) were used including:

- Outcomes of the comparison of sediment and surface water chemistry data to aquatic health-based quality guidelines, respectively, and to reference area sediment and surface water data;
- Results of the aquatic habitat survey within Hendry Brook and Unnamed Brook compared to reference locations; and
- Results of the electrofishing effort in Hendry and Unnamed Brook, relative to the reference brook, Armstrong Brook.

An interpretation and / or evaluation of each of the LOEs was conducted and data summaries are provided for these evaluation in the following sections, where applicable. Following the evaluation of the LOEs, a weight of evidence approach was used to provide a final conclusion of the potential for risks to aquatic receptors (See Section 9.6.5).

9.6.1 Comparisons of Chemistry Data to Aquatic Sediment and Surface Water Quality Guidelines and Reference Areas

The presentation of data in the tables within this section is in reverse sequential order of samples (*e.g.*, HENDRY-SED/SW-7 to HENDRY-SED/SW-1), as this is the direction that the water courses flow (*i.e.,* towards Baie des Chaleur). This data presentation approach is predicated on the hypothesis that metal concentrations may increase as sample locations become closer to the smelter (based on outcomes of soil surveys, and air dispersion and deposition modeling of principal smelter emissions (lead and arsenic) conducted by A.J. Chandler & Associates; see Attachment I-1 to Appendix I).

While data for Unnamed Brook and Hendry Brook are presented together in tables, the brooks are discussed separately (where appropriate) in the text that follows, as they are separate watercourses that do not have confluences with each other.

Figure 4-3 (presented previously) shows all aquatic sampling locations within the two Study boundary water bodies as well as within the local reference area water body – Armstrong Brook.

Surface water and sediment samples were collected from the two Study boundary brooks (i.e., Hendry and Unnamed), and Armstrong Brook (local reference) in two separate sampling events: July, 2010 and September, 2011. In addition to Armstrong Brook data, supplementary reference data from a number of other northeastern New Brunswick watercourses (sampled and reported in other studies, including Intrinsik Environmental Sciences Inc., 2009; 2010) were also used in the aquatic ecological risk characterization. Further information regarding the data collected from the Study boundary and reference brooks is provided in Appendix C. Surface water and sediment chemistry data summaries and raw analytical chemistry data for Hendry Brook, Unnamed Brook, and Armstrong Brook are presented in Appendix D.

9.6.1.1 Surface Water Quality

General Water Quality Parameters

Tables 9-24 and 9-25 summarize selected key general water quality parameters data for Hendry Brook and Unnamed Brook (combined together as the Study boundary brooks in this table), and the pooled reference area streams and brooks (which includes Armstrong Brook, the local reference watercourse), for the July, 2010 and September, 2011 sampling events, respectively.

Table 9-24 Key General Water Quality Parameters Summary Statistics (July, 2010 Sampling Event)

Parameter	Units	Max	Min	Arithmetic Mean	Median	90th%ile
Study Boundary Brooks[a]						
pH[b]	unitless	7.53	6.94	7.21	7.16	7.50
Hardness ($CaCO_3$)[c]	mg/L	360	44	105	61	216
Nitrate (N)[c]	mg/L	1.8	<0.05	0.30	0.1	0.54
Nitrate + Nitrite[c]	mg/L	1.8	<0.05	0.30	0.1	0.54
Nitrite (N)[c]	mg/L	0.01	<0.01	0.01	0.01	0.01
Nitrogen (Ammonia Nitrogen)[c]	mg/L	0.48	<0.05	0.12	0.05	0.27
Orthophosphate (P)[c]	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Total Organic Carbon (C)[c]	mg/L	12	6.2	7.73	6.6	11.2
Dissolved Sulphate (SO_4)[c]	mg/L	18	<2	5.56	3	15.6
Reference Area Brooks and Streams (Pooled)[c,d]						
pH	unitless	8.13	6.15	7.18	7.15	8.05
Hardness ($CaCO_3$)	mg/L	110	7	36.1	23	86
Nitrate (N)[e]	mg/L	2.8	<0.05	0.16	0.05	0.15
Nitrate + Nitrite[e]	mg/L	2.8	<0.05	0.16	0.05	0.15
Nitrite (N)[e]	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrogen (Ammonia Nitrogen)	mg/L	0.1	<0.05	0.055	0.05	0.073
Orthophosphate (P)	mg/L	0.01	<0.01	0.01	0.01	0.01
Total Organic Carbon (C)[f]	mg/L	29.3	2.6	11.6	10.5	20
Dissolved Sulphate (SO_4)[g]	mg/L	1200	<2	25.4	2	2.2

Notes:

a N=9.
b Field data.
c Laboratory data.
d Reference area brooks and streams (pooled); N=28 unless otherwise noted.
e N=30.
f N=36.
g N=59.

Table 9-25 Key General Water Quality Parameters Summary Statistics (September, 2011 Sampling Event)

Parameter	Units	Max	Min	Arithmetic Mean	Median	90th%ile
Study Boundary Brooks[a]						
pH[b]	unitless	8.01	7.08	7.54	7.60	8.0
Hardness ($CaCO_3$)[c]	mg/L	360	35	109	57.5	216
Nitrate (N)[c]	mg/L	2.2	<0.05	0.293	0.065	0.373
Nitrate + Nitrite[c]	mg/L	2.2	<0.05	0.293	0.065	0.373
Nitrite (N)[c]	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrogen (Ammonia Nitrogen)[c]	mg/L	1.2	0.05	0.396	0.275	0.759
Orthophosphate (P)[c]	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Total Organic Carbon (C)[c]	mg/L	12	4.0	7.1	7.0	8.2
Dissolved Sulphate (SO_4)[c]	mg/L	20	<2	8.3	6.0	16.4
Reference Area Brooks and Streams (Pooled)[c,d]						
pH	unitless	8.17	6.15	7.32	7.43	8.09
Hardness ($CaCO_3$)	mg/L	110	7	43	33	97.8
Nitrate (N)[e]	mg/L	2.8	<0.05	0.15	0.05	0.15
Nitrate + Nitrite[e]	mg/L	2.8	<0.05	0.15	0.05	0.15
Nitrite (N)[e]	mg/L	0.02	<0.01	0.01	0.01	0.01
Nitrogen (Ammonia Nitrogen)	mg/L	0.1	<0.05	0.054	0.05	0.068
Orthophosphate (P)	mg/L	<0.01	<0.01	<0.01	<0.01	0.01
Total Organic Carbon (C)[f]	mg/L	29.3	2.5	10.6	8.9	20
Dissolved Sulphate (SO_4)[g]	mg/L	1200	<2	23.7	2	3.7

Notes:

[a] N=10.

[b] Field data.

[c] Laboratory data.

[d] Reference area brooks and streams (pooled); N=33 unless otherwise noted.

[e] N=35.

[f] N=41.

[g] N=64.

The following bullets describe and discuss the key general water quality parameters that influence metal/metalloid bioavailability, and aquatic productivity.

- pH: In both Study boundary brooks, pH (field-measured) in surface water was in the near-neutral to slightly alkaline range across all samples collected in both the July, 2010 and September, 2011 sampling events (N=19). Overall, the pH in these brooks ranged from 6.9 to 8.01. Based on the pH effects classification system developed by Alabaster and Lloyd (1982), this pH range is considered harmless to fish. Although dated, this system is still recommended by CCME for interpreting potential effects of pH on fish and other aquatic life. In fact, the current CCME water quality guideline for pH in fresh water bodies (6.5 to 9.0) is the “harmless to fish” range from Alabaster and Lloyd (1982). The Study boundary brook pH ranges are also very similar to those in reference brooks and streams. Of the reference water body surface water samples where pH was measured (N=35), the pH (lab-measured, which tends to be result in slightly more alkaline values than field-measured due to the water samples equilibrating with air in the laboratory) ranged from 6.2 to 8.2.

- Hardness: Hardness is an important modifying factor for metals in fresh water systems, and the water quality benchmarks for some metals are hardness-dependent (See Appendix H). In the Study boundary brooks, hardness ranged from 35 to 360 mg/L $CaCO_3$, in the July, 2010 and September, 2011 sampling events (N=19), with the highest hardness values determined for the Unnamed Brook samples. According to United States Geological Survey (USGS) categories for hardness, the Unnamed Brook surface water samples would be classified as very hard (>180 mg $CaCO_3$/L), while the Hendry Brook surface water samples would span the categories of soft (18-60 mg $CaCO_3$/L) to moderately hard (60-120 mg $CaCO_3$/L). The water hardness in Unnamed and Hendry brooks is generally higher than that which is typically determined in northeastern New Brunswick streams and brooks. Of the reference water body surface water samples where hardness was determined (N=33), it ranged from 7 to 110 mg $CaCO_3$/L, with a mean of 43 mg/L. Reference water body hardness values span the USGS categories of very soft (<18 mg $CaCO_3$/L) to soft (18-60 mg $CaCO_3$/L), to moderately hard (60-120 mg $CaCO_3$/L).

- Nutrients and Major Anions: Both Study boundary and reference area water bodies were low in nitrogenous nutrients (as indicated by generally low to non-detectable concentrations of nitrate, nitrite, ammonia), and orthophosphate, which suggests that these systems have generally low primary productivity. Sulphate concentrations in the Study boundary brooks ranged from <2 mg/L to 20 mg/L, in the July, 2010 and September, 2011 sampling events (N=19). In the reference area brooks and streams where sulphate was measured (N=64), surface water concentrations were generally low to non-detectable (*i.e.*, <2 mg/L) with the exceptions of a few peak elevated concentrations observed at certain times of year. In the two Study boundary brooks, neither measured sulphate maxima exceeds, nor even approaches the maximum acceptable sulphate concentration of 100 mg/L from BC MOE (http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html), or the new revised draft maximum concentration of 250 mg/L and a 30-d average of 65 mg/L. These limits are still under review and may change.

- Organic Carbon: Although there are no benchmarks available for organic carbon in surface waters, the presence of organic carbon is an important modifying factor that can affect the bioavailability and toxicity of metals and metalloids in solution. Total organic carbon concentrations in the Study boundary brooks ranged from 4.0 mg/L to 12.0 mg/L, in the July, 2010 and September, 2011 sampling events (N=19). These concentration ranges are similar to those observed in the reference area brooks and streams, where total organic carbon (based on 41 samples where this parameter was measured) ranged from 2.5 to 29.3 mg/L.

COPC Comparisons

Based on the COPC identification process described in Appendix H, the following chemicals were identified as the final COPCs in Study boundary surface water (*i.e.*, Unnamed Brook and Hendry Brook) for both the July, 2010 and September, 2011 sampling events.

- Lead (July, 2010 sampling event only).
- Manganese (both sampling events).

The inclusion of both these chemicals as COPCs in Study boundary surface water was marginal in the July, 2010 and September, 2011 sampling events. In the 2011 event, lead was actually not identified as a COPC, as total and dissolved lead concentrations in all collected Study boundary surface water samples were low, and were largely below the RDL.

Table 9-25 presents the surface water chemistry data for these COPCs, expressed as both the total recoverable and dissolved element, for each sample (from both the July, 2010 and September, 2011 sampling events), and compares these data to the full range of reference surface water concentrations (which includes the Armstrong Brook reference data from the 2010 and 2011 sampling events), and to the 90th percentile[9] reference surface water concentration. Water quality benchmarks are not provided in this table as the total recoverable-based benchmarks for both lead and manganese are hardness-dependent and sample-specific. This is also the case for the dissolved lead water quality benchmark. Manganese has no dissolved-based water quality benchmark available. The range of sample-specific water quality benchmarks for lead and manganese are provided in Appendix H, and the limited exceedances over these benchmarks are briefly described below.

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[9] As discussed in Appendix H, the 90th percentile is a common regulatory agency-recommended value for a reference concentration statistic. In addition, the 90th percentiles of reference water and sediment concentrations were used within the aquatic COPC identification process.

Table 9-26 Study Boundary Surface Water COPC Concentrations Versus Reference Surface Water Concentrations (Total Recoverable and Dissolved Element); µg/L

COPC	Lead	Manganese
Surface Water Reference Concentration Range and 90th Percentile – Total Recoverable Element (N=67)[a]	Range: <0.5-6.0 90th%ile: 1.6	Range: <2-3820 90th%ile: 765
Surface Water Reference Concentration Range and 90th Percentile - Dissolved Element (N=67)[a]	Range: <0.5-1.3 90th %ile: 0.9	Range: <2-3560 90th %ile: 765
Hendry Brook Stations	**Total / Dissolved**	**Total / Dissolved**
HENDRY-SW-7 2010	4.7 / 1.2	54.6 / 34
HENDRY-SW-7 2011	<0.5 / <0.5	22.1 / 19.3
HENDRY-SW-6 2010	1.4 / 1.0	86.6 / 41
HENDRY-SW-6 2011	<0.5 / <0.5	78.3 / 65.3
HENDRY-SW-5 2010	1.6 / <0.5	41.7 / 22
HENDRY-SW-5 2011	0.62 / <0.5	33.3 / 26.1
HENDRY-SW-4 2010	0.99 / 0.7	20.5 / 10
HENDRY-SW-4 2011	0.6 / <0.5	31.2 / 26.1
HENDRY-SW-3 2010	0.72 / 1.0[b]	13.8 / 6
HENDRY-SW-3 2011	<0.5 / <0.5	7.4 / 4.7
HENDRY-SW-2 2010	1.2 / 0.9	27.2 / 17
HENDRY-SW-2 2011	<0.5 / <0.5	9.9 / 7.7
HENDRY-SW-1 2010	0.92 / 0.9	13.9 / 6
HENDRY-SW-1 2011	<0.5 / <0.5	5.5 / 3.3
Unnamed Brook Stations	**Total / Dissolved**	**Total / Dissolved**
UNNAMED-SW-3 2011	<0.5 / <0.5	13.3 / 12.7
UNNAMED-SW-2 2010	<0.5 / <0.5	**3880** / 3200
UNNAMED-SW-2 2011	1.54 / <0.5	**5370 / 4920**
UNNAMED-SW-1 2010	0.69 / <0.5	429 / 400
UNNAMED-SW-1 2011	<0.5 / <0.5	1700 / 1760[b]

Notes:

Bolded values exceed the reference maxima. Underlined values exceed the reference 90th percentile.

[a] Reference streams and brooks include Armstrong Brook and several other northeastern New Brunswick watercourses.

[b] The dissolved concentration is greater than the total recoverable concentration. While this is counterintuitive (as the dissolved analyses utilize filtered samples, and total recoverable analyses do not filter samples, resulting in total recoverable concentrations typically being higher than dissolved concentrations), it is not an uncommon observation. This issue is discussed further in Appendix F. It does not denote a data quality problem.

As shown in Table 9-26, the total recoverable and dissolved surface water concentrations of lead at all Study boundary stations were within the reference surface water concentration ranges. Table 9-26 also shows that the total recoverable and dissolved surface water concentrations of manganese at all but one Study boundary stations, were within the reference surface water concentration ranges: Total recoverable manganese concentrations in UNNAMED-SW-2 (2010 and 2011) were slightly above the reference maxima, as was the dissolved manganese concentration from UNNAMED-SW-2 (2011). In the July, 2010 sampling event, there were some exceedances over the 90th percentile reference concentrations for total recoverable lead (HENDRY-SW-7), and dissolved lead (HENDRY-SW-7; HENDRY-SW-6; HENDRY-SW-3).

However, the samples taken at these locations in the September, 2011 event were non-detectable (<RDL) for both total and dissolved lead. There were also were some exceedances over the 90th percentile reference concentrations for total recoverable and dissolved manganese (UNNAMED-SW-2 (2010 and 2011), and UNNAMED-SW-1 (2011)).

In both sampling events, the manganese concentrations at UNNAMED-SW-2 (total recoverable and dissolved) were markedly higher than those at all other Study boundary stations. This particular station is located in relatively close proximity to an active slag disposal area, the former site of a proposed zinc refinery, and a road. Thus, the disturbed nature of the area surrounding this sample location may be influencing surface water chemistry. However, as described below for sediments, it was station UNNAMED-SED-1 (same location as UNNAMED-SW-1) that appeared to be most influenced by the characteristics of this location, with the more upstream UNNAMED-SED-2 (same location as UNNAMED-SW-2) station showing sediment chemistry that was not distinctly different from other Study boundary or reference area sediment samples. It is possible that a localized area of manganese enrichment exists at or near station UNNAMED-SW-2.

There is no clear trend in Hendry Brook of increasing surface water concentrations (total recoverable and dissolved) of lead or manganese with increasing proximity to the smelter. In fact, the three highest surface water concentrations (total recoverable and dissolved) of lead and manganese in this brook occur at the three most upstream stations (*i.e.*, HENDRY-SW-7 down to HENDRY-SW-5). This is contrary to what was observed in sediments. As described below, the sediment chemistry at these stations was very similar to that in reference streams and brooks.

Sample size and spatial locations of the Unnamed Brook surface water samples preclude the identification of data trends for lead and manganese (*i.e.*, N=5; the samples are located near each other; and, downstream reaches of this watercourse become the east diversion ditch around the smelter property; See Figure 4-3).

With respect to exceedances over water quality benchmarks, the following was observed with respect to lead and manganese.

- In the July, 2010 sampling event, Study boundary surface water concentrations of total recoverable lead exceeded sample-specific hardness-dependent benchmarks (1 µg/L) in only two samples (*i.e.*, HENDRY-SW-5 (1.6 µg/L) and HENDRY-SW-7 (4.7 µg/L)). No exceedances over water quality benchmark values occurred for total recoverable lead in the September, 2011 sampling event.

- In the July, 2010 sampling event, Study boundary surface water concentrations of dissolved lead exceeded sample-specific hardness-dependent benchmarks (1.02 µg/L) in only one sample (*i.e.*, HENDRY-SW-7 (1.2 µg/L)). No exceedances over water quality benchmark values occurred for dissolved lead in the September, 2011 sampling event (all samples had dissolved lead concentrations below the RDL of 0.5 µg/L).

- In both the July, 2010 and September, 2011 sampling events, Study boundary surface water concentrations of total recoverable manganese exceeded sample-specific hardness-dependent benchmarks at the UNNAMED-SW-2 sample location only. In the 2010 event, the total manganese concentration was 3880 µg/L. The sample-specific benchmark in this case was 2524 µg/L; thus, the degree of exceedance is considered to be relatively small (1.5-fold). In the 2011 event, the total manganese concentration was 5370 µg/L and the sample specific benchmark was 2744 µg/L. The degree of exceedances was again relatively small (roughly 2-fold). Manganese has no dissolved element-based water quality benchmark available.

9.6.1.2 Sediment Quality

Based on the COPC identification process described in Appendix H, the following chemicals were identified as the final COPCs in Study boundary brook sediments for both the July, 2010 and September, 2011 sampling events:

- Arsenic (September, 2011 sampling event only);
- Barium (July, 2010 sampling event only);
- Cadmium (both sampling events);
- Iron (both sampling events);
- Lead (both sampling events);
- Lithium (both sampling events);
- Thallium (both sampling events);
- Tin (both sampling events);
- Vanadium (both sampling events); and
- Zinc (both sampling events).

For many of these substances, the basis for identification as COPCs was a lack of sediment quality benchmarks, and maximum sediment concentrations that exceeded the reference sediment concentration statistic, and/or Study boundary sediment concentrations that were significantly greater than reference area sediment concentrations. The COPCs lacking freshwater sediment quality benchmarks are: barium, lithium, thallium, tin, and vanadium.

Table 9-27 presents the sediment chemistry data for the COPCs, for each sample (from both the July, 2010 and September, 2011 sampling events), and compares these data to adverse effect level freshwater sediment quality benchmarks (the PEL, SEL and FEL, where available), and to the full range of reference sediment concentrations. The PEL, SEL, and FEL are considered together as these benchmarks, while derived using similar methodologies, can represent different degrees of the potential for adverse effects in benthic organisms. The PELs represent the lower end of the spectrum where adverse effects may be anticipated, while the FELs and SELs represent a higher potential for adverse effects, which if exceeded, indicate a level of sediment contamination that is considered to have the potential to be detrimental to the majority of benthic organisms (MOE, 2008; EC-MDDEPQ, 2007).

As described in Appendix H, adverse effect level sediment quality guidelines (which include the PEL, SEL, and FEL) were given preference over LEL and similar sediment quality guidelines (such as ISQG, ERL, and TEL). Numerous studies of contaminated sediments have shown that the LEL and similar values are highly conservative, and their exceedance often does not correlate well with other endpoints that are commonly evaluated in aquatic risk assessments (*e.g*., sediment bioassay results and benthic community parameters). In practice, exceedance of the PEL (and similar benchmarks) is the more realistic indicator of a potential for population level adverse effects. This is supported by a study by Long *et al*., (1998), who examined the predictive ability of marine sediment quality guidelines, and noted that PELs are considerably better at predicting the likelihood for toxicity than TELs or similar guideline values (such as ISQGs, LELs, ERLs). Similarly, NOAA (1999) notes that effects range median (ERM) values are better indicators of adverse effects than effects range low (ERL) values, and MDEP (2006) states that there is no evidence of significant risk of harm to benthic organisms when sediment concentrations are below probable effect levels (PELs).

While it is recognized that PELs and similar benchmarks are generic, with no consideration given to site-specific populations/communities or sediment conditions that influence bioavailability and/or toxicity, their use in screening level aquatic risk assessment and sediment monitoring programs is commonplace, and it is generally accepted that such benchmarks are reasonable and typically conservative screening tools.

Table 9-27 Study Boundary Brook Sediment COPC Concentrations Versus Freshwater Sediment Quality Benchmarks and Reference Sediment Concentrations; mg/kg

COPC	Arsenic	Barium	Cadmium	Iron	Lead	Lithium	Thallium	Tin	Vanadium	Zinc
SQB – PEL[a]	17	NBA	3.5	NBA	91.3	NBA	NBA	NBA	NBA	315
SQB – SEL[b]	33	NBA	10	40,000	250	NBA	NBA	NBA	NBA	820
SQB –FEL[c]	23	NBA	12	NBA	150	NBA	NBA	NBA	NBA	770
Sediment Reference Concentration Range [d]	<2-65	23-390	<0.3-2.5	8100-93000	7.1-73	6-27	<0.1-0.6	<2-2	16-53	47-280
Hendry Brook Stations										
HENDRY-SED-7-2010	10	69	0.5	28000	36	19	0.2	<2	38	100
HENDRY-SED-7-2011	14	59	0.4	41000	41	**31**	0.2	<2	52	110
HENDRY-SED-6-2010	5	120	<0.3	42000	6.9	**51**	0.1	<2	**80**	74
HENDRY-SED-6-2011	*20*	94	1.0	38000	**81**	21	0.2	<2	53	220
HENDRY-SED-5-2010	11	79	0.5	30000	36	27	0.2	<2	**54**	150
HENDRY-SED-5-2011	12	45	<0.3	41000	18	25	0.1	<2	**93**	100
HENDRY-SED-4-2010	15	140	0.6	26000	19	**34**	0.3	<2	42	190
HENDRY-SED-4-2011	*27*	99	0.8	50000	49	**46**	0.3	<2	**99**	270
HENDRY-SED-3-2010	*20*	180	2.2	22000	**87**	20	0.4	<2	37	260
HENDRY-SED-3-2011	*31*	140	1.4	52000	54	**48**	0.4	<2	**91**	260
HENDRY-SED-2-2010	*19*	140	**2.8**	22000	***160***	23	0.6	**3**	41	**310**
HENDRY-SED-2-2011	*30*	150	2.3	42000	50	**35**	0.4	<2	**62**	**300**
HENDRY-SED-1-2010	*24*	130	2.1	21000	***160***	22	0.5	**3**	40	280
HENDRY-SED-1-2011	*35*	79	1.1	30000	49	**28**	0.3	<2	**59**	170
Unnamed Brook Stations										
UNNAMED-SED-3- 2011	*22*	190	2	33000	***140***	26	0.3	**3**	**63**	***400***
UNNAMED-SED-2- 2010	16	170	1.5	33000	**85**	26	0.4	2	49	190
UNNAMED-SED-2- 2011	13	190	1.1	31000	61	25	0.4	2	52	190
UNNAMED-SED-1- 2010	*43*	**1600**	***4.4***	75000	***140***	14	**1.4**	**7**	38	***760***
UNNAMED-SED-1- 2011	*54*	**1800**	***4.3***	**120000**	***150***	18	**1.4**	**8**	52	***680***

Notes: NBA = no benchmark available. SQB = sediment quality benchmark.

Bolded entries exceed the reference maxima; Italics entries exceed the PEL or similar benchmark (where available); Underlined entries exceed the SEL (where available); Shaded entries exceed the FEL (where available).

a CCME (http://ceqg-rcqe.ccme.ca/?config=ccme&thesite=ceqg&words=&image.x=12&image.y=10). Probable Effect Levels (PELs).

b MOE (2008) Severe Effect Levels (SELs).

c Environnement Canada et Ministere du Developpement durable, de l'Environnement et des Parcs du Quebec (2007) Frequent Effects Levels (FELs).

d **N=25;** Reference streams and brooks include Armstrong Brook samples (collected in July, 2010 and September, 2011) and several other northeastern New Brunswick watercourses.

The comparisons provided in Table 9-26 for each of the COPCs are discussed in the following subsections.

Arsenic

Arsenic concentrations in Study boundary brook sediments fall within the reference concentration range. While a number of sediment samples contained arsenic at concentrations that exceed the PEL, FEL, and SEL sediment quality benchmark values (i.e., 11/19 samples exceed the PEL, 7/19 samples exceed the FEL, and 3/19 samples exceed the SEL), there are also a couple of samples in the reference sediment chemistry dataset that exceed these benchmark values (i.e., 2, 1, and 1 reference area samples exceed the PEL, FEL, and SEL, respectively; N=25). The degree of exceedance of Study boundary arsenic sediment concentrations over these benchmarks is generally small. There appears to be a general trend in Hendry Brook of increasing sediment arsenic concentrations with increasing proximity to the smelter, but the trend is not strong. The UNNAMED-SED-1 samples (in both 2010 and 2011) are likely influenced by the proximity of this sampling location to an active slag disposal area (where windblown dusts from the slag pile could be a potential source of metals and metalloids), the former site of a proposed zinc refinery, and a road. Thus, the disturbed nature of the area surrounding this sample location may be influencing sediment chemistry. On balance, despite the exceedances over sediment quality benchmark values, the arsenic sediment concentrations in the Study boundary brooks are not atypical of what is observed in reference (or background) northeastern New Brunswick brooks and streams, and it is considered unlikely that these sediment concentrations would pose an ecological concern to benthic organisms.

Barium

Barium concentrations in Study boundary brook sediments were mostly within the reference concentration range. The only exceptions were the 2010 and 2011 samples collected at the UNNAMED-SED-1 station, which contained substantially higher barium sediment concentration than any of the other Study boundary sediment samples. As noted above, this particular station is located in relatively close proximity to an active slag disposal area (where windblown dusts from the slag pile could be a potential source of metals and metalloids), the former site of a proposed zinc refinery, and a road. Thus, it appears that the disturbed nature of the area surrounding this sample location may be influencing sediment chemistry. The further upstream samples (UNNAMED-SED-2 and UNNAMED-SED-3), contained a barium concentration that is similar to that in other Study boundary and reference area sediment samples. Barium has no adverse effect level sediment quality benchmarks available, which makes it difficult to comment on the potential for effects. Given the general similarity of Study boundary sediment concentrations to reference area sediment concentrations, it is unlikely that barium poses an ecological concern to benthic organisms in either of the Study boundary brooks. There is no clear trend in Hendry Brook of increasing sediment barium concentrations with increasing proximity to the smelter. Sample size and spatial locations of the Unnamed Brook sediment samples preclude the identification of data trends (*i.e.*, N=5; the sampling stations are located quite near each other; and, downstream reaches of this watercourse become the east diversion ditch around the smelter property; See Figure 4-3)[10].

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[10] This applies to all other sediment COPCs as well.

Cadmium

Cadmium concentrations in Study boundary brook sediments were mostly within the reference concentration range, with only three exceptions. Sample HENDRY-SED-2 (2010) slightly exceeded the reference maxima, while sample UNNAMED-SED-1 contained a considerably higher cadmium sediment concentration than any of the other Study boundary sediment samples in both the 2010 and 2011 sampling events. As noted for barium and arsenic, this particular station is located in relatively close proximity to an active slag disposal area, the former site of a proposed zinc refinery, and a road, all or some of which may be influencing sediment chemistry. The further upstream samples, UNNAMED-SED-2 and UNNAMED-SED-3, contained a cadmium concentration that was similar to that in other Study boundary and reference area sediment samples. Only the UNNAMED-SED-1 station had cadmium sediment concentrations that exceeded the PEL, and only by a small margin (*i.e.*, 4.4 mg/kg in 2010 and 4.3 mg/kg in 2011). These concentrations are below both the SEL and FEL sediment quality benchmarks. Thus, there is likely no risk of harm to benthic organisms (with respect to cadmium) at any of the Study boundary sediment stations with the possible exception of station UNNAMED-SED-1. Even at this station, there is considered to be a relatively low probability that significant adverse effects would occur in benthic organisms. While there does appear to be a weak trend in Hendry Brook of increasing sediment cadmium concentrations with increasing proximity to the smelter, all cadmium sediment concentrations in this brook are below the PEL, and are considered unlikely to pose a significant ecological concern to benthic organisms.

Iron

Iron concentrations in Study boundary brook sediments were mostly within the reference concentration range. The sole exception was the September, 2011 sample from the UNNAMED-SED-1 station, which contained a substantially higher iron sediment concentration than any of the other Study boundary sediment samples. In the July, 2010 sampling event, two samples had iron concentrations that exceeded adverse effect level sediment quality benchmarks (*i.e.*, HENDRY-SED-6 slightly exceeded the SEL; UNNAMED-SED-1 exceeded the SEL by a considerable margin (i.e., 75000 mg/kg)). In the September 2011 sampling event, six sediment samples had iron concentrations that exceeded adverse effect level sediment quality benchmarks (*i.e.*, HENDRY-SED-7, HENDRY-SED-5, HENDRY-SED-4, HENDRY-SED-3 and HENDRY-SED-2 slightly exceeded the SEL, while UNNAMED-SED-1 exceeded the SEL by a considerable margin (i.e., 120,000 mg/kg)). The highest iron sediment concentrations in both sampling events occurred at sampling location UNNAMED-SED-1, which as mentioned previously, likely reflects the fact that this particular station is located in relatively close proximity to an active slag disposal area, the former site of a proposed zinc refinery, and a road, all or some of which may be influencing sediment chemistry. Three of the reference iron sediment concentrations also exceeded the SEL. It is not uncommon for iron to be present at elevated concentrations in freshwater sediments that are not impacted by anthropogenic activity. However, iron is generally not considered to pose a sediment toxicity concern, relative to trace elements. Rather, iron is well established as a modifier of the bioavailability and toxicity of other metals (and some metalloids); wherein higher iron concentrations are typically desirable in the presence of elevated trace metals and metalloid concentrations. For example, it is well established that iron-containing minerals can adsorb trace metals and metalloids onto their surfaces (a pH-dependent process), and iron ions can compete for uptake into biota with various divalent and trivalent metals. Both of these processes tend to reduce the absorption of metals and some metalloids by biota. There is no clear trend in Hendry Brook of increasing sediment iron concentrations with increasing proximity to the smelter. In general, Study boundary iron sediment concentrations were higher in the September, 2011 event than in the July, 2010 event. The reason for this is not clear, but the higher 2011 iron sediment concentrations remain within the reference concentration range (with the exception of UNNAMED-SED-1).

Given the above considerations, it is unlikely that iron poses an ecological concern to benthic organisms in either of the Study boundary brooks.

Lead

In the July, 2010 sampling event, five of the Study boundary brook sediment samples contained lead concentrations that were higher than the reference concentration range, and there was a general trend in Hendry Brook of increasing sediment lead concentrations with increasing proximity to the smelter. In this sampling event, three samples exceeded the PEL (HENDRY-SED-2, HENDRY-SED-1, and UNNAMED-SED-1), and two samples exceeded the FEL (HENDRY-SED-2, HENDRY-SED-1). No samples exceeded the SEL.

In the September, 2011 event, three of the Study brook sediment samples contained lead concentrations that were higher than the reference concentration range (UNNAMED-SED-1, UNNAMED-SED-3, and HENDRY-SED-6), but the trend of increasing sediment lead concentrations with increasing proximity to the smelter in Hendry Brook is no longer apparent in the 2011 sediment chemistry data. In this sampling event, two samples exceeded the PEL (UNNAMED-SED-3 and UNNAMED-SED-1), and no samples exceeded either the FEL or the SEL. As noted for most of the other COPCs, the UNNAMED-SED-1 station's proximity to the slag pile and other disturbances may be influencing sediment chemistry. In 2010 and 2011, the further upstream sample, UNNAMED-SED-2, contained a lead sediment concentration that was below the PEL and similar to the range of reference area sediment lead concentrations.

Overall, it is considered unlikely that lead in Study boundary brook sediments poses an ecological concern to benthic organisms. While a potential for adverse effects is suggested at stations which exceed the PEL and FEL values, the lead sediment concentrations are not at a level that would likely be detrimental to the majority of benthic organisms, and the spatial extent of the potentially affected area is relatively small, given the length of these brooks. The lead sediment concentrations in Study boundary brooks also appear to be quite variable, based on the differences observed between the 2010 and 2011 sediment chemistry data. Furthermore, natural elevated lead sediment concentrations were documented in Hendry Brook and numerous other local watercourses in pre-smelter geological surveys conducted by the Geological Survey of Canada. For example, Boyle *et al*., (1966; 1968) reported natural sediment lead concentrations in Hendry Brook of 130 to 150 mg/kg, within about a kilometer on both sides of the CN rail line. In other nearby watercourses, these surveys reported natural sediment lead concentrations up to 360 mg/kg in Belledune River, up to 140 mg/kg in Guitar Brook, and up to 420 mg/kg in Fournier Brook. Thus, it is clear that there are a number of lead-bearing mineral deposits in the Belledune and surrounding area that influence stream or brook sediment chemistry. While the 1960's geological surveys suggest that naturally elevated sediment lead concentrations do occur in portions of Hendry Brook, samples collected near where Hendry Brook discharges to the Baie des Chaleurs were in the 30 to 50 mg/kg range in the early 1960's (Boyle *et al*., 1966). Samples HENDRY-SED-2 and HENDRY-SED-1 are located near these previous Geological Survey of Canada sample locations. While the 2010 data for these sampling locations suggested that roughly 44 years of smelter operations may have influenced sediment lead concentrations in the lower reach of Hendry Brook, the 2011 lead sediment concentrations at these stations were much lower, and very similar to those reported in the early 1960s (pre-smelter).

Lithium

In both the July, 2010 and September, 2011 sampling events, lithium concentrations in half of the Hendry brook sediment samples were higher (albeit slightly) than the reference concentration range. However, lithium sediment concentrations in Unnamed Brook were within the reference concentration range in both sampling events. Contrary to the other COPCs, the highest sediment concentration of lithium did not occur at station UNNAMED-SED-1, but rather, occurred at an upstream station (HENDRY-SED-6; 2010). Although several Hendry Brook lithium sediment concentrations exceeded the reference range for northeastern New Brunswick streams and brooks, the measured concentrations are within a range that is considered typical background. For example, in a review, Aral and Vecchio-Sadus (2008) noted that a typical freshwater sediment concentration of lithium is 56 mg/kg. All Study boundary brook sediment concentrations are below this level. There is no clear trend in Hendry Brook of increasing sediment lithium concentrations with increasing proximity to the smelter. Lithium has no adverse effect level sediment quality benchmarks available, which makes it difficult to comment on the potential for effects. Although, given the above considerations, it is unlikely that lithium poses an ecological concern to benthic organisms in either of the Study boundary brooks. Furthermore, in their review, Aral and Vecchio-Sadus (2008) noted that lithium is not expected to bioaccumulate, and its environmental toxicity is low relative to other trace metals.

Thallium

Thallium concentrations in Study boundary brook sediments were mostly within the reference concentration range. In both the July, 2010 and September, 2011 sampling events, the only exception was sample location UNNAMED-SED-1, which contained a considerably higher thallium sediment concentration relative to the other Study boundary sediment samples (1.4 mg/kg in both 2010 and 2011). As mentioned previously for most of the other COPCs, the UNNAMED-SED-1 station's location may be influencing sediment chemistry. The further upstream samples (UNNAMED-SED-2 and UNNAMED-SED-3), contained thallium sediment concentrations that are similar to those in other Study boundary and reference area sediment samples. There is an apparent increase in thallium sediment concentrations within the 2010 and 2011 Hendry Brook sediment datasets with increasing proximity to the smelter. This is not surprising, as thallium is emitted from the facility. Thallium has no adverse effect level sediment quality benchmarks available, which makes it difficult to comment on the potential for effects. Although, given the general similarity of Study boundary and reference area sediment concentrations, it is unlikely that thallium poses an ecological concern to benthic organisms in either of the Study boundary brooks.

Tin

Tin concentrations in Study boundary brook sediments were mostly within the reference concentration range (which is largely concentrations at or below the RDL) in both sampling events. There were five exceptions though (*i.e.*, HENDRY-SED-2 and HENDRY-SED-1 in 2010, UNNAMED-SED-1 (in both 2010 and 2011), and UNNAMED-SED-3 in 2011). As mentioned previously for most of the other COPCs, the UNNAMED-SED-1 station's location may be influencing sediment chemistry. The further upstream samples (UNNAMED-SED-2, UNNAMED-SED-3) contained a tin concentration that is similar to those in other Study boundary and reference area sediment samples. There is no clear trend within the 2010 and 2011 Hendry Brook sediment datasets of increasing sediment tin concentrations with increasing proximity to the smelter. Tin has no adverse effect level sediment quality benchmarks available, which makes it difficult to comment on the potential for effects. However, given the general similarity of Study boundary and reference area sediment concentrations, it is unlikely that tin poses an ecological concern to benthic organisms in either of the Study boundary brooks.

Vanadium

In the July, 2010 sampling event, vanadium concentrations in Study boundary brook sediments were mostly within the reference concentration range. There were two exceptions though (*i.e.*, HENDRY-SED-6, and HENDRY-SED-5). Both of these are upstream stations. Similarly to lithium, the highest sediment vanadium concentration did not occur at station UNNAMED-SED-1, but rather, occurred at an upstream station in Hendry Brook (i.e., HENDRY-SED-6). In the September, 2011 sampling event, Study boundary vanadium sediment concentrations were generally higher than those observed in July, 2010. All stations except HENDRY-SED-7, HENDRY-SED-6, UNNAMED-SED-1, and UNNAMED-SED-2 exceeded the reference vanadium sediment concentration range. In both sampling events, there was no clear trend in Hendry Brook of increasing sediment vanadium concentrations with increasing proximity to the smelter. Vanadium has no adverse effect level sediment quality benchmarks available, which makes it difficult to comment on the potential for effects. However, given the general similarity of Study boundary to reference area sediment concentrations, and the lack of a trend for higher sediment concentrations closer to the smelter, it is unlikely that vanadium poses an ecological concern to benthic organisms in either of the Study boundary brooks.

Zinc

Zinc concentrations in Study boundary brook sediments were mostly within the reference concentration range, with five exceptions (i.e., HENDRY-SED-2 in 2010 and 2011, UNNAMED-SED-1 in 2010 and 2011, and UNNAMED-SED-3 in 2011). The zinc sediment concentrations at station UNNAMED-SED-1 were most elevated over the reference sediment concentration range. As mentioned previously for most of the other COPCs, the UNNAMED-SED-1 station's location may be influencing sediment chemistry. The further upstream samples, UNNAMED-SED-2 and UNNAMED-SED-3, contained zinc sediment concentrations that were lower and similar to those in other Study boundary and reference area sediment samples; although, at 400 mg/kg, the 2011 zinc sediment concentration at UNNAMED-SED-3 is above the reference range. Only the UNNAMED-SED-1 and UNNAMED-SED-3 stations had zinc sediment concentrations (*i.e.*, 760 mg/kg (2010), 680 mg/kg (2011) and 400 mg/kg (2011), respectively) that exceeded the PEL. However, these concentrations were below both the SEL and FEL sediment quality benchmarks. Thus, there is likely no risk of harm to benthic organisms (with respect to zinc) in any of the Study boundary sediment stations with the possible exception of station UNNAMED-SED-1. Even at this station, there is a relatively low probability that significant adverse effects would occur in benthic organisms. Zinc sediment concentrations in Hendry Brook do not show a clear trend of increasing with increasing proximity to the smelter. Furthermore, all zinc sediment concentrations in this brook are below the PEL, and are considered unlikely to pose a significant ecological concern to benthic organisms.

9.6.2 Fish Habitat Survey Outcomes

With respect to Hendry Brook, the downstream area of the brook is composed mainly of riffle habitat with exposed bedrock in the streambed and along the banks. In areas further upstream, run habitat is the dominant habitat type, and the percentage of sand, gravel, and fines increases. Overall, stream banks were stable and the proportion of fines in the streambed was very low. Areas of Hendry Brook running through cedar swamps had a high amount of woody debris. Hendry Brook has several small shallow pools and a high degree of shade cover. Hiding cover for fish occurred in the form of coarse substrate, overhanging vegetation, undercut stream banks and large woody debris. The only observed obstruction to fish movement was an old wooden dam structure 80 m upstream of the head of tide.

Using an adapted salmonid classification system to classify brook trout habitat, Currie (2011) ranked the lower portion of Hendry Brook as good rearing habitat with limited spawning potential due to the high amounts of bedrock. The rest of the stream habitat has both good rearing and spawning potential for brook trout.

Unnamed Brook had an average wet width of approximately 1.5 m. The habitat types were alternating riffle and run habitat, and the dominant substrate was gravel. The stream banks were stable and well vegetated. A large section of the stream was channelized approximately 25 years ago. At that time, it appears a rock-lined ditch was constructed to replace the natural stream channel. Cover is available for fish in the form of undercut stream banks, overhanging grass and shrub vegetation, as well as surface turbulence in relation to riffle habitat.

Currie (2011) determined that 95% of the lower surveyed section would be good spawning and rearing habitat for salmonids. The remaining 5% of the surveyed section in the vicinity of sampling station UNNAMED-SED-1, had little flow and abundant bedrock providing little potential for rearing and spawning habitat.

Obstructions to fish movement include a culvert running under the old airstrip that was mostly blocked with brush debris. The culverts further upstream at the road crossing also block upstream fish passage.

With respect to the comparative reference stream, the eastern branch of Armstrong Brook was evaluated by Currie (2011). The habitat types in this area were alternating sections of riffle and run habitat with a number of small lateral and plunge pools. The most dominant substrates were gravel, sand and rubble. Stream banks were stable; however, there was evidence of recent erosion at several locations. Hiding cover for fish was found to be abundant. For the most part, the habitat of Armstrong Brook reflects good salmonid rearing habitat with fair to good spawning potential. The short stream segment immediately upstream of the railway tracks contained a ponded stream section that was the only area with a complete absence of spawning and rearing potential. No serious obstructions to fish passage were found within the surveyed section of Armstrong Brook.

9.6.3 Electrofishing Survey Outcomes

During electrofishing in Hendry Brook, 18 fish were caught (Currie, 2011; see Figure 4-8 for locations). The catch comprised 4 blacknose dace, 1 American eel, and 13 brook trout. The captured brook trout appeared to represent 3 age classes (4 were age class 0+, 6 were age class 1+ and 3 were age class 2+). All of the fish were caught upstream of the obstruction formed by the old wooden dam structure. A catch rate of 0.018 fish per second indicated a moderate fish density.

A limited amount of spot electrofishing was conducted in Unnamed Brook in the vicinity of the water sampling station UNNAMED-SED-1 to determine if fish were present at this location. This effort resulted in the capture of 7 small blacknose dace and two small brook trout. Additional electrofishing was conducted further downstream, and 30 brook trout were captured. These combined efforts resulted in the capture of 39 fish during 899 seconds of sampling. The catch per unit effort of 0.043 fish per second when both events were combined suggests a high fish density in this brook.

Electrofishing in Armstrong Brook was conducted at the upstream end. A total of 23 fish were captured, comprising 1 Atlantic salmon parr, 6 slimy sculpin, 2 blacknose dace and 14 brook trout. A catch rate of 0.023 fish per second was reported and indicates a moderate fish density. In addition to the fish, 1 frog (species unknown) and 1 salamander were also captured.

9.6.4 Aquatic Receptor Weight of Evidence

The various LOE used to assess potential risks to aquatic life are identified in Table 9-28 along with the interpretation of each LOE.

Based on information for freshwater aquatic life resident in Hendry Brook:

- Sediment and surface water concentrations do not suggest potential for adverse effects in benthic organisms or pelagic species;
- Fish habitat survey indicates good spawning/rearing fish habitat;
- Fish density was moderate and similar to reference;
- Most abundant species was brook trout; multiple age classes caught; other captured fish species (dace, eel) are common to streams in northeastern NB

Based on information for freshwater aquatic life resident in Unnamed Brook:

- Surface water Mn exceeded guidelines in both 2010 and 2011 and cadmium was elevated in 1 sample in 2011 (total; not dissolved);

- Sediments, As, Cd, Pb and Zn exceed effect-level sediment quality guidelines in 2010 and 2011 surveys, most predominantly near the Slag storage area.
- The fish habitat survey indicated the lower surveyed section of Unnamed Brook is good spawning/rearing fish habitat, whereas the upper station in Unnamed Brook (which also exhibits among the higher metals concentrations) is not good fish habitat due to little flow and abundant bedrock
- Fish density was high (in the sections with good fish habitat)
- Most abundant species was brook trout
- Brook trout are known to be sensitive to environmental degradation, yet the highest density was found near the slag storage area; captured trout represented multiple age classes indicating that resident brook trout are reproducing successfully and maintaining a robust population;

Overall, risks to freshwater aquatic life in Hendry Brook are considered to be negligible to low, whereas those in unnamed brook are considered to be low to moderate. The low frequency and degree of exceedance of water quality benchmarks, and the general similarity of Study boundary surface water concentrations to reference surface water concentrations (both total recoverable and dissolved), suggests that lead and manganese in the two Study boundary brooks do not pose an ecological concern to freshwater aquatic life.

With respect to sediments, concentrations in Hendry brook suggest there are no ecological concerns for benthic organisms, and hence, the potential for risk is considered to be negligible to low. With respect to Unnamed Brook, where sediment metals levels are more elevated, the sediment concentrations suggest a potential for adverse effects in benthic organisms, but the degree of exceedance and the spatial extent of the potentially affected area(s) is limited. Thus, it is concluded that COPC sediment concentrations in Unnamed Brook could pose a moderate degree of risk to benthic species.

The 2011 surveys of Hendry Brook, Armstrong Brook and Unnamed Brook found all three watercourses to be viable salmonid habitat that supported a moderate to high fish density. Brook trout was the most abundant fish species in each brook and multiple age classes were caught. Other captured fish species common to streams in northeastern NB included blacknose dace, American eel, slimy sculpin, and Atlantic salmon.

The fish habitat survey of Hendry Brook indicates good fish spawning and rearing fish habitat. Fish density in the brook was moderate and similar to reference. Overall, there was no evidence that the operation of the smelter is adversely affecting freshwater fish populations or fish community in Hendry Brook.

Despite being closest to the smelter and slag pile, and having the most modified habitat, the fish survey found that the highest fish density of fish occurred in Unnamed Brook. This brook also had the highest density of brook trout that represented several age classes. Overall, the results of the fish survey indicate no overt evidence that the operation of the smelter, or presence of the slag pile, is having a negative impact on fish populations in Unnamed Brook.

Given the various LOEs, using a weight of evidence approach and considering the uncertainties and study limitations presented in Section 10.0, the following conclusions for the health of freshwater aquatic life can be made:

- Risks to freshwater aquatic life in Hendry Brook are considered to be negligible to low.
- Risks to freshwater aquatic life in Unnamed Brook area considered to be low for freshwater pelagic species and moderate for benthos, largely due to the influence of the slag storage area in a portion of that brook.

Table 9-28 Lines of Evidence for Evaluating Freshwater Aquatic Life

Surface Water and Sediment Chemistry Data Comparisons to Effect Level Surface Water / Sediment Quality Guidelines and Reference		**Stream Surveys (Currie, 2011)**		**Potential Risk to Aquatic Life**
2010 – 2011 Surface Water (mg/L)	**2010 – 2011 Sediments**	**Habitat Survey**	**Electrofishing Survey**	
Hendry Brook: Pb had marginal exceedances over guidelines and/or reference concentrations in 2010; no exceedances in 2011. Unnamed Brook: Mn exceeded FWAL guidelines in both 2010 and 2011, and Cd was elevated in one sample in 2010 (total cadmium; not elevated in dissolved fraction)	Ba, Fe, Li, Tl, Sb, V have no SQG. Comparisons to reference sediments suggest limited potential for adverse effects in benthic community related to these metals. Hendry Brook: As and Pb at some stations exceeded effect –level guidelines in sediments in either 2010 or 2011; exceedances were either not repeated between years (Pb), or were within 2-fold of PEL guidelines (As) Unnamed Brook: Several metals (Cd, Zn, Pb, As) exceed effect-level guidelines in parts of the brook, particularly at station closest to slag storage area. Degree of exceedance was small in most cases, and limited in aerial extent.	Lower Hendry Brook: good rearing habitat with limited spawning potential due to the high amounts of bedrock. Middle and Upper Hendry Brook: good rearing and spawning potential for brook trout. Unnamed Brook: good spawning and rearing habitat for salmonids, with the exception of the area around Unnamed Sed-1 (closest to slag storage area), where it was considered to be poor due to exposed bedrock and low flow.	Hendry Brook: moderate fish density; brook trout for 3 age classes, and black nose dace and atlantic eel also present. Unnamed Brook: high fish density, brook trout with multiple age classes found; as well as black nose dace.	Risks to freshwater aquatic life in Hendry Brook are considered to be negligible to low, based on few metal exceedances over benchmarks in either sediment or surface water, presence of good fish habitat and moderate fish density; Risks to freshwater aquatic life in Unnamed Brook are higher than those in Hendry Brook, largely due to the influence of the slag storage area. Sediments have several metals over effect-level benchmarks, which suggests a moderate potential for adverse effects in benthos, albeit limited, due to the small degree of exceedance and aerial extent. The likelihood of adverse effects in fish is considered to be low, based on surface water concentrations and reported high fish densities in brook.

9.6.5 Considerations for Consumers of Aquatic Biota

Although the surface water and sediment concentrations of some COPCs exceed benchmark values at a few stations, none of the water or sediment quality benchmarks are applicable to evaluating the potential for bioaccumulation within aquatic biota and subsequent consumption of these biota by avian or mammalian consumers. With the exception of a few stations that comprise a relatively small spatial area, surface water and sediment concentrations of COPCs in Hendry and Unnamed brooks are essentially the same as those in reference area streams and brooks. Thus, there is likely limited potential for significant bioaccumulation of COPCs in fish, or other aquatic organisms, beyond that which would occur in any northeastern New Brunswick aquatic ecosystem. As such, COPC tissue residue levels in aquatic biota from Hendry and Unnamed brooks are unlikely to be substantially different from those in the biota that inhabit reference streams and brooks. It follows then, that COPC exposure for avian or mammalian consumers of aquatic biota is also unlikely to differ substantially between Hendry and Unnamed brooks, and the reference area watercourses. Furthermore, given the small spatial area that appears to be affected by elevated COPC water or sediment concentrations, and considering that avian and mammalian consumers of aquatic biota have large foraging ranges, it is unlikely that significant exposures to COPCs would occur as a result of foraging within Hendry and Unnamed brooks. It is improbable that any bird or mammal consumer of aquatic organisms would forage exclusively in the most impacted sections of these brooks, as the size of these areas would likely not support sufficient aquatic food resources for these receptors.

9.6.6 Considerations for Amphibians

Amphibian species are present in both Hendry and Unnamed brooks. NB DNR (2009) indicates that 16 amphibian species are known to occur in various ecoregions and ecosites throughout northeastern New Brunswick. During their 2011 fish survey, R.A. Currie found both frogs and salamanders in Armstrong Brook, and other field survey crews noted significant numbers of frogs eggs and tadpoles in the upper reach of Unnamed Brook, and 4 Blue-spotted Salamanders (*Ambystoma laterale*), 1 Eastern Red-backed Salamander (*Plethodon cinereus*) and 2 Yellow-spotted Salamanders (*Ambystoma maculatum*) were caught in terrestrial soil invertebrate pitfall traps in fall of 2011 (LGL, 2012a).

Due to the behavioural habits of many amphibians (*e.g.,* close contact with water, soils or sediments, high dermal absorption, etc.,), one would expect these species to have a high chemical exposure potential (Hopkins, 2000; Linder *et al*., 2010a). Therefore, chemical exposures incurred by these species could be potentially elevated. As most amphibian species have multiple life stages with both aquatic and terrestrial phases, there is opportunity for multimedia exposure via a variety of exposure pathways.

Data also exist that indicate amphibians may be highly susceptible to environmental chemical stressors due to such aspects of their physiology and ecology as: limited home range, habitat preferences, position in the food web, permeability of their skin, and foraging behaviour (Henry, 2000; Linder *et al*., 2010a, b). Juvenile and adult skin is highly permeable to a number of chemicals as these animals primarily breathe through their skin (*i.e*., cutaneous or transdermal respiration). In addition, amphibians lack dermal defenses such as hair, feathers or scales that would act to reduce dermal exposure. Amphibian eggs and larvae are highly permeable to a wide variety of chemicals, and amphibian eggs may be particularly sensitive to aqueous chemical exposures as this life stage is incapable of avoidance behavior. Although, the eggs of many amphibians are afforded some degree of protection through the jelly-like coating that covers the egg masses (Henry, 2000; Linder *et al*., 2010a,b). Similar to aquatic species, greater chemical sensitivity is usually displayed in early life stages of amphibians (*e.g*., eggs, larvae, tadpoles), although there are exceptions to this, and key exposure pathways can vary at different life stages, which can lead to marked differences in exposure and subsequent risks (*e.g*., a tadpole may receive little exposure to sediment-bound contaminants but an adult frog may ingest considerable amounts of sediment contaminants that accumulate in insects during their larval benthic stages).

Many amphibians are opportunistic foragers and can have a varied diet throughout their life cycle that may include detritus, phytoplankton, zooplankton, periphyton, insects, small fish, other aquatic invertebrates, other amphibians, and aquatic plants (Murphy *et al*., 2000; Linder *et al*., 2010b). Modes of feeding change in most amphibians as they mature (*e.g*., from filter feeding in tadpoles to insect predation as adults) (Henry, 2000). The highly variable diets of amphibians make it difficult to accurately assess food chain exposure. This issue is compounded by the fact that in many amphibians, feeding varies by season, temperature, activity level, and moisture level, and assimilation efficiency varies markedly with the type of food ingested (Birge *et al*., 2000). Therefore, while an important exposure pathway, food ingestion is too complex and too variable to be assessed quantitatively in ecological risk assessments with any degree of accuracy.

In light of the difficulties in evaluating dietary exposures, the vast majority of available toxicity data for amphibians comes from aqueous exposure studies. Sediment and soil exposure studies are extremely limited, and none were identified in the literature that pertained to the chemicals of interest in the current ERA. Even aqueous toxicity data are limited for amphibians. This reflects the fact that ecotoxicological research on amphibians is a relatively new field of study. Thus, available data regarding the effects of chemicals on individuals and populations are limited and incomplete and there are consequently few regulatory environmental quality criteria available that incorporate amphibian toxicity data.

Despite the considerable gaps and uncertainties in the available toxicity database for amphibians, the data that do exist indicate high sensitivity to a number of common environmental contaminants (including metals, pesticides, chlorinated organics, and petroleum hydrocarbons). However, the usual uncertainties related to extrapolating laboratory toxicity data to the field are even more pronounced for amphibians, as their responses to chemical stressors are complex and variable, and depend on a multitude of interacting biological, physical, chemical, and ecological factors.

While the above paragraphs illustrate the potential sensitivity of amphibians to chemical exposures, the surface water and sediment COPC concentrations in Hendry and Unnamed brooks are suggestive of a low potential for effects in amphibian species. This is because exceedances over water and sediment quality benchmarks (which likely do not reflect amphibian toxicity data) are limited to a few stations, were generally marginal, and affect a relatively small spatial area within these brooks. Furthermore, at most sampling stations in these two brooks, surface water and sediment concentrations of COPCs are similar to those in reference area streams and brooks. Thus, in Hendry and Unnamed brooks, there is likely no higher potential for toxicity in amphibians beyond that which would occur in any northeastern New Brunswick watercourse.

9.7 Sensitive Species

A sensitive species is one that is considered extirpated, threatened, endangered or of special concern. The potential for significant effects on sensitive species was examined considering a variety of LOEs including:

- Risk characterization results for the receptors selected for evaluation in this ERA;
- LGL (2008) Biodiversity report for the smelter;
- D. Peck Botanical (2007) and B&B Botanical (2011) rare vegetation surveys;
- Small mammal survey (LGL, 2012a); and
- Breeding bird and fledgling survey (LGL, 2012b).

Unlike non-sensitive species, which are assessed based on population level endpoints, potential risks to sensitive species are generally examined at the individual level. Potential risks to the sensitive species observed / expected to be found within the Study boundary are discussed in the following sections.

9.7.1 Vegetation

As previously stated in Section 3.1.2.3, D. Peck Botanical (2007) found four rare plant species in various locations and numbers within the woodlands in the vicinity of the Belledune Smelter, while B&B Botanical (2011) identified 4 rare to very rare vegetation species within the Study boundary.

Based on previous reports of rare vascular plant species in the region of the Glencore woodlands in the ACCDC (Atlantic Canada Conservation Data Centre) records, fifteen species of rare vascular plants had been reported previously (D. Peck Botanical, 2007). Of these species, only eight of the 15 might be expected to be found within the habitat typical of the Glencore woodlands, with the remaining species being more typical of estuarine habitats and would not be expected to be found in woodland environments (D. Peck Botanical, 2007). Two of the eight species previously identified and expected to be found within the habitat type, were actually found during the vegetation survey. Two additional rare plants were also reported (new sightings for the province). However, 6 of the 8 species previously reported were not identified. While this may appear that the number of rare vascular plant species in the vicinity of the smelter has decreased, the author noted that the data presented in her report represent a onetime only examination an area within a 5 km radius around the smelter. Had additional site visits been conducted at other times during the growing season, additional evidence of other species may have been found (D. Peck Botanical, 2007). It is difficult to confirm whether the absence of previously reported rare plants are a result of exposure to emissions, or changes in habitat (*i.e.,* presence of beaver dams creating wetland areas which used to previously be more dry, *etc*.), or other factors (such as presence of new invasive species, *etc*.).

Similarly, the authors of the B&B Botanical (2011) study indicated that the surveyed portion of Hendry Brook and those areas 100 m to either side are in general, not typical of the rich habitat defined by the other species listed by ACCDC for the area and that Hendry Brook is a good example of a typical brook found in the area.

These surveys were not specifically designed to identify whether metals contamination is affecting the presence of rare vegetation species in the immediate area of the facility, and therefore specific conclusions related to effects cannot be drawn with confidence. Based on the outcomes of the surveys significant numbers of rare species would not be expected to occur in the study area, based on previous sightings, and habitat.

9.7.2 Mammalian Species

No sensitive mammalian species were observed or reported to be expected within the Study boundary.

9.7.3 Avian Species

With respect to birds, only one sensitive species, the Canada Warbler, was observed within the Study boundary. The Canada Warbler is ranked threatened by COSEWIC, SARA Schedule 1 and was found within 2 km of the smelter where soil concentrations for some metals exceed soil quality guidelines. No other sensitive avian species were reported to be found within the Study boundary based on the biodiversity report conducted by LGL (2008), or the avian breeding bird survey. The Canada warbler, like the dark eyed junco, eats mainly invertebrates. Potential risks to the Canada warbler can be examined by using the risk assessment results for the junco. The junco ER_{NOAEL} results (protective at the individual level) indicate that insectivorous avian species may potentially be at risk as a result of predicted exposures to cadmium, lead and zinc (generally within 1 km of the smelter and in the vicinity of the slag pile)(See ERs in Table 9-9). These ERs were calculated using a variety of conservative assumptions and likely over-estimated exposures of avian insectivores to metals (*e.g.*, exposure modeling used the UCLM 95 which is an upper bound estimate of soil concentrations; bioavailability in soil and diet was assumed to be 100%). These ERs did not reflect results of the bird survey, where several insectivorous ground feeding birds were found within the Study boundary (LGL, 2012b). Results of the breeding bird survey indicate that birds are establishing breeding territories in areas near the Belledune smelter with medium and high soil metals concentrations at similar density to unaffected (*i.e.*, control) areas. Similarly, results of the fledgling survey indicate that the ground feeding species (in addition to other species) are producing young in areas where metal exposures are elevated over guidelines. Furthermore, of the 31 soil samples collected within 3 km of the smelter, only four are greater than the site-specific soil PRG of 530 mg/kg derived for Coeur D'Alene basin by US EPA (Sample et al., 2011), which was based on the potential for development of subclinical effects in the most sensitive of 3 avian species assessed. Given all of the LOE and the size of the Study boundary, avian home ranges, and the limited area exceeding a recently derived site-specific PRG from another site, potential risks to the Canada warbler (or other avian species of concern) are considered to be low.

9.7.4 Aquatic Species

In May 2012, the status of the American Eel was reexamined and designated from special concern to threatened by COSEWIC. The rationale for this designation states that the population is widespread throughout eastern Canada. The reevaluation was based on significant declines in the species' distribution in Lake Ontario and the upper St. Lawrence River. Results of the electrofishing survey found an American Eel in Hendry Brook. Based on the abundance of the species in the eastern portion of its range potential risks to the American Eel in the Belledune Area are considered to be low. The Wood Turtle and Snapping Turtle are also ranked by COSEWIC as Threatened and Special Concern, respectively. These species may or may not be present in the Study Area; however, this could not be assessed due to lack of toxicological data. No aquatic species at risk or sensitive aquatic species were identified in the New Brunswick Species at Risk Act, SNB 2012, c6.

9.7.5 Summary

Based on the available information, risks to sensitive species are likely low (possible effects on some individuals expected, but effects are not considered adverse or measureable). There is considerable uncertainty in this conclusion, but the limited number of sensitive species and limited size of areas with significant contamination suggests that this is likely a reasonable conclusion.

10.0 CONSIDERATION OF UNCERTANITIES, LIMITATION AND CONSERVATIVE ASSUMPTIONS IN THE ERA

One component of ERA involves assigning numerical values to various input parameters in models to obtain estimates of exposure and risk. Numerical values are typically required to describe chemical concentrations in environmental media, their fate and transport, wildlife exposure and receptor parameters and toxicity. The conclusions of any risk assessment are dependent on the data and assumptions that are evaluated within it, and are greatly influenced by the variability and uncertainty that is associated with these data and assumptions. Therefore, the key areas of variability and uncertainty and any major study limitations should be characterized and understood so as to avoid possible underestimating, or artificially overestimating risks, to the extent possible. Risk managers need this information to make informed decisions regarding whether or not risks need to be managed, to what extent, and how the risks can best be managed. By understanding variability and uncertainty, risk managers can identify situations where the use of more sophisticated approaches and/or further data collection can reduce or refine key sources of uncertainty and/or variability before making final risk management decisions.

Where variability and uncertainty are known to exist, it is standard risk assessment practice to make assumptions and select data that overestimate, rather than underestimate potential exposure and risk. Given the tendency for the numerous conservative assumptions used in the ERA to overestimate potential exposure and hazards for the COPCs, it is considered extremely likely that the ERA has overestimated potential COPC exposures and risks in the receptors evaluated.

The inherent tendency of ERAs to overestimate exposures and toxicity to ecological receptors favours Type I errors (false positives; calculated ER>1.0 when in reality ER<1.0) and reduces the probability of Type II errors (false negatives; calculated ER<1.0 when in reality ER>1.0). For example, in the COPC identification approach used in this ERA, both simple comparisons of maximum soil concentrations collected within the Study boundary to soil guidelines and/or reference concentration statistics, and statistical comparison tests are prone to a high Type I error (Myers and Thorbjornsen, 2004; Leadon et al., 2007; CalEPA, 1997; U.S. EPA, 2001b; 2002). Some reasons why these approaches tend to have a high rate of false positives is that trace element distributions in soil tend to have very large ranges (two or three orders of magnitude are not uncommon), and are highly right-skewed, often having, or resembling lognormal distributions. The accurate characterization of the upper tails of such skewed distributions requires a large number of background samples, which are often not available. The probability of false positives increases if the site dataset is larger than the background dataset (which is common, and was the case for all media and biota samples in the three phases of the overall ERA Study). In addition, statistical comparison tests treat each COPC as an independently behaving entity, and do not consider the geochemical, ecological or biological contexts in which each chemical occurs (Myers and Thorbjornsen, 2004). The U.S. EPA (2001b) notes that a Type I error is less serious than a Type II error (false negative) when selecting COPCs, and the use of approaches that favour Type I errors are inherently more protective of environmental health.

Uncertainty should not be confused with variability. Uncertainty is a lack of confidence in a result or estimate stemming from limited data, or missing information. Variability describes differences in parameter values such as metal concentrations at different locations within the Study boundary, differences in body weight or food intake rates for individual animals (*i.e.*, population heterogeneity). In other words, variability is defined by the range or "spread" of values in a given population, and is influenced by sample size, repeated measures and area of coverage.

Gaining and maintaining an open acknowledgement and characterization of uncertainty and variability in an assessment is crucial to the success of the decision-making process (Moore and Bartell, 2000). The method used to assess the uncertainty surrounding the exposure estimates depends on the complexity of the model, the information available, and sources of uncertainty. Potential sources of uncertainty in the ERA can be divided into one of the following categories (U.S. EPA, 2001b):

- Parameter uncertainty;
- Model uncertainty; and,
- Scenario uncertainty.

One of the more difficult issues in assessing exposures and risks to ecological receptors, and characterizing the uncertainty and variability in the approaches used, is the establishment of *a priori* performance criteria for model results (Moore and Bartell, 2000). There are numerous complicating factors that can impede the efficiency and success of developing *a priori* criteria though, and all *a priori* approaches require at least some information on some variables from within the Study boundary (which may not exist prior to initiating a study), and some assumptions must be made. Such requirements can make establishing *a priori* criteria impractical. This is especially the case when the assessors must design and conduct sampling programs for environmental and biological media, over a large and heterogeneous spatial area (which is the case in the current ERA).

In the evaluation of uncertainty and variability, what is ultimately most important is that one has reasonably high certainty that the ERA does not under-predict exposures and risks, and that the models used will rarely predict the absence of risk when there is indeed a risk (*i.e.*, avoid or minimize the occurrence of false negatives or Type II errors).

Therefore, the objective for the analysis of variability and uncertainty in any ERA is to demonstrate the following:

- Model input variables reflect the natural variability in the environment; and,
- Model input variables are assigned conservative values in the face of uncertainty.

A key question when characterizing uncertainty and variability in relation to a particular model input parameter is: "Will the collection of more information dramatically improve the understanding of the variability, and/or reduce uncertainty?"At some point, the collection of additional data will reach the point of diminishing returns, when the effort and resources that are expended to further understand variability and reduce uncertainty are no longer producing meaningful improvements. For example, if additional soil chemistry data collection were to occur, and the new data yielded concentrations that fell well within the range of existing data, with no substantial changes to values that measure the "spread" of the data (such as variance, standard error, standard deviation, coefficient of variation etc.), then the need for still further data collection would be considered unnecessary and impractical, particularly if data collection efforts are time and resource (or cost) intensive.

The variability and uncertainty related to each item listed above were characterized according to the following criteria (Tables 10-1 and 10-2). These criteria have been used in other wide area ERAs conducted in Canada (*e.g*., Brunswick Mines ERA; Intrinsik, 2011; Sudbury Soils Study; SARA Group, 2008). It is recognized however, that these criteria are qualitative rather than quantitative descriptors. It is generally not possible to confidently or reliably assign quantitative values to the major areas or sources of variability and uncertainty in an ERA. This is because ERAs involve the use of both quantitative and qualitative information, in an integrated manner, which includes the application of default assumptions, intentional conservatism, and professional judgment throughout the ERA process.

Table 10-1 Definition of Variability Qualifiers

Qualifier	**Definition**
Well characterized	Sample size is adequate for the area of coverage, and/or includes multiple sampling events or multiple species or groups. Repeated measures confirm or fall within an order of magnitude of previous measurements. Good spatial coverage across the Study boundary.
Moderately characterized	Sample size is moderate for the area of coverage, and may include multiple species or groups. Typically only one sampling event or interval. Missing coverage in certain regions or locations across the Study boundary.
Poorly characterized	Sample size is low or small for the area of coverage, and /or includes only one species or group. Only one sampling event or interval. Missing coverage in a number of regions or locations across the Study boundary

Table 10-2 Definition of Uncertainty Qualifiers

Qualifier	**Definition**
Low	Collection of additional data unlikely to improve understanding of existing distributions or reduce uncertainty.
Medium	Collection of additional data may improve understanding of existing distributions and reduce uncertainty. For this category, it is assumed that site-specific conditions are not significantly different from literature studies used to develop models (*i.e*., assumptions or differences are within a factor of 10).
High	Collection of additional data likely will improve understanding of existing distributions and substantially reduce uncertainty For this category, it is assumed that site-specific conditions are significantly different from the assumptions and methodologies in the literature studies used to develop models (*i.e*., assumptions or differences may be greater than a factor of 10).

Table 10-3 provides qualifiers for the overall confidence related to the items considered. The confidence qualifiers are qualitative and are simply based on equal consideration of both the variability and uncertainty qualifiers. It is acknowledged that true confidence in any measured or estimated value is ideally determined in a statistical manner where it can be quantified (e.g., in a statistical comparison test, confidence is dependent on the type of test being applied, its inherent assumptions being satisfied, the constraints put on that test (*e.g*., alpha), any assumptions made about the data or its distribution, and the sample size). However, because ERAs integrate qualitative and quantitative information to produce exposure and risk estimates, and apply default assumptions and professional judgment throughout the process, deriving a meaningful numerical estimate of confidence is difficult, if not impossible.

Table 10-3 Definition of Overall Confidence Qualifiers

Variability	**Uncertainty**	**Overall Confidence Qualifier**
Well characterized	Low	High
	Medium	Medium
	High	Medium
Moderately characterized	Low	Medium
	Medium	Medium
	High	Low
Poorly characterized	Low	Medium
	Medium	Low
	High	Low

Table 10-4 provides the variability, uncertainty and overall confidence qualifiers for the major ERA modelling inputs and LOE. Further details regarding uncertainties, variability, limitations and conservative assumptions in the ERA are provided in Appendix Q.

Table 10-4 Variability, Uncertainty and Overall Confidence in the ERA Parameters and Models

Parameters	# Samples (or Stations)	Variability	Uncertainty	Overall Confidence	Comments
Environmental Media and Biota COPC Concentrations [a]					
Soil (metals and metalloids)	N = 61 (2009) N = 17 (2010) Reference: N = 23	Well characterized	Low	High	Soil samples were collected over a 7 km radius from the site, at various depths (0 to 5; 5 to 15 and 15 to 30 cm) during the summer months (July and / or August) in 2009 and 2010. A total of 78 samples were collected and analyzed at the 0 to 5 cm depth (excluding field duplicates). Twenty of these samples were core samples which included soil analysis of the 0 to 5 cm; 5 to 15 cm and 15 to 30 cm soil depths. A total of 23 reference soil samples were collected with 10 of these being core samples for which various depths were analyzed. Because metals do not degrade or volatilize, little seasonal variation is expected. All soil samples were composite samples and comprised of 5 subsamples.
Soil pH and TOC	N=7 (2009) N=5 (2011) Reference: N=3 (2009) N=1 (2011)	Moderate	Medium	Medium	A total of 12 soil pH and TOC were collected from within the principle sampling area in July, 2009 and October, 2011. Of the 7 samples collected in 2009, 1 was collected within a 0 to 3 km radius from the smelter and 6 were collected within a 3 to 7 km radius. In October 2011, 5 pH samples were collected within a 2 km radius of the smelter and 1 reference pH sample was collected. As part of the soil nutrient analysis study, an additional 13 Study boundary and 4 reference area pH samples were collected in 2011 but were not used in conjunction with the other pH samples as they were analyzed using a different method. As such, these pH samples are not included in the total sample number provided in this table.
Soil Nutrient Analysis	N=13 (2011) Reference: N=4 (2011)	Moderately characterized	Medium	Medium	A total of 13 soil samples were collected within the Study boundary and analyzed for soil nutrients in October, 2011. These samples were collected along transects within a 2 km radius of the smelter. A total of 4 reference area soil nutrient sample were collected and analyzed.

Table 10-4 Variability, Uncertainty and Overall Confidence in the ERA Parameters and Models

Parameters	# Samples (or Stations)	Variability	Uncertainty	Overall Confidence	Comments
Soil Bioaccessibility	No samples analyzed	Poorly characterized	High	High[b]	Soil bioaccessibility tests were derived to assess bioaccessibility in humans in the Shore Road Study and application of these test results to wildlife species has high uncertainty. As such, no additional soil samples were analyzed for bioaccessibility, rather in the exposure modelling, it was assumed that the bioavailability of all COPCs in soil was 100%. Of the species with elevated risk levels (shrew and junco), soil exposure accounted for 13% of total exposure (shrew; lead), and 10 – 40% in the junco (lead and zinc). Completing mammalian-based soil bioaccessibility testing would therefore not dramatically reduce risk estimates, and avian soil bioaccessibility testing is highly uncertain.
Surface Water	Unnamed Brook: N=2 (2010) N=3 (2011) Hendry Brook: N=7 (2010) N=7 (2011) Reference: N=5 (2010) N=5 (2011)	Moderately Characterized	Medium	Medium	Water bodies sampled within the Study boundary included: Unnamed Brook (N=2 plus 1 field duplicate in 2010 and N=3 plus 1 field duplicate in 2011) and Hendry Brook (N=7 plus 1 field duplicate in both 2010 and 2011). Reference samples were collected from Armstrong Brook (N = 5 with 1 field duplicate in both 2010 and 2011). Samples were collected in July of 2010 and September of 2011. Both total and dissolved samples were analyzed at each sampling location. Surface water samples were collected in locations /depths considered relevant for wildlife exposures. For comparison to reference samples, reference surface water data previously collected for the Brunswick Mines Study were also used resulting in a total of 67 reference area water samples (10 samples from Armstrong Brook collected in 2010 and 2011 and 57 from the Brunswick Mines reference areas).

Table 10-4 Variability, Uncertainty and Overall Confidence in the ERA Parameters and Models

Parameters	# Samples (or Stations)	Variability	Uncertainty	Overall Confidence	Comments
Sediment	Unnamed Brook: N=2 (2010) N=3 (2011) Hendry Brook: N=7 (2010) N=7(2011) Reference: N=5 (2010) N=5 (2011)	Moderately Characterized	Medium	Medium	Sediment samples were collected from Unnamed Brook (N=2 plus 1 field duplicate in 2010 and N=3 in 2011) and Hendry Brook (N=7 plus 1 field duplicate in 2010 and N=7 in 2011). Reference samples were collected from Armstrong Brook (N = 5 with 1 field duplicate in 2010 and N=5 with 2 field duplicates in 2011). Sediment samples were collected in locations /depths considered relevant for wildlife exposures (e.g., top 10 cm of sediment). For comparison to reference samples, reference sediment data previously collected for the Brunswick Mines Study were also used resulting in a total of 25 reference area sediment samples (10 samples from Armstrong Brook and 15 from the Brunswick Mines reference areas).
Soil invertebrate tissue residue	N = 5 (2010) Reference: N = 2	Poorly characterized	High	Low	Metals and metalloids were analyzed in soil invertebrates in 2010 during one season (summer). While numerous samples were collected, because of the limited size of the samples (from a tissue mass perspective), they had to be composited to enable metals analysis. Five soil invertebrate composite samples were obtained within a 0 to 2 km radius of the smelter as this area was shown to have the greatest soil metal concentrations. In addition, 2 reference soil invertebrate composite samples were also analyzed. Invertebrate samples were composites of different species (within and between samples), and therefore they were considered to be representative of dietary exposures to insectivores as receptors would feed on a variety of invertebrates. While the mix of species that comprised composite samples is considered realistic for receptors that consume soil invertebrates, these data limit the understanding of metal and metalloid uptake and effects in soil invertebrate species. There are likely considerable differences across invertebrate species with respect to uptake and tolerance of the COPCs.

Table 10-4 Variability, Uncertainty and Overall Confidence in the ERA Parameters and Models

Parameters	# Samples (or Stations)	Variability	Uncertainty	Overall Confidence	Comments
Small Mammal Liver	N = 6 (2011) Reference: N = 2	Poorly Characterized	High	Low	Shrews were sacrificed 18 to 20 October. Initially only shrews were sacrificed; however, because the number of shrews being trapped per site was small (< 5) all small mammals captured from October 21 to October 24 were sacrificed to increase sample size. Specimens were analysed for metals. Site tissue concentrations were compared to reference area concentration and to tissue residue effects data in the literature.
Small Mammal Kidney	N = 2 (2010) Reference: N = 1	Poorly characterized	High	Low	
Small Mammal Whole Body	N = 4 (2011) Reference: N = 1	Poorly characterized	High	Low	1 Northern short-tailed shrew and 3 common shrews were collected in October, 2011 from within the Study boundary and sent for analysis of metals. One reference area common shrew was also sent for analysis for comparison purposes.
Field Studies					
Terrestrial Vegetation and Rare Vegetation Surveys	Various stations within the vicinity of the Glencore smelter	Moderate	Medium	Medium	A survey of vegetation was undertaken in August of 2010, within 2 km of the smelter. In addition, rare vascular plants surveys were conducted in six areas of the Glencore woodlands in 2007 and within 100 m of either side of the lower 2.5 km of Hendry Brook in August, 2011.
Invertebrate Pitfall Traps	N = 17 (2010) Reference: N = 4	Poorly characterized	High	Low	17 pitfall traps were placed within the Study boundary. Traps were placed along a transect 1.5 m apart from each other 100 m away from the sampling grid to collect soil invertebrates. Sampling occurred during 2010 in the summer.
Breeding Bird Survey and Nestling Survey	N = 4 medium exposure; N = 4 high exposure Reference: N = 6	Moderate	Medium	Medium	Breeding bird surveys were conducted during June 27 to 30, 2011. Survey plots were selected near the smelter in areas of potential medium (4 plots) and high exposure (4 plots) and a control area (6 plots) 25 km distant from the smelter. Surveys specifically designed for confirmed breeders were conducted from July 20 to 25, 2011, where nests, nestlings and fledglings were the target of observers. Limitations of study were primarily the level of effort and habitat differences between comparison plots.

Table 10-4 Variability, Uncertainty and Overall Confidence in the ERA Parameters and Models

Parameters	# Samples (or Stations)	Variability	Uncertainty	Overall Confidence	Comments
Small Mammal Survey	N = 5 Reference: N = 2	Moderately Characterized	Medium	Medium	Small mammal trapping occurred in five high metal concentration areas representing two different habitat types (shrub/meadow and mixed wood forest) and two reference areas ~ 25 km away for a period of three to seven nights in the fall of 2011. Small mammal (initially shrews, but due to small number collected, this was expanded to other species), were collected and sacrificed between October 18th to 24th.
Stream Habitat Survey	Hendry Brook (2400 m) Unnamed Brook (966 m) Reference: Armstrong Brook (2023 m)	Moderately Characterized	Low	Medium	Streams were surveyed during one or two days in September, 2011. Hendry Brook was at normal stream flow; Unnamed Brook at low to normal stream flow and Armstrong Brook at / near normal stream flow but showed recent evidence of high storm flow. Given streams were surveyed only at one point in time, variability was considered moderate.
Media-to-Biota Uptake Models (or Factors)					
Soil-to-Woody Browse	Not applicable	Moderately characterized	Medium	Medium	Woody browse, non-woody browse and soil invertebrate tissue concentrations were predicted using trophic transfer models and measured soil concentrations within the Study boundary (i.e., the UCLM 95 and 95th percentile of 0 to 3 km soil concentrations and UCLM 95 of 0 to 1 km, 1 to 2 km; 2 to 3 km soil concentrations). Uncertainty in the uptake models is classified as Medium since the trophic transfer models used were standard generic uptake models from Oak Ridge National Laboratory [Sample et al., 1998; Bechtel Jacobs, 1998 and U.S. EPA (2005a)]. A comparison of the available measured invertebrate tissue data to modelled invertebrate tissue data (See Appendix Q) suggests that for some COPCs, modelled exposures could have been underestimated or overestimated for some metals. However, the measured invertebrate tissue data are too limited to make definitive statements on trends. No measured vegetation data were available to compare to modelled data. Based on all the considerations, the overall confidence in the uptake models were ranked as medium, since the approach taken was a
Soil-to-Non-Woody Browse	Not applicable	Moderately characterized	Medium	Medium	
Soil-to-Soil Invertebrate	Not applicable	Moderately characterized	Medium	Medium	

Table 10-4 Variability, Uncertainty and Overall Confidence in the ERA Parameters and Models

Parameters	# Samples (or Stations)	Variability	Uncertainty	Overall Confidence	Comments
					standardized approach and the uptake models used have been validated in other studies.
Soil-to-Small Mammal	Not applicable	Moderate	Medium	Medium	Predicted using measured soil concentrations (i.e., UCLM 95 and 95th percentile of 0 to 3 km soil concentrations and UCLM 95 of 0 to 1 km, 1 to 2 km; 2 to 3 km soil concentrations), and trophic transfer models (Sample et al., 1998; See Section 2.3.1). Overall confidence was ranked as medium, since the approach taken is a standardized approach.
Other Key Sources of Uncertainty					
Receptor Selection	Not applicable	Not applicable	Medium	Medium	In general, the receptor identification step seeks to identify ecological receptors which occur within the Study boundary, and that have the greatest potential for exposure to COPCs, and/or are the most sensitive to the effects of the COPCs. Thus, the likelihood for occurrence of adverse effects in less exposed or less sensitive receptors would be lower than for the assessed receptors. In selecting receptors, careful consideration was given to a number of factors including: behavioural patterns that would increase the potential for chemical exposure; food chain/food web structure; relative abundance; home ranges; percentage of time spent within potentially impacted areas and fraction of diet obtained from these areas; the availability of biological data describing their characteristics; the physical-chemical and environmental fate/behaviour properties of the COPCs; toxicological properties of the COPCs; and, professional judgement. However, there always remains the possibility that there are species living in (or possibly extirpated from) the Study boundary that are more sensitive to one or more of the COPCs than those receptors that were evaluated in the ERA.
Dietary Apportionment	Not applicable	Moderately characterized	Medium	Medium	Literature searches were conducted and various sources reviewed to determine dietary apportionment for the selected ecological receptors. While wildlife diets will always vary, diets were selected to bias COPC exposures high, where possible (i.e., if the literature suggested a wide range of intake of a certain food item, food preferences were biased towards food items that would most likely result in the greatest exposure to the receptor). In addition, all dietary items were assumed to come from within the Study boundary, even though some of the

Table 10-4 Variability, Uncertainty and Overall Confidence in the ERA Parameters and Models

Parameters	# Samples (or Stations)	Variability	Uncertainty	Overall Confidence	Comments
					receptors evaluated have large home ranges and would likely forage in un-impacted areas outside the Study boundary.
General Wildlife Exposure Variables (i.e., food and water ingestion rates, body weights)	Not Applicable	Moderately characterized	Low	Medium to High	Literature searches were conducted to locate data on the key exposure variables for each wildlife receptor that was assessed. Where literature values were not available, recognized allometric equations were used to derive exposure variables. Given the use of recognized allometric equations (which account for free metabolizable energy in the case food ingestion equations), the variability in the exposure variables is judged to be well characterized for the most part. Uncertainty in wildlife exposure variables is judged to be low overall, as all values used in the modelling are well within the ranges cited in the scientific literature. While no site-specific data were available for the derivation or adjustment of key exposure variables, significant differences between the Study boundary receptor populations and those located elsewhere is not expected.
Exposure Point Concentrations (EPCs) selected for exposure modelling	Provided above for all media and biota considered	Moderately characterized overall (qualifier varies across media and biota)	Low	Medium to High	Where possible, a 95th upper confidence level on the mean (UCLM95) was selected as the EPC in the exposure modeling for each media and biota type that were evaluated. The UCLM95 is considered representative of a reasonably maximally exposed (RME) individual (Fairbrother, 2003) and tends to overestimate central tendency exposures. Most regulatory agencies recognize that the best approximation of the exposure point concentration, often referred to as the "true mean" or the concentration most likely to be contacted over time, is the UCLM95. Where it was not possible to derive a UCLM95, upper percentiles or maxima were used.

Table 10-4 Variability, Uncertainty and Overall Confidence in the ERA Parameters and Models

Parameters	# Samples (or Stations)	Variability	Uncertainty	Overall Confidence	Comments
TRVs	Not applicable	Moderately characterized	High	Low to Medium	Toxicity data for the wildlife species selected for assessment was limited (and in some cases lacking). Toxicity data from other similar species were therefore used to derive TRVs. For the Phase II ERA, NOAELs (no-observable–adverse-effect levels) based TRVs derived by the U.S. EPA were selected for use in the assessment. In the Phase II ERA, LOAELs (lowest-observable-adverse-effects levels) were used. If species were not closely related, a 3-fold uncertainty factor was applied to the LOAEL to derive the TRV. NOAEL and LOAEL values were selected from U.S. EPA compilations of multiple studies (i.e., studies used for deriving U.S. EPA EcoSSLs). Although the overall confidence in the TRVs is low, they were selected to bias risk estimates high wherever possible. For other receptors (aquatic life, soil invertebrates and microbial receptors; vegetation), generic regulatory benchmarks were used, which are widely considered to be conservative.

Notes:

a Qualifiers for variability, uncertainty, and overall confidence that are assigned to data sets are focused on potential sampling error, and primarily consider whether or not adequate spatial and temporal coverage was achieved. Analytical measurement error is addressed separately in Appendix Q

b Overall confidence ranked as high since the exposure modelling assumed that the bioavailability of all COPCs in soil was 100%.

11.0 SUMMARY OF ECOLOGICAL RISK ASSESSMENT CONCLUSIONS

A comprehensive ecological risk assessment has been completed on terrestrial and freshwater environments south of the smelter.

Conclusions are:

- Risks to vegetation are considered to be low, with the exception of near-field areas immediately South – South-West of the facility, where they are considered moderate. The effects on vegetation South and South-West of the facility are likely related to a number of factors, including site disturbance, soil contamination, possible SO_2 in the near-field, salt spray, nutrient deficiency, amongst others.
- Risks to soil invertebrates and soil micro-organisms are considered to be low. Based on the results of the assessment, some individual level effects could be occurring in some species, but community level effects within the vicinity of the Belledune smelter as a result of smelter operations are considered unlikely.
- Risks to avian species (herbivorous, carnivorous or insectivorous) are considered to be low. Based on the results of the assessment, some individual level effects could be occurring in some species, but population level effects within the vicinity of the Belledune smelter as a result of smelter operations are considered unlikely.
- Risks to herbivorous and carnivorous mammalian species are considered to be negligible, whereas risks to insectivorous small mammals are considered to be low. Based on the results of the assessment, some individual level effects could be occurring in some species, but population level effects within the vicinity of the Belledune smelter as a result of smelter operations are considered unlikely.
- Risks to freshwater aquatic life in Hendry Brook are considered to be negligible to low, whereas risks to freshwater aquatic life in Unnamed Brook area considered to be low for freshwater pelagic species and moderate for benthos, largely due to the influence of the slag storage area in a portion of that brook.
- Based on the available information, risks to sensitive species known to be present on the site (which are limited in number) are likely low (possible effects on some individuals expected, but effects are not considered adverse or measureable). There is considerable uncertainty in this conclusion, but the limited number of sensitive species, and limited size of areas with significant contamination suggests that this is likely a reasonable conclusion.

Therefore, based on the outcomes of this study, risks associated with exposures to metals and SO_2 near the Glencore smelter facility are considered to be low to negligible for the terrestrial and freshwater environments. Based on these findings, the uncertainties in this study and the various studies that comprised this work, it is suggested that Glencore conduct a review of their environmental monitoring program, and consider including aspects of the ecosystem identified in this study as having higher exposure potential to their releases.

12.0 REFERENCES

Adaros, G. *et al*. 1991a. Concurrent exposure to SO_2 alters the growth and yield responses of wheat and barley to low concentrations of CO_2. New Phytologist 118:581-591. Cited In: WHO, 2000.

Adaros, G. *et al*. 1991b. Single and interactive effects of low levels of O_3, SO_2 and NO_2 on the growth and yield of spring rape. Environmental Pollution 72:269-286. Cited In: WHO, 2000.

AENV (Alberta Environment). 2009a. Alberta Tier 1 Soil and Groundwater Remediation Guidelines. Alberta Environment, Climate Change, Air, and Land Policy Branch, Environmental Assurance Division, Edmonton, Alberta.

AENV (Alberta Environment). 2009b. Ambient Air Quality Objectives and Guidelines. http://environment.gov.ab.ca/info/library/5726.pdf

Ainsworth, N., Cooke, J.A. and Johnson, M.S. 1990. Distribution of antimony in contaminated grassland: 2 – Small mammals and invertebrates. Environmental Pollution 65:79-87.

Alabaster, J.S. and Lloyd, R. 1982. Water quality criteria for freshwaterfish, second edition. Butterworth Scientific, London.

Allard, P., Fairbrother, A., Hope, B.K., Hull, R.N., Johnson, M.S., Kapustka, K., Mann, G., McDonald, B. and Sample, B. 2010. Recommendations for the development and application of wildlife toxicity reference values. Integrated Environmental Assessment and Management 6(1):28-37.

Aral, H. and Vecchio-Sadus, A. 2008 Toxicity of lithium to humans and the environment--a literature review. Ecotoxicol Environ Saf. 2008 Jul;70(3):349-56. doi: 10.1016/ j.ecoenv.2008.02.026.

Ashmore, M.R. and R.B. Wilson (eds.). 1994. Critical Levels in Europe. London: Department of the Environment. Cited In: WHO, 2000.

Ashmore, M.R. *et al*. 1988. Crop growth along a gradient of air pollution. Environmental Pollution 53:99-221. Cited In: WHO, 2000.

Antonovics, J., A.D. Bradshaw, and R.G. Turner. 1971. Metal tolerance in plants. Adv. Ecol. Res. 7:1-85.

Azimuth Consulting Group. 2012. Federal Contaminated Sites Action Plan (FCSAP) Ecological Risk Assessment Guidance. 215 pp. http://www.geoenvirologic.ca/Documents/20120631_ERAGuidance_Final_En.pdf

Barnthouse, L.W. and Brown, J. 1994. Conceptual model development. Chapter 3 in Ecological Risk Assessment Issue Papers. EPA/630/R-94/009. U.S. Environmental Protection Agency, Washington, DC. Cited In: Suter, 2007.

Baes, C.F. (III), Sharp, R., Sjoreen, A., and Shor, R. 1984. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radio-Nuclides Through Agriculture. Department of Energy, US (DOE), Washington, DC.

B&B Botanical. 2011. Rare Plant Survey of Lower 2.5 km of Hendry Brook Gloucester County, NB. Submitted to Neil Brodie, P.Eng. Project Manager Conestoga-Rovers & Associates. 30 September 2011.

Bechtel Jacobs. 1998. Empirical models for the uptake of inorganic chemicals from soil by plants. Prepared for the United States Department of Energy, Oak Ridge, BJC/OR-133

Beyer, W.N. and Meador, J.P. 2011. Environmental Contaminants in Biota: Interpreting tissue concentrations 2nd ed. Taylor and Francis Group CRC Press: Boca Raton, USA. pp. 564-604.

Beyer, W.N. and Storm, G. 1995. Ecotoxicological damage from zinc smelting at Palmerton, Pennsylvania. Pages 596-608 in D.J. Hoffman, B. Ratter, G.A. Burton, and J. Cairns (eds.) Handbook of Ecotoxicology. Lewis Publishers, Boca Raton, FL.

Beyer, W.N., Pattee, O.H., Sileo, L., Hoffman, D.J., and Mulhern, B.M. 1985. Metal contamination in wildlife living near two zinc smelters. Environ. Pollut. Ser. A. 38: 63-68.

BC MELP. 1998. Recommended Guidance and Checklist for Tier-1 Ecological Risk Assessment of Contaminated Sites in British Columbia. Approved January 1998. Prepared for the Ministry of Environment, Lands and Parks. Environmental Protection Department.

BC MOE. 2006. A Compendium of Working Water Quality Guidelines for British Columbia Science and Information Branch Water Quality. Science and Information Branch Water Quality. http://www.env.gov.bc.ca/wat/wq/BCguidelines/working.html

Birds of North America On-Line. 2009. http://bna.birds.cornell.edu/bna.

Birge, W.J., Westerman, A.G., and Spromberg, J.A. 2000. Chapter 14a: Comparative Toxicology and Risk Assessment of Amphibians. In: Sparling, D.W., Linder, G., and Bishop, C.A. Ecotoxicology of Amphibians and Reptiles. SETAC Technical Publications Series. pp. 727-810

Boyle, R.W., Tupper, W.M., Lynch, J., Friedrich, G., Ziauddin, M., Shafiquillah, M., Carter, M., and Bygrave, K. 1966. Geochemistry of Pb, Zn, Cu, As, Sb, Mo, Sn, W, Ag, Ni, Co, Cr, Ba and Mn in the waters and stream sediments of the Bathurst-Jacquet River District, New Brunswick. 21 P/12, 21 P/13, 21 O/9E, 21 O/16E. Geological Survey of Canada, Department of Mines and Technical Surveys. Paper 65-42.

Boyle, R.W., Shafiquillah, M., Durham, C.C., Tupper, W.M., Friedrich, G., Ziauddin, M., Carter, M., and Bygrave, K. 1968. Minor and Trace element Distribution in the Heavy Minerals of the Rivers and Streams of the Bathurst-Jacquet River District, New Brunswick. 21 P/12, 21 P/13, 21

O/9E, 21 O/16E. Geological Survey of Canada, Department of Energy, Mines and Resources. Paper 67-45.

Cabe, P. R. 1993. European Starling (*Sturnus vulgaris*). *in* The Birds of North America, no. 48. (Poole, A. and F. Gill, Eds.) Acad. Nat. Sci., Philadelphia, PA, and Am. Ornithol. Union, Washington, D.C.

CalEPA. 1997. Selecting Inorganic Constituents of Chemicals of Potential Concern at Risk Assessments at Hazardous Waste Sites and Permitted Facilities. Final Policy. Prepared by: Human and Ecological Risk Division, Department of Toxic Substances Control, California Environmental Protection Agency. February, 1997.

Campbell, P.G.C., P.M. Chapman, and B.A. Hale. 2006. Risk assessment of metals in the environment. Issues in Environmental Science and Technology 22:102-130.

CCME. 2011. Canadian environmental quality guidelines on-line. Canadian Council of Ministers of the Environment, Winnipeg. Accessed in 2011. http://ceqg-rcqe.ccme.ca/

CCME (Canadian Council of Ministers of the Environment). 2001. Canadian water quality guidelines for the protection of aquatic life: Arsenic. Updated. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg. http://ceqg-rcqe.ccme.ca/

CCME (Canadian Council of Ministers of the Environment). 1999a. Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (cadmium, lead, thallium, zinc): http://ceqg-rcqe.ccme.ca/

CCME. 1999b. Canadian Soil Quality Guidelines. Arsenic (Environmental and Human Health Effects). Scientific Supporting Document. National Guidelines and Standards Office, Environmental Canada.

CCME. 1999c. Canadian Soil Quality Guidelines. Lead (Environmental Effects). Scientific Supporting Document. National Guidelines and Standards Office, Environmental Canada.

CCME. 1999d. Canadian Soil Quality Guidelines. Thallium (Environmental and Human Health Effects). Scientific Supporting Document. National Guidelines and Standards Office, Environmental Canada.

CCME. 1999e. Canadian Soil Quality Guidelines. Zinc. (Environmental Effects). Scientific Supporting Document. National Guidelines and Standards Office, Environmental Canada.

CCME (Canadian Council of Ministers of the Environment). 1997. Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (arsenic): http://ceqg-rcqe.ccme.ca/

CCME. 1996. A Framework for Ecological Risk Assessment: General Guidance. Canadian Council of Ministers of the Environment. CCME Subcommittee on Environmental Quality Criteria for Contaminated Sites. The National Contaminated Sites Remediation Program, Winnipeg, MB.

CCREM (Canadian Council of Resource and Environment Ministers). 1987. Canadian water quality guidelines. Prepared by the Task Force on Water Quality Guidelines. Winnipeg, MB.

Chandler, C.R., E.D. Ketterson, and V. Nolan, Jr. 1997. Effects of testosterone on use of space by male dark-eyed juncos when their mates are fertile. Animal Behaviour 54:543-549.

Chapman, P. 2008. Perspective: Environmental risks of inorganic metals and metalloids: A continuing, evolving scientific odyssey. HERA 14:5-40.

Chmielnicka et al., 1989 Chmielnicka, J., T. Halatek and U. Jedlinska, 1989. Correlation of cadmium-induced nephropathy and the metabolism of endogenous copper and zinc in rats. Ecotoxicol. Environ. Sat, 18: 268-276.

Congiu, L., Chicca, M., Pilastro, A., Turchetto, M., and Tallandini, L. (2000). Effects of chronic dietary cadmium on hepatic gluthione peroxidase activity in starling (*Strunus vulgaris*). Archives of Environmental Contamination and Toxicology, 38, 357-61.

CRA (Conestoga Rovers and Associates). 2009. Preliminary Environmental Assessment (Aquatic) - Grand Lake, Grand Lake Generating Station, Newcastle Centre, NB, March 2009.

Csuti, B., A.J. Kimerling, T.A. O'Neil, M.M. Shaughnessy, E.P. Gaines, and M.M.P. Huso. 1997. Atlas of Oregon wildlife: distribution, habitat, and natural history. Oregon State University Press, Corvallis, OR.

D. Peck Botanical. 2007. Rare Vascular Plant Assessment – Xstrata Woodlands. Prepared for Mr. Mark Mullin Environmental Coordinator Glencore.

Desrosiers, M., Babut, M.P., Pelletier, M., Belanger, C., Thibodeau, S., and Martel, L. 2010. Efficiency of sediment quality guidelines for predicting toxicity: The case of the St. Lawrence River. Integrated Environmental Assessment and Management. 6(2):225-239.

Dodds-Smith ME, Johnson MS, Thompson DJ (1992) Trace metal accumulation by the shrew Sorex araneus. I. Total body burden, growth, and mortality. Ecotox Environ Safe 24:102–117.

Douay F., Pruvot C., Waterlot C., Fritsch C., Fourrier H., Loriette A., Bidar G., Grand C., de Vauflery A., Scheiffler R. (2009) – Contamination of woody habitat soils around a former lead smelter in the North of France. *Science of the total Environment*, 407, 5564-5577.

Environnement Canada et Ministere du Developpement durable, de l'Environnement et des Parcs du Quebec (EC-MDDEPQ) 2007

Edens, F. W., and J. D. Garlich. 1983. Lead induced egg production decrease in leghorn and Japanese quail hens. Poultry Science 64:1757–1763.

Efroymson, R.A., M.E. Will, and G.W. Suter II, 1997a, Toxicological Benchmarks for Potential Contaminants of Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process. ES/ER/TM-126/R2, Oak Ridge National Laboratory, Oak Ridge, TN.

Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten, 1997b, Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision, ES/ER/TM-85/R3, Oak Ridge National Laboratory, Oak Ridge, TN.

Environnement Canada et ministere du Developpement durable, de l'Environnement et des Parcs du Quebec (2007).

Environment Canada. 1995. A National Ecological Framework for Canada. Ecological Stratification Working Group. Agriculture and Agri-Food Canada, Research Branch, Centre for Land and Biological Resources Research and Environment Canada, State of the Environment Directorate, Ecozone. http://sis.agr.gc.ca/cansis/publications/ecostrat/cad_report.pdf

European Commission. 1980. Council Directive 18/779/EEC of 15 July 1980 on air quality limit values and guide values for sulphur dioxide and suspended particulates. Official journal of the European Communities L229:0030-0048. Cited In: WHO, 2000.

Fairbrother, A., and L.A. Kapustka. 1997. Hazard classification of inorganic substances in terrestrial systems: A discussion paper. International Council on Metals and the Environment, Ottawa, Canada. Cited In: U.S. EPA, 2004.

FHW Consulting. 2012. Xstrata Belledune Lead Smelter Soil Analysis Program. Report prepared for Intrinsik Environmental Sciences by Fred Wilkinson F.H.W. Consulting. April, 2012.

FPACAQ (Federal- Provincial Advisory Committee on Air Quality). 1987. Review of national ambient air quality objectives for sulphur dioxide (desirable and acceptable levels).

Fritsch C, Giraudoux P, Cœurdassier M, Douay F, Raoul F, Pruvot C, Waterlot C, de Vaufleury A, and Scheifler R. 2010. Spatial distribution of metals in smelter-impacted soils of woody habitats: influence of landscape and soil properties, and risk for wildlife. Chemosphere: 81(2):141-55. doi: 10.1016/j.chemosphere.2010.06.075.

Furman, O., Strawn, D.G., Heinz, G.H., & Williams, B. (2006). Risk assessment test for lead bioaccessibility to waterfowl in mine-impacted soils. *Journal of Environmental Quality 35*, 450–458. doi:10.2134/jeq2005.0316

Gaudet, *et al*. 1994. A Framework for Ecological Risk Assessment at Contaminated Sites in Canada: Review and Recommendations. Prepared by Gaudet, C., EVS Environment Consultants and Environment and Social System Analysts for Environment Canada. ISBN 0-662-22156-7.

Goss Gilroy Inc., Environmental & Occupational Health+Plus, and Senes Consultants Limited. 2005. Belledune Area Health Study: Summary Report and Appendices. Prepared for the Department of Health and Wellness, Government of New Brunswick.

Gotelli, Nicholas J. 1995. A Primer of Ecology. Sinauer Associates, Inc.

Goyer, R.A., Leonard, D.L., Moore, L.F., Rhyne, B., and Krigman, M.R. 1970. Lead dosage and the role of the intranuclear inclusion body. Arch. Environ. Health, 20: 705-711.

Henry, P.F.P. 2000. Chapter 3a: Aspects of Amphibian Anatomy and Physiology. In: Sparling, D.W., Linder, G., and Bishop, C.A. Ecotoxicology of Amphibians and Reptiles. SETAC Technical Publications Series. pp. 141-178

Hill, G. M., E. R. Miller, P. A. Whetter, and D. E. Ullrey. 1983. Concentration of minerals in tissues of pigs from dams fed different levels of dietary zinc. J. Anim. Sci. 57:130-138.

Hopkins, W.A., Roe, J.H., Snodgrass, J.W., Jackson, B.P., Kling, D.E., Rowe, C.L., and Congdon, J.D. 2000. Nondestructive indices of trace element exposure in squamate reptiles. Environmental Pollution, 115 (1) 1-7.

ICMM. 2007. MERAG: Metals Environmental Risk Assessment Guidance. International Council on Mining and Metals. www.metalsriskassessment.org.

Intrinsik Environmental Sciences Inc; Conestoga Rovers and Associates, Globaltox and Genivar. 2008. The Shore Road Soil Study, Belledune, New Brunswick. Prepared For: Glencore.

Intrinsik Environmental Sciences Inc., Swanson Environmental Strategies Ltd., Delphinium Holdings Inc. and Teck Metals Ltd. 2011. Terrestrial Ecological Risk Assessment for the Teck Metals Ltd. Smelter at Trail, BC. Main Report. Revised, May 2011.

Intrinsik Environmental Sciences Inc. 2009. Preliminary Ecological Risk Assessment, Brunswick Mines: Results of Phase II Sampling Program and Proposed Approach for Phase III. Final Report. Prepared for: Rick Schwenger, Glencore. June, 2009.

Intrinsik Environmental Sciences Inc. 2011. Ecological Risk Assessment of Fugitive Dusting from Tailings, Brunswick Mine No. 12. Final Report. Prepared for: Rick Schwenger, Glencore. March 22, 2011.

Keith, L.B. 1990. Dynamics of snowshoe hare populations. *In* Genoways, H.H. (Ed.), Current Mammalogy. Plenum Press, New York, NY. pp. 119-195.

Ketcheson M.R., Barron, G.P. and Cox, D.H. 1969. Relationships of maternal dietary zinc during gestation & lactaction to development and zinc, iron and copper content of the postnatal rat. J Nutr, 98: 303-31 1.

Klerks, P.L., and J.S. Levinton. 1993. Evolution of resistance and changes in community composition in metal-polluted environments: a case study on Foundry Cove. In: Dallinger, R., and P.S. Rainbow, eds. Ecotoxicology of metals in invertebrates. SETAC Special Publication Series. Ann Arbor, MI: Lewis Publishers, pp. 223-241. Cited In: U.S. EPA, 2004.

Klerks, P.L., and J.S. Weis. 1987. Genetic adaptation to heavy metals in aquatic organisms: A review. Envir. Poll. 45:173-205. Cited In: U.S. EPA, 2004.

Koch, I., Mace, J.V., and Reimer, K.J. 2005. Arsenic speciation in terrestrial birds from Yellowknife, Northwest Territories, Canada: the unexpected finding of arsenobetaine. Environ. Toxicol. Chem.: 24 (6):1468-74.

Leadon, C.J., McDonnell, T.R., Laer, J., and Barclift, D. 2007. Calculating Background Levels for Ecological Risk Parameters in Toxic Harbour Sediment. Soil and Sediment Contamination 16:433-350.

LGL Ltd 2012a. Brunswick Smelter Ecological Risk Assessment Belledune Small Mammals. 2011 Report Final. Prepared for Intrinsik Environmental Sciences by Virgil C. Hawkes and Janean Sharkey. 29 March 2012.

LGL Ltd. 2012b. Belledune Smelter Breeding Bird Study: Belledune, New Brunswick. Prepared for Intrinsik Environmental Sciences by LGL Ltd. January 2012. LGL Project TA8048.

LGL Ltd. 2012c. Vegetation Health Report: Xtrata Lead Belledune Smelter. Prepared for Intrinsik Environmental Sciences Inc. by LGL Limited Environmental Research Associates/ LGL File TA4803

LGL. 2008. Assessment of Biodiversity near Canadian Operations. Brunswick Smelter. New Brunswick. Prepared by LGL Limited. PROJECT TA4547

Linder, G., Lehman, C.M., and Bidwell, J.R. 2010a. Chapter 4: Ecotoxicology of Amphibians and Reptiles in a Nutshell. In: Sparling, G.W., Linder, G., Bishop, C.A., Krest, S.K. Ecotoxicology of Amphibians and Reptiles. Second Edition. SETAC Technical Publications Series. CRC Press. pp 69-104.

Linder, G., Palmer, B.D., Little, E.E., Rowe, C.L., and Henry, P.F.P. 2010b. Chapter 5: Physiological Ecology of Amphibians and Reptiles: Natural Histroy and Life History Attributes Framing Chemical Exposure in the Field. In: Sparling, G.W., Linder, G., Bishop, C.A., Krest, S.K. Ecotoxicology of Amphibians and Reptiles. Second Edition. SETAC Technical Publications Series. CRC Press. pp 105-166.

Long, E.R., L.J. Field, and D.D. MacDonald. 1998. Predicting toxicity in marine sediments with numerical sediment quality guidelines. *Environmental Toxicology and Chemistry* 17:714-727. et al 1998

Ma, W.C. 1994. Methodological principles of using small mammals for ecological hazard assessment of chemical soil pollution, with examples on cadmium and lead. In: Ecotoxicology of Soil Pollution, Eds. M.H. Donker, H. Eijsdackers and F. Heimbach, pp. 357-371. Boac Raton, FL: Lewis Publishers. Cited In: Beyer and Meador, 2011.

Ma,W.C., Denneman, W. and Faber, J. 1991. Hazardous exposure of ground-living small mammals to cadmium and lead in contaminated terrestrial ecosystems. Arch. Environ. Contam. Toxicol.: 20, 266-270.

Ma, W.C. 1989. Effect of soil pollution with metallic lead pellets on lead bioaccumulation and organ / body weight alternations in small mammals. Arch Environ Contam Toxicol 18:617-622.

Ma, W.C. and Broekhuizen, S. 1989. Heavy metals in badgers (*Meles meles*): possible effect of the contaminated flood plains of the river Meuse. Lutra 32:151 (in Dutch with English Summary).

Ma, W. 1987. Heavy metal accumulation in the mole, *Talpa europea*, and earthworms as terrestrial environments. Bull. Environ. Contam. Toxicol. 39: 933-938.

Makela, A. et al. 1987. Direct effects of sulfur on forests in Europe – a regional model of risk. Laxenburg, International Institute for Applied Systems Analysis (Working paper 87-57). Cited In: WHO, 2000.

MDEP. 2006. Technical Update. Revised Sediment Screening Values. Massachusetts Department of Environmental Protection, Office of Research and Standards. http://www.mass.gov/dep/water/laws/ecoturss.pdf

MacRae Environmental Services Inc. 2009. Xstrata Canada Inc. Stack Emission Testing Program, Brunswick Smelter, Belledune, NB. December, 2009.

Marques, C.C., Sanchez-Chardi, A., Gabriel, S.I., Nadal, J., Viegas-Crespo, A.M. and da Luz Mathias, M. 2007. How does the greater white-toothed shrew, *Crocidura russula*,responds to the long-term heavy metal contamination?- A Case Study. Science of the Total Environment: 376, 128-133.

Marshall, L., Sigal, E., Willis, R. and Teed, S. (Intrinsik Environmental Sciences). 2010. *In vitro* Bioaccessibility of Metals in Soil: Considerations for Ecological Risk Assessment. Platform Presentation SETAC November 11th, 2010. Portland Oregon.

Martley, E., Gulson, B. L., and Pfeifer, H.R. Metal concentrations in soils around the copper smelter and surrounding industrial complex of Port Kembla, NSW, Australia. Sci Total Environ. 2004 Jun 5;325(1-3):113-27.

Martin A.C., Zim, H.S., and Nelson, H.L. 1951. American wildlife and plants: A guide to wildlife food habits. Dove Publications, Inc., N.Y.

Miller, W. J., Amos, H. E., Gentry, R. P., Blackmon, D. M., Durrance, R. M., Crowe, C. T., Fielding, A. S., and Neathery, M. W. 1989. long-term feeding of high zinc sulfate diets to lactating and gestating dairy cows. *J Dairy Sci.* 72(6): 1499-508. Ref No. 14685. Cited In: U.S. EPA, 2007b.

MOE 2008. Guidelines for Identifying, Assessing and Managing Contaminated Sediments in Ontario: An integrated approach. R. Fletcher, P. Welsh, and T Fletcher. PIBS 6658e

Mooi, J. 1984. Wirkungen von SO_2, NO_2, O_3 und ihrer Mischungen auf Pappeln und einige andere Pflanzenarten. Der Forst- & Holzwirt 18:438-444. Cited In: WHO, 2000.

Moore, D.R.J, and Bartell, S.M. 2000. Estimating ecological risks of multiple stressors: Advanced methods and difficult issues. In Multiple Stressors in Ecological Risk and Impact Assessment: Approaches to Risk Estimation, J. Foran and S. Ferenc (eds.). SETAC Press, Pensacola, FL. Pp. 117-168.

Murphy, J.E., Phillips, C.A., and Beasley, V.R. 2000. Chapter 4a: Aspects of Amphibian Ecology. In: Sparling, D.W., Linder, G., and Bishop, C.A. Ecotoxicology of Amphibians and Reptiles. SETAC Technical Publications Series. pp. 141-178

Myers, J; Thorbjornsen, K. (2004). Identifying metals contamination in soil: A geochemical approach, *Soil & sediment contamination*, 13(1), 1-16

NAS (National Academy of Sciences). 2005. Mineral Tolerance of Animals, 2nd ed. Committee on Minerals and Toxic Substances in Diets and Water for Animals, Board of Agriculture and Natural Resources, Division on Earth and Life Sciences, National Research Council. The National Academies Press, Washington, D.C. URL: http://www.nap.edu/catalog/11309.html

NatureServe. 2009. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, Virginia. Available at http://www.natureserve.org/explorer

NB DOE. 2010. New Brunswick Ambient Air Quality Monitoring Results for the Year 2008. New Brunswick Department of Environment, State of the Environment Branch, Fredericton, NB.

NB DNR. 2009. New Brunswick Department of Natural Resources. Species at risk. http://www1.gnb.ca/0078/WildlifeStatus/search-e.asp

Neudorf, D.L., D.J. Ziolkowski Jr., V. Nolan Jr., and E.D. Ketterson. 2002. Testosterone manipulation of male attractiveness has no detectable effect on female home-range size and behaviour during the fertile period. Ethology 108:713-726.

Newman, M.C. and W.H. Clements 2008. *Ecotoxicology: A Comprehensive Treatment*. Taylor and Francis, Boca Raton, FL, 852 pp.

Nicholas T., Wolfe G., Soltysik S.S., Garcia J.L., Wilson W.J., Abraham P. (1983) Postnatal development of heart rate patterns elicited by an aversive CS and US in cats. Pavlov J. Biol. Sci. 18: 144-153.

NOAA. 1999. Sediment Quality Guidelines developed for the National Status and Trends Program.

NRC (National Research Council). 2005. Mineral Tolerance of Domestic Animals. Second Edition. National Academy of Sciences: Washington, D.C.

Nyholm, E.S. 1959. About the ermine and the weasel and their winter territory. Suomen Riista 13:106-116.

Ollson, C.A., Koch, I., Smith, P. Knopper, L.D., Hough, C., and Reimer, K.J. 2009. Addressing arsenic bioaccessibility in ecological risk assessment: A novel approach to avoid overestimating risk. Environmental Toxicology and Chemistry: 28(3), 68-675.

OMOE. 2008. Ontario's Ambient Air Quality Criteria (Sorted by Chemical name). Standards Development Branch. Ontario Ministry of the Environment. February, 2008. PIBS # 6570e.

OMOE (Ontario Ministry of the Environment). 2010. Air Quality in Ontario. 2008 Report. PIBS 7356e, Queen's Printer for Ontario. http://www.ene.gov.on.ca/publications/7356e.pdf

Pain, D.J. (1996), 'Lead in waterfowl', in W.M. Beyer, G.H. Heinz, and A.W. Redman-Norwood (eds.), *Environmental contaminants in wildlife: interpreting tissue concentrations* (Boca Raton, Florida, USA: Lewis Publishers), 251-64.

Pankakoski, E.I., Koivisto, H., Hyvärinen, J., Terhivuo, J. and Tähkä, K.M. 1994. Experimental accumulation of lead from soil through earthworms to common shrews. Chemosphere 29: 1639-1649.

Pilastro, A, Tallandini L & Turchetto M (1993). Effects of Chronic Dietary-Cadmium on Mfo Activity in Male and Female Starlings (*Sturnus vulgaris*). *Bollettino Di Zoologia* 60 (3): 311-315

R.A Currie Ltd. 2011. Belledune Stream Habitat Survey. Submitted to Conestoga-Rovers and Associates November 2011.

Roberts, R.D., Johnson, M.S., and Hutton M. 1978.Lead contamination of small mammals from abandoned metalliferous mines. Environ. Pollut.: 15, 61-69.

Roux, K. and Marra, Peter P. 2007. The presence and impact of environmental lead in passerine birds along an urban to rural land-use gradient. *Archives of Environmental Contamination and Toxicology*, 53: 261-268

Rising, J. D., and D. D. Beadle. 1996. A guide to the identification and natural history of the sparrows of the United States and Canada. Academic Press, Boston. 365 pp.

Rusch, D.H., S. DeStefano, M.C. Reynolds, and D. Lauten. 2000. Ruffed Grouse (*Bonasa umbellus*). *In* Poole, A. and F. Gill (Eds.), The Birds of North America, No. 515. The Birds of North America, Inc., Philadelphia, PA.

Sample, B.E., Hansen, J.A., Dailey, A. and Duncan, B. 2011. Assessment of risks to ground-feeding songbirds from lead in the Coeur d'Alene Basin, Idaho, USA. Integrated Environmental Assessment and Management 7(4):596-611.

Sample, B.E., J.J. Beauchamp, R.A. Efroymoson, and G.W. Suter, II. 1998. Development and Validation of Bioaccumulation Models for Small Mammals. Prepared for the U.S. Department of Energy, Office of Environmental Management. February 1998. ES/ER/TM-219.

Sample, B.E., M.S. Aplin, R.A. Efroymson, G.W. Suter, and C.J.E. Welsh. 1997. Methods and Tools for Estimation of the Exposure of Terrestrial Wildlife to Contaminants. Oak Ridge National Laboratory, Oak Ridge, TN. October, 1997.

Sample, B.E., Opresko, D.M., and Suter II, G.W. 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. Prepared for the U.S. Department of Energy. Lockheed Martin, Environmental Restoration Program, ES/ER/TM-86/R3.

Sample, B.E. and G.W. Suter II. 1994. Estimating Exposure of Terrestrial Wildlife to Contaminants. Oak Ridge National Laboratory, Environmental Sciences Division, Oak Ridge, TN.

Sánchez-Chardi, A., Marques, C.C., Nadal, J., and da Luz Mathias, M. 2007. Metal bioaccumulation in the greater white-toothed shrew, Crocidura, inhabiting an abandoned pyrite mine site. Chemosphere: 67, 121-130.

SARA (Sudbury Area Risk Assessment). 2008. Sudbury Soils Study - Volume III: Ecological Risk Assessment. Prepared by the SARA Group.

Saunders, J.R., Knopper, L.D., Koch, I. and Reimer, K.J. 2011. Inclusion of soil arsenic bioaccessibility in ecological risk assessment and comparison with biological effects. Science of the Total Environment. 412-413: 132-137.

Sawicka-Kapusta, K., Zakrzewska, M., and Zuber, A. 1994. effect of orally administered cadmium on postnatal development of laboratory mice. *Polish Ecological Studies.* 20(1-2): 33-42. Ref ID: 694. Cited In: U.S. EPA, 2005d.

Schoof R (2003) Guide for incorporating bioavailability adjustments into human health and ecological risk assessments at department of defense facilities Part 2: Technical background document for assessing metals bioavailability. Technical report, Naval Facilities Engineering Service Center, Port Hueneme, USA.

Schwarz, M.S. 2003. Deer mouse and meadow vole population and community dynamics in metal and arsenic contaminated areas at the Anaconda Smelter Site, Deer Lodge County, Montana. Environmental Toxicology [Thesis].

Shore, R. F., & Douben, P. E. (1994). The ecotoxicological significance of cadmium intake and residues in terrestrial small mammals. *Ecotoxicology and environmental safety*, *29*(1), 101-112.

Stahl, J. L., J. L. Greger, and M. E. Cook, 1990. Breeding-hen and progeny performance when hens are fed excessive dietary zinc. Poultry Sci. 69:259–263.

Stevenson, M. H., Gibson, S. W., and Jackson, N. 1987. Withdrawal of zinc oxide-containing diets from mature, female domestic fowl: effects on selected tissue mineral contents. *Br. Poult. Sci.* 28(3): 449-59.

Suter II, G. 2007. Ecological Risk Assessment. Second Edition. CRC Press.

Suter, G.W. II, R.A Efroymson, B.E. Sample, and D.S. Jones. 2000. Ecological Risk Assessment for Contaminated Sites. Lewis Publishers, CRC Press LLC.

Suter, G.W. 1999. A framework for assessment of ecological risks from multiple activities. Human and Ecological Risk Assessment 5(2):397-413.

Suter, G.W. 1990. Endpoints for regional ecological risk assessments. Environ Man 14(1):19-23. Cited In: CCME, 2006.

Suter, G.W. 1989. Ecological endpoints. Pages 2-1 in W. Warren-Hicks, B.R. Parkhurst, and S.S. Baker Jr. (eds.) Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference document. EPA 600/3-89/013. Corvallis Environmental Research Laboratory, Corvallis, OR. Cited In: Suter, 2007.

Talmage, S.S. and Walton, B.T. 1991. Small mammals as monitors of environmental contaminants. Rev Environ Contam Toxicol 119:47-145. Cited In: US Department of the Interior, 1998.

Tohyama, et al., 1987; Liu et al., 1998; Mitsumori et al., 1998; Noel et al., 2004). (Chmielnicka et al., 1989); cell necrosis and degenerative changes in proximal tubules (Itokawa et al., 1978; Aughey et al., 1984)

UNECE (United Nations Economic Commission for Europe). 1988. Cited In: WHO, 2000. http://www.euro.who.int/__data/assets/pdf_file/0016/123091/AQG2ndEd_10effso2.pdf

U.S. Army Centre for Health Promotion and Preventive Medicine, 2007. Wildlife Toxicity Assessment for Thallium. Final Report. http://chppm-www.apgea.army.mil/erawg/tox/files/Thallium(final).pdf.

U.S. Department of the Interior. 1998. National irrigation water quality program information report No. 3. Guidelines for interpretation of the biological effects of selected constituents in biota, water and sediment. Zinc. http://www.usbr.gov/niwqp/guidelines/pdf/Guidelines.pdf.

U.S. EPA. 1988. Recommendations and documentation of biological values used in risk assessment. PB88-179874.

U.S. EPA. 1993. Wildlife Exposure Factors Handbook. Volumes I and II. Office of Research and Development. ORD. EPA-600-R-93-187. December 1993.

U.S. EPA. 1998. Guidelines for Ecological Risk Assessment. EPA/630/R-95/002F. Risk Assessment Forum, U.S. Environmental Protection Agency, Washington, D.C.

U.S. EPA. 1999. Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities, Volume I Peer Review Draft. (US) United States Environmental Protection Agency Region 6. Multimedia Planning and Permitting Division. Center for Combustion Science and Engineering. U.S. EPA Office of Solid Waste.

U.S. EPA. 2001a. Final Ecological Risk Assessment – Coeur d'Alene Basin Remedial Investigation/Feasibility Study. United States Environmental Protection Agency, Region 10. Prepared by: CH2M Hill and URS Corp. May, 2001.

U.S. EPA. 2001b. Guidance for Characterizing Background Chemicals in Soil at Superfund Sites. External Review Draft. United States Environmental Protection Agency, Office of Emergency and Remedial Response. EPA 540-R-01-003. OSWER 9285.7-41. June, 2001.

U.S. EPA. 2002. Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites. United States Environmental Protection Agency, Office of Emergency and Remedial Response. EPA 540-R-01-003. OSWER 9285.7-41. September, 2002.

U.S. EPA. 2003a. Ecological Soil Screening Levels for Aluminum: Interim Final. OSWER Directive 9285.7-60. URL: http://www.epa.gov/ecotox/ecossl/pdf/eco-ssl_aluminum.pdf

U.S. EPA. 2003b. Ecological Soil Screening Levels for Iron: Interim Final. OSWER Directive 9285.7-69. URL: http://www.epa.gov/ecotox/ecossl/pdf/eco-ssl_iron.pdf

US EPA. 2003c. Generic Ecological Assessment Endpoints (GEAEs) for Ecological Risk Assessment. EPA/630/P-02/004F.

U.S. EPA. 2005a. Guidance for Developing Ecological Soil Screening Levels. OSWER Directive 9285.7-55. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. November 2003; Revised February 2005. http://www.epa.gov/ecotox/ecossl/pdf/ecossl_guidance_chapters.pdf

U.S. EPA. 2005b. Ecological Soil Screening Levels (Eco-SSL). Guidance Documents and SOPs. Ecological Soil Screening levels for Antimony. Interim Final. February 2005. http://www.epa.gov/ecotox/ecossl/pdf/eco-ssl_antimony.pdf

U.S. EPA. 2005c. Ecological Soil Screening Levels for Arsenic: Interim Final. OSWER Directive 9285.7-62. URL: http://www.epa.gov/ecotox/ecossl/pdf/eco-ssl_arsenic.pdf

U.S. EPA. 2005d. Ecological Soil Screening Levels for Cadmium. Interim Final. http://www.epa.gov/ecotox/ecossl/pdf/eco-ssl_cadmium.pdf

U.S. EPA. 2005e. Ecological Soil Screening Levels for Lead: Interim Final. http://www.epa.gov/ecotox/ecossl/pdf/eco-ssl_lead.pdf

U.S. EPA. 2005f. Species Sensitivity Galleries (http://www.epa.gov/caddis/ex_galleries_ssd.html)

U.S. EPA. 2007a. Framework for Metals Risk Assessment. Office of the Science Advisor, Risk Assessment Forum, U.S. Environmental Protection Agency. Washington, DC. EPA 120/R-07/001. March, 2007.

U.S. EPA. 2007b. Ecological Soil Screening Levels for Zinc. Interim Final. OSWER Directive 9285.7-73. http://www.epa.gov/ecotox/ecossl/pdf/eco-ssl_zinc.pdf

U.S. EPA. 2007c. Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs). Attachment 4-5. Eco-SSL Standard Operating Procedure (SOP) # 6: Derivation of Wildlife Toxicity Reference Value (TRV). Revised June 2007.

U.S. EPA. 2008. Integrated Science Assessment: Oxides of Nitrogen and Sulfur - Ecological Criteria December 2008. EPA/600/R-08/082F http://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=198843

U.S. EPA (2011) National Recommended Water Quality Criteria http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm#altable

U.S. EPA. Region 8. 2011. Toxicity Assessment information presented on-line. http://www.epa.gov/region8/r8risk/eco_toxicity.html. Accessed in 2011.

Vidal, D.E., and Bay, S.M. 2005. Comparative sediment quality guideline performance for predicting sediment toxicity in Southern California, USA. Environ Toxicol Chem 24(12): 3173-3182.

Watters, R.L., D.N. Edgington, T.E. Hakonson, W.C. Hanson, M.H. Smith, F.W. Whicker, and R.E. Wildung. 1980. Synthesis of the Research Literature. In: Transuranic Elements in the Environment. U.S. Department of Energy. Cited In: Sample et al., 1997.

Wentzel, K.F. 1983. IUFRO studies on maximal SO_2 emissions standards to protect forests. In: Ulrich, B. and Pankarth, J., ed. Effects of accumulation of air pollutants in forest ecosystems. Dordrecht, D. Reidel, 295-302. Cited In: WHO, 2000.

WHO. 2000. Air Quality Guideline – Second Edition. Chapter 10: Effects of sulfur dioxides on vegetation: critical levels. http://www.euro.who.int/document/aiq/10effso2.pdf

Will, M.E. and G.W. Suter II. 1995. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process. Prepared by the Environmental Restoration Risk Assessment Program for the U.S. Department of Energy. ES/ER/TM-126/R1.

APPENDIX A

PHASE I SOIL SAMPLING PROTOCOL

PHASE I SOIL SAMPLING PROTOCOL FOR OFF-SITE TERRESTRIAL AREAS ASSOCIATED WITH THE XSTRATA ZINC LEAD SMELTER IN BELLEDUNE, NEW BRUNSWICK

FINAL PROTOCOL

JULY 2009

Prepared For:
Rick Schwenger
Xstrata Zinc
Belledune Lead Smelter
Belledune NB

PHASE I SOIL SAMPLING PROTOCOL FOR OFF-SITE TERRESTRIAL AREAS ASSOCIATED WITH XSTRATA ZINC LEAD SMELTER IN BELLEDUNE, NEW BRUNSWICK

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PHASE I SOIL SAMPLING PROTOCOL FOR OFF-SITE TERRESTRIAL AREAS ASSOCIATED WITH XSTRATA ZINC LEAD SMELTER IN BELLEDUNE, NEW BRUNSWICK

1.0 INTRODUCTION

Xstrata Zinc (formerly Noranda) has operated a lead smelter in Belledune, New Brunswick since 1966 (then under the name Brunswick Mining and Smelting). The facility converts lead feed into a saleable product by sintering the feed to remove sulphur, smelting to transform the lead oxide in the sinter to unrefined lead metal, and refining to ultimately produce refined lead, and a series of by-products (copper matte, silver dore, lead-antimony bullion, *etc*.). In addition to the smelter, there are other industrial activities in the area, including the NB Power thermal generating facility, a battery recycling facility, a former fertilizer facility (Xstrata Zinc), a gypsum facility (Canadian Gypsum) and a sawmill. The Xstrata owned lands (including the smelter property and surrounding areas) are illustrated in Figure 1-1.

Recently, a detailed soil study was conducted to investigate the potential for human health effects associated with exposures to metals and metalloids in soil in residential areas near the facility (Shore Road Soil Study; Intrinsik Environmental Sciences Inc. *et al.*, 2008). Xstrata Zinc is now interested in determining whether emissions from the smelter have influenced terrestrial areas off-site which could be inhabited by vegetation, small and large mammals, and bird species. This study will provide current data on soil element concentrations in areas within a 7-km distance from the Xstrata Zinc Lead smelter site, and background or reference metals concentrations. These data will be used to determine:

- Whether any of the metals are elevated over background/reference concentrations;
- Whether areas that exceed reference areas have been influenced by external factors related or unrelated to smelter site activities;
- What event or factor can be confirmed as the source, with consideration of reference data;
- Whether any of the metals sourced to the site exceed environmental health guidelines; and,
- Whether further study with respect to ecological health is warranted concerning any such metals.

Data collected within this Phase I program will be limited to soil chemistry, since the study area is largely terrestrial. These data will be used to determine if any further study is necessary, based on whether or not measured metal levels exceed both background concentrations and ecologically based guidelines, and are related to past Xstrata activities. If further study is necessary in some areas (based on exceedance of both background concentrations and ecological health-based guidelines), a second protocol will be developed and submitted outlining the proposed approach for the elements and areas considered to be of interest. All elements and areas which are less than background levels, and less than ecological health-based guidelines will be excluded from further study.

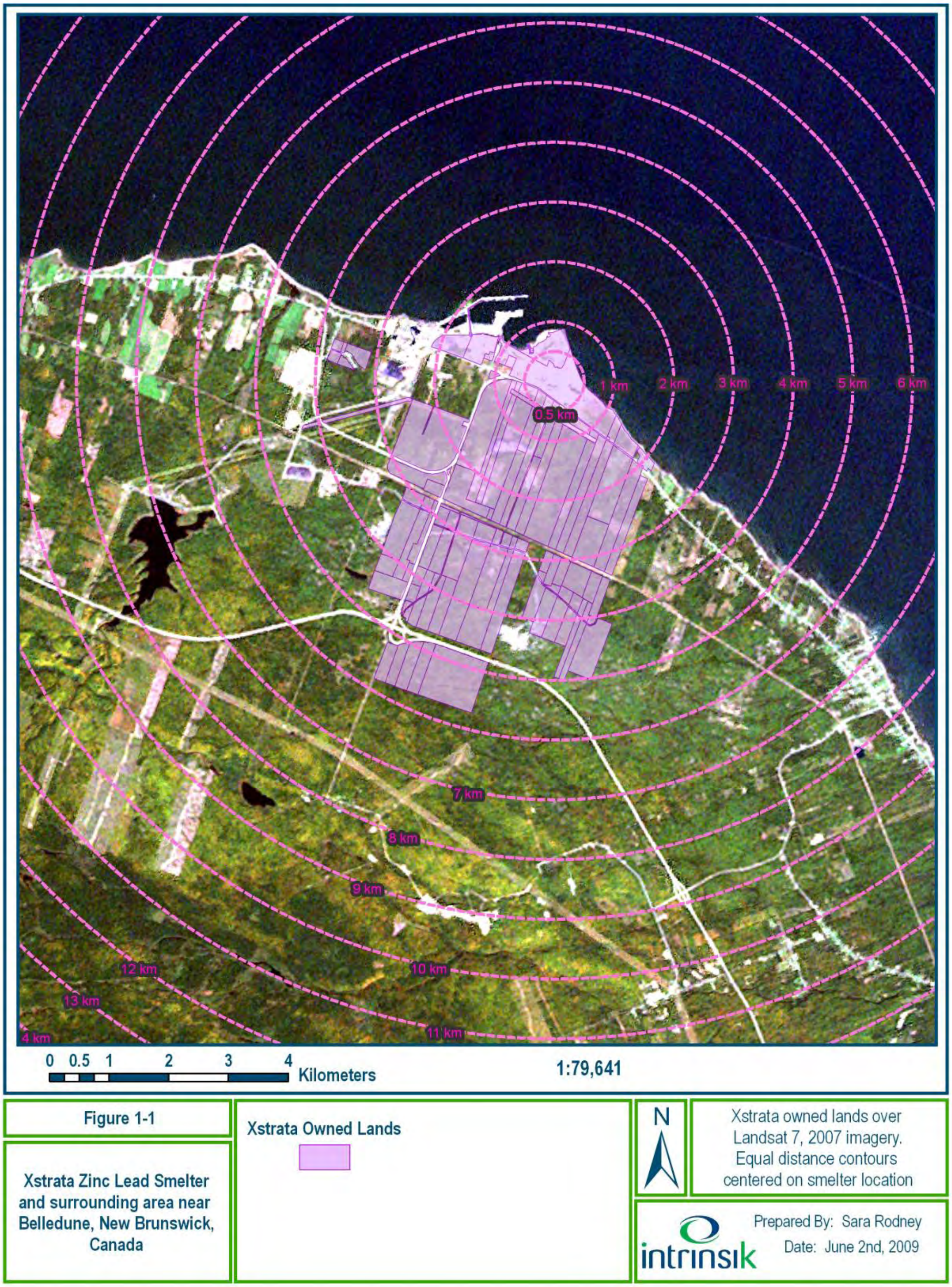

Figure 1-1 **Xstrata Zinc Lead Smelter and surrounding area near Belledune, New Brunswick, Canada**

2.0 STUDY OBJECTIVES AND SCOPE

2.1 Study Objectives

The objectives of the Phase I terrestrial soil study are as follows:

- Conduct a soil sampling program in ecologically relevant areas to determine the spatial extent and direction of potential sources of elevated metals/metalloids other than those related to natural geological formation.
- Areas previously sampled in the Shore Road Soil Study will not be re-sampled. These are largely residential lands, which represent limited ecological habitat, and these areas have been extensively characterized for several metals of interest already, which limits the necessity of having to re-sample.
- Soil sampling will be limited to Xstrata owned lands and crown lands, pending approval.
- Determine the background concentrations of elements in local soils. Naturally occurring concentrations of the elements of interest must be clearly defined, in order to understand whether or not measured concentrations of elements in the study area are elevated, as the northeastern region of New Brunswick has many naturally enriched areas.
- Determine from the collected data whether measured elements can be linked to a specific source (such as the smelter). This will be initially undertaken using specific elemental ratios, from a variety of available data sources.
- Identify the area potentially impacted by the Belledune smelter activities/events, and the specific Chemicals of Potential Concern (COPCs), if any, which merit further study. This identification will be based on comparisons of study area soil chemistry data to background soil chemistry data, and to appropriate ecological health-based soil quality guidelines, and will also involve investigating elemental ratios. All elements with soil concentrations greater than reference/background and greater than identified soil quality guidelines, and that are believed to be related to smelter activities, will be identified as COPCs.

The focus of the terrestrial Phase I program will be on soils. This will enable identification of the appropriate study boundary of the affected area (with respect to terrestrial ecological receptors), and will also help determine if any additional sampling or assessment is necessary.

2.2 Study Scope

The Phase I terrestrial soil sampling will include the following aspects:

- A detailed soil sampling program for metals and metalloids (ICP-MS metals) in addition to Total Organic Carbon (TOC) and pH on selected soil samples within the initial principle sampling area (identified in Section 3). Surface soil composite samples (0 to 5 cm) will be collected at all sampling locations.
- The depth of sampling (0 to 5 cm) was selected as this is an appropriate depth when investigating an atmospheric deposition source (such as smelter emissions). A depth of 0 to 5 cm is also ecologically relevant for soil invertebrates and early emerging vegetation. While deeper depths may be of greater relevance for some receptors, it is expected that the focus on the top 5 cm soil layer will provide a conservative estimate of potential exposures.
- Coring will be conducted on a subset of samples to confirm element distribution with depth throughout the study area (0 – 5 cm; 5 – 15 cm and 15-30 cm).

- Analytical soil chemistry data for available metals will be evaluated against CCME ecological health based Soil Quality Guidelines or appropriate ecological health soil quality benchmarks from other jurisdictions as necessary. The soil chemistry data will also be compared to reference area soil metals chemistry data.

Further details on the soil sampling protocol are provided in Appendix A.

3.0 SPATIAL EXTENT OF PHASE I SAMPLING AREA

In determining the Phase I Sampling Area, the aim is to be inclusive of all areas potentially affected by smelter emissions. The sampling program was designed in consideration of data gathered in previous studies of the area, including:

- Shore Road Soil Study (SRSS; Intrinsik Environmental Sciences et. al, 2008).
- Xstrata Zinc Environmental Monitoring Program (various years).
- Wind direction and frequency data (Goss Gilroy et al, 2005)

While these data do not provide comprehensive spatial coverage of all areas potentially influenced by smelter emissions, and are limited to select metals of interest, they suggest that lead and arsenic concentrations in soil are predominantly below Canadian Council of Ministers of the Environment (CCME) soil quality guidelines for the protection of environmental health beyond a distance of 2 to 4 km (depending on direction) from the smelter (CCME ecological health based guidelines are 300 mg Pb/kg soil and 17 mg As/kg soil), with the possible exception of areas with natural enrichment. Wind direction and frequency data indicated that wind predominantly blows from the west (22 – 25% of the time) and west north west (17% of the time), followed by winds from the east-south-east direction (approximately 10% of the time) (Goss Gilroy et al, 2005). Using data from the above mentioned studies as a guide, a sampling area of 7 km from the smelter site (called the Principal sampling area) was conservatively selected to investigate whether soils in ecological areas surrounding the smelter may be potentially influenced by historical releases. This Principal sampling area did not include areas previously sampled in the Shore Road Soil Study.

Sampling within the 7 km principle sampling area is limited by property ownership. Thus, sampling will be restricted to Xstrata and New Brunswick Department of Natural Resources owned lands to ensure efficient collection of data within the current field sampling season. Land ownership in the vicinity of the smelter is presented in Figure 3-1.

Within the principal sampling area, some specific locations will be omitted from soil sampling. For example, current industrial land use areas such as the two slag piles and the main industrial complex at the smelter site will be not be sampled in the Phase I program.

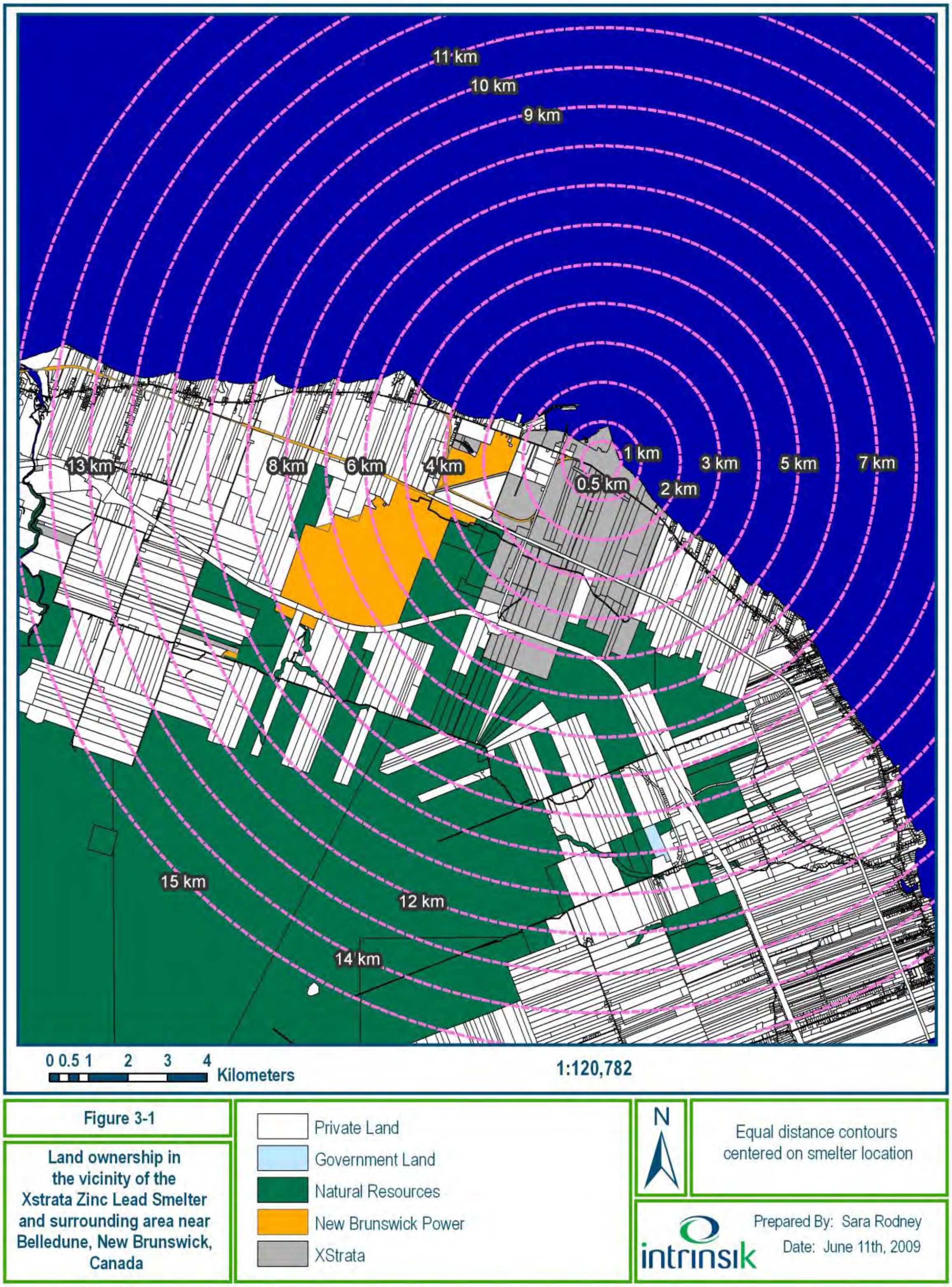

Figure 3-1 **Land ownership in the vicinity of the Xstrata Zinc Lead Smelter and surrounding area near Belledune, New Brunswick, Canada.**

4.0 PHASE I SAMPLING DESIGN

4.1 Soil – Potentially Affected Area

The grid sampling (also known as systematic or regular sampling) method was selected in the design of the soil sampling plan. Grid sampling ensures uniform coverage of the site, and is commonly used for estimating spatial patterns and searching for hot spots. It is the preferred sampling method for developing prediction surfaces using kriging. Grid sampling is also practical, and can be conveniently implemented in the field (U.S. EPA, 2000), which is favourable in a large study area. An equilateral triangle grid design was selected because it has been shown that this design tends to perform better than other grid patterns on scales of accuracy and efficiency (Yfantis *et al*., 1987). To make the sampling design probability-based, an arbitrary starting point was selected (U.S. EPA, 2000) by randomly off-setting the grid. The Repeating Shapes extension for ArcGIS was used to generate the sampling grid (Jenness, 2006).

Soil samples will be collected at the node of each grid intersection (or as close to this location as is feasible). A distance of 750 m between grid nodes was selected (see Figure 4-1). The grid was laid over the land within 7 km of the smelter site, excluding private lands and NB power lands (See Figure 3-1), and excluding Xstrata owned industrial lands that were previously assessed. The total number of proposed soil samples in the principal sampling area (excluding field duplicates) is 61 (See Figure 4-1).

Coring will be conducted at a subset of locations, as indicated in Figure 4-2. To ensure limited bias due to the possible overrepresentation of unaffected areas, the principle sampling area will be divided into a near-field (0.5 – 4 km zone) and far-field (4 – 7 km zone), with each of these zones containing 10 coring locations. Similarly, the reference area will contain 10 coring locations. The near- and far-field zones will be separately compared with reference area results.

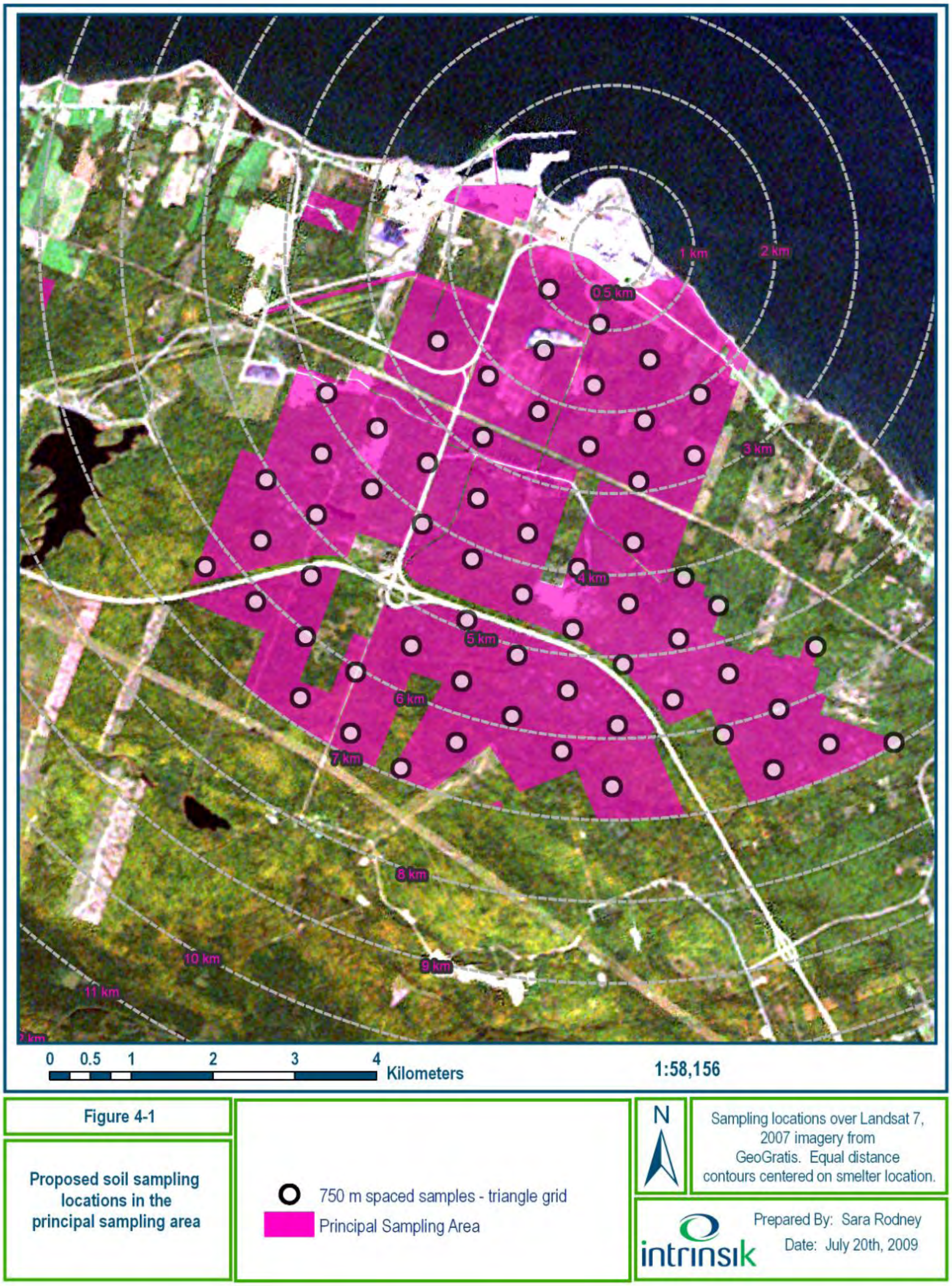

Figure 4-1 **Principal sampling area and proposed soil sampling locations in the area surrounding the Xstrata Zinc Lead Smelter near Belledune, New Brunswick.**

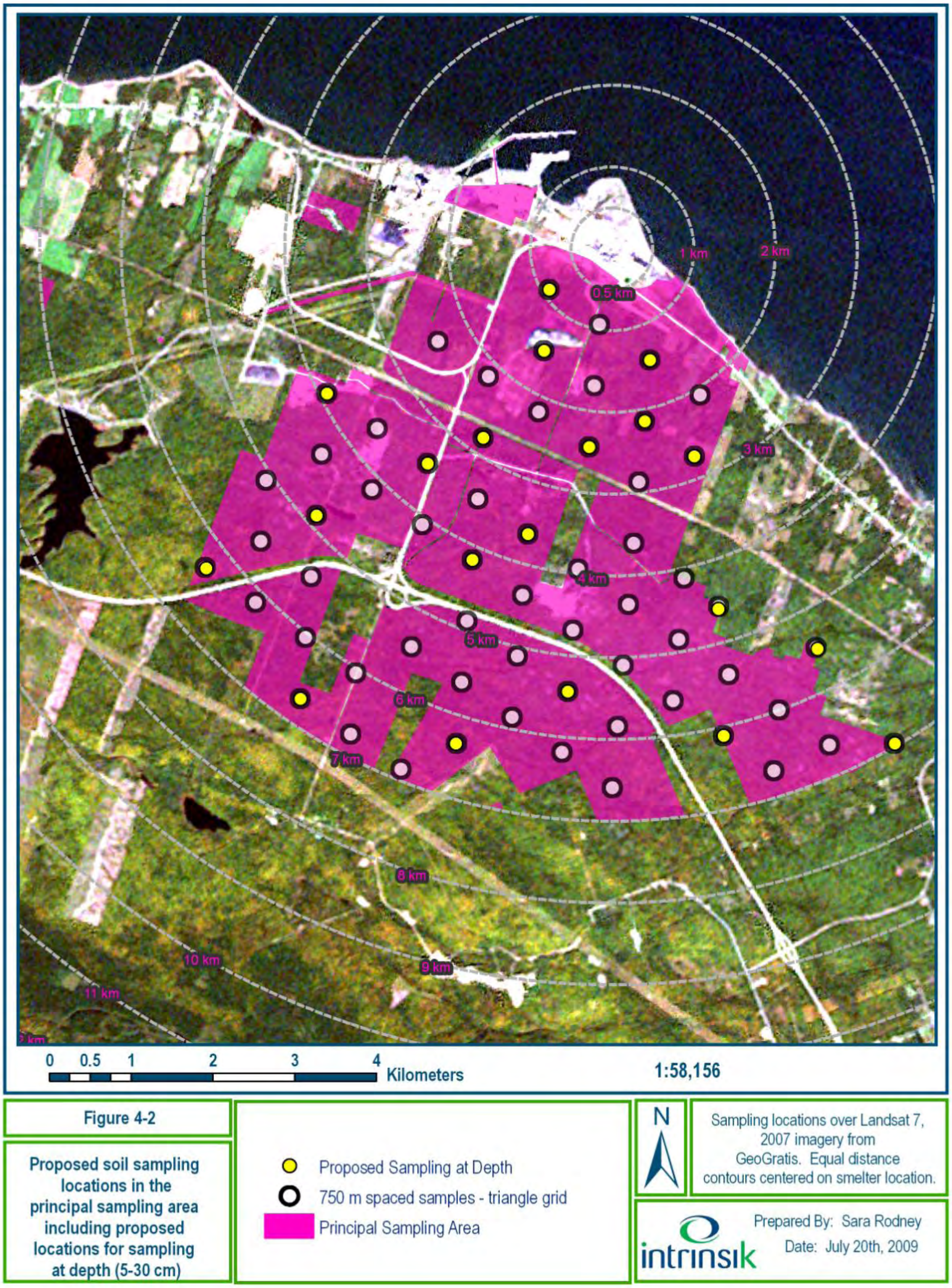

Figure 4-2 Principal sampling area and proposed soil sampling locations, and locations of sampling at depth (5-30 cm) in the area surrounding the Xstrata Zinc Lead Smelter near Belledune, New Brunswick.

4.2 Reference Area Sampling

Reference sites are often used to establish regional background or baseline concentrations. It is important that the selected reference sites not be differentially influenced by atmospheric deposition of metals. The selected reference sites should have similar characteristics to the area(s) sampled within the study area (*e.g.,* similar geology, vegetation cover, soil type, *etc.*) to minimize these variables as confounding factors (U.S. EPA, 1992). Also, to account for the variability that may arise among suitable reference locations, a number of reference sites may be selected and sampled.

The criteria for selecting proposed reference area(s) included: (1) the reference area must occur on crown land to facilitate efficient sampling, (2) the area must occur on land with characteristics similar to those of the principal sampling area, and (3) the reference area must be in a location that is unaffected by smelter emissions or other sources of COPCs. In order to meet these criteria, two spatial data layers were overlain: (1) crown lands of New Brunswick acquired through Service New Brunswick, and (2) Ecosite mapping for a 30 km radius from the smelter site acquired through New Brunswick Department of Natural Resources.

The Ecosite mapping contains data regarding the ecological land classification of New Brunswick. Seven New Brunswick Ecoregions delineate areas of different climate (precipitation and temperature), based principally on elevation above sea level and marine influences. Ecodistricts are nested subdivisions of Ecoregions based on geomorphologic and geological (lithologic) differences. The principal sampling area occurs in the Nicolas Denys ecodistrict in the Northern Uplands region of New Brunswick. The Nicolas Denys ecodistrict is a narrow, slightly sloping land that meets the coast of Chaleur Bay. It extends from the Dalhousie Peninsula southward to the Nepisiguit River mouth, at which point the river itself becomes the boundary. In the northern portion of the ecodistrict (where the principal sampling area is found), the bedrock is composed mainly of Silurian and Devonian mafic and felsic volcanic rocks accompanied by calcareous and noncalcareous sedimentary strata of both ages.

Ecosections are nested subdivisions of Ecoregions based on topographic and relief differences. Ecosites are nested subdivisions of Ecosections that capture individual landforms that in theory outline a single forest ecosystem type at the 1:50,000 mapping scale. Ecosites are generally uniform from the standpoint of moisture and nutrient regime, and of topoclimate. The principal sampling area intersects several Ecosites within Ecosection 2 of the Nicolas Denys Ecodistrict.

In order to ensure that the reference area was unaffected by smelter emissions, only areas beyond 20 km from the smelter site were considered. Only one area of sufficient size, that intersected both crown lands and the Nicolas Denys Ecodistrict, was located between 20 km and 30 km of the smelter site (See Figure 4-3). This area is approximately 1226 hectares in size, and is located approximately 21 km due west of the smelter site. Although it is located in Ecosection 1, like the principal study area, it intersects several Ecosites, making it quite representative of the Ecodistrict in general. Although topographic and relief differences are expected between the principal sampling area and the reference area, in general these areas are expected to have similar climate and geology, and because a wide range of Ecosites are present in both areas, variability in metals concentrations due to moisture, nutrient regime, and topoclimate is expected to be accounted for.

In a fashion consistent with the sampling design for the principal sampling area, an equilateral triangle grid was laid over the proposed reference area with 750 m grid spacing. The grid was off-set randomly by 44.7615 degrees. This sampling design resulted in 23 proposed reference area samples (excluding field duplicates; See Figure 4-3). The exact location of the reference samples can be confirmed following a site visit to ensure that sampling locations are appropriate and accessible. This sample size is expected to be large enough for comparison with results from the principal sampling area.

Within the reference sampling area, 10 representative locations (selected from the proposed reference sampling locations for even coverage across the reference area) were selected for coring at 5-30 cm depths (See Figure 4-4).

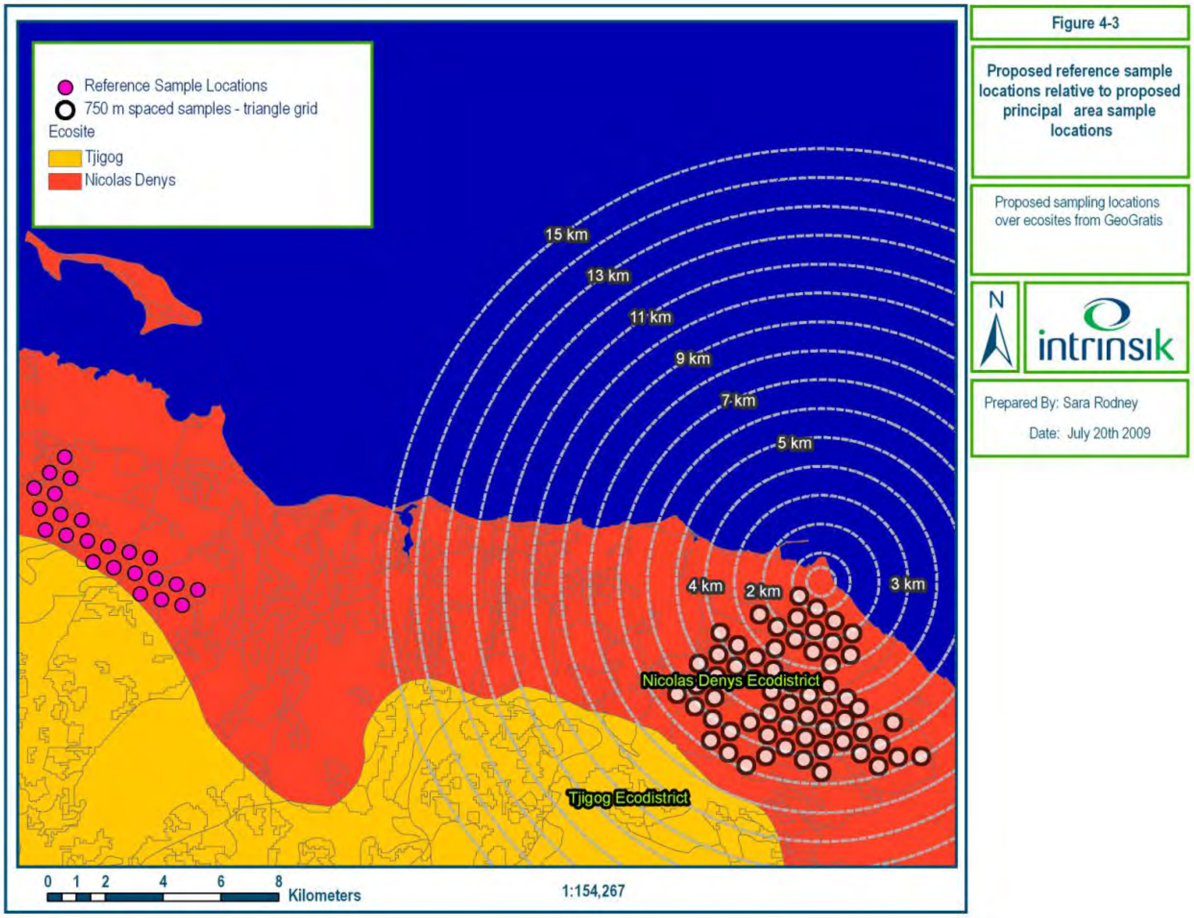

Figure 4-3 Proposed reference area sample locations relative to the principal sampling area and local Ecosites.

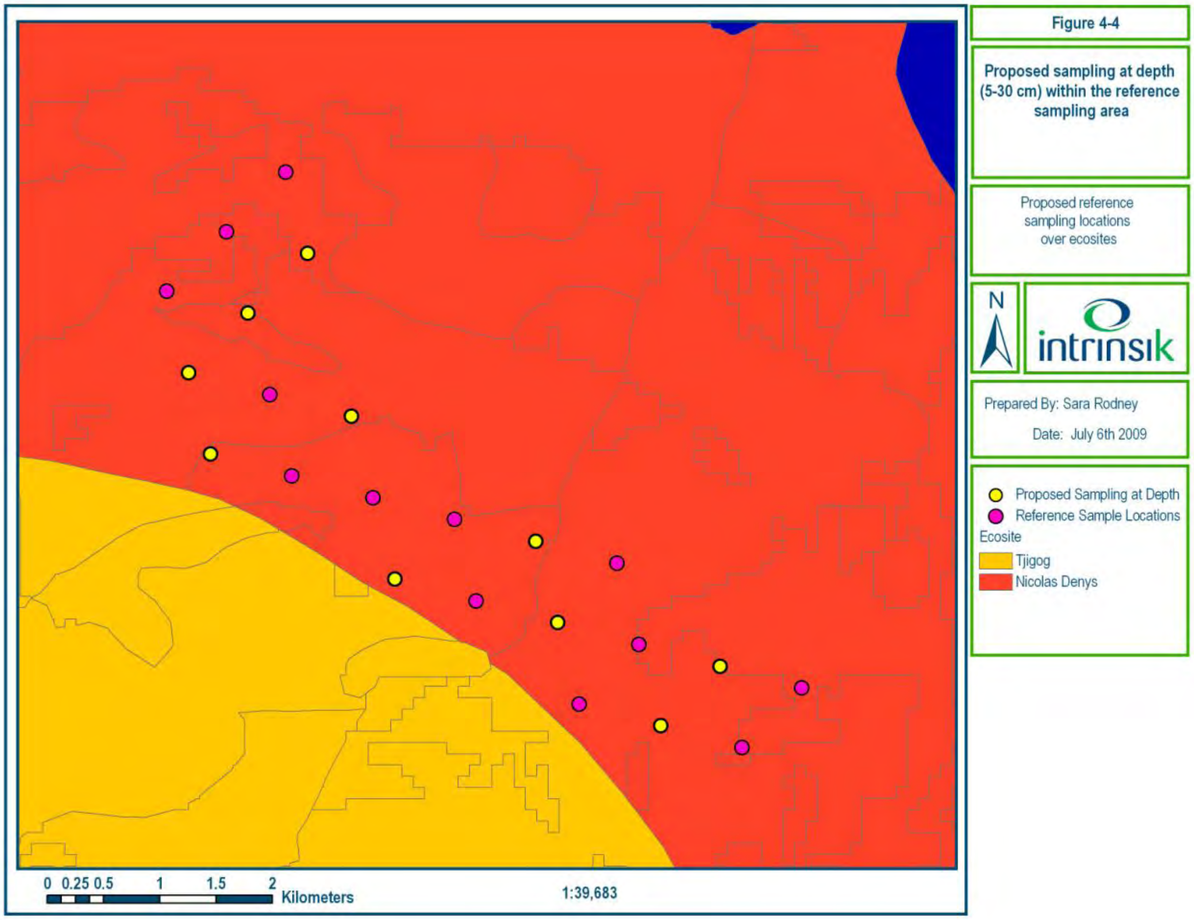

Figure 4-4 **Proposed reference area soil sample locations with locations of proposed sampling at depth (5-30 cm).**

5.0 SELECTION OF TARGET ANALYTES FOR PHASE I

Based on previous studies, the focus of the analytical program will be available metals in soils. Since there are only limited data available from previous studies collected in areas that would be considered relevant for ecological receptors, a broad list of metals will be analyzed for, as per the standard ICP- MS set of target analytes (see Table 5-1). Physical/chemical parameters such as pH and TOC can modify the fate and behaviour, and toxicity of metals in the environment. As such, these parameters will also be analyzed as part of the Phase I terrestrial sampling program in a select number of samples only (i.e, 10%, distributed throughout the study area and reference area).

Table 5-1 Proposed Analytes and Parameters for Phase I

Element (based on ICP-MS)	***Chemical Abstract Services Registration Number (CASRN)***
Aluminum (Al)	7429-90-5
Antimony (Sb)	7440-36-0
Arsenic (As)	7440-38-2
Barium (Ba)	7440-39-3
Beryllium (Be)	7440-41-7
Boron (B)	7440-42-8
Cadmium (Cd)	7440-43-9
Chromium (Cr)	7440-47-3
Cobalt (Co)	7440-48-4
Copper (Cu)	7440-50-8
Iron (Fe)	7439-89-6
Lead (Pb)	7439-92-1
Manganese (Mn)	7439-96-5
Molybdenum (Mo)	7439-98-7
Nickel (Ni)	7440-02-0
Selenium (Se)	7782-49-2
Silver (Ag)	7440-22-4
Strontium (Sr)	7440-23-5
Thallium (Tl)	7440-28-0
Uranium (U)	7440-61-1
Vanadium (V)	7440-62-2
Zinc (Zn)	7440-66-6
Total Organic Carbon (TOC)	
pH	

The data collected in Phase I will be used to identify COPCs and to determine if further sampling and/or assessment is necessary. This will be accomplished by comparing the Phase I analytical results to ecological health-based soil quality benchmarks and to reference area concentrations. Canadian Council of Ministers of the Environment (CCME) Soil Quality Guidelines will be used preferentially as benchmarks, where available. Table 5-2 provides the proposed environmental soil quality guideline values for the target analytes and parameters. If there is no CCME guideline available for a given analyte, an appropriate guideline will be selected from another jurisdiction, as necessary.

Chemicals will be identified as being “of potential ecological concern” if study area soil concentrations exceed **both** the reference area concentrations and the soil quality benchmarks, and if it is determined that the elevated soil concentrations are reasonably related to smelter activities or events. The choice of statistics to use in the COPC identification procedure will be determined following receipt and analysis of all Phase I data.

The overall hierarchy for selection of ecological health-based soil quality benchmarks is as follows: CCME (2007, Update 7.0) > U.S. EPA ecoSSLs > Alberta Environment (2009) > Efroymson *et al*., (1997a) > Efroymson *et al*., (1997b) > CCME (1991).

Table 5-2 Environmental Health-Based Guidelines for Screening Soils

Element	Ecological Health-Based Soil Quality Benchmark (mg/kg dw)
Aluminum	Soil pH<5.5[a]
Antimony	0.27[b]
Arsenic	17[c]
Barium	330[b]
Beryllium	21[b]
Boron	2[d]
Cadmium	10[c]
Chromium	52[c]
Cobalt	13[b]
Copper	63[c]
Iron	Soil pH<5 or >8[e]
Lead	300[c]
Manganese	220[b]
Molybdenum	4[d]
Nickel	50[c]
Selenium	1[c]
Silver	4.2[b]
Strontium	NGA
Thallium	1.4[c]
Uranium	500[c]
Vanadium	130[c]
Zinc	200[c]

Notes:

a. U.S. EPA (2003a) reports that total aluminum in soils is not a suitable or reliable predictor of toxicity and bioaccumulation and that aluminum be carried forward for further evaluation as a COPC at sites where the soil pH is <5.5.

b. U.S. EPA EcoSSLs (http://www.epa.gov/ecotox/ecossl/index.html); benchmark selected is the lower of the plant, soil or wildlife EcoSSL.

c. CCME (2007). Canadian Soil Quality Guidelines (Environmental Soil Quality Guidelines); Residential/Parkland land use category; benchmark selected is the lower of the soil contact guideline, soil and food ingestion guideline or the nutrient and energy cycling guideline). Update 7.0.

d. AENV (2009) Alberta Tier I Soil and Groundwater Remediation Guidelines; Residential/Parkland land use category (while AENV also has a natural areas land use designation, there is currently no procedure for deriving soil quality benchmarks for this land use – rather, for metals and metalloids, residential/parkland soil quality guidelines are the default values for the natural areas land use category; benchmark selected is the lower of the soil contact guideline, soil and food ingestion guideline or the nutrient and energy cycling guideline.

e. U.S. EPA (2003b) reports that identifying a specific benchmark for iron in soils is difficult since iron's bioavailability to plants and resulting toxicity are dependent upon site-specific soil conditions such as pH, Eh, moisture. In well-aerated soils between pH 5 and 8, the iron demand of plants is higher than the amount available. Thus, plants have evolved various mechanisms to enhance iron uptake. Under these soil conditions, iron is not expected to be toxic to plants. The U.S. EPA reported that the main concern from an ecological risk perspective is not the direct chemical toxicity of iron, but the effect of iron as a mediator in the geochemistry of other (potentially toxic) metals and the potential physical hazard of depositing flocculent.

6.0 SOIL SAMPLING PROCEDURE SUMMARIES

The soil sampling protocol for Phase I is described in detail in Appendix A. Generally, surface soil samples will be taken from a depth of 0 to 5 cm from each of the 84 sampling sites (i.e., 61 within the principle sampling area, and 23 within the reference area). Twenty stations within the principle sampling area will be cored (0 – 5; 5 – 15 and 15 – 30 cm) to examine soil chemistry with depth. In order to provide comparison data, 10 of the reference stations will be similarly cored. In total, this will add 60 samples to the total sample count (84 + 30 B layer + 30 C layer = 144 soil samples in total). A composite sampling approach is proposed where each composite sample will consist of five sub-samples collected at equal distances from each other over a "W" pattern in a 20 by 20 m area (the mid-sampling point of the W should be located in the centre of the 20 x 20 m block). The five sub-samples will be homogenized and one sample representing the composited sub-samples will be analyzed. Additional samples of the homogenized soil will be taken for QA/QC purposes. The soil samples will be digested using method U.S. EPA 3050b (available metals analysis) and analyzed using ICP-MS. A subset of surface soil samples (10%) will also be analyzed for pH and Total Organic Carbon (TOC).

7.0 REFERENCES

Alberta Environment. 2009. Alberta Tier 1 Soil and Groundwater Remediation Guidelines. Edmonton, Alberta. February 2009.

CCME. 2007. Update 7.0. Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

CCME. 1991. Interim Canadian Environmental Quality Criteria for Contaminated Sites. Prepared by the CCME Subcommittee on Environmental Quality Criteria for Contaminated Sites, National Contaminated Sites Remediation Program. Report # EPC-CS34.

Efroymson, R.A., M.E. Will, and G.W. Suter II, 1997a, Toxicological Benchmarks for Potential Contaminants of Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process. ES/ER/TM-126/R2, Oak Ridge National Laboratory, Oak Ridge, TN.

Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten, 1997b, Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision, ES/ER/TM-85/R3, Oak Ridge National Laboratory, Oak Ridge, TN.

Goss Gilroy Inc., Environmental & Occupational Health+Plus, and SENES Consultants Ltd. 2005. Belledune Area Health Study. Appendix AB – Air Quality Modeling. Prepared for Department of Health and Wellness, Government of New Brunswick. February 2005.

Intrinsik Environmental Sciences Inc., Conestoga Rover and Associates, Genivar, and GlobalTox International Consultants Inc. 2008. The Shore Road Soil Study, Belledune, New Brunswick. Prepared for Xstrata Zinc.

Jenness, J. 2006. Repeating shapes for ArcGIS. Jenness Enterprises. Available at: http://www.jennessent.com/arcgis/repeat_shapes.htm.

U.S. EPA (U.S. Environmental Protection Agency). 1992. Preparation of Soil Sampling Protocols: Sampling Techniques and Strategies. EPA/600/R-92/128. Office of Research and Development, U.S. Environmental Protection Agency, Washington DC 20460.

U.S. EPA (U.S. Environmental Protection Agency). 2000. Guidance for Choosing Sampling Design for Environmental Data Collection: Use in the Development of a Quality Assurance Project Plan. EPA QA/G-5S. Quality Staff, Office of Environmental Information, U.S. Environmental Protection Agency, Washington DC 20460. (Peer Review Draft)

U.S. EPA. 2003a. Ecological Screening Level for Aluminum: Interim Final. OSWER Directive 9285.7-60. URL: http://www.epa.gov/ecotox/ecossl/pdf/eco-ssl_aluminum.pdf

U.S. EPA. 2003b. Ecological Screening Level for Iron: Interim Final. OSWER Directive 9285.7-69. URL: http://www.epa.gov/ecotox/ecossl/pdf/eco-ssl_iron.pdf

Yfantis, A. A., G. T. Flatman, and J.V. Behar. 1987. Efficiency of kriging estimation for square, triangular, and hexagonal grids. Mathematical Geology 19: 183-205.

APPENDIX A

SOIL SAMPLING PROTOCOL – PHASE I

APPENDIX A: SOIL SAMPLING PROTOCOL – PHASE I

A-1.0 INTRODUCTION

The following protocol is based largely upon sampling and analytical procedures outlined by the Ontario Ministry of the Environment (OMEE) in their publication "Field Investigation Manual, Part 1, General Methodology" (OMEE, 1996). These methods and procedures are also based on, and consistent with, soil sampling guidance developed by CCME (1996) and US EPA (1996). In addition, guidance from other ecological field programs (such as that developed for Teck Cominco, Trail Operations), was also considered (Cantox Environmental, 2001, in conjunction with Larkspur Biological Consultants, Golder Inc, Parametrix and the Geological Survey of Canada). This same protocol has been used on other soil studies conducted for Xstrata.

A-2.0 SOIL SAMPLING PROTOCOL

A-2.1 Initial Considerations

Prior to the initiation of sampling at any location, the following information will need to be obtained and considered.

- Before sampling at a specified location, the field sampling team will identify on-site exclusion areas where sampling should not be conducted. These include areas such as: outcroppings, roadways, bridges, railway lines, or other physical structures that may interfere with the sample acquisition, sample results, or the health and safety of the field crew. If sampling cannot be conducted at a specific location an entry field log book indicating what the issue was and an appropriate adjustment should be made resulting in a sample taken from a location in close proximity to the original.
- A setback distance of 7 m from any road, rail line, ditch, utility pole, or other structure should be used to guide sample locations. Any sampling locations within 7 m of any of these items should be re-located by the field crew at their discretion, so as to respect the set back distance outlined.
- The sampler will note the characteristics of the area around the sample site, as follows:
  - Describe main vegetation characteristics (general vegetation species present).
  - Describe habitat features for the sample area.
  - Describe soil substrate from which the sample is being taken (presence of moss/significant leaf litter, *etc*.).
  - Measure the depth of the humic layer at the sampling locations (5 measurements; one at each composite sampling location).
  - In addition, a handheld GPS unit will be used to confirm the sample coordinates, and in the case where a sampling location must be moved for some reason, new sampling coordinates will be recorded.
- All sample locations should have corresponding GPS coordinates and a site description/photo to facilitate precise identification.
- Where possible, sampling should be focused on mineral soils, as opposed to leaf litter at this time. If the sampling location is covered by vegetation, the grass or vegetation layer should be peeled back to expose the underlying soil to obtain the necessary samples. Observations related to bare soil/grass/vegetation coverage for each sampling location should be described in the sampling log book.
- Very rocky soil or gravel will not be sampled.

A-3.2 Sampling Protocol

Composite surface soil samples (0 to 5 cm) will be collected and analyzed as indicated in Table A-1. Composite soil samples are used to minimize variability at any one sampling location and also reduce sampling costs (U.S. EPA, 1992). The locations of the required composite surface soil samples are identified in Figure 4-3 of the study design. Precise initial locations are provided using spatial coordinates in Table A-1 (principle study area) and A-2 (reference area). In addition to the composite soil samples within the principle study area, samples are also proposed in one reference area. It is important that the reference area not be influenced by deposition of metals in any significant way (*e.g.,* the reference site should be distant to the smelter and not influenced by any other direct source of potential metal contamination). The reference site should also have similar characteristics to the soil sample areas (*e.g.,* similar geology, vegetation cover, depth to groundwater, soil types *etc.*) to minimize these variables as confounding factors (U.S. EPA, 1992). A reference location approximately 1226 hectares in size and located approximately 21 km due west of the smelter site was selected (See Section 4.3). The reference location and the sampling locations within reference areas will be confirmed by a site visit, to ensure that sampling locations are accessible and appropriate.

In addition, 10% of surface soil samples should be selected by the sampling crew for pH and Total organic carbon analysis (TOC). Three (3) surface soils in the reference area should be analyzed for pH and TOC (these are pre-selected in Table A-2); and an additional 7 surface soil samples in the principle study area should be analyzed for pH and TOC (total of 10 samples).

Table A-1 Phase I Soil Sampling Locations in UTM NAD 83 Zone 20 Eastings and Northings

Area	Sample ID	Easting	Northing	Sample at Depth (5-30 cm)
Principal Sampling Area	S1	2544924	7651979	Yes
Principal Sampling Area	S2	2545538	7651549	
Principal Sampling Area	S3	2545604	7652296	
Principal Sampling Area	S4	2545669	7653043	
Principal Sampling Area	S5	2546087	7650371	Yes
Principal Sampling Area	S6	2546153	7651118	
Principal Sampling Area	S7	2546218	7651866	
Principal Sampling Area	S8	2546283	7652613	Yes
Principal Sampling Area	S9	2546349	7653360	
Principal Sampling Area	S10	2546414	7654107	Yes
Principal Sampling Area	S11	2546702	7649941	
Principal Sampling Area	S12	2546767	7650688	
Principal Sampling Area	S13	2546963	7652930	
Principal Sampling Area	S14	2547028	7653677	
Principal Sampling Area	S15	2547316	7649511	
Principal Sampling Area	S16	2547447	7651005	
Principal Sampling Area	S17	2547577	7652499	
Principal Sampling Area	S18	2547643	7653247	Yes
Principal Sampling Area	S19	2547774	7654741	
Principal Sampling Area	S20	2547996	7649828	Yes
Principal Sampling Area	S21	2548061	7650575	
Principal Sampling Area	S22	2548126	7651322	
Principal Sampling Area	S23	2548192	7652069	Yes

Table A-1 Phase I Soil Sampling Locations in UTM NAD 83 Zone 20 Eastings and Northings				
Area	Sample ID	Easting	Northing	Sample at Depth (5-30 cm)
Principal Sampling Area	S24	2548257	7652816	
Principal Sampling Area	S25	2548323	7653564	Yes
Principal Sampling Area	S26	2548388	7654311	
Principal Sampling Area	S27	2548675	7650145	
Principal Sampling Area	S28	2548741	7650892	
Principal Sampling Area	S29	2548806	7651639	
Principal Sampling Area	S30	2548872	7652386	Yes
Principal Sampling Area	S31	2549002	7653881	
Principal Sampling Area	S32	2549068	7654628	Yes
Principal Sampling Area	S33	2549133	7655375	Yes
Principal Sampling Area	S34	2549290	7649715	
Principal Sampling Area	S35	2549355	7650462	Yes
Principal Sampling Area	S36	2549421	7651209	
Principal Sampling Area	S37	2549486	7651956	
Principal Sampling Area	S38	2549617	7653450	Yes
Principal Sampling Area	S39	2549682	7654198	
Principal Sampling Area	S40	2549747	7654945	
Principal Sampling Area	S41	2549904	7649284	
Principal Sampling Area	S42	2549970	7650032	
Principal Sampling Area	S43	2550035	7650779	
Principal Sampling Area	S44	2550100	7651526	
Principal Sampling Area	S45	2550166	7652273	
Principal Sampling Area	S46	2550231	7653020	
Principal Sampling Area	S47	2550296	7653767	Yes
Principal Sampling Area	S48	2550362	7654514	Yes
Principal Sampling Area	S49	2550649	7650349	
Principal Sampling Area	S50	2550715	7651096	
Principal Sampling Area	S51	2550780	7651843	
Principal Sampling Area	S52	2550911	7653337	Yes
Principal Sampling Area	S53	2550976	7654084	
Principal Sampling Area	S54	2551203	7651500	Yes
Principal Sampling Area	S55	2551264	7649918	Yes
Principal Sampling Area	S56	2551329	7650666	
Principal Sampling Area	S57	2551878	7649488	
Principal Sampling Area	S58	2551943	7650235	
Principal Sampling Area	S59	2552397	7650999	Yes
Principal Sampling Area	S60	2552558	7649805	
Principal Sampling Area	S61	2553352	7649827	Yes

Table A-2 Phase I Reference Soil Sampling Locations in UTM NAD 83 Zone 20 Eastings and Northings

Area	Sample	Easting	Northing	TOC and pH	Sample at Depth (5-30 cm)
Reference	R1	2526358	7655455		
Reference	R2	2527083	7655261		Yes
Reference	R3	2527807	7655067		
Reference	R4	2524715	7656568		Yes
Reference	R5	2525440	7656374		
Reference	R6	2526164	7656180		Yes
Reference	R7	2526888	7655986		
Reference	R8	2527613	7655792	Yes	Yes
Reference	R9	2528337	7655598		
Reference	R10	2523072	7657681		Yes
Reference	R11	2523797	7657487		
Reference	R12	2524521	7657293		
Reference	R13	2525245	7657098	Yes	
Reference	R14	2525970	7656904		Yes
Reference	R15	2526694	7656710		
Reference	R16	2522878	7658405		Yes
Reference	R17	2523602	7658211		
Reference	R18	2524327	7658017		Yes
Reference	R19	2522684	7659130		
Reference	R20	2523408	7658936	Yes	Yes
Reference	R21	2523214	7659660		
Reference	R22	2523939	7659466		Yes
Reference	R23	2523745	7660190		

Collection of Composite Surface Soil Samples

Each composite surface soil sample will consist of five sub-samples collected at equal distances from each other over a “W” pattern. The centre of the W will be located in a 20 by 20 m sampling square, from which the remaining subsamples will be taken. Each sub-sample will be placed into a stainless steel bowl and mixed/composited to yield one composite surface soil sample. To prevent any cross-contamination of composite soil samples, all soil sampling equipment and mixing containers will be thoroughly cleaned between the collection of composite soil samples. The cleaning will involve washing with a detergent solution, followed by several rinses with distilled water and then air-drying, prior to the collection of the next composite soil sample. During sample collection and the cleaning procedure, all sampling technicians will wear disposable nitrile gloves. The field sampling team will also adhere to any additional cleaning protocols recommended by the manufacturer of the sampling equipment used. All cleaning practices or deviations from these practices should be carefully noted.

All sub-samples used to prepare the composite samples will be collected from a depth of 0 to 5 cm from ground surface. Each sub-sample will consist of at least 16 g of soil; the composite soil sample will therefore comprise at least 150 g. It is important that all sub-samples within the composite be of similar mass. This sample volume will be more than adequate for the analytical procedures to be conducted, and will also allow for later analyses (if deemed necessary) on the archived portion of the composite sample. Each sub-sample will be collected using a hand trowel or an acceptable field soil sampler recommended by agencies such as the CCME, the OMOE, or the U.S. EPA (*e.g.,* an Oakfield soil sampler, Star Quality sampler, or equivalent).

Each composite surface soil sample, once mixed in the stainless steel bowl, will be placed into a clearly-labelled sample container (*i.e.,* a large Zip-Lock® freezer bag labelled with the composite sample ID (*i.e.,* grid identifier – location identifier – composite soil sample number), and the date on which the composite soil sample was collected. As mentioned, sufficient soil (*i.e.,* at least 150 g) will be collected for the initial analytical work and any follow-up work, at a later date, on the remaining archived portion. All vegetation, moss, sticks, pebbles, and rocks will be removed from the composite soil samples prior to placement into sample containers. Samples will be sieved in the laboratory facility, as per standard methods for soil analysis (*e.g.,* 2 mm sieve as per reference method U.S. EPA 3050B).

A selected number of the surface soil samples taken will be cored, whereby the soil profiles at 0 to 5 cm; 5 to 15 cm and 15 to 30 cm will be analyzed separately to determine element distribution with depth. To collect these coring profiles, a standard core sampling unit will be used. Each sub-sample within the “W” composite sampling station will be split into the 3 depth profiles and placed into three clearly labelled sampling containers (0 to 5 cm; 5 to 15 cm; 15 to 30 cm), as outlined above. The sampling team will select the coring sampling stations for the reference area in the field (10 stations will be cored), whereas coring in the principle sampling area is pre-selected (20 stations; see Figure 4-2). Areas where coring is not possible (*i.e.,* bedrock outcroppings) or where an artificial substrate (*e.g.,* fill from another location) exists will be avoided.

All samples will be shipped to the selected, accredited analytical laboratory facility. Shipments will be accompanied by a completed and signed Chain of Custody form provided by the laboratory.

A-3.3 Field Log Book

A detailed log will be kept by the field sampling team. This log will describe conditions encountered at each location from which composite soil samples are collected. Included in this log will be descriptions of the sampling location, including:

- Sampling sub-areas;
- Locations of composite soil sample and sub-samples;
- Nearby landforms and habitat description (dominant vegetation; topographical features/sheltering effects (under specific vegetation types; open clear cut areas; nearby roads, *etc.*);
- Exact GPS coordinates of the sampling location (with a maximum of 30 m accuracy);
- Descriptions of any problems encountered, especially those that may necessitate a change to the sampling program at that location;
- Weather conditions at the time of sampling;
- Date and time of sampling;
- Presence/absence of vegetation cover at the sampling location and specific vegetation/grass cover at the sample location;
- Staining and/or odours;
- Depth of humic/leaf litter layer at each sampling location;
- Approximate depth range of all sub-samples collected;
- Visual appearance and texture of soil; and,
- List any wildlife signs noted.

Sampling locations must be marked with flags. In addition, digital photos of each sampling location will be taken, and should include any features of the location that could influence soil chemistry. Such features will also be described briefly in the log.

A-3.4 Analytical Chemistry and Selection of a Laboratory

All composite soil samples from all sampling locations will be submitted to a selected accredited laboratory for metals/metalloids analysis, and other parameters as deemed necessary (pH; organic carbon; *etc.*) The soil should be acid-digested based on U.S. EPA method 3050B, and analyzed using ICP-MS based on U.S. EPA method 6020A or equivalent. For the Phase I sampling plan, the objective is to identify elements of potential concern. Given the limited historical data available, analysis for available metals using ICP-MS is appropriate. The analytical laboratory may select an alternate method if data quality objectives cannot be met with ICP-MS.

A second lab will also be used, to provide a second level of Quality Assurance. Ten percent of samples will be sent to the second laboratory facility (10 samples in total).

The laboratory selected to conduct the soil analyses will be verified as accredited by the Standards Council of Canada (SCC) and the Canadian Association for Environmental Analytical Laboratories (CAEAL). These accreditations will ensure that the minimum ISO/IEC Guide 17025:2001 accreditation standard is being complied with. Moreover, the selected laboratory will be required to have Standard Operating Procedures (SOPs) for quality assurance and quality control (QA/QC), including procedures for: duplicate samples, internal blanks, spiked replicates, reagent/instrument blanks, preparation control samples, certified reference material (CRM) analysis and instrument control samples.

A-3.5 QA/QC Program

The QA/QC program will be finalized prior to the initiation of the soil sampling and analysis program and in consultation with the field sampling team. It will comprise the following elements, at a minimum.

Field and Laboratory Duplicate Samples

Field duplicate composite soil samples will be collected at a number of sampling locations, selected at random. The study team will identify the specific locations. The total number of field duplicates collected will comprise 10% of the total number of composite surface soil samples. All field duplicate samples will be collected, processed, shipped, and analyzed in exactly the same manner as the other composite soil samples.

In addition, and as part of standard laboratory QA/QC, a selected number of composite soil samples will be analyzed as laboratory duplicates. It is anticipated that laboratory duplicates will be analyzed for at least 10% of the composite soil samples submitted for analysis.

As part of the overall QA program, 10% of the surface soil samples collected will be split (after ensuring complete homogenization, drying and sieving) and submitted to another accredited laboratory for confirmatory analyses (*i.e.,* inter-laboratory comparison of digest and analysis). This allows the reliability of the data from the primary laboratory to be evaluated.

Data Quality Objectives (DQOs)

The main purpose of DQOs is to establish acceptability criteria for the analytical data, and to ensure that the data obtained are reasonable and of appropriate quality.

The DQOs for the Phase I study will include (but are not limited to) the following elements:

- Sampling and analytical data collection techniques will be reviewed to ensure that standard, widely-accepted procedures (*e.g.,* use of standardized, validated, published techniques; newly-provided clean sampling containers, chain of custody forms; duplicate analyses on a randomly select number of samples) are used when collecting samples.
- Samples will be analyzed by a nationally-accredited laboratory that employs standardized, validated, and widely-accepted procedures.
- All test reports with final analytical data will be reviewed to ensure that analyses met external (*i.e.,* quality assurance) and internal laboratory (*i.e.,* quality control) standards of acceptability.
- Field logs will be reviewed to determine whether there were any circumstances of concern with regard to the sampling effort.
- If analyte values are above the maximum detection limit of the equipment or method, an appropriate series of dilutions should be created to better quantify the analyte value in the sample. The object is to eliminate greater than (>) flags in the analytical data.
- The percent (%) recoveries provided by the analytical facility for laboratory-spiked samples will be reviewed to ensure that the MDL achieved by the laboratory was appropriate. For samples where the percent recovery falls outside an acceptable range (*e.g.,* 85 to 115%), dialogue with the laboratory will help to determine the possible cause

of poor recovery (*e.g.,* matrix interference), prior to deciding whether to reject the affected sample data.

- A review of laboratory duplicate data will be undertaken to ensure that analyses were within acceptable ranges (*i.e.,* samples will be rejected if the duplicates yield relative percent differences (RPD) of more than 25%).
- MDLs will be reviewed to ensure that the laboratory-achieved limits are less than applicable environmental quality criteria (*e.g.,* environmental quality guidelines).
- Inter-laboratory data will be reviewed and analyzed to determine RPDs between laboratories; while a specific RPD range is not recommended to “reject” data from the primary laboratory, any RPDs of more than 30% will require further investigation to resolve any potential reasons for these differences.

A-4.0 REFERENCES

Cantox Environmental. 2001. Sampling Plans in Support of the Ecological Risk Assessment (ERA) for Cominco Operations at Trail, BC. Draft for Review. Prepared for Cominco Ltd., Trail, BC. June 2001.

CCME (Canadian Council of Ministers of the Environment). 1996. A Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines. March 1996. The National Contaminated Sites Remediation Program. CCME-EPC-101E.

OMEE (Ontario Ministry of the Environment and Energy). 1996. Guidance on sampling and analytical methods for use at contaminated sites in Ontario (Version 1.1). Standards Development Branch. ISBN-0-7778-4056-1.

US EPA. 1992. Preparation of Soil Sampling Protocols: Sampling Techniques and Strategies. EPA/600/R-92/128. Office of Research and Development, U.S. Environmental Protection Agency, Washington DC 20460.

US EPA (United States Environmental Protection Agency). 1996. Method 1638: Determination of trace elements in ambient waters by inductively coupled plasma – mass spectrometry. Office of Water, Engineering and Analysis Division, Washington, D.C.

APPENDIX B

TECHNICAL MEMORANDUM ON SOIL SAMPLING SITES FOREST CHARACTERISTICS

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TECHNICAL MEMORANDUM

TO: **Lisa Marshall, Environmental Scientist, Intrinsik Environmental**

FROM: **Jennifer Noel, Botanist, LGL Limited**

DATE: **April 21 2010**

RE: **Soil Sampling Analysis**

Introduction

Soil Sampling Sites Forest Characteristics

Sites	Forest Composition	Dev Stage	Forest Type	% Canopy Closure
1	n/a	n/a	n/a	None
2	Softwoods (>50% Balsam Fir)	immature	Coniferous	50-70
3	Hardwoods,>50% Poplar	mature	Deciduous	70-90
4	Hardwoods,>50% Poplar	mature	Deciduous	50-70
5	Hardwoods, Red Maple, Cedar, Pines, Balsam Fir, Spruces	mature	Mixed	50-70
6	Softwoods (>=40% Spruces and <70% Black Spruce and no Balsam Fir)	immature	Coniferous	50-70
7	Hardwoods,>50% Poplar	mature	Deciduous	50-70
8	Poplar, Birch, Red Maple, Cedar, Pines, Spruce, Balsam Fir	mature	Mixed	50-70
9	Poplar, Birch, Red Maple, Cedar, Pines, Spruce, Balsam Fir	immature	Mixed	50-70
10	Poplar, Birch, Red Maple, Cedar, Pines, Spruce, Balsam Fir	immature	Mixed	50-70

Sites	Forest Composition	Dev Stage	Forest Type	% Canopy Closure
11	Hardwoods and Cedar, Pines, Balsam Fir, Spruces	mature	Mixed	50-70
12	Balsam Fir, Intolerant Hardwoods	immature	Mixed	50-70
13	Softwoods (>=40% Spruces and <70% Black Spruce and no Balsam Fir)	immature	Coniferous	50-70
14	Softwoods, Spruces and Shade Tolerant Hardwoods	immature	Mixed	50-70
15	Tolerant (Red Maple) >= Intolerant Hardwoods	n/a	Deciduous	50-70
16	Softwoods (>50% Balsam Fir)	mature	Coniferous	50-70
17	Hardwoods,>50% Poplar	mature	Deciduous	50-70
18	Poplar, Birch, Red Maple, Cedar, Pines, Balsam Fir	mature	Mixed	50-70
19	Softwoods (>=70% Spruces and <70% Black Spruce)	n/a	Coniferous	70-90
20	Softwoods (>50% Balsam Fir)	immature	Coniferous	50-70
21	Softwoods (>50% Balsam Fir)	immature	Coniferous	70-90
22	Hardwoods, >40% Black Spruce	immature	Mixed	50-70
23	Shade Intolerant, Red Maple >=tolerant	mature	Deciduous	70-90
24	Shade Intolerant, Red Maple < tolerant	immature	Deciduous	50-70
25	Poplar, Birch, Red Maple, Cedar, Pines, Balsam Fir	mature	Mixed	50-70
26	Softwoods, Spruces and Shade Tolerant Hardwoods	Regenerating	Mixed	30-50
27	Softwoods, >=70% Eastern Cedar	immature	Coniferous	70-90
28	Poplar, Birch, Red Maple, Cedar, Pines, Spruce, Balsam Fir	mature	Mixed	50-70
29	Balsam Fir, Intolerant Hardwoods	immature	Coniferous	50-70
30	Hardwoods, Red Maple, Cedar, Pines, Balsam Fir, Spruces	immature	Mixed	70-90
31	Softwood mix	young	Coniferous	70-90
32	Balsam Fir, white Spruce	young	Coniferous	50-70
33	n/a	n/a	n/a	None
34	Poplar, Birch, Red Maple, Cedar, Pines, Spruce, Balsam Fir	mature	Mixed	50-70

Sites	Forest Composition	Dev Stage	Forest Type	% Canopy Closure
35	Poplar, Birch, Red Maple, Cedar, Pines, Spruce, Balsam Fir	immature	Mixed	50-70
36	Hardwoods,>50% Poplar	mature	Deciduous	50-70
37	Hardwoods,>50% Poplar	immature	Deciduous	30-50
38	Softwoods, >=70% Eastern Cedar	mature	Coniferous	70-90
39	n/a	n/a	n/a	None
40	Poplar, Birch, Red Maple, Cedar, Pines, Balsam Fir	immature	Mixed	70-90
41	Softwoods, >=70% Eastern Cedar	immature	Coniferous	70-90
42	Poplar, Birch, Red Maple, Cedar, Pines, Spruce, Balsam Fir	mature	Mixed	50-70
43	Hardwoods,>50% Poplar	mature	Deciduous	50-70
44	Shade Intolerant, Red Maple < tolerant	immature	Deciduous	50-70
45	Poplar, Birch, Red Maple, Cedar, Pines, Spruce, Balsam Fir	mature	Mixed	50-70
46	Hardwoods,>50% Poplar	immature	Deciduous	50-70
47	Poplar, Birch, Red Maple, Cedar, Pines, Balsam Fir	young	Mixed	70-90
48	Hardwoods,>50% Poplar	immature	Deciduous	50-70
49	Hardwoods,>50% Poplar	mature	Deciduous	50-70
50	Softwoods, Spruces and Shade Tolerant Hardwoods	immature	Mixed	50-70
51	Poplar, Birch, Red Maple, Cedar, Pines, Balsam Fir	mature	Mixed	70-90
52	n/a	n/a	n/a	None
53	Hardwoods,>50% Poplar	immature	Deciduous	70-90
54	Hardwoods,>50% Poplar	mature	Deciduous	50-70
55	Hardwoods,>50% Poplar	mature	Deciduous	50-70
56	Hardwoods,>50% Poplar	mature	Deciduous	50-70
57	Poplar, Birch, Red Maple, Cedar, Pines, Balsam Fir	mature	Mixed	50-70
58	Hardwoods,>50% Poplar	mature	Deciduous	50-70

Sites	Forest Composition	Dev Stage	Forest Type	% Canopy Closure
59	Shade Intolerant, Red Maple < tolerant	immature	Deciduous	50-70
60	Hardwoods>70% Shade intolerant hardwoods	mature	Deciduous	50-70
61	n/a	n/a	n/a	None

Canopy closure Analysis of sampling locations.

Canopy closure	No. Sampling locations	% Composition
None (urban)	5	8.20
<10	0	0
10-30	0	0
30-50	2	3.28
50-70	41	67.21
70-90	13	21.31
>90	0	0

Forest Cover Analysis of Sampling Locations.

Forest Cover Type	Forest Type	Developmental Stage	No. Sampling locations	% Composition	% Composition by Forest Type
No Forest Cover	None	None	4	6.56	27.88
Balsam Fir, white Spruce	Coniferous	Young	1	1.64	
Softwoods, >=70% Eastern Cedar	Coniferous	Immature> mature	3	4.92	
Softwoods (>50% Balsam Fir)	Coniferous	Immature> mature	4	6.56	
Softwoods (>=70% Spruces and <70% Black Spruce)	Coniferous	N/A	1	1.64	

Softwoods (>=40% Spruces and <70% Black Spruce and no Balsam Fir)	Coniferous	Immature	3	4.92	
Softwood mix	Coniferous	Young	1	1.64	
Balsam Fir, Intolerant Hardwoods	Mixed	Immature	2	3.28	37.71
Hardwoods, >40% Black Spruce	Mixed	Immature	1	1.64	
Hardwoods, Red Maple, Cedar, Pines, Balsam Fir, Spruces	Mixed	Mature> Immature	2	3.28	
Softwoods, Spruces and Shade Tolerant Hardwoods	Mixed	Immature> Regeneration	3	4.92	
Hardwoods and Cedar, Pines, Balsam Fir, Spruces	Mixed	Mature	1	1.64	
Poplar, Birch, Red Maple, Cedar, Pines, Balsam Fir	Mixed	Mature> Immature = Young	6	9.84	
Poplar, Birch, Red Maple, Cedar, Pines, Spruce, Balsam Fir	Mixed	Mature> Immature	8	13.11	
Tolerant (Red Maple) >= Intolerant Hardwoods	Deciduous	N/A	1	1.64	34.43
Shade Intolerant, Red Maple >=tolerant	Deciduous	Mature	1	1.64	
Shade Intolerant, Red Maple < tolerant	Deciduous	Immature	3	4.92	
Hardwoods>70% Shade intolerant hardwoods	Deciduous	Mature	1	1.64	
Hardwoods,>50% Poplar	Deciduous	Mature> Immature	15	24.59	

Developmental Stages	Forest Type	% Canopy Closure	No. Sampling Station	Total by Forest type
Regeneration	Mixed	30-50	1	1
Young	Coniferous	50-70	1	2
		70-90	1	
	Mixed	70-90	1	1
Immature	Coniferous	50-70	5	8
		70-90	3	
	Mixed	50-70	7	9
		70-90	2	
	Deciduous	30-50	1	7
		50-70	5	
		70-90	1	
Mature	Coniferous	50-70	1	2
		70-90	1	
	Mixed	50-70	10	11
		70-90	1	
	Deciduous	50-70	11	13
		70-90	2	

From what I can see you have good coverage of the mature forest types in soil samples. You could collect more in the coniferous realm but their leaf litter is not as extensive as deciduous. Coniferous trees only lose their leaves on a three year cycle so I'm not sure how much valuable information that will provide you.

APPENDIX C

FRESHWATER AQUATIC SAMPLING PROTOCOL AND SOIL INVERTEBRATE SAMPLING PROTOCOL

SCIENCE INTEGRITY KNOWLEDGE

intrinsik

SURFACE WATER AND SEDIMENT SAMPLING PROTOCOLS BELLEDUNE, NB

FINAL PROTOCOL

July 16, 2010

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SURFACE WATER AND SEDIMENT SAMPLING PROTOCOLS
BELLEDUNE, NB FIELD PROGRAM

1.0 SURFACE WATER SAMPLING PROTOCOL

Introduction

This sampling protocol adheres to the Ontario Ministry of the Environment guidance on sampling for use at contaminated sites (OMEE, 1996). Minor departures from OMEE (1996) as well as supplementary procedures are documented herein.

This surface water sampling protocol is meant to be used in conjunction with the stream sediment sampling protocol (see Section 2.0). Due to the size and location of watercourses, all aquatic sampling will be completed by personnel wading into the streams.

At each aquatic sampling location both sediment and surface water samples should be acquired. **It is imperative that surface water samples be collected prior to sediment samples, and that sampling proceed from downstream locations to upstream locations, with sampling always occurring on the upstream side of the person acquiring the sample to avoid sample contamination**. All aquatic sampling information gathered in the field, including sample records, should be detailed in an aquatic field log book.

The objective of the surface water sampling will be to provide results that allow for the comparison of water quality within a 3 km radius of the Belledune Smelter (*i.e.*, comparing samples upstream and downstream of the facility) in addition to comparison to reference area surface water (as well as water quality criteria for the protection of aquatic life, and historic, pre-smelting sediment metals levels comparisons, using data collected by the Geological Survey of Canada). For such comparisons to be made, replicate sampling is essential (at 5% of sampling stations, or at a minimum of one station per stream), and QC procedures that reduce the potential for contamination must be followed. This protocol outlines methods and procedures that should assist in producing high quality data.

The selection of this particular study boundary is based on the existing soil data from the terrestrial component of this study, as well as from the Shore Road Soil Study (Intrinsik Environmental Sciences *et al*., 2008), as well as consideration of air deposition from a study conducted by A. J. Chandler & Associates (2010) (see Attachment I-1 to Appendix I), historical and recent geological studies (*i.e.*, Geological Survey of Canada maps from the area; Parkhill and Desrosier, 2007, in prep). The purpose of the sampling is to focus on streams which have the highest potential of impacts, based on these considerations. Watercourses near the facility which are currently regulated, such as the waterway near the existing slag pile and the operational discharge points from the facility (east and west diversion ditches) are excluded from this sampling since they are monitored by Xstrata and have to meet established guidelines at their release points.

In the field, measurements of temperature, pH and conductivity will be taken prior to the filtering, preservation and storage of samples. Both total metals and dissolved metals will be determined. In the laboratory, samples will be analyzed using a Rapid Chemical Analysis package – Mass Spectrometry (RCAp-MS). This package includes a full ICP-MS metals scan.

Table 1 and Figure 1 provides the location and names (where possible) of the stream systems to be sampled in the Study boundary, along with the number of samples to be collected in each system. Each stream, and the reference area, will have 1 field duplicate, or QAQC sample (blind). Definitions of QC samples are given in the last section of this protocol, entitled: "Field Quality Control". Laboratory duplicates will be generated by Maxxam Analytics from individual samples in the lab for a minimum of 5% of samples in each analysis batch. Exact sampling locations are being left to the discretion of the sampling team. Locations should be selected that are representative of the stream system within the 3 km radius, and at locations where it is also possible to acquire sediment samples. Spacing of stations should be as even as possible across the stream system within the 3 km radius (See Figure 1), with sampling stations being no closer to one another than 100 m. Also, if streams merge together, sampling should occur below the confluence of two streams.

The reference stream system has not been selected at the time of writing this protocol, and will be selected by the field crew. Two candidate streams have been identified, based on their distance from the facility, upwind location (west of the facility), and their approximate size, as well as some consideration of historic geology in the areas (GSC maps, 1965). The website www.geonb.snb.ca was used to assist in their selection. These two streams include Armstrong Brook (which is east of Jacquet River, but west of the smelter) and Louison Creek, which is west of Jacquet River. The field crew should examine both of these, and select one or an alternate, if these streams appear inappropriate due to size, volume, *etc*. Following the selection of a single reference stream, five sampling locations, in addition to one QAQC station will be sampled. Additional reference data will be provided from a similar program near the Brunswick Mines site. The sampling protocols for sediments and surface waters used in the Brunswick Mines program are identical to those cited here, and the field sampling is being conducted by the same firm (Conestoga Rovers), and the same analytical laboratory (Maxxam Analytics) as that used in the Brunswick Mines program. The Belledune area reference stream should be examined by the field crew to determine whether the reference stream is similar to those found in the study boundary - considering characteristics such as volume, flow, surrounding environment, gradient as well as the capacity to yield sufficient sediment samples. These two streams do not contain some of the enrichment noted in Hendry Brook in the 1965 GSC maps, but appear to be good candidates apart from that.

At each surface water sampling station, a minimum of three laboratory containers must be filled using a single grab sample. One bottle will not be chemically preserved (this bottle is for the analysis of all parameters other than metals in the RCAp-MS). The second bottle will be preserved chemically for total metals determination, the third will be filtered and preserved for the determination of dissolved metal (nitric acid provided by lab). Field duplicate or inter-laboratory samples will repeat these four subsamples from the same initial grab sample.

Table 1 Sample Numbers and Locations

Stream System	Number of Sampling Stations	Field Duplicate
Hendry Brook	7	1
Unnamed Stream	3	1
Reference Stream	5	1

Figure 1 Map showing the stream systems to be sampled, and the approximate sampling locations within the Study Boundary (orange stars)

Equipment

Sampling requirements for surface water analysis can be fulfilled by manual sampling (*i.e.*, grab sampling) using simple field equipment including: buckets, funnels, and suitable lengths of chain or dip poles. All wettable surfaces that contact the water sample must be inert (*i.e.*, must not contaminate, absorb nor desorb chemicals required to be analyzed in the water sample). This requirement can generally be met through consistent use of materials such as Teflon or glass. In accordance with U.S. EPA Method 1669 ("Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels"; 1996), **all sampling equipment and sample containers must be nonmetallic and free from any material that may contain metals**. A**ll sampling equipment and sample containers must be precleaned in a laboratory or cleaning facility, before they are shipped to the field site**. Sample containers will be provided by the laboratory and will be made of polyethyleneterephthalate or glass, with plastic lined caps. Extreme care must be taken to ensure that sampling equipment and sample containers are not contaminated on route to, or at the sampling location.

Because samples will be collected by personnel wading into the stream it is imperative that personnel wear clean rubber boots or hip-waders (with no metallic parts that will make contact with the surface water or sediments). As with the grab sampler, boots or hip-waders should be rinsed twice with ambient water between sampling to ensure no sediment or other materials are attached

Sample Type and Technique

All samples obtained for analysis should be from a point in the stream that is representative of the whole stream composition. The volume of sample taken must be sufficient to allow for analysis of all required parameters plus associated quality control samples (*i.e.*, field duplicates). Samples will be sent to Maxxam Analytics in Bedford, Nova Scotia.

A grab sample is meant to represent the water stream at a given point in time. Grab samples will be collected by dipping an appropriate container, bucket bottle or vial, into the stream using an appropriate retrieval device. The GRAB 2 sample (OMEE, 1996) will be used for all surface water sampling. A GRAB 2 sample is taken when *water is collected in a bucket or other container and immediately transferred to the appropriate laboratory container(s), preserved as necessary and capped. The bucket must be thoroughly cleaned before it is used again.* The sampling container should be moved slowly through the depth profile of the water body as it is filling (**CAUTION**: it is imperative that the sampler avoid disturbing bottom sediment as much as possible in this process). This method of acquiring a sample should be used for all surface water sampling. When done properly, this method produces a sample that approximates the full depth profile of the constituents of interest in the water body. The sampler should be careful to **in no way contaminate or disturb the water upstream prior to sampling**. In divergence from the strict definition of a GRAB 2 sample, electrical conductivity and pH must be measured in triplicate using appropriate clean equipment (*i.e.*, portable pH and conductance meter) before transfer to appropriate laboratory container(s), and before the preservation and storage of samples. Temperature, conductivity and pH measurement devices must be thoroughly cleaned before being used on subsequent samples. At each sampling station, some collected surface water will be filtered through a 0.45 µm capsule filter at the field site into two appropriate laboratory containers (in accordance with U.S. EPA Method 1669 for dissolved metals determination) prior to preservation and storage. The other two laboratory containers will be filled at each sampling station without filtration, and one of them will be preserved with acid for total metals analysis. Sampling within a stream should proceed from downstream locations to upstream locations. Throughout all sample collection procedures at a given station, new clean nitrile gloves should be worn. If samples are collected from adjacent sites (*e.g.*, immediately upstream), rinsing of the sampling equipment with water that is to be sampled should be sufficient. Otherwise, a clean set of sampling equipment should be used (*i.e.*, equipment that has been precleaned in a cleaning facility or laboratory).

To clarify and summarize, the general steps to be taken at each surface water sampling location include:

1. Ensure all sampling equipment and measuring devices are working properly and are clean.
2. A setback distance of 10-15 m from any road, rail line, ditch, utility pole, or other structure should be used to guide sample locations. Any sampling locations within 10-15 m of any of these items should be re-located by the field crew at their discretion, so as to respect the set back distance outlined.
3. Acquire a sufficiently large grab sample (to account for all necessary laboratory bottles) following the methods detailed above.
4. Take measures of temperature, pH and conductivity in triplicate using appropriate clean portable devices.
5. For each sample location there will be three laboratory containers (excluding duplicates):
    - 1 ***unfiltered and unpreserved sample*** for general chemistry (*i.e.*, for measurement of RCAp-MS parameters other than metals (200 mL));
    - 1 ***unfiltered and preserved sample*** for total metals determination (50 mL);
    - 1 field ***filtered and preserved sample*** for dissolved metals determination (50 mL); and

   Each of these containers must be filled and labeled appropriately, and preserved and stored accordingly.
6. If random assignment dictates the acquisition of a field duplicate at the given station, repeat Step 5 for that duplicate. Water should be acquired from the original grab sample (*i.e.*, a new grab sample should not have to be acquired for this; a large enough volume of water should have been gathered in Step 3).

Sample Preservation and Storage

Samples require preservation to ensure stability of the target compounds during transportation and storage. The maximum holding time for metals in water other than mercury and chromium is 60 days when proper preservation methods are used. Samples for metals determination must be preserved immediately upon collection (*i.e.*, after the field measurements of pH and conductivity for unfiltered samples, after filtration of filtered samples for dissolved metals determination, and prior to storage of the sample in field). Preservation will require the addition of 10% HNO_3 (approximately 5 mL per every 1 L of sample water). Samples are to be preserved at a pH between 1.5 and 2. Care must be taken that the set point has been reached according to the best available detection technique applicable to the sampling location. This may include the use of: confined range pH paper or pocket/portable pH meters. The use of these techniques and/or devices must not contaminate the sample. Devices must be thoroughly cleaned before being used on subsequent samples.

All samples should be stored for as short a time interval as possible and under conditions which will minimize sample degradation. Upon collection in the field, samples must be kept in the dark at temperatures above the freezing point of the water (0^oC) and under 10^oC. Sample temperatures should be brought down to **below 4^oC within 6 hours of collection**. **Samples must be transported in coolers and stored in refrigerators**. Storage temperatures should be monitored, preferably with min-max thermometers, and documented in a log book.

Special Considerations and Precautions

Use caution on acid preservation of samples.

Field Log Book

Log books should be maintained to track samples from containers through the sampling process to shipment to the laboratory (including storage temperatures). A detailed log will be kept by the field sampling team. In addition to tracking samples, this log will describe conditions encountered at each location from which water samples are collected. Included in this log will be the following:

- Triplicate measures of temperature, pH and conductivity for each grab sample;
- description of surroundings including presence of inflow/outflow points and nearby shoreline features;
- exact GPS coordinates of the sampling location (with a minimum of 20 metre accuracy);
- descriptions of any problems encountered, especially those that may necessitate a change to the sampling program at that location;
- weather conditions at the time of sampling;
- date and time of sampling; and,
- approximate water depth

- A sample may be taken at a site in addition to the sites required in the sampling program if an anomalous condition is present, such as increased algal growth or fish kill (BC MOE 2004). A new site location description should be included in the log book (BC MOE 2004).
- Record observations of aquatic organisms and wildlife found in the aquatic environment (*e.g.*, presence of fish, water striders, or other aquatic life species are found, or racoon tracks, mink, scat, *etc.*).

Field Quality Control

During the planning stages for sampling, potential sources of error and of variability should be listed and quality control checks (QC) should be specified for each. The method of documentation of the results of these QC checks should be stated. Field QC plans should detail the types of field observations that are to be made during the sampling and the terminology to be used in describing them. Details such as water colour can be important later in interpreting the results of the sampling, as well as during any remediation phase. The sampling plan should specify the number and type of field QC samples that field personnel should submit to the lab. Field replicates should be submitted systematically. See Table 1 for the numbers of replicates proposed for each stream system.

Throughout all sampling and sample handling, care must be taken to prevent cross contamination of samples. Sampling equipment should be cleaned carefully between sites, and appropriate, clean sample containers used. It is advisable for sampling to proceed from the least contaminated sites to the most contaminated sites in order to minimize the potential for cross contamination.

A replicate sample is any additional sample collected at the same time as another in a manner that minimizes differences. Also referred to as field duplicates, these samples will help to establish estimates of variability of the matrix and site contaminant levels. Replicate samples should be collected for all test groups and analyzed for all test groups.

Spiked blanks will not be generated or analyzed because variability associated with storage and transport of metals in water is expected to be negligible.

2.0 SEDIMENT SAMPLING PROTOCOL

Introduction

This stream sediment sampling protocol adheres to the Ontario Ministry of the Environment guidance on sampling methods for use at contaminated sites (OMEE, 1996). Minor departures from OMEE (1996) as well as supplementary procedures are documented herein.

This sediment sampling protocol is meant to be used in conjunction with the surface water sampling protocol for this site (see Section 1.0 above). Due to the small size and location of watercourses, sampling from a boat or other platform is not possible. Therefore, all aquatic sampling will be completed by personnel wading into the streams.

At each aquatic sampling location both sediment and surface water samples should be acquired. **It is imperative that surface water samples be collected prior to sediment samples and that sampling proceed from downstream locations to upstream locations**, with sampling always occurring on the upstream side of the person acquiring the sample to avoid sample contamination. All aquatic sampling information gathered in the field, including sample records, should be detailed in a field log book.

The objective of the sampling is to provide results that allow for the comparison of sediment quality within a 3 km radius of the Belledune Smelter (*i.e.*, comparing samples upstream and downstream of the facility) in addition to comparison to reference area sediments (as well as sediment quality criteria for the protection of aquatic life, and historic sediment data from the Geological Survey of Canada, which pre-dates the smelter operations). For such comparisons to be made, replicate sampling is essential (at 5% of sampling stations, or at a minimum of one station per stream), and QC procedures that reduce the potential for contamination must be followed. This protocol outlines methods and procedures that should assist in producing high quality data.

Information will be recorded in the field log book, and the sample will then be mixed and divided amongst the necessary laboratory sub-sample containers. In the laboratory, the sample will be analyzed for available metals based on U.S. EPA Methods 3050b followed by 6020A. The analytes included in this scan, are appended, along with their reported detection limits (RDLs).

Table 1 (in the surface water sampling section of this protocol) provides the number of samples to be taken concurrently with surface water samples from the stated stream systems. A total of five reference sediment samples and one field duplicate sample should be collected. **Sample stations should be a minimum of 100 m apart**. Exact sampling sites are to be determined by the field crew.

Sediment Sampling Equipment

For this stage of stream sediment sampling, grab samplers will suffice for sample collection. Grab samplers, such as hand-held Dutch augers, are designed to collect surficial sediments by scooping out a defined area of the sediment surface. The depth of collection is limited by the height of the sampler (*i.e.*, the volume) and the nature of the sediment material. Since the vertical profile of sediment concentrations is not important to the aims of the current phase of the study (screening), a grab sampler will be more efficient than a core sampler. It is desirable that all sampling equipment be nonmetallic, however, stainless steel parts are acceptable (BC MOE 2004).

Before samples are collected, all sampling equipment should be appropriately cleaned and stored by a cleaning facility or laboratory. The grab sampler should be rinsed twice with ambient water between sampling to ensure no sediment or other materials are attached. Clean sample containers will be provided by the receiving laboratory. Every effort must be made to ensure that these containers are not contaminated en route to, or at the sampling station. Sample containers must be kept in a clean environment, away from dust, dirt, fumes and grime. Containers must be capped at all times and stored in clean shipping containers (coolers) both before and after the collection of the sample (BC MOE 2004).

Because samples will be collected by personnel wading into the stream it is imperative that personnel wear clean rubber boots or hip-waders (with no metallic parts that will make contact with the surface water or sediments). As with the grab sampler, boots or hip-waders should be rinsed twice with ambient water between sampling to ensure no sediment or other materials are attached.

Sediment Sampling, Storage and Handling Methods

Exact sampling locations are to be determined by the field crew, who will select sampling stations such that they are representative of the selected stream system within the 3 km radius of the smelter, and so that ideally, it is possible to acquire both representative surface water and sediment samples at the same location. **Sediment samples should be acquired after surface water samples**. Sampling should proceed from downstream locations to upstream locations, and **should always take place in depositional zones**. The following steps should be taken in acquiring sediment grab samples:

(a) Lower the sampler until it is resting on the sediment (slight pressure may be required to penetrate sediments).

(b) Retrieve the sampler slowly to minimize the effect of turbulence (that might result in loss/disturbance of surface sediments).

(c) Place a container (*i.e.*, a shallow non-metallic pan) beneath the sampler as soon as possible after it breaks the surface of the water. The grab sampler must retrieve a complete sample (*i.e.*, loss of fine particle should be avoided when bringing the sample to the water surface, and while transferring the sample to the pan). If the sample is incomplete, or loss of sediment is suspected, discard the sample into a bucket, and make another collection attempt in the same general area. Dump the unwanted sample only after a sample has been successfully collected (a minimum of **50 grams of sediment per sample is required –** please try to ensure that at least twice that volume is collected for purposes of archiving).

(d) Immediately record (in the field logbook) observations regarding the appearance of the sediment (*i.e.*, texture, colour, odour, presence of biota, presence of detritus, and the depth of sediment sampled).

(e) The top 10 cm of the grab sample should be transferred into a clean (nonmetallic) pan and thoroughly mixed using a large, clean Teflon or ceramic spoon. Stainless steel bowl would be an acceptable alternate. Carefully divide the sample into the required number of replicates with a clean nonmetallic spatula. Samples should be placed in clean plastic or glass bottles. The inner portion of sample container must not be touched with anything (*e.g.*, bare hands, gloves, *etc.*) other than the sample itself (BC MOE 2004). Sample containers should be carefully labeled with indelible ink pens. Labels should contain the following information:

- date and time of collection
- identification of collector
- site identification (including stream name)

This information should correspond to information recorded in the field log book (See section entitled: “Field Recording and Log Books” below).

(f) Place the samples in a cooler with ice packs as soon as possible. The samples must be kept at 4°C and out of sunlight. Samples should be shipped to the laboratory as soon as possible after collection.

A number of basic requirements must be met to obtain representative sediment samples:

- The grab sampler must penetrate the sediment to a sufficient depth to measure the variables of concern accurately
- The grab sampler must enclose the same approximate quantity of sediment each time
- Care should be taken not to disturb the sediments prior to deployment of the sampling device.

Archive Samples

Sediments may be heterogenous and therefore must be thoroughly mixed before they are sub-sampled. Each container should be mixed and sub-samples taken for the required analysis. Remaining material should be combined into one container and this preserved frozen as an archive sample. This should be retained for at least one year or until the study is completed.

The purpose of the archive sample is to permit subsequent re-analysis for a particular constituent or external audit analysis.

Field Recording and Log Books

Sample site locations should be determined as accurately as possible in the field and precisely located on a map (accurate to within 20 m). Positioning is especially important if the sites are to be re-sampled at a later date. Accurate positioning is also important for later analysis of the data using Geographical Information Systems, and should include geographic coordinates. The sample sites must be determined with a GPS unit (global positioning system).

The information gathered for sediment evaluation should include field notes covering the following points:

- observations regarding current water speed near bottom;
- depth;
- weather conditions;
- time and date of collection;
- positioning information;
- type of sampler used;
- name of sampling personnel;
- notation of odd or unusual events which occurred during sampling (*e.g.*, "sampler returned only a few rocks");
- field description of samples:
  - odour,
  - approximate particle size,
  - colour,
  - presence of non-decomposed organics (*e.g.*, wood fibers),
  - presence of oil and grease,

- presence of distinct layering as given by changes in colour or particle size,
- presence and type (to broad groupings) of aquatic biota, and
- notation where there was a deviation from standard handling and splitting procedures.

A standardized form covering the field information is recommended.

Physical Analysis

Before a sample is mixed and split in the field, the odour and colour should be noted. Odour can be divided into four categories:

- Odourless
- Chemical
    - chlorine
    - petroleum
    - medicinal - phenol, iodine
    - sulphurous
- Decaying Organic
    - manure
    - sewage
- Natural
    - earthy
    - peat
    - grassy
    - moldy

Colour can be best determined by comparison of the sediment to the Munson colour code system. Colours will range from reddish-brown to jet black.

Field Quality Control

During the planning stages for sampling, potential sources of error and of variability should be listed and quality control checks (QC) should be specified for each. The method of documentation of the results of these QC checks should be stated. Field QC plans should detail the types of field observations that are to be made during the sampling and the terminology to be used in describing them. Details such as water colour can be important later in interpreting the results of the sampling. The sampling plan should specify the number and type of field QC samples that field personnel should submit to the lab. Field replicates should be submitted systematically. See Table 1 for the numbers of replicates proposed for each stream system.

Throughout all sampling and sample handling, care must be taken to prevent cross contamination of samples. Sampling equipment should be cleaned carefully between sites, and appropriate, clean sample containers used. It is advisable for sampling to proceed from the least contaminated sites to the most contaminated sites in order to minimize the potential for cross contamination.

A replicate sample is any additional sample collected at the same time as another in a manner that minimizes differences. Also referred to as field duplicates, these samples will help to establish estimates of variability of the matrix and site contaminant levels. Replicate samples should be collected for all test groups and analyzed for all test groups.

Data QAQC and Analysis

The QA/QC program will comprise the following elements, at a minimum.

Field and Laboratory Duplicate Samples

Field duplicate samples will be collected at a number of sampling locations, selected at random. The sampling crew will identify the specific locations. The total number of field duplicates collected will be 1 per stream sampled, including reference stream, which is more than 10%. All field duplicate samples will be collected, homogenized, processed, shipped, and analyzed in exactly the same manner as the other samples.

In addition, and as part of standard laboratory QA/QC, a selected number of samples will be analyzed as laboratory duplicates. It is anticipated that laboratory duplicates will be analyzed for at least 5% of the samples submitted for analysis.

Data Quality Objectives (DQOs)

The main purpose of DQOs are to establish acceptability criteria for the analytical data, and to ensure that the data obtained are reasonable, and of appropriate quality.

The DQOs for the study will include (but are not limited to) the following elements:

- Sampling and analytical data collection techniques will be reviewed to ensure that standard, widely-accepted procedures (*e.g.*, use of standardized, validated, published techniques; newly-provided clean sampling containers, chain of custody forms; duplicate analyses on a randomly select number of samples) are used when collecting samples;
- Samples will be analyzed by a nationally-accredited laboratory that employs standardized, validated, and widely-accepted procedures;
- All test reports with final analytical data will be reviewed to ensure that analyses met external (*i.e.*, quality assurance) and internal laboratory (*i.e.*, quality control) standards of acceptability;
- Field logs will be reviewed to determine whether there were any circumstances of concern with regard to the sampling effort;
- If analyte values are above the maximum detection limit of the equipment or method, an appropriate series of dilutions should be created to better quantify the analyte value in the sample. The object is to eliminate greater than (>) flags in the analytical data;
- The percent (%) recoveries provided by the analytical facility for laboratory-spiked samples will be reviewed to ensure that the MDL achieved by the laboratory was appropriate. For samples where the percent recovery falls outside an acceptable range (*e.g.*, 85 to 115%), dialogue with the laboratory will help to determine the possible cause of poor recovery (*e.g.*, matrix interference), prior to deciding whether to reject the affected sample data;
- A review of laboratory duplicate data will be undertaken to ensure that analyses were within acceptable ranges (*i.e.*, samples will be examined further if the duplicates yield relative percent differences (RPD) of more than 35% for sediments and 20% for surface waters), according to US EPA (2006);
- MDLs will be reviewed to ensure that the laboratory-achieved limits are less than applicable environmental quality criteria (*e.g.*, environmental quality guidelines).

Assessment of the data will be initially conducted using Probable Effect Level Sediment quality guidelines (CCME), and freshwater aquatic life guidelines for total metals (CCME), and dissolved metals (US EPA), from the most recently available versions of these documents. Where CCME guidelines are lacking, guidelines will be sourced from other jurisdictions, as appropriate.

3.0 REFERENCES

BC MOE (British Columbia Ministry of the Environment). 2004. British Columbia Field Sampling Manual: 2003 — For Continuous Monitoring and the Collection of Air, Air-Emission, Water, Wastewater, Soil, Sediment and Biological Samples. Environmental Quality Branch. http://www.env.gov.bc.ca/air/wamr/labsys/field_man_03.html

Geological Survey of Canada (GSC). 1965. Geochemistry of Pb, Zn, Cu, As, Sb, Mo, Sn, W, Ag, Ni, Co, Cr, Ba, and Mn in the Waters and Stream Sediments of the Bathurst – Jacquet River District, New Brunswick 21 P/12, 21 P/13, 21 0/9E, 21 0/16E. Paper 65-42. Department of Mines and Technical Surveys.

Intrinsik Environmental Sciences Inc., Conestoga-Rovers and Associates, Genivar, and GlobalTox International Consultants Inc. 2008. The Shore Road Soil Study, Belledune, New Brunswick. Prepared for Xstrata Zinc June, 2008.

OMEE (Ontario Ministry of the Environment and Energy). 1996. Guidance on sampling and analytical methods for use at contaminated sites in Ontario (Version 1.1). Standards Development Branch. ISBN-0-7778-4056-1.

Parkhill and Desrosiers (2007). In Prep. Unpublished Report. Personal Communication from New Brunswick Department of Natural Resources to H. Macdonald of Conestoga Rovers & Associates (February, 2008).

U.S. EPA. 2006. Validation of Metals for the Contract Laboratory Program (CLP) based on SOW ILMO5.3 (SOP Revision 13). Data Assessment and Contract Compliance Review. Standard Operating Procedure. U.S. EPA Region 2. SOP; HW – 2. Revision 13 Appendix A.1. September, 2006.

U.S. EPA (United States Environmental Protection Agency). 1996. Method 1669: Sampling ambient water for trace metals at EPA water quality criteria levels. Office of Water, Engineering and Analysis Division, Washington, D.C.

TERRESTRIAL SOIL INVERTEBRATE SAMPLING PROTOCOL BELLEDUNE SMELTER

FINAL PROTOCOL

August 6, 2010

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Xstrata Zinc
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TERRESTRIAL BIOTA SAMPLING PROTOCOL FOR THE BELLEDUNE LEAD SMELTER SUMMER 2010 FIELD PROGRAM

1.0 SOIL INVERTEBRATE SAMPLING

1.1 Introduction

The overall study design for soil invertebrates is linked to the vegetation survey conducted by LGL, 2010 (see Appendix K). The vegetation survey was designed to assess vegetation health within a 2 km radius of the smelter, in the areas south, south east and south west of the smelter.

The study design for soil invertebrate sampling is a transect-based design, involving five transects. The location of the transects is based on soil chemistry data from the summer 2009 sampling event. Within each transect, up to four sampling stations will be established at set distances (approximately 0.5 km intervals). At transects #1, #2 and #3, four sampling stations will be established within each transect. Within transect #4 and transect #5, due to land ownership constraints, three and two sampling station will be respectively established. At each of the transect sampling station locations, pitfall traps will be set up. There will also be soil sample collection at each station (as per the sampling protocol provided in Appendix A), as well as detailed vegetation surveys at each station (see Appendix K). A reference area will also be sampled in this program.

The objective of the pitfall sampling will be to provide a basic observation count of species present within the pitfalls (identified to family level), and to analyze uptake of metals and metalloids by soil dwelling invertebrates within a 2 km radius of the smelter. The soil invertebrate chemistry data will provide quantitative data that could be used to ground truth modeled predictions of exposure for insectivorous species (such as masked shrew, and junco).

Quality control procedures that reduce the potential for contamination must be followed in the pitfall sampling program.

In the laboratory, prior to metals analysis, invertebrates will be homogenized, and samples will be dissolved with a nitric acid mixture. Biota samples will be analysed for available metals following U.S. EPA SW846 Method #6020A / EPA 200.3. A list of the analytes for this method and their associated RDLs is provided below in Table 1. Lower RDLs may possibly be achieved by pre-ashing of the samples. This decision will be made prior to preparing invertebrates for analysis, and will be dependent upon achievable metal/metalloid recovery rates.

Table 1 RDLs for Metals Tissues Analysis in mg/kg (as provided by Maxxam)

Aluminum (Al) 2.50	Cadmium (Cd) 0.05	Lithium (Li) 0.50	Strontium (Sr) 1.50
Antimony (Sb) 0.50	Chromium (Cr) 0.50	Manganese (Mn) 0.50	Thallium (Tl) 0.02
Arsenic (As) 0.50	Cobalt (Co) 0.20	Molybdenum (Mo) 0.50	Tin (Sn) 0.50
Barium (Ba) 1.50	Copper (Cu) 0.50	Nickel (Ni) 0.50	Uranium (U) 0.02
Beryllium (Be) 0.50	Iron (Fe) 15	Selenium (Se) 0.50	Vanadium (V) 0.5
Boron (B) 1.50	Lead (Pb) 0.18	Silver (Ag) 0.12	Zinc (Zn) 1.50

Notes:
Test Code: ICPMF7-TI
Test Name: Metals Tissue MS - Nitric
Method: Based on EPA6020A Reference Number: ATL SOP 00024 R5

1.2 Arthropod Sampling with Pitfall Traps

Pitfall traps are containers (*e.g.*, jars, plastic bottles) that are buried so that the rim of the collecting container is flush with the surface of the ground. Pitfall traps are efficient traps for ground-dwelling arthropods such as Carabid and Staphylinid beetles, Hymenoptera including Formicine ants, and Orthoptera including wingless grasshoppers. A cover should be placed about over the trap to exclude the rain, and a mesh screen placed flush with the opening to exclude wildlife. The details of the trap are shown in Figure 1 (RIC, 1998). For the purpose of this study, the mesh screen may or may not be used at the discretion of the field crew.

The pitfall program will result in 17 arthropod samples corresponding to 17 surface soil sampling stations, plus 4 stations in the reference area, and 2 field duplicate stations to be selected at random by the field crew. Two individual pitfall traps will be laid at each designated soil sampling station provided that the station appears to have adequate terrestrial biota present (the goal is to collect a minimum of 10 g of soil invertebrates at each station). If pitfall traps do not yield an adequate number or mass of soil invertebrates, some ad hoc foraging by the field crew will be conducted in an attempt to obtain enough soil invertebrates for analysis purposes.

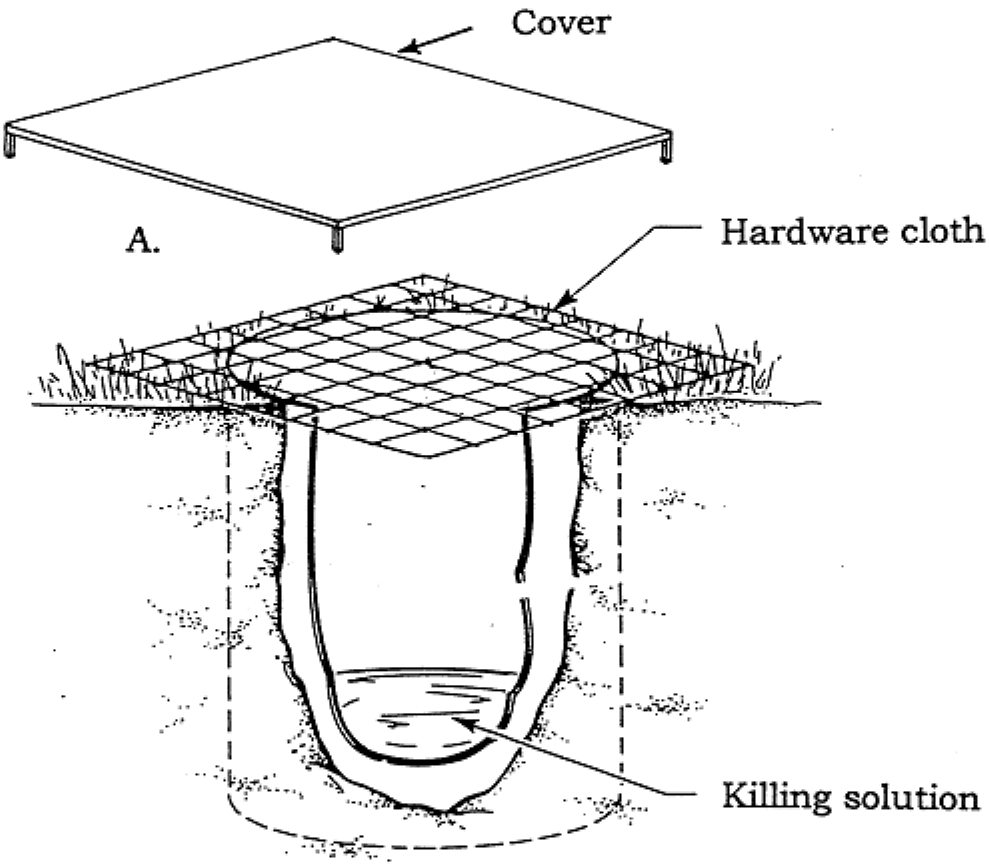

Figure 1 Design of a standard pitfall trap (from Martin, 1977)

Two (450 to 600 mL) wide-mouthed (minimum of 8 cm diameter) glass jars will be set in the ground (see Figure 1). Jars will be placed in holes in the ground that are dug with a circular cutter, which minimizes impact to the surrounding area (MacGown, 2008). The traps should be set approximately 5 m from the centre of the 10 x 10 or 20 x 20 m square encompassing the composite soil sampling locations. The stations should lie on a straight line intersecting the centre of the square (*i.e.*, so that the two traps are at least 10 m apart). Distilled water will be used to trap insects inside the pitfall traps. The trap should be filled with the distilled water to the 3/4 mark (RIC, 1998). A cover (*e.g.*, a sheet of plastic or stainless steel) will be placed about two cm above the ground directly over the trap to exclude the rain but allow arthropods to easily access the jar (*i.e.*, the cover must make minimal contact with the ground to allow clearance for arthropods; see Figure 1). A half inch (approximately 1.25 cm) mesh (*i.e.*, stainless steel Hexmesh™) screen is typically placed flush with the jar opening, but as mentioned, use of the mesh screen is at the discretion of the field crew.

The time of exposure is expected to be at least 48 hours per trap, which is within the two week RIC (1998) recommended trap exposure. **Pitfall traps should be checked within the 48 hour period to ensure that screens and lids are secure, and that no non-target organisms have been caught**. Invertebrates will be removed from the traps with pre-cleaned plastic forceps, whilst wearing unpowdered latex (or nitrile) gloves, and care will be taken not to expose trapped insects to any further dust once they are collected (Enns *et al*., 2002). Insects from each terrestrial sampling station (*i.e.*, two pitfall traps) will be placed into one glass jar (unless a field duplicate is acquired, in which case half the contents of each jar will be put into two new jars). Jars will be labeled and stored in coolers with ice (at approximately 4°C until they can be transferred to the lab fridge (Enns *et al*., 2002). Care must be taken to ensure that sampling equipment is properly cleaned before being transported for use at the next sampling location. **Prior to shipping to the analytical laboratory, a count of number and family-level identification of species found at each station should be recorded. Samples should be shipped in a cooler on ice to the analytical laboratory within 24-48 hours of collection.**

The laboratory must rinse samples with distilled/deionized water, and allow to air dry, prior to analysis. Samples should be prepared an analyzed as soon as possible, and at most analysis should occur within 4 weeks of being received by the laboratory.

2.0 REFERENCES

Enns, K.A., J.M. Cooper and S. Beauchesne. 2002. Field sampling plans for the 2002 Ecological Risk Assessment for Teck Cominco Metals Ltd., at Trail, B.C.

MacGowan, J. 2008. Pitfall Traps. Mississippi Entomological Museum (website). http://mississippientomologicalmuseum.org.msstate.edu/collecting.preparation.methods/Pitfalls.htm

RIC. 1998. Inventory methods for terrestrial arthropods. Version 2.0. Standards for Components of British Columbia's Biodiversity No. 40. Resources Inventory Committee, Ministry of Environment, Lands and Parks, Victoria,BC.

APPENDIX D

RAW DATA

D-1.0 ANALYTICAL CHEMISTRY RESULTS

D-1.1 Soil Analytical Results

Table D-1 Reference Area Summary Statistics for A Layer (0 to 5 cm) Soil Chemistry Data (2009)

Element	Units	Max	Min	Arithmetic Mean	Median	95th%ile
Aluminum (Al)	mg/kg	70000	1700	15061	12000	25700
Antimony (Sb)	mg/kg	<2	<2	<2	<2	<2
Arsenic (As)	mg/kg	10	<2	3.74	3	7.7
Barium (Ba)	mg/kg	460	14	89.8	52	417
Beryllium (Be)	mg/kg	7	<2	2.22	2	2
Bismuth (Bi)	mg/kg	<2	<2	<2	<2	<2
Boron (B)	mg/kg	5	<5	5	5	5
Cadmium (Cd)	mg/kg	4.2	<0.3	0.77	0.4	1.6
Chromium (Cr)	mg/kg	47	4	20	19	35.4
Cobalt (Co)	mg/kg	17	<1	7.52	6	14
Copper (Cu)	mg/kg	91	4	12	8	16.9
Iron (Fe)	mg/kg	42000	3500	23109	21000	40800
Lead (Pb)	mg/kg	87	8.6	34.2	26	73.4
Lithium (Li)	mg/kg	15	<2	7.35	6	15
Manganese (Mn)	mg/kg	17000	57	1332	350	4100
Molybdenum (Mo)	mg/kg	7	<2	2.26	2	2.9
Nickel (Ni)	mg/kg	47	3	16.5	13	43.4
Rubidium (Rb)	mg/kg	9	<2	4.74	4	8
Selenium (Se)	mg/kg	3	<2	2.04	2	2
Silver (Ag)	mg/kg	1.2	<0.5	0.53	0.5	0.5
Strontium (Sr)	mg/kg	37[a]	<5	16	8	48.7
Thallium (Tl)	mg/kg	0.9	<0.1	0.19	0.1	0.3
Tin (Sn)	mg/kg	<2	<2	<2	<2	<2
Uranium (U)	mg/kg	4	<0.1	0.66	0.3	3.19
Vanadium (V)	mg/kg	80	9	40.9	39	69.5
Zinc (Zn)	mg/kg	130	17	53.7	57	78.3
TOC	g/kg	260	50	180	230	257
pH	NA	6.17	4.17	4.96	4.53	6.01

Notes:

N=23 for soil metals data; N=3 for soil pH and TOC data; NA = not applicable as soil pH is unitless.

a Highest measured concentration that was quantifiable. In some samples, the RDL (reported detection limit) was elevated and was the highest value reported. However, such values are not true maxima.

Data collected by CRA, 2009.

Table D-2 Reference Area Summary Statistics for B Layer (5 to 15 cm) Soil Chemistry Data (2009)

Element	Units	Max	Min	Arithmetic Mean	Median	95th%ile
Aluminum (Al)	mg/kg	45000	7600	23460	23000	40950
Antimony (Sb)	mg/kg	<2	<2	<2	<2	<2
Arsenic (As)	mg/kg	17	<2	4.6	3.5	12.1
Barium (Ba)	mg/kg	170	24	71.5	50.5	165.5
Beryllium (Be)	mg/kg	3	<2	2.1	2	2.55
Bismuth (Bi)	mg/kg	<2	<2	<2	<2	<2
Boron (B)	mg/kg	<5	<5	<5	<5	<5
Cadmium (Cd)	mg/kg	1.6	<0.3	0.45	0.3	1.1
Chromium (Cr)	mg/kg	64	10	28.7	23	59.1
Cobalt (Co)	mg/kg	28	5	12.2	11	23.1
Copper (Cu)	mg/kg	81	3	18.1	11	54
Iron (Fe)	mg/kg	41000	14000	31000	33500	39650
Lead (Pb)	mg/kg	50	6.5	15.9	11	37.4
Lithium (Li)	mg/kg	21	3	12.2	12.5	20.6
Manganese (Mn)	mg/kg	6000	78	1254.8	435	4560
Molybdenum (Mo)	mg/kg	3	<2	2.1	2	2.6
Nickel (Ni)	mg/kg	65	7	21.2	17	49.7
Rubidium (Rb)	mg/kg	11	2	6.2	6	10.1
Selenium (Se)	mg/kg	<2	<2	<2	<2	<2
Silver (Ag)	mg/kg	1	<0.5	0.55	0.5	0.78
Strontium (Sr)	mg/kg	23[a]	<5	13.2	6	37.9
Thallium (Tl)	mg/kg	0.2	<0.1	0.11	0.1	0.16
Tin (Sn)	mg/kg	<2	<2	<2	<2	<2
Uranium (U)	mg/kg	4.8	0.3	1.12	0.45	3.8
Vanadium (V)	mg/kg	96	34	57.7	54.5	83.9
Zinc (Zn)	mg/kg	99	20	58.8	61.5	97.7

Notes:

N=10 for soil metals data.

[a] Highest measured concentration that was quantifiable. In some samples, the RDL (reported detection limit) was elevated and was the highest value reported. However, such values are not true maxima.

Data collected by CRA, 2009.

Table D-3 Reference Area Summary Statistics for C Layer (15 to 30 cm) Soil Chemistry Data (2009)

Element	Units	Max	Min	Arithmetic Mean	Median	95th%ile
Aluminum (Al)	mg/kg	60000	21000	30200	27000	49200
Antimony (Sb)	mg/kg	<2	<2	<2	<2	2
Arsenic (As)	mg/kg	7	<2	3.6	3	6.1
Barium (Ba)	mg/kg	220	26	74.8	55	175
Beryllium (Be)	mg/kg	3	<2	2.1	2	2.6
Bismuth (Bi)	mg/kg	<2	<2	<2	<2	2
Boron (B)	mg/kg	<5	<5	<5	<5	5
Cadmium (Cd)	mg/kg	0.6	<0.3	0.34	0.3	0.51
Chromium (Cr)	mg/kg	67	26	37.5	35.5	56.2
Cobalt (Co)	mg/kg	36	10	16.6	14.5	28.4
Copper (Cu)	mg/kg	150	7	26.2	13	90.2
Iron (Fe)	mg/kg	43000	30000	36000	35500	42550
Lead (Pb)	mg/kg	35	7.7	13.58	11	26.9
Lithium (Li)	mg/kg	30	12	18.4	17.5	25.95
Manganese (Mn)	mg/kg	3700	230	957	405	3025
Molybdenum (Mo)	mg/kg	3	<2	2.2	2	3
Nickel (Ni)	mg/kg	81	22	34.1	29.5	63.9
Rubidium (Rb)	mg/kg	9	5	7.1	6.5	9
Selenium (Se)	mg/kg	<2	<2	<2	<2	2
Silver (Ag)	mg/kg	<0.5	<0.5	<0.5	<0.5	0.5
Strontium (Sr)	mg/kg	17	<5	8.2	6	15.7
Thallium (Tl)	mg/kg	0.2	0.1	0.11	0.1	0.16
Tin (Sn)	mg/kg	<2	<2	<2	<2	2
Uranium (U)	mg/kg	5.1	0.4	0.99	0.5	3.21
Vanadium (V)	mg/kg	72	35	55.9	57	70.2
Zinc (Zn)	mg/kg	100	39	66.1	58.5	100

Notes:
N=10 for soil metals data.
Data collected by CRA, 2009.

Table D-4 Reference Area Summary Statistics for A Layer (0 to 5 cm) Soil Chemistry Data (2010)

Element	Units	SOIL REF-1	SOIL REF2	SOIL REF3	SOIL REF4
Aluminum (Al)	mg/kg	6800	4900	13000	18000
Antimony (Sb)	mg/kg	<2	<2	<2	<2
Arsenic (As)	mg/kg	3	<2	3	<2
Barium (Ba)	mg/kg	51	48	43	78
Beryllium (Be)	mg/kg	<2	<2	<2	<2
Bismuth (Bi)	mg/kg	<2	<2	<2	<2
Boron (B)	mg/kg	<5	<5	<5	<5
Cadmium (Cd)	mg/kg	<0.3	<0.3	<0.3	<0.3
Chromium (Cr)	mg/kg	13	9	17	20
Cobalt (Co)	mg/kg	4	2	6	27
Copper (Cu)	mg/kg	8	5	6	25
Iron (Fe)	mg/kg	25000	17000	33000	50000
Lead (Pb)	mg/kg	36	30	16	4.6
Lithium (Li)	mg/kg	3	2	9	12
Manganese (Mn)	mg/kg	600	200	910	1400
Molybdenum (Mo)	mg/kg	<2	<2	<2	<2
Nickel (Ni)	mg/kg	5	4	9	22
Rubidium (Rb)	mg/kg	4	3	6	<2
Selenium (Se)	mg/kg	<2	<2	<2	<2
Silver (Ag)	mg/kg	<0.5	<0.5	<0.5	<0.5
Strontium (Sr)	mg/kg	5	7	<5	81
Thallium (Tl)	mg/kg	0.1	0.1	<0.1	0.2
Tin (Sn)	mg/kg	<2	<2	<2	<2
Uranium (U)	mg/kg	0.3	0.3	0.3	0.2
Vanadium (V)	mg/kg	54	32	58	84
Zinc (Zn)	mg/kg	33	27	48	78
TOC (g/kg)[a]	g/kg	190	NA	NA	NA
pH[a]	NA	4.8	NA	NA	NA

Notes:
NA = not applicable
Soil pH is unitless.
Data collected by LGL, 2010.
a TOC and pH data collected by LGL (2011). This sample was collected during the small mammal survey study.

Table D-5 Summary Statistics for A Layer (0 to 5 cm) Soil Chemistry Data from the Principal Sampling Area (0 to 7 km) (2009)

Element	Units	Max	Min	Arithmetic Mean	Median	95th%ile
Aluminum (Al)	mg/kg	44000	2900	16231	14000	32000
Antimony (Sb)	mg/kg	14	<2	2.39	2	4
Arsenic (As)	mg/kg	310	<2	32.8	15	98
Barium (Ba)	mg/kg	300	6	95.8	83	220
Beryllium (Be)	mg/kg	2	<2	2	2	2
Bismuth (Bi)	mg/kg	<2	<2	<2	<2	<2
Boron (B)	mg/kg	6	<5	5.03	5	5
Cadmium (Cd)	mg/kg	7.2	<0.3	1.70	1	5.9
Chromium (Cr)	mg/kg	140	7	39.7	29	100
Cobalt (Co)	mg/kg	78	2	11.6	9	23
Copper (Cu)	mg/kg	77	4	18.7	15	38
Iron (Fe)	mg/kg	89000	4600	29792	29000	49000
Lead (Pb)	mg/kg	740	10	110	73	340
Lithium (Li)	mg/kg	48	<2	14.4	14	30
Manganese (Mn)	mg/kg	5900	53	1128	450	4300
Molybdenum (Mo)	mg/kg	8	<2	2.23	2	4
Nickel (Ni)	mg/kg	89	6	25.1	20	66
Rubidium (Rb)	mg/kg	15	<2	7.31	8	14
Selenium (Se)	mg/kg	4	<2	2.05	2	2
Silver (Ag)	mg/kg	1.7	<0.5	0.63	0.5	1.1
Strontium (Sr)	mg/kg	45[a]	<5	12.6	8	50
Thallium (Tl)	mg/kg	1.5	<0.1	0.38	0.3	0.9
Tin (Sn)	mg/kg	26	<2	2.70	2	5
Uranium (U)	mg/kg	5.1	<0.1	0.65	0.3	2.4
Vanadium (V)	mg/kg	510	14	75.4	60	150
Zinc (Zn)	mg/kg	1800	17	154	94	360
TOC	g/kg	61	24	41.4	32	60.7
pH	NA	6.02	4.15	5.10	4.97	5.86

Notes:

N=61 for soil metals data; N=7for soil pH and TOC data; NA = not applicable as soil pH is unitless.

a Highest measured concentration that was quantifiable. In some samples, the RDL (reported detection limit) was elevated and was the highest value reported. However, such values are not true maxima.

Data collected by CRA, 2009.

Table D-6 Summary Statistics for B Layer (5 to 15 cm) Soil Chemistry Data from the Principal Sampling Area (0 – 7 km) (2009)

Element	Units	Max	Min	Arithmetic Mean	Median	95th%ile
Aluminum (Al)	mg/kg	43000	10000	19500	18500	39200
Antimony (Sb)	mg/kg	<2	<2	<2	<2	<2
Arsenic (As)	mg/kg	120	3	26.4	16.5	77.25
Barium (Ba)	mg/kg	390	26	90.3	65.5	200
Beryllium (Be)	mg/kg	<2	<2	<2	<2	<2
Bismuth (Bi)	mg/kg	<2	<2	<2	<2	<2
Boron (B)	mg/kg	5	<5	5	5	5
Cadmium (Cd)	mg/kg	4	<0.3	0.86	0.5	3.81
Chromium (Cr)	mg/kg	120	22	43.8	43	61.1
Cobalt (Co)	mg/kg	34	2	12.4	11	18.8
Copper (Cu)	mg/kg	80	5	18.6	14	37.25
Iron (Fe)	mg/kg	83000	5500	34925	34500	56400
Lead (Pb)	mg/kg	110	13	34.3	27	65.35
Lithium (Li)	mg/kg	36	6	21.3	21	34.1
Manganese (Mn)	mg/kg	3700	210	770	475	2370
Molybdenum (Mo)	mg/kg	6	<2	2.4	2	5.05
Nickel (Ni)	mg/kg	53	15	29.7	27	49.2
Rubidium (Rb)	mg/kg	13	3	6.85	7	11.1
Selenium (Se)	mg/kg	8	<2	2.3	2	2.3
Silver (Ag)	mg/kg	1	<0.5	0.55	0.5	0.715
Strontium (Sr)	mg/kg	60	<5	12	6	50.5
Thallium (Tl)	mg/kg	0.3	<0.1	0.15	0.1	0.3
Tin (Sn)	mg/kg	<2	<2	<2	<2	<2
Uranium (U)	mg/kg	7.9	0.2	1.01	0.5	2.865
Vanadium (V)	mg/kg	210	27	72.1	58.5	124.5
Zinc (Zn)	mg/kg	600	45	128	80.5	457.5

Notes:
N=20 for soil metals data.
Data collected by CRA, 2009.

Table D-7 Summary Statistics for C Layer (15 to 30 cm) Soil Chemistry Data from the Principal Sampling Area (0 – 7 km) (2009)

Element	Units	Max	Min	Arithmetic Mean	Median	95th%ile
Aluminum (Al)	mg/kg	40000	9600	22430	22500	37150
Antimony (Sb)	mg/kg	2	<2	2	2	2
Arsenic (As)	mg/kg	180	2	36.4	18.5	171
Barium (Ba)	mg/kg	600	22	90.1	53.5	154
Beryllium (Be)	mg/kg	3	<2	2.05	2	2.05
Bismuth (Bi)	mg/kg	<2	<2	<2	<2	<2
Boron (B)	mg/kg	<5	<5	<5	<5	<5
Cadmium (Cd)	mg/kg	2.7	<0.3	0.57	0.3	2.04
Chromium (Cr)	mg/kg	180	19	53.2	48	85
Cobalt (Co)	mg/kg	49	8	15.4	14	20.5
Copper (Cu)	mg/kg	86	4	20.3	17	34.7
Iron (Fe)	mg/kg	92000	15000	36300	35500	51150
Lead (Pb)	mg/kg	69	7.7	24.53	19.5	59.5
Lithium (Li)	mg/kg	38	14	25.1	23.5	36.1
Manganese (Mn)	mg/kg	5500	200	748	505	931
Molybdenum (Mo)	mg/kg	8	<2	2.7	2	7.05
Nickel (Ni)	mg/kg	60	22	41.4	42	55.3
Rubidium (Rb)	mg/kg	12	3	6.5	6	11.1
Selenium (Se)	mg/kg	5	<2	2.15	2	2.15
Silver (Ag)	mg/kg	1.3	<0.5	0.56	0.5	0.83
Strontium (Sr)	mg/kg	23[a]	<5	8.95	5.5	24.4
Thallium (Tl)	mg/kg	0.3	<0.1	0.13	0.1	0.21
Tin (Sn)	mg/kg	<2	<2	<2	<2	<2
Uranium (U)	mg/kg	9.4	0.1	1.01	0.5	2.75
Vanadium (V)	mg/kg	190	25	64.7	52	124
Zinc (Zn)	mg/kg	540	35	131	73	445

Notes:

N=20 for soil metals data.

a Highest measured concentration that was quantifiable. In some samples, the RDL (reported detection limit) was elevated and was the highest value reported. However, such values are not true maxima.

Data collected by CRA, 2009.

Table D-8 Summary Statistics for A Layer (0 to 5 cm) Supplemental Soil Chemistry Data Collected Within the ERA Study Boundary (0 to 2 km; 2010)

Element	Units	Max	Min	Arithmetic Mean	Median	95th%ile
Aluminum (Al)	mg/kg	16000	1900	9906	12000	14400
Antimony (Sb)	mg/kg	11	<2	3.7	3	8.6
Arsenic (As)	mg/kg	50	5	21	19	42
Barium (Ba)	mg/kg	230	22	85	66	182
Beryllium (Be)	mg/kg	<2	<2	<2	<2	<2
Bismuth (Bi)	mg/kg	7	<2	2.5	2	5.4
Boron (B)	mg/kg	6	<5	<5	<5	5.2
Cadmium (Cd)	mg/kg	16	1	5.0	3.1	10.64
Chromium (Cr)	mg/kg	31	6	21	23	31
Cobalt (Co)	mg/kg	17	1	7.6	8	13
Copper (Cu)	mg/kg	99	6	29	25	54.2
Iron (Fe)	mg/kg	39000	3100	22594	24000	32600
Lead (Pb)	mg/kg	1600	51	395	180	1200
Lithium (Li)	mg/kg	19	<2	12	14	18.2
Manganese (Mn)	mg/kg	1300	56	581	540	1300
Molybdenum (Mo)	mg/kg	<2	<2	<2	<2	<2
Nickel (Ni)	mg/kg	37	4	17	18	30.6
Rubidium (Rb)	mg/kg	11	<2	7.6	8	10.2
Selenium (Se)	mg/kg	<2	<2	<2	<2	<2
Silver (Ag)	mg/kg	2.9	<0.5	0.82	0.5	2.1
Strontium (Sr)	mg/kg	48[a]	<5	13	6	48.4
Thallium (Tl)	mg/kg	6.2	0.3	1.8	1	6.04
Tin (Sn)	mg/kg	10	<2	3.2	2	7.6
Uranium (U)	mg/kg	9	0.2	1	0.6	2.44
Vanadium (V)	mg/kg	72	17	46	45	63.2
Zinc (Zn)	mg/kg	480	35	184	140	448
TOC	g/kg	130	40	73	72	121
pH	NA	5.7	4.2	5.2	5.5	5.7

Notes:

N=17 for soil metals data; NA = not applicable; Soil pH is unitless.

Data collected by LGL, 2010.

a Highest measured concentration that was quantifiable. In some samples, the RDL (reported detection limit) was elevated and was the highest value reported. However, such values are not true maxima.

b TOC and pH data collected by LGL (2011). Five samples were collected within the Study boundary by LGL (2011) as part of the small mammal survey study, which were analyzed for TOC and pH.

D-1.2 Freshwater Aquatic Analytical Results

Table D-9 Reference Area (Armstrong Brook) Sediment Chemistry Data (2010)

Metals	Units	ARMSTRONG -SED-1 (SED)	ARMSTRONG -SED-2 (SED)	ARMSTRONG -SED-3 (SED)	ARMSTRONG -SED-4 (SED)	ARMSTRONG -SED-5 (SED)
Aluminum (Al)	mg/kg	7700	13000	12000	11000	7200
Antimony (Sb)	mg/kg	<2	<2	<2	<2	<2
Arsenic (As)	mg/kg	8	9	12	10	8
Barium (Ba)	mg/kg	39	150	100	160	210
Beryllium (Be)	mg/kg	<2	<2	<2	<2	<2
Bismuth (Bi)	mg/kg	<2	<2	<2	<2	<2
Boron (B)	mg/kg	<5	<5	<5	<5	<5
Cadmium (Cd)	mg/kg	<0.3	0.7	0.7	0.4	0.8
Chromium (Cr)	mg/kg	14	26	27	26	15
Cobalt (Co)	mg/kg	8	15	17	18	12
Copper (Cu)	mg/kg	9	18	22	18	11
Iron (Fe)	mg/kg	19000	30000	34000	36000	23000
Lead (Pb)	mg/kg	27	31	73	23	26
Lithium (Li)	mg/kg	14	19	19	14	8
Manganese (Mn)	mg/kg	420	2100	1400	2300	3000
Molybdenum (Mo)	mg/kg	<2	<2	<2	<2	<2
Nickel (Ni)	mg/kg	20	44	48	55	26
Rubidium (Rb)	mg/kg	5	9	7	8	8
Selenium (Se)	mg/kg	<2	<2	<2	<2	<2
Silver (Ag)	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Strontium (Sr)	mg/kg	20	15	12	11	15
Thallium (Tl)	mg/kg	<0.1	0.2	0.1	0.1	0.2
Tin (Sn)	mg/kg	<2	<2	2	<2	<2
Uranium (U)	mg/kg	0.3	0.6	0.4	0.3	0.4
Vanadium (V)	mg/kg	28	31	32	29	19
Zinc (Zn)	mg/kg	62	110	230	130	110

Notes:
N=5.
Data collected by CRA, 2010.

Table D-10 Reference Area (Armstrong Brook) Sediment Chemistry Data (2011)

Metals	Units	ARMSTRONG -SED-1 (SED)	ARMSTRONG -SED-2 (SED)	ARMSTRONG -SED-3 (SED)	ARMSTRONG -SED-4 (SED)	ARMSTRONG -SED-5 (SED)
Aluminum (Al)	mg/kg	13000	17000	19000	15000	11000
Antimony (Sb)	mg/kg	<2	<2	<2	<2	<2
Arsenic (As)	mg/kg	11	9	10	12	10
Barium (Ba)	mg/kg	48	100	88	150	130
Beryllium (Be)	mg/kg	<2	<2	<2	<2	<2
Bismuth (Bi)	mg/kg	<2	<2	<2	<2	<2
Boron (B)	mg/kg	<5	<5	<5	<5	<5
Cadmium (Cd)	mg/kg	<0.3	0.3	<0.3	0.4	0.4
Chromium (Cr)	mg/kg	22	32	39	39	23
Cobalt (Co)	mg/kg	10	19	17	23	15
Copper (Cu)	mg/kg	10	17	22	24	14
Iron (Fe)	mg/kg	21000	42000	35000	54000	38000
Lead (Pb)	mg/kg	23	21	25	25	21
Lithium (Li)	mg/kg	20	23	27	20	13
Manganese (Mn)	mg/kg	610	1300	1000	1900	2000
Molybdenum (Mo)	mg/kg	<2	<2	<2	<2	<2
Nickel (Ni)	mg/kg	28	59	50	78	36
Rubidium (Rb)	mg/kg	10	8	8	11	8
Selenium (Se)	mg/kg	<2	<2	<2	<2	<2
Silver (Ag)	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5
Strontium (Sr)	mg/kg	19	11	11	14	14
Thallium (Tl)	mg/kg	0.1	0.1	0.1	0.2	0.2
Tin (Sn)	mg/kg	<2	<2	<2	<2	<2
Uranium (U)	mg/kg	0.4	0.4	0.6	0.5	0.4
Vanadium (V)	mg/kg	32	40	53	44	34
Zinc (Zn)	mg/kg	63	100	110	170	260

Notes:
N=5.
Data collected by CRA, 2011.

Table D-11 Summary Statistics for Sediment Chemistry Data Collected from Hendry Brook and Unnamed Brook (2010)

Element	Units	Max	Min	Arithmetic Mean	Median	95th%ile
Aluminum (Al)	mg/kg	26000	8300	17367	17000	25200
Antimony (Sb)	mg/kg	5	<2	2.6	2	4.6
Arsenic (As)	mg/kg	43	5	18.1	16	35.4
Barium (Ba)	mg/kg	1600	69	292	140	1032
Beryllium (Be)	mg/kg	<2	<2	<2	<2	<2
Bismuth (Bi)	mg/kg	<2	<2	<2	<2	<2
Boron (B)	mg/kg	<5	<5	<5	<5	<5
Cadmium (Cd)	mg/kg	4.4	0.3	1.66	1.5	3.76
Chromium (Cr)	mg/kg	66	22	37.1	30	60
Cobalt (Co)	mg/kg	34	10	16.6	14	29.2
Copper (Cu)	mg/kg	39	5	21.2	21	33.4
Iron (Fe)	mg/kg	75000	21000	33222	28000	61800
Lead (Pb)	mg/kg	160	6.9	81.1	85	160
Lithium (Li)	mg/kg	51	14	26.2	23	44.2
Manganese (Mn)	mg/kg	26000	390	3817	920	16560
Molybdenum (Mo)	mg/kg	2	<2	2	2	2
Nickel (Ni)	mg/kg	49	29	39.6	37	48.6
Rubidium (Rb)	mg/kg	11	5	8.33	9	10.6
Selenium (Se)	mg/kg	2	<2	2	2	2
Silver (Ag)	mg/kg	0.6	<0.5	0.51	0.5	0.56
Strontium (Sr)	mg/kg	39	<5	13.8	11	31
Thallium (Tl)	mg/kg	1.4	0.1	0.46	0.4	1.08
Tin (Sn)	mg/kg	7	<2	2.8	2	5.4
Uranium (U)	mg/kg	1.1	0.2	0.62	0.7	0.98
Vanadium (V)	mg/kg	80	37	46.6	41	69.6
Zinc (Zn)	mg/kg	760	74	257	190	580

Notes:
N=9.
Data collected by CRA, 2010.

Table D-12 Summary Statistics for Sediment Chemistry Data Collected from Hendry Brook and Unnamed Brook (2011)

Element	Units	Max	Min	Arithmetic Mean	Median	95th%ile
Aluminum (Al)	mg/kg	8300	32000	20900	19500	31100
Antimony (Sb)	mg/kg	<2	5	2.3	2	3.65
Arsenic (As)	mg/kg	5	54	25.8	24.5	45.45
Barium (Ba)	mg/kg	45	1800	284.6	119.5	1075.5
Beryllium (Be)	mg/kg	<2	<2	<2	<2	<2
Bismuth (Bi)	mg/kg	<2	<2	<2	<2	<2
Boron (B)	mg/kg	<5	<5	<5	<5	<5
Cadmium (Cd)	mg/kg	0.3	4.4	1.47	1.1	3.4
Chromium (Cr)	mg/kg	22	82	45.5	37.5	75.7
Cobalt (Co)	mg/kg	10	34	19.1	18	28.15
Copper (Cu)	mg/kg	5	39	23.7	23.5	36.75
Iron (Fe)	mg/kg	21000	120000	47800	41000	89400
Lead (Pb)	mg/kg	6.9	160	69.3	52	145.5
Lithium (Li)	mg/kg	14	51	30.3	27	47.1
Manganese (Mn)	mg/kg	390	45000	6206	1750	26775
Molybdenum (Mo)	mg/kg	<2	3	2.1	<2	2.55
Nickel (Ni)	mg/kg	29	60	46.5	46.5	59.1
Rubidium (Rb)	mg/kg	5	15	8.6	7.5	13.65
Selenium (Se)	mg/kg	<2	<2	<2	<2	<2
Silver (Ag)	mg/kg	0.5	0.7	0.52	0.5	0.61
Strontium (Sr)	mg/kg	5	46	16.7	12	39.7
Thallium (Tl)	mg/kg	0.1	1.4	0.4	0.3	0.95
Tin (Sn)	mg/kg	2	8	2.7	2	5.75
Uranium (U)	mg/kg	0.2	1.1	0.54	0.5	0.755
Vanadium (V)	mg/kg	37	99	67.6	60.5	96.3
Zinc (Zn)	mg/kg	74	760	270	240	554

Notes:
N=10.
Data collected by CRA, 2011.

D-1.3 Surface Water

Table D-13 Reference Area (Armstrong Brook) Surface Water Chemistry Data; Total Recoverable Metals (2010)

Metals	Units	ARMSTRONG -SED-1 (WATER)	ARMSTRONG -SED-2 (WATER)	ARMSTRONG -SED-3 (WATER)	ARMSTRONG -SED-4 (WATER)	ARMSTRONG -SED-5 (WATER)
Aluminum (Al)	µg/L	29.3	107	181	89.5	347
Antimony (Sb)	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Arsenic (As)	µg/L	<1.0	<1.0	<1.0	1.0	1.1
Barium (Ba)	µg/L	38.8	34.9	35.5	40.4	55.7
Beryllium (Be)	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Bismuth (Bi)	µg/L	<2.0	<2.0	<2.0	<2.0	<2.0
Boron (B)	µg/L	22.0	6.4	6.9	6.6	5.1
Cadmium (Cd)	µg/L	<0.017	0.033	0.061	0.029	0.053
Calcium (Ca)	µg/L	28200	25500	25600	34200	32100
Chromium (Cr)	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Cobalt (Co)	µg/L	<0.40	<0.40	<0.40	<0.40	0.65
Copper (Cu)	µg/L	<2.0	<2.0	<2.0	<2.0	<2.0
Iron (Fe)	µg/L	251	432	531	1230	1680
Lead (Pb)	µg/L	<0.50	0.82	2.85	0.97	1.49
Magnesium (Mg)	µg/L	7210	4190	4270	6280	5790
Manganese (Mn)	µg/L	71.1	73.5	79.2	193	478
Molybdenum (Mo)	µg/L	<2.0	<2.0	<2.0	<2.0	<2.0
Nickel (Ni)	µg/L	<2.0	<2.0	<2.0	<2.0	<2.0
Phosphorus (P)	µg/L	<100	<100	<100	<100	<100
Potassium (K)	µg/L	1790	657	684	710	645
Selenium (Se)	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Silver (Ag)	µg/L	<0.10	<0.10	<0.10	<0.10	<0.10
Sodium (Na)	µg/L	33700	5930	6120	6910	4060
Strontium (Sr)	µg/L	91.4	65.6	67.1	71.1	65.5
Thallium (Tl)	µg/L	<0.10	<0.10	<0.10	<0.10	<0.10
Tin (Sn)	µg/L	<2.0	<2.0	<2.0	<2.0	<2.0
Titanium (Ti)	µg/L	<2.0	<2.0	2.1	<2.0	2.9
Uranium (U)	µg/L	<0.10	<0.10	<0.10	<0.10	<0.10
Vanadium (V)	µg/L	<2.0	<2.0	<2.0	<2.0	<2.0
Zinc (Zn)	µg/L	<5.0	6.6	9.1	5.8	9.2

Notes:
N=5.
Data collected by CRA, 2010.

Table D-14 Reference Area (Armstrong Brook) Surface Water Chemistry Data; Total Recoverable Metals (2011)

Metals	Units	ARMSTRONG -SED-1 (WATER)	ARMSTRONG -SED-2 (WATER)	ARMSTRONG -SED-3 (WATER)	ARMSTRONG -SED-4 (WATER)	ARMSTRONG -SED-5 (WATER)
Aluminum (Al)	µg/L	73.5	52.1	63.2	46.9	195
Antimony (Sb)	µg/L	<1	<1	<1	<1	<1
Arsenic (As)	µg/L	<1	<1	<1	<1	<1
Barium (Ba)	µg/L	30.7	25.7	25.7	30.7	36.7
Beryllium (Be)	µg/L	<1	<1	<1	<1	<1
Bismuth (Bi)	µg/L	<2	<2	<2	<2	<2
Boron (B)	µg/L	<50	<50	<50	<50	<50
Cadmium (Cd)	µg/L	<0.017	<0.017	<0.017	<0.017	<0.017
Calcium (Ca)	µg/L	23100	22100	21900	28000	28400
Chromium (Cr)	µg/L	<1	<1	<1	<1	<1
Cobalt (Co)	µg/L	<0.4	<0.4	<0.4	<0.4	<0.4
Copper (Cu)	µg/L	<2	<2	<2	<2	<2
Iron (Fe)	µg/L	226	230	233	444	543
Lead (Pb)	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Magnesium (Mg)	µg/L	3900	3790	3670	5600	5500
Manganese (Mn)	µg/L	34.7	25.3	27.8	45.7	87.0
Molybdenum (Mo)	µg/L	<2	<2	<2	<2	<2
Nickel (Ni)	µg/L	<2	<2	<2	<2	<2
Phosphorus (P)	µg/L	<100	<100	<100	<100	<100
Potassium (K)	µg/L	633	471	449	531	513
Selenium (Se)	µg/L	<1	<1	<1	<1	<1
Silver (Ag)	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Sodium (Na)	µg/L	7210	4790	4630	5430	3830
Strontium (Sr)	µg/L	53.5	48.7	46.9	49.5	49.4
Thallium (Tl)	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Tin (Sn)	µg/L	<2	<2	<2	<2	<2
Titanium (Ti)	µg/L	3.3	<2	<2	<2	<2
Uranium (U)	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium (V)	µg/L	<2	<2	<2	<2	<2
Zinc (Zn)	µg/L	<5	<5	<5	<5	<5

Notes:
N=5.
Data collected by CRA, 2011.

Table D-15 Reference Area (Armstrong Brook) Surface Water Chemistry Data; Dissolved Metals (2010)

Metals	Units	ARMSTRONG -SED-1 (WATER)	ARMSTRONG -SED-2 (WATER)	ARMSTRONG -SED-3 (WATER)	ARMSTRONG -SED-4 (WATER)	ARMSTRONG -SED-5 (WATER)
Aluminum (Al)	µg/L	17	32	31	16	24
Antimony (Sb)	µg/L	<1	<1	<1	<1	<1
Arsenic (As)	µg/L	<1	<1	<1	<1	<1
Barium (Ba)	µg/L	37	31	31	34	40
Beryllium (Be)	µg/L	<1	<1	<1	<1	<1
Bismuth (Bi)	µg/L	<2	<2	<2	<2	<2
Boron (B)	µg/L	22	6	5	6	<5
Cadmium (Cd)	µg/L	<0.02	<0.02	0.02	<0.02	<0.02
Calcium (Ca)	µg/L	29000	25000	25000	33000	32000
Chromium (Cr)	µg/L	<1	<1	<1	<1	<1
Cobalt (Co)	µg/L	<0.4	<0.4	<0.4	<0.4	<0.4
Copper (Cu)	µg/L	<2	<2	<2	<2	<2
Iron (Fe)	µg/L	200	260	260	850	600
Lead (Pb)	µg/L	<0.5	<0.5	0.8	0.7	0.5
Magnesium (Mg)	µg/L	7600	4200	4200	6200	6000
Manganese (Mn)	µg/L	64	38	32	62	140
Molybdenum (Mo)	µg/L	<2	<2	<2	<2	<2
Nickel (Ni)	µg/L	<2	<2	<2	<2	<2
Potassium (K)	µg/L	1700	600	630	670	630
Selenium (Se)	µg/L	<1	<1	<1	<1	<1
Silver (Ag)	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Sodium (Na)	µg/L	35000	6100	6100	7000	4300
Strontium (Sr)	µg/L	89	62	61	65	63
Thallium (Tl)	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Tin (Sn)	µg/L	<2	<2	<2	<2	<2
Titanium (Ti)	µg/L	<2	<2	<2	<2	<2
Uranium (U)	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium (V)	µg/L	<2	<2	<2	<2	<2
Zinc (Zn)	µg/L	<5	<5	11	<5	<5

Notes:
N=5.
Data collected by CRA, 2010.

Table D-16 Reference Area (Armstrong Brook) Surface Water Chemistry Data; Dissolved Metals (2011)

Metals	Units	ARMSTRONG -SED-1 (WATER)	ARMSTRONG -SED-2 (WATER)	ARMSTRONG -SED-3 (WATER)	ARMSTRONG -SED-4 (WATER)	ARMSTRONG -SED-5 (WATER)
Aluminum (Al)	µg/L	20.6	18.3	19.3	17.2	14.3
Antimony (Sb)	µg/L	<1	<1	<1	<1	<1
Arsenic (As)	µg/L	<1	<1	<1	<1	<1
Barium (Ba)	µg/L	29.1	24.6	24.8	29	35.0
Beryllium (Be)	µg/L	<1	<1	<1	<1	<1
Bismuth (Bi)	µg/L	<2	<2	<2	<2	<2
Boron (B)	µg/L	<50	<50	<50	<50	<50
Cadmium (Cd)	µg/L	<0.017	<0.017	<0.017	<0.017	<0.017
Calcium (Ca)	µg/L	23100	22400	22100	28100	29900
Chromium (Cr)	µg/L	<1	<1	<1	<1	1.6
Cobalt (Co)	µg/L	<0.4	<0.4	<0.4	<0.4	<0.4
Copper (Cu)	µg/L	<2	<2	<2	<2	<2
Iron (Fe)	µg/L	164	177	176	374	214
Lead (Pb)	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Magnesium (Mg)	µg/L	3810	3780	3740	5660	5880
Manganese (Mn)	µg/L	29.8	16.9	19.4	34.4	59.5
Molybdenum (Mo)	µg/L	<2	<2	<2	<2	<2
Nickel (Ni)	µg/L	<2	<2	<2	<2	<2
Potassium (K)	µg/L	575	448	553	513	472
Selenium (Se)	µg/L	<1	<1	<1	<1	<1
Silver (Ag)	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Sodium (Na)	µg/L	7520	5100	5110	5600	4210
Strontium (Sr)	µg/L	50.9	47.6	46.0	48.2	50.2
Thallium (Tl)	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Tin (Sn)	µg/L	<2	<2	<2	<2	<2
Titanium (Ti)	µg/L	<2	<2	<2	<2	<2
Uranium (U)	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium (V)	µg/L	<2	<2	<2	<2	<2
Zinc (Zn)	µg/L	<5	<5	6.9	<5	<5

Notes:
N=5.
Data collected by CRA, 2011.

Table D-17 Summary Statistics for Surface Water Chemistry Data Collected from Hendry Brook and Unnamed Brook; Total Recoverable Metals (2010)

Element	Units	Max	Min	Arithmetic Mean	Median	95th%ile
Aluminum (Al)	µg/L	139.0	5.7	68.1	70.5	137.8
Antimony (Sb)	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Arsenic (As)	µg/L	1.8	<1.0	1.2	1.1	1.68
Barium (Ba)	µg/L	151.0	21.5	54.6	34.5	135
Beryllium (Be)	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Bismuth (Bi)	µg/L	<2.0	<2.0	<2.0	<2.0	<2.0
Boron (B)	µg/L	16.1	5.1	7.9	6.6	14.02
Cadmium (Cd)	µg/L	0.1	0.03	0.048	0.04	0.081
Calcium (Ca)	µg/L	134000	16800	39356	23100	107800
Chromium (Cr)	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Cobalt (Co)	µg/L	<0.4	<0.4	<0.4	<0.4	<0.4
Copper (Cu)	µg/L	2.4	<2.0	2.0	2.0	2.24
Iron (Fe)	µg/L	482	76.0	150.8	109.0	355.6
Lead (Pb)	µg/L	4.7	<0.5	1.4	1.0	3.42
Magnesium (Mg)	µg/L	6630	1530	2668	1850	5482
Manganese (Mn)	µg/L	3880	13.8	507.5	41.7	2500
Molybdenum (Mo)	µg/L	<2.0	<2.0	<2.0	<2.0	<2.0
Nickel (Ni)	µg/L	<2.0	<2.0	<2.0	<2.0	<2.0
Phosphorus (P)	µg/L	<100	<100	<100	<100	<100
Potassium (K)	µg/L	2830	372	949.9	553	2410
Selenium (Se)	µg/L	<1.0	<1.0	<1.0	<1.0	<1
Silver (Ag)	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Sodium (Na)	µg/L	18800	7160	11098	10000	17320
Strontium (Sr)	µg/L	311	38.3	97.1	56.8	253.8
Thallium (Tl)	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Tin (Sn)	µg/L	<2.0	<2.0	<2.0	<2.0	<2.0
Titanium (Ti)	µg/L	2.9	<2.0	2.1	2.0	2.54
Uranium (U)	µg/L	0.24	<0.1	0.1	0.1	0.22
Vanadium (V)	µg/L	<2.0	<2.0	<2.0	<2.0	<2.0
Zinc (Zn)	µg/L	33.8	<5.0	9.6	6.3	24.5

Notes:
N=9.
Data collected by CRA, 2010.

Table D-18 Summary Statistics for Surface Water Chemistry Data Collected from Hendry Brook and Unnamed Brook; Total Recoverable Metals (2011)

Metals	Units	ARMSTRONG -SED-1 (WATER)	ARMSTRONG -SED-2 (WATER)	ARMSTRONG -SED-3 (WATER)	ARMSTRONG -SED-4 (WATER)	ARMSTRONG -SED-5 (WATER)
Aluminum (Al)	µg/L	354.0	18.0	104.9	64.1	327.45
Antimony (Sb)	µg/L	<1	<1	<1	<1	<1
Arsenic (As)	µg/L	1.4	<1	1.1	<1	1.31
Barium (Ba)	µg/L	174.0	18.0	64.9	29.6	166.8
Beryllium (Be)	µg/L	<1	<1	<1	<1	<1
Bismuth (Bi)	µg/L	<2	<2	<2	<2	<2
Boron (B)	µg/L	<50	<50	<50	<50	<50
Cadmium (Cd)	µg/L	0.0610	0.0170	0.0273	0.0240	0.0480
Calcium (Ca)	µg/L	133000.0	11600.0	39710.0	20400.0	107530
Chromium (Cr)	µg/L	<1	<1	<1	<1	<1
Cobalt (Co)	µg/L	0.53	<0.4	0.4	0.4	0.5255
Copper (Cu)	µg/L	<2	<2	<2	<2	<2
Iron (Fe)	µg/L	1450.0	<50	355.8	166.0	1198.9
Lead (Pb)	µg/L	1.5	<0.5	0.6	<0.5	1.126
Magnesium (Mg)	µg/L	6400.0	1170.0	2506.0	1735.0	5275
Manganese (Mn)	µg/L	5370.0	5.5	727.1	26.7	3718.5
Molybdenum (Mo)	µg/L	<2	<2	<2	<2	<2
Nickel (Ni)	µg/L	<2	<2	<2	<2	<2
Potassium (K)	µg/L	100.0	100.0	100.0	100.0	100
Selenium (Se)	µg/L	2480.0	143.0	837.5	509.0	2048
Silver (Ag)	µg/L	<1	<1	<1	<1	<1
Sodium (Na)	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Strontium (Sr)	µg/L	16200.0	6560.0	9399.0	8345.0	15075
Thallium (Tl)	µg/L	285.0	27.9	88.5	44.9	230.1
Tin (Sn)	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Titanium (Ti)	µg/L	<2	<2	<2	<2	<2
Uranium (U)	µg/L	6.3	<2	3.1	2.0	6.075
Vanadium (V)	µg/L	<2.0	<0.1	<0.1	<0.1	<0.1655
Zinc (Zn)	µg/L	<2	<2	<2	<2	<2

Notes:
N=5.
Data collected by CRA, 2011.

Table D-19 Summary Statistics for Surface Water Chemistry Data Collected from Hendry Brook and Unnamed Brook; Dissolved Metals (2010)

Element	Units	Max	Min	Arithmetic Mean	Median	95th%ile
Aluminum (Al)	µg/L	91	5	32. 9	35	71
Antimony (Sb)	µg/L	<1	<1	<1	<1	<1
Arsenic (As)	µg/L	1	<1	1	1	1
Barium (Ba)	µg/L	150	20	50. 9	33	128
Beryllium (Be)	µg/L	<1	<1	<1	<1	<1
Bismuth (Bi)	µg/L	<2	<2	<2	<2	<2
Boron (B)	µg/L	13	5	8.3	8	12.6
Cadmium (Cd)	µg/L	0.06	0.02	0.036	0.04	0.052
Calcium (Ca)	µg/L	140000	15000	39444	22000	113200
Chromium (Cr)	µg/L	<1	<1	<1	<1	<1
Cobalt (Co)	µg/L	<0.4	<0.4	<0.4	<0.4	<0.4
Copper (Cu)	µg/L	<2	<2	<2	<2	<2
Iron (Fe)	µg/L	250	<50	91	71	194
Lead (Pb)	µg/L	1.2	<0.5	0.8	0.9	1.12
Magnesium (Mg)	µg/L	7400	1400	2744	1800	6080
Manganese (Mn)	µg/L	3200	6	415	22	2080
Molybdenum (Mo)	µg/L	<2	<2	<2	<2	<2
Nickel (Ni)	µg/L	<2	<2	<2	<2	<2
Potassium (K)	µg/L	3200	240	9656	510	2680
Selenium (Se)	µg/L	<1	<1	<1	<1	<1
Silver (Ag)	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Sodium (Na)	µg/L	17000	7900	10844	9800	16200
Strontium (Sr)	µg/L	320	35	94. 6	51	260
Thallium (Tl)	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Tin (Sn)	µg/L	<2	<2	<2	<2	<2
Titanium (Ti)	µg/L	<2	<2	<2	<2	<2
Uranium (U)	µg/L	0.2	<0.1	0.11	0.1	0.16
Vanadium (V)	µg/L	<2	<2	<2	<2	<2
Zinc (Zn)	µg/L	7	<5	5.3	5	6.6

Notes:
N=9.
Data collected by CRA, 2010.

Table D-20 Summary Statistics for Surface Water Chemistry Data Collected from Hendry Brook and Unnamed Brook; Dissolved Metals (2011)

Metals	Units	ARMSTRONG -SED-1 (WATER)	ARMSTRONG -SED-2 (WATER)	ARMSTRONG -SED-3 (WATER)	ARMSTRONG -SED-4 (WATER)	ARMSTRONG -SED-5 (WATER)
Aluminum (Al)	µg/L	72.3	7.4	33.2	35.7	70.86
Antimony (Sb)	µg/L	<1	<1	<1	<1	<1
Arsenic (As)	µg/L	1.1	<1	1.0	<1	<1
Barium (Ba)	µg/L	154.0	17.1	60.9	28.2	152.65
Beryllium (Be)	µg/L	<1	<1	<1	<1	<1
Bismuth (Bi)	µg/L	<2	<2	<2	<2	<2
Boron (B)	µg/L	<50	<50	<50	<50	<50
Cadmium (Cd)	µg/L	0.0570	0.0170	0.0268	0.0235	0.0476
Calcium (Ca)	µg/L	132000.0	12100.0	39460.0	20250.0	106395
Chromium (Cr)	µg/L	<1	<1	<1	<1	<1
Cobalt (Co)	µg/L	0.54	<0.4	0.42	<0.4	0.48
Copper (Cu)	µg/L	2.3	<2	2.0	<2	2.165
Iron (Fe)	µg/L	540.0	63.0	158.9	95.5	443.25
Lead (Pb)	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Magnesium (Mg)	µg/L	6680.0	1200.0	2532.0	1725.0	5451.5
Manganese (Mn)	µg/L	4920.0	3.3	684.5	22.7	3498
Molybdenum (Mo)	µg/L	<2	<2	<2	<2	<2
Nickel (Ni)	µg/L	2.9	<2	2.1	<2	2.495
Potassium (K)	µg/L	2450.0	125.0	830.8	478.5	2018
Selenium (Se)	µg/L	<1	<1	<1	<1	<1
Silver (Ag)	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Sodium (Na)	µg/L	17000.0	6970.0	9974.0	8735.0	16145
Strontium (Sr)	µg/L	276.0	26.5	85.7	43.1	223.35
Thallium (Tl)	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Tin (Sn)	µg/L	<2	<2	<2	<2	<2
Titanium (Ti)	µg/L	<2	<2	<2	<2	<2
Uranium (U)	µg/L	0.2	0.1	0.1	0.1	0.17
Vanadium (V)	µg/L	<2	<2	<2	<2	<2
Zinc (Zn)	µg/L	18.8	<5	7.1	5.6	14.48

Notes:
N=5.
Data collected by CRA, 2011.

D-1.4 Soil Invertebrate Analytical Results

Table D-21 Reference Area Soil Invertebrate Chemistry Data

Metals	Units	REF-4	COMPOSITE-REF-1, REF-2, & REF-3
Aluminum (Al)	mg/kg	49.3	382
Antimony (Sb)	mg/kg	<1.0	<0.50
Arsenic (As)	mg/kg	<1.0	<0.50
Barium (Ba)	mg/kg	24.3	107
Beryllium (Be)	mg/kg	<1.0	<0.50
Boron (B)	mg/kg	4.0	3.2
Cadmium (Cd)	mg/kg	0.46	6.86
Chromium (Cr)	mg/kg	<1.0	<0.50
Cobalt (Co)	mg/kg	<0.40	<0.20
Copper (Cu)	mg/kg	50.9	26.1
Iron (Fe)	mg/kg	115	405
Lead (Pb)	mg/kg	1.32	3.40
Lithium (Li)	mg/kg	<1.0	<0.50
Manganese (Mn)	mg/kg	61.8	2760
Molybdenum (Mo)	mg/kg	<1.0	<0.50
Nickel (Ni)	mg/kg	<1.0	<0.50
Selenium (Se)	mg/kg	<1.0	1.03
Silver (Ag)	mg/kg	<0.24	0.47
Strontium (Sr)	mg/kg	14.2	19.9
Thallium (Tl)	mg/kg	<0.040	0.111
Tin (Sn)	mg/kg	<1.0	0.54
Uranium (U)	mg/kg	<0.040	<0.020
Vanadium (V)	mg/kg	<1.0	0.79
Zinc (Zn)	mg/kg	164	247

Notes:
N=2 (as most pitfall traps had insufficient sample mass; compositing was necessary).
Data collected by LGL, 2010.

Table D-22 Soil Invertebrate Chemistry Data Collected Within the Study Boundary

Metals	Units	T1-1	COMPOSITE -T2-1, T3-1, T4-1, & T5-1	COMPOSITE -T1-2, T3-2, T4-2, & T5-2	COMPOSITE -T1-3 & T2-3	COMPOSITE -T3-3 & T4-3	COMPOSITE -T1-4, T2-4, & T3-4
Aluminum (Al)	mg/kg	306	85.4	511	1440	35.9	699
Antimony (Sb)	mg/kg	<0.50	1.65	0.52	1.54	<0.50	<0.50
Arsenic (As)	mg/kg	2.93	31.9	13.5	14.1	5.29	4.48
Barium (Ba)	mg/kg	29.7	21.6	27.1	38.6	3.6	10.6
Beryllium (Be)	mg/kg	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Boron (B)	mg/kg	5.1	7.5	3.6	3.9	2.1	3.6
Cadmium (Cd)	mg/kg	3.55	59.8	26.3	64.1	9.27	17.1
Chromium (Cr)	mg/kg	1.38	0.62	1.52	2.65	<0.50	1.09
Cobalt (Co)	mg/kg	0.48	0.37	0.73	1.38	<0.20	0.71
Copper (Cu)	mg/kg	60.5	55.4	19.6	42.1	14.5	28.3
Iron (Fe)	mg/kg	478	330	743	2240	107	1270
Lead (Pb)	mg/kg	0.96	254	395	116	4.52	18.8
Lithium (Li)	mg/kg	<0.50	<0.50	0.55	1.77	<0.50	0.62
Manganese (Mn)	mg/kg	28.2	71.0	108	92.9	20.1	329
Molybdenum (Mo)	mg/kg	<0.50	<0.50	<0.50	<0.50	0.50	<0.50
Nickel (Ni)	mg/kg	0.96	<0.50	0.88	2.55	<0.50	1.37
Selenium (Se)	mg/kg	2.70	2.79	4.72	4.05	2.46	1.33
Silver (Ag)	mg/kg	0.80	2.21	0.27	3.83	0.12	0.76
Strontium (Sr)	mg/kg	10.3	11.6	5.9	14.8	2.8	4.4
Thallium (Tl)	mg/kg	0.543	3.85	0.688	1.03	0.213	0.284
Tin (Sn)	mg/kg	2.31	3.07	2.44	<0.50	0.57	1.74
Uranium (U)	mg/kg	0.025	0.071	0.051	0.074	<0.020	0.021
Vanadium (V)	mg/kg	0.74	0.68	1.48	4.86	<0.50	1.95
Zinc (Zn)	mg/kg	332	1640	296	933	167	345

Notes:
N=6 (as most pitfall traps had insufficient sample mass; compositing was necessary).
Data collected by LGL, 2010.

D-1.5 SMALL MAMMAL TISSUE RESIDUE DATA

Table D-23 Whole Body, Liver and Kidney Metals Concentrations in Reference Area Small Mammals in 2011 (mg/kg ww)

		Whole Body	**Liver**		**Kidney**
Metals	**Units**	**REF-SOCI-BODY**	**REF-PEMA-LIVER**	**REF-MYGA-LIVER**	**MYGA-PEMA KIDNEY**
Aluminum (Al)	mg/kg	123	<2.5	<2.5	<2.5
Antimony (Sb)	mg/kg	<0.5	<0.5	<0.5	<0.5
Arsenic (As)	mg/kg	<0.5	<0.5	<0.5	<0.5
Barium (Ba)	mg/kg	3.9	<1.5	<1.5	<1.5
Beryllium (Be)	mg/kg	<0.5	<0.5	<0.5	<0.5
Boron (B)	mg/kg	<1.5	<1.5	<1.5	<1.5
Cadmium (Cd)	mg/kg	0.275	0.180	1.16	3.09
Chromium (Cr)	mg/kg	<0.5	<0.5	<0.5	<0.5
Cobalt (Co)	mg/kg	<0.2	<0.2	<0.2	<0.2
Copper (Cu)	mg/kg	3.29	4.78	4.76	5.21
Iron (Fe)	mg/kg	252	91	199	99
Lead (Pb)	mg/kg	5.67	<0.18	0.39	1.02
Lithium (Li)	mg/kg	<0.5	<0.5	<0.5	<0.5
Manganese (Mn)	mg/kg	120	2.62	3.75	2.03
Molybdenum (Mo)	mg/kg	<0.5	1.20	0.93	0.56
Nickel (Ni)	mg/kg	<0.5	<0.5	<0.5	<0.5
Selenium (Se)	mg/kg	0.65	0.53	0.62	1.14
Silver (Ag)	mg/kg	<0.12	<0.12	<0.12	<0.12
Strontium (Sr)	mg/kg	3.3	<1.5	<1.5	<1.5
Thallium (Tl)	mg/kg	0.098	<0.02	<0.02	0.058
Tin (Sn)	mg/kg	0.50	<0.5	<0.5	<0.5
Uranium (U)	mg/kg	<0.02	<0.02	<0.02	<0.02
Vanadium (V)	mg/kg	<0.5	<0.5	<0.5	<0.5
Zinc (Zn)	mg/kg	33.0	19.5	21.4	23.3

Table D-24 Whole Body, Liver and Kidney Metals Concentrations in Study Boundary Small Mammals in 2011 (mg/kg ww)

	Whole Body				**Liver**						**Kidney**	
Metals	**F-SOCI-Bodies**	**F-BLBR-Bodies**	**A-SOCI-Bodies**	**D-SOCI-Bodies**	**A-MIPE-Liver**	**A-PEMA-Liver**	**F-PEMA-Liver**	**G-MYGA-Liver**	**B-MYGA-PEMA Liver**	**F-BLBR-Liver**	**A-F-PEMA-MIPE Kidney**	**G-B-MYGA-PEMA Kidney**
Aluminum (Al)	101	23.1	33.5	132	<2.5	<2.5	<5	<2.5	<2.5	<2.5	<2.5	<2.5
Antimony (Sb)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1	<0.5	<0.5	<0.5	<0.5	<0.5
Arsenic (As)	0.91	2.81	1.08	1.06	<0.5	<0.5	<1	<0.5	<0.5	0.82	<0.5	<0.5
Barium (Ba)	4.5	2.3	2.6	3.7	<1.5	<1.5	<3	<1.5	<1.5	<1.5	<1.5	<1.5
Beryllium (Be)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1	<0.5	<0.5	<0.5	<0.5	<0.5
Boron (B)	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<3	<1.5	<1.5	<1.5	<1.5	<1.5
Cadmium (Cd)	2.89	0.885	2.65	2.41	1.44	1.28	<0.1	9.18	5.05	23.5	5.06	9.28
Chromium (Cr)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1	<0.5	<0.5	<0.5	<0.5	<0.5
Cobalt (Co)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.4	<0.2	<0.2	<0.2	<0.2	<0.2
Copper (Cu)	3.83	2.85	3.93	3.05	5.09	4.46	4.3	4.34	5.65	9.22	5.49	5.74
Iron (Fe)	169	64	139	182	243	118	87	177	148	442	102	95
Lead (Pb)	27.3	18.5	30.8	23.9	3.27	0.82	0.36	1.29	0.86	6.45	14.1	7.11
Lithium (Li)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1	<0.5	<0.5	<0.5	<0.5	<0.5
Manganese (Mn)	10.4	1.48	6.30	5.10	2.13	2.19	2.1	3.24	2.78	4.54	1.49	2.06
Molybdenum (Mo)	<0.5	<0.5	<0.5	<0.5	0.54	1.10	1.2	0.95	0.99	1.20	<0.5	<0.5
Nickel (Ni)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1	<0.5	<0.5	<0.5	<0.5	<0.5
Selenium (Se)	0.91	0.77	1.05	0.92	0.76	0.82	<1	0.69	0.60	2.11	3.60	1.27
Silver (Ag)	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.24	<0.12	<0.12	<0.12	<0.12	<0.12
Strontium (Sr)	3.8	1.9	1.9	2.4	<1.5	<1.5	<3	<1.5	<1.5	<1.5	<1.5	<1.5
Thallium (Tl)	1.56	1.40	4.11	1.24	1.43	0.270	0.081	0.155	0.220	1.32	3.73	1.12
Tin (Sn)	1.08	<0.5	2.94	0.66	<0.5	<0.5	<1	<0.5	<0.5	<0.5	<0.5	<0.5
Uranium (U)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.04	<0.02	<0.02	<0.02	<0.02	<0.02

Metals	Whole Body				Liver						Kidney	
	F-SOCI-Bodies	F-BLBR-Bodies	A-SOCI-Bodies	D-SOCI-Bodies	A-MIPE-Liver	A-PEMA-Liver	F-PEMA-Liver	G-MYGA-Liver	B-MYGA-PEMA Liver	F-BLBR-Liver	A-F-PEMA-MIPE Kidney	G-B-MYGA-PEMA Kidney
Vanadium (V)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1	<0.5	<0.5	<0.5	<0.5	<0.5
Zinc (Zn)	36.7	35.2	31.3	32.5	25.7	19.1	<16.5	25.5	24.6	39.4	21.0	26.8

Notes:
Units = mg/kg wet weight
Data collected by LGL Limited, 2011

Your Project #: 055453
Site: BELLEDUNE ECO
Your C.O.C. #: B 65302

Attention: Christine Moore
Intrinsik Environmental Sciences
5121 Sackville Street
Suite 506
Halifax, NS
CANADA B3J 1K1

Report Date: 2009/09/18

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: A9B8179
Received: 2009/09/09, 8:07

Sample Matrix: Soil
Samples Received: 16

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Metals Solid Avail. Unified MS - Nper	10	N/A	2009/09/17	ATL SOP 00024 R4	Based on EPA6020A
Metals Solid Avail. Unified MS - Nper	6	N/A	2009/09/18	ATL SOP 00024 R4	Based on EPA6020A
pH (5:1 DI Water Extract)	11	N/A	2009/09/18	ATL SOP 00005 R6	Based on EPA150.1
dry aqueous leach	11	N/A	2009/09/17	ATL SOP 00033	Based onCart.93 16.2
Total Organic Carbon in Soil	8	N/A	2009/09/15	ATL SOP 00044 R3/00045 R4	LECO 203-601-224
Total Organic Carbon in Soil	3	N/A	2009/09/16	ATL SOP 00044 R3/00045 R4	LECO 203-601-224

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
* Results relate only to the items tested.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

MICHELLE HILL, Project Manager
Email: Michelle.Hill.Reports@maxxamanalytics.com
Phone# (902) 420-0203

==
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. SCC and CALA have approved this reporting process and electronic report format.

For Service Group specific validation please refer to the Validation Signature Page

Total cover pages: 1

Maxxam Job #: A9B8179
Report Date: 2009/09/18

Intrinsik Environmental Sciences
Client Project #: 055453
Project name: BELLEDUNE ECO

RESULTS OF ANALYSES OF SOIL

Maxxam ID		DQ4349		DQ4353	DQ4354	DQ4355		DQ4356		DQ4357	DQ4358		DQ4359		
Sampling Date		2009/07/01		2009/07/01	2009/07/01	2009/07/01		2009/07/01		2009/07/01	2009/07/01		2009/07/01		
	Units	**S4A**	**RDL**	**S11A**	**S13A**	**S37A**	**RDL**	**S40A**	**RDL**	**S49A**	**S60A**	**RDL**	**R8A**	**RDL**	**QC Batch**
Charge/Prep Analysis															
Dry Mass to Volume Ratio	N/A	1:5	N/A	1:5	1:5	1:5	N/A	1:5	N/A	1:5	1:5	N/A	1:10	N/A	1942280
Inorganics															
Organic Carbon (TOC)	g/kg	28	0.5	24	32	60	0.3	53	0.5	31	61	0.4	230	2	1938046
Soluble (5:1) pH	pH	5.38	N/A	4.15	4.92	4.77	N/A	5.75	N/A	4.97	6.02	N/A	6.17	N/A	1943321

Maxxam ID		DQ4359			DQ4362	DQ4362		DQ4363		DQ4366		
Sampling Date		2009/07/01			2009/07/01	2009/07/01		2009/07/01		2009/07/01		
	Units	**R8A Lab-Dup**	**RDL**	**QC Batch**	**R13**	**R13 Lab-Dup**	**RDL**	**R20A**	**RDL**	**QA/QC-2**	**RDL**	**QC Batch**
Charge/Prep Analysis												
Dry Mass to Volume Ratio	N/A		N/A	1942280	1:5		N/A	1:10	N/A	1:5	N/A	1942280
Inorganics												
Organic Carbon (TOC)	g/kg	250	2	1938046	50	46	0.3	260	20	54	0.6	1940928
Soluble (5:1) pH	pH		N/A	1943321	4.53		N/A	4.17	N/A	5.50	N/A	1943321

N/A = Not Applicable
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Intrinsik Environmental Sciences
Maxxam Job #: A9B8179
Client Project #: 055453
Report Date: 2009/09/18
Project name: BELLEDUNE ECO

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		DQ4349	DQ4353		DQ4354		DQ4355	DQ4356		DQ4357		DQ4358		
Sampling Date		2009/07/01	2009/07/01		2009/07/01		2009/07/01	2009/07/01		2009/07/01		2009/07/01		
	Units	**S4A**	**S11A**	**RDL**	**S13A**	**RDL**	**S37A**	**S40A**	**RDL**	**S49A**	**RDL**	**S60A**	**RDL**	**QC Batch**
Metals														
Available Aluminum (Al)	mg/kg	21000	9600	10	21000	10	9700	11000	10	27000	10	44000	100	1942837
Available Antimony (Sb)	mg/kg	ND	ND	2	ND	2	ND	5	2	ND	2	ND	2	1942837
Available Arsenic (As)	mg/kg	7	10	2	15	2	10	27	2	20	2	49	2	1942837
Available Barium (Ba)	mg/kg	84	23	5	47	5	35	92	5	60	5	300	5	1942837
Available Beryllium (Be)	mg/kg	ND	ND	2	ND	2	ND	ND	2	ND	2	2	2	1942837
Available Bismuth (Bi)	mg/kg	ND	ND	2	ND	2	ND	ND	2	ND	2	ND	2	1942837
Available Boron (B)	mg/kg	ND	ND	5	ND	5	ND	ND	5	ND	5	ND	5	1942837
Available Cadmium (Cd)	mg/kg	0.4	ND	0.3	0.4	0.3	0.8	6.3	0.3	0.4	0.3	1.5	0.3	1942837
Available Chromium (Cr)	mg/kg	100	16	2	27	2	41	24	2	38	2	65	2	1942837
Available Cobalt (Co)	mg/kg	10	4	1	10	1	5	8	1	9	1	22	1	1942837
Available Copper (Cu)	mg/kg	8	6	2	11	2	12	32	2	14	2	34	2	1942837
Available Iron (Fe)	mg/kg	24000	24000	50	41000	500	28000	24000	50	43000	500	40000	50	1942837
Available Lead (Pb)	mg/kg	16	19	0.5	45	0.5	84	430	0.5	38	0.5	94	0.5	1942837
Available Lithium (Li)	mg/kg	22	4	2	18	2	8	14	2	25	2	22	2	1942837
Available Manganese (Mn)	mg/kg	360	210	2	890	2	150	410	2	360	2	5900	2	1942837
Available Molybdenum (Mo)	mg/kg	ND	ND	2	ND	2	ND	ND	2	ND	2	ND	2	1942837
Available Nickel (Ni)	mg/kg	34	9	2	16	2	25	22	2	27	2	66	2	1942837
Available Rubidium (Rb)	mg/kg	9	9	2	9	2	4	7	2	11	2	15	2	1942837
Available Selenium (Se)	mg/kg	ND	ND	2	ND	2	ND	ND	2	ND	2	ND	2	1942837
Available Silver (Ag)	mg/kg	ND	ND	0.5	ND	0.5	ND	0.8	0.5	ND	0.5	0.8	0.5	1942837
Available Strontium (Sr)	mg/kg	6	ND	5	ND	5	ND	13	5	ND	5	8	5	1942837
Available Thallium (Tl)	mg/kg	0.2	0.2	0.1	0.2	0.1	0.3	1.4	0.1	0.3	0.1	0.5	0.1	1942837
Available Tin (Sn)	mg/kg	ND	ND	2	ND	2	ND	8	2	ND	2	ND	2	1942837
Available Uranium (U)	mg/kg	0.2	0.3	0.1	0.3	0.1	0.2	0.6	0.1	0.5	0.1	1.2	0.1	1942837
Available Vanadium (V)	mg/kg	80	76	2	77	2	67	52	2	79	2	76	2	1942837
Available Zinc (Zn)	mg/kg	50	31	5	78	5	61	360	5	98	5	200	5	1942837

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		DQ4359		DQ4360			DQ4361	DQ4362	DQ4363		
Sampling Date		2009/07/01		2009/07/01			2009/07/01	2009/07/01	2009/07/01		
	Units	**R8A**	**RDL**	**R8B**	**RDL**	**QC Batch**	**R8C**	**R13**	**R20A**	**RDL**	**QC Batch**
Metals											
Available Aluminum (Al)	mg/kg	18000	10	45000	10	1942837	27000	7500	14000	10	1943397
Available Antimony (Sb)	mg/kg	ND	2	ND	2	1942837	ND	ND	ND	2	1943397
Available Arsenic (As)	mg/kg	4	2	6	2	1942837	3	10	2	2	1943397
Available Barium (Ba)	mg/kg	98	5	160	5	1942837	100	20	31	5	1943397
Available Beryllium (Be)	mg/kg	ND	2	3	2	1942837	ND	ND	ND	2	1943397
Available Bismuth (Bi)	mg/kg	ND	2	ND	2	1942837	ND	ND	ND	2	1943397
Available Boron (B)	mg/kg	ND	5	ND	5	1942837	ND	ND	ND	5	1943397
Available Cadmium (Cd)	mg/kg	1.1	0.3	1.6	0.3	1942837	0.6	ND	0.6	0.3	1943397
Available Chromium (Cr)	mg/kg	36	2	64	2	1942837	67	26	47	2	1943397
Available Cobalt (Co)	mg/kg	14	1	28	1	1942837	19	9	12	1	1943397
Available Copper (Cu)	mg/kg	16	2	21	2	1942837	14	8	8	2	1943397
Available Iron (Fe)	mg/kg	18000	50	33000	50	1942837	33000	24000	21000	50	1943397
Available Lead (Pb)	mg/kg	60	0.5	50	0.5	1942837	17	21	51	0.5	1943397
Available Lithium (Li)	mg/kg	15	2	21	2	1942837	30	3	5	2	1943397
Available Manganese (Mn)	mg/kg	1200	2	6000	2	1942837	2200	300	490	2	1943397
Available Molybdenum (Mo)	mg/kg	ND	2	ND	2	1942837	ND	2	ND	2	1943397
Available Nickel (Ni)	mg/kg	47	2	65	2	1942837	81	27	29	2	1943397
Available Rubidium (Rb)	mg/kg	6	2	8	2	1942837	9	4	3	2	1943397
Available Selenium (Se)	mg/kg	ND	2	ND	2	1942837	ND	ND	ND	2	1943397
Available Silver (Ag)	mg/kg	ND	0.5	1.0	0.5	1942837	ND	ND	ND	0.5	1943397
Available Strontium (Sr)	mg/kg	37	5	ND(1)	50	1942837	14	ND	8	5	1943397
Available Thallium (Tl)	mg/kg	0.3	0.1	0.2	0.1	1942837	0.1	0.1	0.1	0.1	1943397
Available Tin (Sn)	mg/kg	ND	2	ND	2	1942837	ND	ND	ND	2	1943397
Available Uranium (U)	mg/kg	0.8	0.1	2.6	0.1	1942837	0.9	0.1	0.3	0.1	1943397
Available Vanadium (V)	mg/kg	21	2	34	2	1942837	35	29	51	2	1943397
Available Zinc (Zn)	mg/kg	79	5	96	5	1942837	89	23	56	5	1943397

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
(1) - Elevated reporting limit due to sample matrix.

Maxxam Job #: A9B8179
Report Date: 2009/09/18

Intrinsik Environmental Sciences
Client Project #: 055453
Project name: BELLEDUNE ECO

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		DQ4364	DQ4365	DQ4365	DQ4366		DQ7283		
Sampling Date		2009/07/01	2009/07/01	2009/07/01	2009/07/01		2009/09/09		
	Units	**R20B**	**R20C**	**R20C Lab-Dup**	**QA/QC-2**	**QC Batch**	**Batch #1 - NIST 2711**	**RDL**	**QC Batch**
Metals									
Available Aluminum (Al)	mg/kg	24000	24000	26000	13000	1943397	12000	10	1942837
Available Antimony (Sb)	mg/kg	ND	ND	ND	6	1943397	18	2	1942837
Available Arsenic (As)	mg/kg	2	2	2	29	1943397	100	2	1942837
Available Barium (Ba)	mg/kg	26	26	27	110	1943397	180	5	1942837
Available Beryllium (Be)	mg/kg	ND	ND	ND	ND	1943397	ND	2	1942837
Available Bismuth (Bi)	mg/kg	ND	ND	ND	ND	1943397	3	2	1942837
Available Boron (B)	mg/kg	ND	ND	ND	ND	1943397	6	5	1942837
Available Cadmium (Cd)	mg/kg	ND	ND	ND	6.7	1943397	41	0.3	1942837
Available Chromium (Cr)	mg/kg	53	36	33	28	1943397	19	2	1942837
Available Cobalt (Co)	mg/kg	13	12	12	9	1943397	9	1	1942837
Available Copper (Cu)	mg/kg	14	17	14	37	1943397	110	2	1942837
Available Iron (Fe)	mg/kg	41000	33000	37000	26000	1943397	18000	50	1942837
Available Lead (Pb)	mg/kg	16	10	11	450	1943397	1200	0.5	1942837
Available Lithium (Li)	mg/kg	17	18	18	14	1943397	12	2	1942837
Available Manganese (Mn)	mg/kg	450	310	360	420	1943397	520	2	1942837
Available Molybdenum (Mo)	mg/kg	ND	ND	ND	ND	1943397	ND	2	1942837
Available Nickel (Ni)	mg/kg	31	30	27	24	1943397	17	2	1942837
Available Rubidium (Rb)	mg/kg	6	6	6	8	1943397	24	2	1942837
Available Selenium (Se)	mg/kg	ND	ND	ND	ND	1943397	ND	2	1942837
Available Silver (Ag)	mg/kg	ND	ND	ND	1.0	1943397	5.0	0.5	1942837
Available Strontium (Sr)	mg/kg	ND	ND	ND	15	1943397	38	5	1942837
Available Thallium (Tl)	mg/kg	ND	0.1	0.1	1.5	1943397	1.6	0.1	1942837
Available Tin (Sn)	mg/kg	ND	ND	ND	8	1943397	2	2	1942837
Available Uranium (U)	mg/kg	0.4	0.5	0.5	0.6	1943397	1.1	0.1	1942837
Available Vanadium (V)	mg/kg	96	68	67	61	1943397	44	2	1942837
Available Zinc (Zn)	mg/kg	58	53	55	400	1943397	320	5	1942837

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

GENERAL COMMENTS

Sample DQ4362-01: Initial analysis of duplicate generated a result of 68.208 g/kg giving a RPD value of >25%. Analysis was repeated with acceptable results; sample inhomogeneity is suspected.

Sample DQ4363-01: Due to the sample matrix a 1:10 aqueous leachate was done on the sample.

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**	**% Recovery**	**QC Limits**
1938046	Organic Carbon (TOC)	2009/09/14					ND, RDL=0.2	g/kg	6.3	35	97	75 - 125
1940928	Organic Carbon (TOC)	2009/09/16					ND, RDL=0.2	g/kg	7.7	35	96	75 - 125
1942280	Dry Mass to Volume Ratio	2009/09/17					1:5, RDL=0	N/A	0	N/A		
1942837	Available Aluminum (Al)	2009/09/17	NC	75 - 125	93	75 - 125	ND, RDL=10	mg/kg	3.3	35	80	75 - 125
1942837	Available Antimony (Sb)	2009/09/17	76	75 - 125	110	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942837	Available Arsenic (As)	2009/09/17	75	75 - 125	93	75 - 125	ND, RDL=2	mg/kg	NC	35	113	75 - 125
1942837	Available Barium (Ba)	2009/09/17	NC	75 - 125	88	75 - 125	ND, RDL=5	mg/kg	3.3	35	99	75 - 125
1942837	Available Beryllium (Be)	2009/09/17	95	75 - 125	92	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942837	Available Bismuth (Bi)	2009/09/17	95	75 - 125	97	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942837	Available Boron (B)	2009/09/17	76	75 - 125	86	75 - 125	ND, RDL=5	mg/kg	NC	35		
1942837	Available Cadmium (Cd)	2009/09/17	91	75 - 125	91	75 - 125	ND, RDL=0.3	mg/kg	NC	35		
1942837	Available Chromium (Cr)	2009/09/17	NC	75 - 125	101	75 - 125	ND, RDL=2	mg/kg	6.2	35	84	75 - 125
1942837	Available Cobalt (Co)	2009/09/17	NC	75 - 125	99	75 - 125	ND, RDL=1	mg/kg	8.7	35	98	75 - 125
1942837	Available Copper (Cu)	2009/09/17	NC	75 - 125	99	75 - 125	ND, RDL=2	mg/kg	10.4	35	97	75 - 125
1942837	Available Iron (Fe)	2009/09/17	NC	75 - 125	99	75 - 125	ND, RDL=50	mg/kg	5.7	35	93	75 - 125
1942837	Available Lead (Pb)	2009/09/17	NC	75 - 125	96	75 - 125	ND, RDL=0.5	mg/kg	1.3	35	100	75 - 125
1942837	Available Lithium (Li)	2009/09/17	NC	75 - 125	92	75 - 125	ND, RDL=2	mg/kg	4.0	35		
1942837	Available Manganese (Mn)	2009/09/17	NC	75 - 125	91	75 - 125	ND, RDL=2	mg/kg	1.7	35	101	75 - 125
1942837	Available Molybdenum (Mo)	2009/09/17	84	75 - 125	93	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942837	Available Nickel (Ni)	2009/09/17	NC	75 - 125	100	75 - 125	ND, RDL=2	mg/kg	0.3	35	102	75 - 125
1942837	Available Rubidium (Rb)	2009/09/17	71(1)	75 - 125	90	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942837	Available Selenium (Se)	2009/09/17	75	75 - 125	90	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942837	Available Silver (Ag)	2009/09/17	97	75 - 125	97	75 - 125	ND, RDL=0.5	mg/kg	NC	35		
1942837	Available Strontium (Sr)	2009/09/17	83	75 - 125	91	75 - 125	ND, RDL=5	mg/kg	NC	35	88	75 - 125
1942837	Available Thallium (Tl)	2009/09/17	100	75 - 125	98	75 - 125	ND, RDL=0.1	mg/kg	NC	35		
1942837	Available Tin (Sn)	2009/09/17	94	75 - 125	94	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942837	Available Uranium (U)	2009/09/17	96	75 - 125	98	75 - 125	ND, RDL=0.1	mg/kg	NC	35		
1942837	Available Vanadium (V)	2009/09/17	NC	75 - 125	107	75 - 125	ND, RDL=2	mg/kg	6.0	35	102	75 - 125
1942837	Available Zinc (Zn)	2009/09/17	89	75 - 125	91	75 - 125	ND, RDL=5	mg/kg	0.2	35	98	75 - 125
1943321	Soluble (5:1) pH	2009/09/18					4.89, RDL=0	pH	1.1	N/A		
1943397	Available Aluminum (Al)	2009/09/18	NC	75 - 125	101	75 - 125	ND, RDL=10	mg/kg	6.5	35	84	75 - 125
1943397	Available Antimony (Sb)	2009/09/18	70(2)	75 - 125	110	75 - 125	ND, RDL=2	mg/kg	NC	35		
1943397	Available Arsenic (As)	2009/09/18	90	75 - 125	95	75 - 125	ND, RDL=2	mg/kg	NC	35	121	75 - 125
1943397	Available Barium (Ba)	2009/09/18	NC	75 - 125	97	75 - 125	ND, RDL=5	mg/kg	1.4	35	115	75 - 125
1943397	Available Beryllium (Be)	2009/09/18	100	75 - 125	91	75 - 125	ND, RDL=2	mg/kg	NC	35		
1943397	Available Bismuth (Bi)	2009/09/18	98	75 - 125	97	75 - 125	ND, RDL=2	mg/kg	NC	35		
1943397	Available Boron (B)	2009/09/18	65(2)	75 - 125	85	75 - 125	ND, RDL=5	mg/kg	NC	35		
1943397	Available Cadmium (Cd)	2009/09/18	103	75 - 125	97	75 - 125	ND, RDL=0.3	mg/kg	NC	35		
1943397	Available Chromium (Cr)	2009/09/18	NC	75 - 125	103	75 - 125	ND, RDL=2	mg/kg	8.2	35	84	75 - 125
1943397	Available Cobalt (Co)	2009/09/18	NC	75 - 125	101	75 - 125	ND, RDL=1	mg/kg	1.9	35	102	75 - 125

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**	**% Recovery**	**QC Limits**
1943397	Available Copper (Cu)	2009/09/18	NC	75 - 125	102	75 - 125	ND, RDL=2	mg/kg	14.2	35	95	75 - 125
1943397	Available Iron (Fe)	2009/09/18	NC	75 - 125	99	75 - 125	ND, RDL=50	mg/kg	10.3	35	98	75 - 125
1943397	Available Lead (Pb)	2009/09/18	NC	75 - 125	97	75 - 125	ND, RDL=0.5	mg/kg	2.1	35	107	75 - 125
1943397	Available Lithium (Li)	2009/09/18	NC	75 - 125	96	75 - 125	ND, RDL=2	mg/kg	1.9	35		
1943397	Available Manganese (Mn)	2009/09/18	NC	75 - 125	94	75 - 125	ND, RDL=2	mg/kg	12.6	35	107	75 - 125
1943397	Available Molybdenum (Mo)	2009/09/18	98	75 - 125	99	75 - 125	ND, RDL=2	mg/kg	NC	35		
1943397	Available Nickel (Ni)	2009/09/18	NC	75 - 125	100	75 - 125	ND, RDL=2	mg/kg	7.9	35	102	75 - 125
1943397	Available Rubidium (Rb)	2009/09/18	89	75 - 125	98	75 - 125	ND, RDL=2	mg/kg	NC	35		
1943397	Available Selenium (Se)	2009/09/18	85	75 - 125	97	75 - 125	ND, RDL=2	mg/kg	NC	35		
1943397	Available Silver (Ag)	2009/09/18	104	75 - 125	99	75 - 125	ND, RDL=0.5	mg/kg	NC	35		
1943397	Available Strontium (Sr)	2009/09/18	98	75 - 125	99	75 - 125	ND, RDL=5	mg/kg	NC	35	96	75 - 125
1943397	Available Thallium (Tl)	2009/09/18	100	75 - 125	93	75 - 125	ND, RDL=0.1	mg/kg	NC	35		
1943397	Available Tin (Sn)	2009/09/18	102	75 - 125	97	75 - 125	ND, RDL=2	mg/kg	NC	35		
1943397	Available Uranium (U)	2009/09/18	102	75 - 125	96	75 - 125	ND, RDL=0.1	mg/kg	0.3	35		
1943397	Available Vanadium (V)	2009/09/18	NC	75 - 125	103	75 - 125	ND, RDL=2	mg/kg	0.8	35	102	75 - 125
1943397	Available Zinc (Zn)	2009/09/18	97	75 - 125	97	75 - 125	ND, RDL=5	mg/kg	2.9	35	107	75 - 125

N/A = Not Applicable

RDL = Reportable Detection Limit

RPD = Relative Percent Difference

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

QC Standard: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.

Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.

NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

(1) - Low recovery due to sample matrix.

(2) - Poor recovery due to sample matrix.

Validation Signature Page

Maxxam Job #: A9B8179

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

ERIC DEARMAN, Scientific Specialist

==

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. SCC and CALA have approved this reporting process and electronic report format.

Your Project #: 055453
Site: BELLEDUNE ECO
Your C.O.C. #: B 65309

Attention: Christine Moore
Intrinsik Environmental Sciences
5121 Sackville Street
Suite 506
Halifax, NS
CANADA B3J 1K1

Report Date: 2009/09/17

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: A9B7567
Received: 2009/09/08, 8:48

Sample Matrix: Soil
Samples Received: 22

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Metals Solid Avail. Unified MS - Nper	22	N/A	2009/09/15	ATL SOP 00024 R4	Based on EPA6020A

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
* Results relate only to the items tested.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

MICHELLE HILL, Project Manager
Email: Michelle.Hill.Reports@maxxamanalytics.com
Phone# (902) 420-0203

==

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. SCC and CALA have approved this reporting process and electronic report format.

For Service Group specific validation please refer to the Validation Signature Page

Total cover pages: 1

Maxxam Job #: A9B7567
Report Date: 2009/09/17

Intrinsik Environmental Sciences
Client Project #: 055453
Project name: BELLEDUNE ECO

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		DQ1570	DQ1577		DQ1578	DQ1578	DQ1579		DQ1580	DQ1581		DQ1582		
Sampling Date		2009/07/31 JUL-AUG	2009/07/31 JUL-AUG		2009/07/31 JUL-AUG	2009/07/31 JUL-AUG	2009/07/31 JUL-AUG		2009/07/31 JUL-AUG	2009/07/31 JUL-AUG		2009/07/31 JUL-AUG		
	Units	**S16A**	**S18A**	**RDL**	**S18B**	**S18B Lab-Dup**	**S18C**	**RDL**	**S19A**	**S20A**	**RDL**	**S20B**	**RDL**	**QC Batch**
Metals														
Available Aluminum (Al)	mg/kg	18000	14000	10	27000	27000	24000	10	12000	7500	10	43000	10	1939481
Available Antimony (Sb)	mg/kg	ND	ND	2	ND	ND	ND	2	5	ND	2	ND	2	1939481
Available Arsenic (As)	mg/kg	7	15	2	27	32	27	2	22	4	2	17	2	1939481
Available Barium (Ba)	mg/kg	12	86	5	51	56	39	5	75	20	5	26	5	1939481
Available Beryllium (Be)	mg/kg	ND	ND	2	ND	ND	ND	2	ND	ND	2	ND	2	1939481
Available Bismuth (Bi)	mg/kg	ND	ND	2	ND	ND	ND	2	ND	ND	2	ND	2	1939481
Available Boron (B)	mg/kg	ND	ND	5	ND	ND	ND	5	ND	ND	5	ND	5	1939481
Available Cadmium (Cd)	mg/kg	ND	1.2	0.3	0.4	0.4	ND	0.3	2.7	0.6	0.3	0.4	0.3	1939481
Available Chromium (Cr)	mg/kg	28	24	2	43	43	37	2	23	15	2	58	2	1939481
Available Cobalt (Co)	mg/kg	8	12	1	13	15	12	1	11	4	1	10	1	1939481
Available Copper (Cu)	mg/kg	12	15	2	19	19	18	2	35	7	2	13	2	1939481
Available Iron (Fe)	mg/kg	38000	33000	50	55000	54000	47000	500	28000	10000	50	44000	500	1939481
Available Lead (Pb)	mg/kg	18	90	0.5	27	30	22	0.5	360	57	0.5	26	0.5	1939481
Available Lithium (Li)	mg/kg	13	16	2	34	34	29	2	13	4	2	23	2	1939481
Available Manganese (Mn)	mg/kg	180	950	2	600	710	540	2	660	140	2	210	2	1939481
Available Molybdenum (Mo)	mg/kg	ND	ND	2	ND	ND	ND	2	ND	ND	2	ND	2	1939481
Available Nickel (Ni)	mg/kg	13	16	2	29	29	30	2	25	10	2	25	2	1939481
Available Rubidium (Rb)	mg/kg	ND	14	2	13	14	10	2	8	ND	2	5	2	1939481
Available Selenium (Se)	mg/kg	ND	ND	2	ND	ND	ND	2	ND	ND	2	ND	2	1939481
Available Silver (Ag)	mg/kg	ND	ND	0.5	ND	ND	ND	0.5	1.2	ND	0.5	ND	0.5	1939481
Available Strontium (Sr)	mg/kg	ND	8	5	ND	ND	ND	5	7	ND	5	ND	5	1939481
Available Thallium (Tl)	mg/kg	0.1	0.4	0.1	0.2	0.2	0.1	0.1	0.8	0.2	0.1	0.2	0.1	1939481
Available Tin (Sn)	mg/kg	ND	ND	2	ND	ND	ND	2	5	ND	2	ND	2	1939481
Available Uranium (U)	mg/kg	0.2	0.4	0.1	0.8	0.8	0.6	0.1	0.4	0.2	0.1	0.6	0.1	1939481
Available Vanadium (V)	mg/kg	140	60	2	67	68	52	2	44	40	2	99	2	1939481
Available Zinc (Zn)	mg/kg	43	110	5	130	130	110	5	360	33	5	45	5	1939481

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		DQ1583	DQ1584		DQ1585		DQ1586		DQ1588		
Sampling Date		2009/07/31 JUL-AUG	2009/07/31 JUL-AUG		2009/07/31 JUL-AUG		2009/07/31 JUL-AUG		2009/07/31 JUL-AUG		
	Units	**S20C**	**QA/QC-30**	**RDL**	**S21A**	**RDL**	**S22A**	**RDL**	**S23A**	**RDL**	**QC Batch**
Metals											
Available Aluminum (Al)	mg/kg	37000	18000	10	36000	10	15000	10	20000	10	1939481
Available Antimony (Sb)	mg/kg	ND	ND	2	ND	2	ND	2	ND	2	1939481
Available Arsenic (As)	mg/kg	15	8	2	61	2	9	2	16	2	1939481
Available Barium (Ba)	mg/kg	37	13	5	77	5	37	5	130	5	1939481
Available Beryllium (Be)	mg/kg	ND	ND	2	ND	2	ND	2	ND	2	1939481
Available Bismuth (Bi)	mg/kg	ND	ND	2	ND	2	ND	2	ND	2	1939481
Available Boron (B)	mg/kg	ND	ND	5	ND	5	ND	5	ND	5	1939481
Available Cadmium (Cd)	mg/kg	ND	ND	0.3	0.3	0.3	ND	0.3	1.8	0.3	1939481
Available Chromium (Cr)	mg/kg	45	29	2	140	2	27	2	50	2	1939481
Available Cobalt (Co)	mg/kg	11	7	1	22	1	7	1	16	1	1939481
Available Copper (Cu)	mg/kg	13	10	2	12	2	9	2	25	2	1939481
Available Iron (Fe)	mg/kg	30000	38000	50	49000	500	40000	50	29000	50	1939481
Available Lead (Pb)	mg/kg	19	23	0.5	14	0.5	25	0.5	89	0.5	1939481
Available Lithium (Li)	mg/kg	21	16	2	48	2	11	2	19	2	1939481
Available Manganese (Mn)	mg/kg	200	200	2	980	2	230	2	2300	2	1939481
Available Molybdenum (Mo)	mg/kg	ND	ND	2	ND	2	ND	2	2	2	1939481
Available Nickel (Ni)	mg/kg	28	14	2	86	2	14	2	42	2	1939481
Available Rubidium (Rb)	mg/kg	5	ND	2	11	2	7	2	11	2	1939481
Available Selenium (Se)	mg/kg	ND	ND	2	ND	2	ND	2	ND	2	1939481
Available Silver (Ag)	mg/kg	ND	ND	0.5	ND	0.5	ND	0.5	0.7	0.5	1939481
Available Strontium (Sr)	mg/kg	ND	ND	5	7	5	ND	5	ND(1)	50	1939481
Available Thallium (Tl)	mg/kg	0.1	ND	0.1	0.2	0.1	0.1	0.1	0.6	0.1	1939481
Available Tin (Sn)	mg/kg	ND	ND	2	ND	2	ND	2	ND	2	1939481
Available Uranium (U)	mg/kg	0.5	0.2	0.1	0.2	0.1	0.3	0.1	1.6	0.1	1939481
Available Vanadium (V)	mg/kg	49	140	2	120	2	100	2	44	2	1939481
Available Zinc (Zn)	mg/kg	44	41	5	95	5	57	5	110	5	1939481

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
(1) - Elevated reporting limit due to matrix interferences.

Intrinsik Environmental Sciences
Maxxam Job #: A9B7567
Client Project #: 055453
Report Date: 2009/09/17
Project name: BELLEDUNE ECO

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		DQ1589	DQ1590	DQ1591	DQ1592	DQ1593	DQ1594		
Sampling Date		2009/07/31 JUL-AUG	2009/07/31 JUL-AUG	2009/07/31 JUL-AUG	2009/07/31 JUL-AUG	2009/07/31 JUL-AUG	2009/07/31 JUL-AUG		
	Units	**S23B**	**S23C**	**S24A**	**S25A**	**S25B**	**S25C**	**RDL**	**QC Batch**
Metals									
Available Aluminum (Al)	mg/kg	21000	16000	14000	11000	10000	11000	10	1939481
Available Antimony (Sb)	mg/kg	ND	ND	ND	ND	ND	ND	2	1939481
Available Arsenic (As)	mg/kg	19	16	3	14	10	11	2	1939481
Available Barium (Ba)	mg/kg	110	91	110	110	100	130	5	1939481
Available Beryllium (Be)	mg/kg	ND	ND	ND	ND	ND	ND	2	1939481
Available Bismuth (Bi)	mg/kg	ND	ND	ND	ND	ND	ND	2	1939481
Available Boron (B)	mg/kg	ND	ND	ND	ND	ND	ND	5	1939481
Available Cadmium (Cd)	mg/kg	0.5	ND	0.5	1.0	0.5	ND	0.3	1939481
Available Chromium (Cr)	mg/kg	52	40	21	30	26	29	2	1939481
Available Cobalt (Co)	mg/kg	17	14	2	9	9	9	1	1939481
Available Copper (Cu)	mg/kg	29	28	17	16	14	14	2	1939481
Available Iron (Fe)	mg/kg	31000	27000	3500	17000	16000	17000	50	1939481
Available Lead (Pb)	mg/kg	34	23	37	54	26	15	0.5	1939481
Available Lithium (Li)	mg/kg	25	19	4	15	15	15	2	1939481
Available Manganese (Mn)	mg/kg	1600	620	23	420	380	390	2	1939481
Available Molybdenum (Mo)	mg/kg	ND	ND	ND	ND	ND	ND	2	1939481
Available Nickel (Ni)	mg/kg	49	41	13	27	26	26	2	1939481
Available Rubidium (Rb)	mg/kg	9	7	ND	6	5	4	2	1939481
Available Selenium (Se)	mg/kg	ND	ND	ND	ND	ND	ND	2	1939481
Available Silver (Ag)	mg/kg	ND	ND	0.9	ND	ND	ND	0.5	1939481
Available Strontium (Sr)	mg/kg	9	8	13	19	19	23	5	1939481
Available Thallium (Tl)	mg/kg	0.3	0.1	0.1	0.2	ND	ND	0.1	1939481
Available Tin (Sn)	mg/kg	ND	ND	ND	ND	ND	ND	2	1939481
Available Uranium (U)	mg/kg	1.5	0.8	2.4	3.2	2.6	2.4	0.1	1939481
Available Vanadium (V)	mg/kg	46	41	9	43	37	41	2	1939481
Available Zinc (Zn)	mg/kg	81	66	14	75	50	45	5	1939481

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam Job #: A9B7567
Report Date: 2009/09/17

Intrinsik Environmental Sciences
Client Project #: 055453
Project name: BELLEDUNE ECO

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		DQ1595			DQ1596	DQ1596		DQ1597		DQ5387		
Sampling Date		2009/07/31 JUL-AUG			2009/07/31 JUL-AUG	2009/07/31 JUL-AUG		2009/07/31 JUL-AUG		2009/09/08		
	Units	**QA/QC-12**	**RDL**	**QC Batch**	**S28A**	**S28A Lab-Dup**	**RDL**	**S29A**	**QC Batch**	**Batch 3 - NIST 2711**	**RDL**	**QC Batch**
Metals												
Available Aluminum (Al)	mg/kg	15000	10	1939481	28000	28000	10	14000	1939483	11000	10	1939481
Available Antimony (Sb)	mg/kg	ND	2	1939481	ND	ND	2	ND	1939483	17	2	1939481
Available Arsenic (As)	mg/kg	3	2	1939481	310	370	2	9	1939483	88	2	1939481
Available Barium (Ba)	mg/kg	150	5	1939481	83	96	5	56	1939483	170	5	1939481
Available Beryllium (Be)	mg/kg	ND	2	1939481	ND	ND	2	ND	1939483	ND	2	1939481
Available Bismuth (Bi)	mg/kg	ND	2	1939481	ND	ND	2	ND	1939483	2	2	1939481
Available Boron (B)	mg/kg	ND	5	1939481	ND	ND	5	ND	1939483	ND	5	1939481
Available Cadmium (Cd)	mg/kg	0.4	0.3	1939481	1.0	1.0	0.3	0.4	1939483	38	0.3	1939481
Available Chromium (Cr)	mg/kg	25	2	1939481	76	76	2	24	1939483	17	2	1939481
Available Cobalt (Co)	mg/kg	3	1	1939481	32	37	1	9	1939483	7	1	1939481
Available Copper (Cu)	mg/kg	22	2	1939481	12	11	2	9	1939483	94	2	1939481
Available Iron (Fe)	mg/kg	5200	50	1939481	83000	89000	500	31000	1939483	16000	50	1939481
Available Lead (Pb)	mg/kg	33	0.5	1939481	59	54	0.5	48	1939483	1100	0.5	1939481
Available Lithium (Li)	mg/kg	8	2	1939481	25	26	2	12	1939483	10	2	1939481
Available Manganese (Mn)	mg/kg	53	2	1939481	3300	4300(1)	2	730	1939483	450	2	1939481
Available Molybdenum (Mo)	mg/kg	ND	2	1939481	8	9	2	ND	1939483	ND	2	1939481
Available Nickel (Ni)	mg/kg	18	2	1939481	23	23	2	14	1939483	14	2	1939481
Available Rubidium (Rb)	mg/kg	3	2	1939481	8	8	2	10	1939483	22	2	1939481
Available Selenium (Se)	mg/kg	ND	2	1939481	ND	ND	2	ND	1939483	ND	2	1939481
Available Silver (Ag)	mg/kg	ND	0.5	1939481	0.6	0.5	0.5	ND	1939483	4.0	0.5	1939481
Available Strontium (Sr)	mg/kg	9	5	1939481	10	10	5	ND	1939483	36	5	1939481
Available Thallium (Tl)	mg/kg	0.1	0.1	1939481	0.4	0.4	0.1	0.3	1939483	1.4	0.1	1939481
Available Tin (Sn)	mg/kg	ND	2	1939481	ND	ND	2	ND	1939483	2	2	1939481
Available Uranium (U)	mg/kg	1.7	0.1	1939481	0.7	0.7	0.1	0.2	1939483	0.9	0.1	1939481
Available Vanadium (V)	mg/kg	14	2	1939481	180	190	2	66	1939483	38	2	1939481
Available Zinc (Zn)	mg/kg	22	5	1939481	140	150	5	65	1939483	270	5	1939481

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
(1) - Poor RPD due to sample inhomogeneity.

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
1939481	Available Aluminum (Al)	2009/09/15	NC	75 - 125	99	75 - 125	ND, RDL=10	mg/kg	0.03	35	84	75 - 125
1939481	Available Antimony (Sb)	2009/09/15	73(1)	75 - 125	108	75 - 125	ND, RDL=2	mg/kg	NC	35		
1939481	Available Arsenic (As)	2009/09/15	NC	75 - 125	94	75 - 125	ND, RDL=2	mg/kg	16.0	35	121	75 - 125
1939481	Available Barium (Ba)	2009/09/15	NC	75 - 125	92	75 - 125	ND, RDL=5	mg/kg	8.6	35	109	75 - 125
1939481	Available Beryllium (Be)	2009/09/15	95	75 - 125	89	75 - 125	ND, RDL=2	mg/kg	NC	35		
1939481	Available Bismuth (Bi)	2009/09/15	104	75 - 125	98	75 - 125	ND, RDL=2	mg/kg	NC	35		
1939481	Available Boron (B)	2009/09/15	71(1)	75 - 125	82	75 - 125	ND, RDL=5	mg/kg	NC	35		
1939481	Available Cadmium (Cd)	2009/09/15	103	75 - 125	94	75 - 125	ND, RDL=0.3	mg/kg	NC	35		
1939481	Available Chromium (Cr)	2009/09/15	NC	75 - 125	89	75 - 125	ND, RDL=2	mg/kg	0.8	35	89	75 - 125
1939481	Available Cobalt (Co)	2009/09/15	NC	75 - 125	92	75 - 125	ND, RDL=1	mg/kg	16.5	35	103	75 - 125
1939481	Available Copper (Cu)	2009/09/15	NC	75 - 125	86	75 - 125	ND, RDL=2	mg/kg	1.7	35	96	75 - 125
1939481	Available Iron (Fe)	2009/09/15	NC	75 - 125	99	75 - 125	ND, RDL=50	mg/kg	2.7	35	96	75 - 125
1939481	Available Lead (Pb)	2009/09/15	NC	75 - 125	90	75 - 125	ND, RDL=0.5	mg/kg	11.3	35	101	75 - 125
1939481	Available Lithium (Li)	2009/09/15	NC	75 - 125	85	75 - 125	ND, RDL=2	mg/kg	1.3	35		
1939481	Available Manganese (Mn)	2009/09/15	NC	75 - 125	96	75 - 125	ND, RDL=2	mg/kg	16.2	35	106	75 - 125
1939481	Available Molybdenum (Mo)	2009/09/15	104	75 - 125	97	75 - 125	ND, RDL=2	mg/kg	NC	35		
1939481	Available Nickel (Ni)	2009/09/15	NC	75 - 125	90	75 - 125	ND, RDL=2	mg/kg	1.2	35	105	75 - 125
1939481	Available Rubidium (Rb)	2009/09/15	NC	75 - 125	99	75 - 125	ND, RDL=2	mg/kg	8.3	35		
1939481	Available Selenium (Se)	2009/09/15	88	75 - 125	84	75 - 125	ND, RDL=2	mg/kg	NC	35		
1939481	Available Silver (Ag)	2009/09/15	107	75 - 125	99	75 - 125	ND, RDL=0.5	mg/kg	NC	35		
1939481	Available Strontium (Sr)	2009/09/15	96	75 - 125	95	75 - 125	ND, RDL=5	mg/kg	NC	35	93	75 - 125
1939481	Available Thallium (Tl)	2009/09/15	87	75 - 125	82	75 - 125	ND, RDL=0.1	mg/kg	NC	35		
1939481	Available Tin (Sn)	2009/09/15	112	75 - 125	106	75 - 125	ND, RDL=2	mg/kg	NC	35		
1939481	Available Uranium (U)	2009/09/15	96	75 - 125	89	75 - 125	ND, RDL=0.1	mg/kg	0.3	35		
1939481	Available Vanadium (V)	2009/09/15	NC	75 - 125	94	75 - 125	ND, RDL=2	mg/kg	1.9	35	109	75 - 125
1939481	Available Zinc (Zn)	2009/09/15	92	75 - 125	88	75 - 125	ND, RDL=5	mg/kg	4.9	35	99	75 - 125
1939483	Available Aluminum (Al)	2009/09/15	NC	75 - 125	92	75 - 125	ND, RDL=10	mg/kg	0.4	35	83	75 - 125
1939483	Available Antimony (Sb)	2009/09/15	62(1)	75 - 125	101	75 - 125	ND, RDL=2	mg/kg	NC	35		
1939483	Available Arsenic (As)	2009/09/15	NC	75 - 125	92	75 - 125	ND, RDL=2	mg/kg	18.4	35	95	75 - 125
1939483	Available Barium (Ba)	2009/09/15	NC	75 - 125	91	75 - 125	ND, RDL=5	mg/kg	14.0	35	101	75 - 125
1939483	Available Beryllium (Be)	2009/09/15	96	75 - 125	91	75 - 125	ND, RDL=2	mg/kg	NC	35		
1939483	Available Bismuth (Bi)	2009/09/15	95	75 - 125	97	75 - 125	ND, RDL=2	mg/kg	NC	35		
1939483	Available Boron (B)	2009/09/15	75	75 - 125	79	75 - 125	ND, RDL=5	mg/kg	NC	35		
1939483	Available Cadmium (Cd)	2009/09/15	97	75 - 125	95	75 - 125	ND, RDL=0.3	mg/kg	NC	35		
1939483	Available Chromium (Cr)	2009/09/15	NC	75 - 125	100	75 - 125	ND, RDL=2	mg/kg	0.08	35	81	75 - 125
1939483	Available Cobalt (Co)	2009/09/15	NC	75 - 125	95	75 - 125	ND, RDL=1	mg/kg	13.8	35	92	75 - 125
1939483	Available Copper (Cu)	2009/09/15	NC	75 - 125	90	75 - 125	ND, RDL=2	mg/kg	6.8	35	88	75 - 125
1939483	Available Iron (Fe)	2009/09/15	NC	75 - 125	92	75 - 125	ND, RDL=50	mg/kg	8.1	35	90	75 - 125
1939483	Available Lead (Pb)	2009/09/15	NC	75 - 125	87	75 - 125	ND, RDL=0.5	mg/kg	9.3	35	99	75 - 125
1939483	Available Lithium (Li)	2009/09/15	NC	75 - 125	87	75 - 125	ND, RDL=2	mg/kg	4.0	35		

Maxxam Job #: A9B7567
Report Date: 2009/09/17

Intrinsik Environmental Sciences
Client Project #: 055453
Project name: BELLEDUNE ECO

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**	**% Recovery**	**QC Limits**
1939483	Available Manganese (Mn)	2009/09/15	NC	75 - 125	88	75 - 125	ND, RDL=2	mg/kg	28.3(2)	35	101	75 - 125
1939483	Available Molybdenum (Mo)	2009/09/15	99	75 - 125	93	75 - 125	ND, RDL=2	mg/kg	NC	35		
1939483	Available Nickel (Ni)	2009/09/15	NC	75 - 125	98	75 - 125	ND, RDL=2	mg/kg	0.5	35	89	75 - 125
1939483	Available Rubidium (Rb)	2009/09/15	90	75 - 125	98	75 - 125	ND, RDL=2	mg/kg	NC	35		
1939483	Available Selenium (Se)	2009/09/15	85	75 - 125	86	75 - 125	ND, RDL=2	mg/kg	NC	35		
1939483	Available Silver (Ag)	2009/09/15	98	75 - 125	93	75 - 125	ND, RDL=0.5	mg/kg	NC	35		
1939483	Available Strontium (Sr)	2009/09/15	NC	75 - 125	92	75 - 125	ND, RDL=5	mg/kg	NC	35	90	75 - 125
1939483	Available Thallium (Tl)	2009/09/15	88	75 - 125	77	75 - 125	ND, RDL=0.1	mg/kg	NC	35		
1939483	Available Tin (Sn)	2009/09/15	102	75 - 125	97	75 - 125	ND, RDL=2	mg/kg	NC	35		
1939483	Available Uranium (U)	2009/09/15	91	75 - 125	88	75 - 125	ND, RDL=0.1	mg/kg	5.2	35		
1939483	Available Vanadium (V)	2009/09/15	NC	75 - 125	98	75 - 125	ND, RDL=2	mg/kg	9.3	35	95	75 - 125
1939483	Available Zinc (Zn)	2009/09/15	87	75 - 125	86	75 - 125	ND, RDL=5	mg/kg	1.7	35	90	75 - 125

N/A = Not Applicable
RDL = Reportable Detection Limit
RPD = Relative Percent Difference
Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.
Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.
QC Standard: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.
NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.
NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.
(1) - Poor recovery due to sample matrix.
(2) - Poor RPD due to sample inhomogeneity.

Validation Signature Page

Maxxam Job #: A9B7567

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

JERRY ARENOVICH, Inorganics Manager

==

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. SCC and CALA have approved this reporting process and electronic report format.

Your Project #: 055453
Site#: BATCH #7
Site: BELLEDUNE ECO
Your C.O.C. #: B 65323

Attention: Christine Moore
Intrinsik Environmental Sciences
5121 Sackville Street
Suite 506
Halifax, NS
CANADA B3J 1K1

Report Date: 2009/09/17

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: A9B7570
Received: 2009/09/08, 8:49

Sample Matrix: Soil
Samples Received: 33

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Metals Solid Avail. Unified MS - Nper	18	N/A	2009/09/15	ATL SOP 00024 R4	Based on EPA6020A
Metals Solid Avail. Unified MS - Nper	15	N/A	2009/09/16	ATL SOP 00024 R4	Based on EPA6020A

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
* Results relate only to the items tested.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

MICHELLE HILL, Project Manager
Email: Michelle.Hill.Reports@maxxamanalytics.com
Phone# (902) 420-0203

==
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. SCC and CALA have approved this reporting process and electronic report format.

For Service Group specific validation please refer to the Validation Signature Page

Total cover pages: 1

Maxxam Job #: A9B7570
Report Date: 2009/09/17

Intrinsik Environmental Sciences
Client Project #: 055453
Project name: BELLEDUNE ECO

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		DQ1610		DQ1618	DQ1619	DQ1620		DQ1621		DQ1622		DQ1623		DQ1624	DQ1625		
	Units	**R5A**	**RDL**	**R6A**	**R6B**	**R6C**	**RDL**	**QA/QC-21**	**RDL**	**R7A**	**RDL**	**R9A**	**RDL**	**R10A**	**R10B**	**RDL**	**QC Batch**
Metals																	
Available Aluminum (Al)	mg/kg	70000	100	1700	7600	28000	10	66000	100	3900	10	12000	10	7500	36000	10	1939483
Available Antimony (Sb)	mg/kg	ND	2	ND	ND	ND	2	ND	2	ND	2	ND	2	ND	ND	2	1939483
Available Arsenic (As)	mg/kg	6	2	4	2	4	2	8	2	3	2	5	2	ND	3	2	1939483
Available Barium (Ba)	mg/kg	360	5	52	24	51	5	450	5	18	5	450	5	34	170	5	1939483
Available Beryllium (Be)	mg/kg	7	2	ND	ND	ND	2	7	2	ND	2	ND	2	ND	ND	2	1939483
Available Bismuth (Bi)	mg/kg	ND	2	ND	ND	ND	2	ND	2	ND	2	ND	2	ND	ND	2	1939483
Available Boron (B)	mg/kg	ND	5	ND	ND	ND	5	ND	5	ND	5	ND	5	ND	ND	5	1939483
Available Cadmium (Cd)	mg/kg	3.3	0.3	1.1	ND	ND	0.3	4.2	0.3	ND	0.3	1.0	0.3	0.5	0.3	0.3	1939483
Available Chromium (Cr)	mg/kg	28	2	4	10	30	2	28	2	8	2	28	2	9	18	2	1939483
Available Cobalt (Co)	mg/kg	10	1	ND	5	10	1	11	1	5	1	8	1	5	13	1	1939483
Available Copper (Cu)	mg/kg	9	2	6	3	7	2	10	2	4	2	12	2	4	7	2	1939483
Available Iron (Fe)	mg/kg	24000	50	3500	18000	43000	50	27000	50	13000	50	15000	50	11000	38000	50	1939483
Available Lead (Pb)	mg/kg	21	0.5	74	6.5	11	0.5	19	0.5	10	0.5	40	0.5	40	13	0.5	1939483
Available Lithium (Li)	mg/kg	15	2	ND	4	21	2	15	2	ND	2	9	2	2	13	2	1939483
Available Manganese (Mn)	mg/kg	13000	2	57	78	230	2	17000	2	110	2	4400	2	480	2800	2	1939483
Available Molybdenum (Mo)	mg/kg	5	2	ND	ND	ND	2	7	2	ND	2	ND	2	ND	ND	2	1939483
Available Nickel (Ni)	mg/kg	45	2	3	7	23	2	45	2	7	2	21	2	5	10	2	1939483
Available Rubidium (Rb)	mg/kg	6	2	ND	3	8	2	8	2	4	2	8	2	3	6	2	1939483
Available Selenium (Se)	mg/kg	3	2	ND	ND	ND	2	2	2	ND	2	ND	2	ND	ND	2	1939483
Available Silver (Ag)	mg/kg	1.2	0.5	ND	ND	ND	0.5	1.2	0.5	ND	0.5	ND	0.5	ND	ND	0.5	1939483
Available Strontium (Sr)	mg/kg	ND(1)	50	22	ND	6	5	ND(2)	50	ND	5	ND(1)	50	7	ND	5	1939483
Available Thallium (Tl)	mg/kg	0.9	0.1	0.2	ND	0.1	0.1	0.9	0.1	ND	0.1	0.2	0.1	0.2	0.1	0.1	1939483
Available Tin (Sn)	mg/kg	ND	2	ND	ND	ND	2	ND	2	ND	2	ND	2	ND	ND	2	1939483
Available Uranium (U)	mg/kg	3.4	0.1	ND	0.3	0.4	0.1	2.9	0.1	0.1	0.1	1.3	0.1	0.2	0.5	0.1	1939483
Available Vanadium (V)	mg/kg	19	2	9	37	59	2	24	2	25	2	26	2	22	53	2	1939483
Available Zinc (Zn)	mg/kg	53	5	62	20	39	5	69	5	17	5	58	5	37	65	5	1939483

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
(1) - Elevated reporting limit due to matrix interferences.
(2) - Elevated reporting limit due to sample matrix.

Maxxam Job #: A9B7570
Report Date: 2009/09/17

Intrinsik Environmental Sciences
Client Project #: 055453
Project name: BELLEDUNE ECO

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		DQ1626	DQ1627	DQ1628	DQ1629	DQ1630	DQ1631		DQ1632		DQ1633		DQ1634	DQ1635		
	Units	**R10C**	**R11A**	**R12A**	**R14A**	**R14B**	**R14C**	**RDL**	**QA/QC-31**	**RDL**	**R15A**	**QC Batch**	**R16A**	**R16B**	**RDL**	**QC Batch**
Metals																
Available Aluminum (Al)	mg/kg	36000	12000	9300	9300	27000	27000	10	11000	10	19000	1939483	23000	24000	10	1941517
Available Antimony (Sb)	mg/kg	ND	ND	ND	ND	ND	ND	2	ND	2	ND	1939483	ND	ND	2	1941517
Available Arsenic (As)	mg/kg	ND	ND	ND	3	4	5	2	5	2	4	1939483	5	2	2	1941517
Available Barium (Ba)	mg/kg	220	34	39	41	51	59	5	460	5	35	1939483	110	77	5	1941517
Available Beryllium (Be)	mg/kg	ND	ND	ND	ND	ND	ND	2	ND	2	ND	1939483	ND	ND	2	1941517
Available Bismuth (Bi)	mg/kg	ND	ND	ND	ND	ND	ND	2	ND	2	ND	1939483	ND	ND	2	1941517
Available Boron (B)	mg/kg	ND	ND	ND	ND	ND	ND	5	ND	5	ND	1939483	5	ND	5	1941517
Available Cadmium (Cd)	mg/kg	ND	ND	ND	0.4	ND	ND	0.3	1.0	0.3	ND	1939483	1.6	0.5	0.3	1941517
Available Chromium (Cr)	mg/kg	36	14	15	24	29	35	2	25	2	30	1939483	17	21	2	1941517
Available Cobalt (Co)	mg/kg	13	4	3	5	9	17	1	7	1	8	1939483	17	17	1	1941517
Available Copper (Cu)	mg/kg	8	5	6	6	9	12	2	11	2	7	1939483	91	81	2	1941517
Available Iron (Fe)	mg/kg	40000	28000	31000	21000	37000	36000	50	15000	50	42000	1939483	10000	14000	50	1941517
Available Lead (Pb)	mg/kg	12	8.6	12	32	10	11	0.5	39	0.5	11	1939483	66	22	0.5	1941517
Available Lithium (Li)	mg/kg	16	7	3	5	20	21	2	7	2	15	1939483	3	3	2	1941517
Available Manganese (Mn)	mg/kg	3700	98	130	180	270	530	2	4300	2	180	1939483	980	960	2	1941517
Available Molybdenum (Mo)	mg/kg	3	ND	ND	ND	ND	ND	2	ND	2	ND	1939483	3	3	2	1941517
Available Nickel (Ni)	mg/kg	26	10	8	16	27	43	2	19	2	21	1939483	10	7	2	1941517
Available Rubidium (Rb)	mg/kg	6	3	3	4	9	9	2	7	2	5	1939483	2	2	2	1941517
Available Selenium (Se)	mg/kg	ND	ND	ND	ND	ND	ND	2	ND	2	ND	1939483	2	ND	2	1941517
Available Silver (Ag)	mg/kg	ND	ND	ND	ND	ND	ND	0.5	ND	0.5	ND	1939483	ND	ND	0.5	1941517
Available Strontium (Sr)	mg/kg	ND	5	6	8	ND	ND	5	ND(1)	50	ND	1939483	27	23	5	1941517
Available Thallium (Tl)	mg/kg	0.1	ND	ND	0.1	ND	ND	0.1	0.2	0.1	ND	1939483	0.3	0.1	0.1	1941517
Available Tin (Sn)	mg/kg	ND	ND	ND	ND	ND	ND	2	ND	2	ND	1939483	ND	ND	2	1941517
Available Uranium (U)	mg/kg	0.5	0.4	0.3	0.2	0.4	0.4	0.1	1.2	0.1	0.2	1939483	4.0	4.8	0.1	1941517
Available Vanadium (V)	mg/kg	55	47	65	39	51	44	2	22	2	62	1939483	25	68	2	1941517
Available Zinc (Zn)	mg/kg	66	19	31	40	99	100	5	59	5	72	1939483	58	30	5	1941517

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
(1) - Elevated reporting limit due to matrix interferences.

Maxxam Job #: A9B7570
Report Date: 2009/09/17

Intrinsik Environmental Sciences
Client Project #: 055453
Project name: BELLEDUNE ECO

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		DQ1636		DQ1637	DQ1638	DQ1639	DQ1640	DQ1640	DQ1641	DQ1642	DQ1643	DQ1644		
	Units	**R16C**	**RDL**	**R17A**	**R18A**	**R18B**	**R18C**	**R18C Lab-Dup**	**R19A**	**QA/QC-23**	**R21A**	**R22A**	**RDL**	**QC Batch**
Metals														
Available Aluminum (Al)	mg/kg	60000	100	26000	11000	15000	29000	28000	18000	17000	20000	9800	10	1941517
Available Antimony (Sb)	mg/kg	ND	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	2	1941517
Available Arsenic (As)	mg/kg	7	2	4	4	ND	4	4	4	2	3	2	2	1941517
Available Barium (Ba)	mg/kg	120	5	32	61	50	65	64	89	36	41	58	5	1941517
Available Beryllium (Be)	mg/kg	3	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	2	1941517
Available Bismuth (Bi)	mg/kg	ND	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	2	1941517
Available Boron (B)	mg/kg	ND	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	5	1941517
Available Cadmium (Cd)	mg/kg	0.4	0.3	0.4	0.8	ND	ND	ND	ND	ND	ND	0.4	0.3	1941517
Available Chromium (Cr)	mg/kg	39	2	13	21	17	33	36	19	19	22	14	2	1941517
Available Cobalt (Co)	mg/kg	36	1	6	5	7	16	15	14	9	10	5	1	1941517
Available Copper (Cu)	mg/kg	150	2	9	10	8	17	18	6	11	15	8	2	1941517
Available Iron (Fe)	mg/kg	32000	50	41000	17000	28000	35000	35000	29000	31000	36000	24000	50	1941517
Available Lead (Pb)	mg/kg	35	0.5	26	87	12	13	13	18	10	12	25	0.5	1941517
Available Lithium (Li)	mg/kg	12	2	8	8	9	16	16	14	11	15	6	2	1941517
Available Manganese (Mn)	mg/kg	1100	2	350	260	210	340	330	1400	260	290	500	2	1941517
Available Molybdenum (Mo)	mg/kg	3	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	2	1941517
Available Nickel (Ni)	mg/kg	22	2	8	13	12	31	31	17	16	19	8	2	1941517
Available Rubidium (Rb)	mg/kg	5	2	4	4	5	9	9	9	6	8	5	2	1941517
Available Selenium (Se)	mg/kg	ND	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	2	1941517
Available Silver (Ag)	mg/kg	ND	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.5	1941517
Available Strontium (Sr)	mg/kg	17	5	7	16	7	6	6	6	ND	6	8	5	1941517
Available Thallium (Tl)	mg/kg	ND	0.1	ND	0.2	ND	ND	ND	0.1	ND	ND	0.1	0.1	1941517
Available Tin (Sn)	mg/kg	ND	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	2	1941517
Available Uranium (U)	mg/kg	5.1	0.1	0.4	0.3	0.4	0.7	0.7	0.4	0.4	0.5	0.3	0.1	1941517
Available Vanadium (V)	mg/kg	68	2	80	31	53	59	60	54	51	57	43	2	1941517
Available Zinc (Zn)	mg/kg	56	5	52	65	36	61	60	49	59	70	52	5	1941517

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Intrinsik Environmental Sciences
Maxxam Job #: A9B7570
Client Project #: 055453
Report Date: 2009/09/17
Project name: BELLEDUNE ECO

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		DQ1645	DQ1646	DQ1647		DQ5441		DQ5442		
Sampling Date						2009/09/08		2009/09/08		
	Units	**R22B**	**R22C**	**R23A**	**QC Batch**	**Batch #7 - NIST 2711 #1**	**QC Batch**	**Batch #7 - NIST 2711 #2**	**RDL**	**QC Batch**
Metals										
Available Aluminum (Al)	mg/kg	22000	26000	5300	1941517	12000	1939483	12000	10	1941517
Available Antimony (Sb)	mg/kg	ND	ND	ND	1941517	15	1939483	19	2	1941517
Available Arsenic (As)	mg/kg	4	3	ND	1941517	96	1939483	100	2	1941517
Available Barium (Ba)	mg/kg	30	32	14	1941517	190	1939483	190	5	1941517
Available Beryllium (Be)	mg/kg	ND	ND	ND	1941517	ND	1939483	ND	2	1941517
Available Bismuth (Bi)	mg/kg	ND	ND	ND	1941517	2	1939483	2	2	1941517
Available Boron (B)	mg/kg	ND	ND	ND	1941517	7	1939483	5	5	1941517
Available Cadmium (Cd)	mg/kg	ND	ND	ND	1941517	39	1939483	42	0.3	1941517
Available Chromium (Cr)	mg/kg	22	26	7	1941517	16	1939483	18	2	1941517
Available Cobalt (Co)	mg/kg	10	13	2	1941517	8	1939483	8	1	1941517
Available Copper (Cu)	mg/kg	11	16	4	1941517	98	1939483	100	2	1941517
Available Iron (Fe)	mg/kg	34000	30000	19000	1941517	18000	1939483	18000	50	1941517
Available Lead (Pb)	mg/kg	9.5	7.7	14	1941517	1100	1939483	1100	0.5	1941517
Available Lithium (Li)	mg/kg	13	17	2	1941517	11	1939483	11	2	1941517
Available Manganese (Mn)	mg/kg	420	390	93	1941517	500	1939483	470	2	1941517
Available Molybdenum (Mo)	mg/kg	ND	ND	ND	1941517	ND	1939483	ND	2	1941517
Available Nickel (Ni)	mg/kg	16	25	5	1941517	14	1939483	16	2	1941517
Available Rubidium (Rb)	mg/kg	7	7	2	1941517	23	1939483	24	2	1941517
Available Selenium (Se)	mg/kg	ND	ND	ND	1941517	ND	1939483	ND	2	1941517
Available Silver (Ag)	mg/kg	ND	ND	ND	1941517	4.6	1939483	4.8	0.5	1941517
Available Strontium (Sr)	mg/kg	ND	ND	ND	1941517	39	1939483	39	5	1941517
Available Thallium (Tl)	mg/kg	ND	ND	ND	1941517	1.3	1939483	1.3	0.1	1941517
Available Tin (Sn)	mg/kg	ND	ND	ND	1941517	2	1939483	2	2	1941517
Available Uranium (U)	mg/kg	0.5	0.5	0.3	1941517	0.8	1939483	0.9	0.1	1941517
Available Vanadium (V)	mg/kg	56	48	34	1941517	38	1939483	42	2	1941517
Available Zinc (Zn)	mg/kg	81	100	20	1941517	300	1939483	320	5	1941517

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam Job #: A9B7570
Report Date: 2009/09/17

Intrinsik Environmental Sciences
Client Project #: 055453
Project name: BELLEDUNE ECO

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
1939483	Available Aluminum (Al)	2009/09/15	NC	75 - 125	92	75 - 125	ND, RDL=10	mg/kg	0.4	35	83	75 - 125
1939483	Available Antimony (Sb)	2009/09/15	62(1)	75 - 125	101	75 - 125	ND, RDL=2	mg/kg	NC	35		
1939483	Available Arsenic (As)	2009/09/15	NC	75 - 125	92	75 - 125	ND, RDL=2	mg/kg	18.4	35	95	75 - 125
1939483	Available Barium (Ba)	2009/09/15	NC	75 - 125	91	75 - 125	ND, RDL=5	mg/kg	14.0	35	101	75 - 125
1939483	Available Beryllium (Be)	2009/09/15	96	75 - 125	91	75 - 125	ND, RDL=2	mg/kg	NC	35		
1939483	Available Bismuth (Bi)	2009/09/15	95	75 - 125	97	75 - 125	ND, RDL=2	mg/kg	NC	35		
1939483	Available Boron (B)	2009/09/15	75	75 - 125	79	75 - 125	ND, RDL=5	mg/kg	NC	35		
1939483	Available Cadmium (Cd)	2009/09/15	97	75 - 125	95	75 - 125	ND, RDL=0.3	mg/kg	NC	35		
1939483	Available Chromium (Cr)	2009/09/15	NC	75 - 125	100	75 - 125	ND, RDL=2	mg/kg	0.08	35	81	75 - 125
1939483	Available Cobalt (Co)	2009/09/15	NC	75 - 125	95	75 - 125	ND, RDL=1	mg/kg	13.8	35	92	75 - 125
1939483	Available Copper (Cu)	2009/09/15	NC	75 - 125	90	75 - 125	ND, RDL=2	mg/kg	6.8	35	88	75 - 125
1939483	Available Iron (Fe)	2009/09/15	NC	75 - 125	92	75 - 125	ND, RDL=50	mg/kg	8.1	35	90	75 - 125
1939483	Available Lead (Pb)	2009/09/15	NC	75 - 125	87	75 - 125	ND, RDL=0.5	mg/kg	9.3	35	99	75 - 125
1939483	Available Lithium (Li)	2009/09/15	NC	75 - 125	87	75 - 125	ND, RDL=2	mg/kg	4.0	35		
1939483	Available Manganese (Mn)	2009/09/15	NC	75 - 125	88	75 - 125	ND, RDL=2	mg/kg	28.3(2)	35	101	75 - 125
1939483	Available Molybdenum (Mo)	2009/09/15	99	75 - 125	93	75 - 125	ND, RDL=2	mg/kg	NC	35		
1939483	Available Nickel (Ni)	2009/09/15	NC	75 - 125	98	75 - 125	ND, RDL=2	mg/kg	0.5	35	89	75 - 125
1939483	Available Rubidium (Rb)	2009/09/15	90	75 - 125	98	75 - 125	ND, RDL=2	mg/kg	NC	35		
1939483	Available Selenium (Se)	2009/09/15	85	75 - 125	86	75 - 125	ND, RDL=2	mg/kg	NC	35		
1939483	Available Silver (Ag)	2009/09/15	98	75 - 125	93	75 - 125	ND, RDL=0.5	mg/kg	NC	35		
1939483	Available Strontium (Sr)	2009/09/15	NC	75 - 125	92	75 - 125	ND, RDL=5	mg/kg	NC	35	90	75 - 125
1939483	Available Thallium (Tl)	2009/09/15	88	75 - 125	77	75 - 125	ND, RDL=0.1	mg/kg	NC	35		
1939483	Available Tin (Sn)	2009/09/15	102	75 - 125	97	75 - 125	ND, RDL=2	mg/kg	NC	35		
1939483	Available Uranium (U)	2009/09/15	91	75 - 125	88	75 - 125	ND, RDL=0.1	mg/kg	5.2	35		
1939483	Available Vanadium (V)	2009/09/15	NC	75 - 125	98	75 - 125	ND, RDL=2	mg/kg	9.3	35	95	75 - 125
1939483	Available Zinc (Zn)	2009/09/15	87	75 - 125	86	75 - 125	ND, RDL=5	mg/kg	1.7	35	90	75 - 125
1941517	Available Aluminum (Al)	2009/09/16	NC	75 - 125	96	75 - 125	ND, RDL=10	mg/kg	2.0	35	81	75 - 125
1941517	Available Antimony (Sb)	2009/09/16	82	75 - 125	106	75 - 125	ND, RDL=2	mg/kg	NC	35		
1941517	Available Arsenic (As)	2009/09/16	101	75 - 125	92	75 - 125	ND, RDL=2	mg/kg	NC	35	109	75 - 125
1941517	Available Barium (Ba)	2009/09/16	NC	75 - 125	96	75 - 125	ND, RDL=5	mg/kg	0.7	35	101	75 - 125
1941517	Available Beryllium (Be)	2009/09/16	91	75 - 125	92	75 - 125	ND, RDL=2	mg/kg	NC	35		
1941517	Available Bismuth (Bi)	2009/09/16	99	75 - 125	95	75 - 125	ND, RDL=2	mg/kg	NC	35		
1941517	Available Boron (B)	2009/09/16	73(3)	75 - 125	96	75 - 125	ND, RDL=5	mg/kg	NC	35		
1941517	Available Cadmium (Cd)	2009/09/16	102	75 - 125	95	75 - 125	ND, RDL=0.3	mg/kg	NC	35		
1941517	Available Chromium (Cr)	2009/09/16	NC	75 - 125	91	75 - 125	ND, RDL=2	mg/kg	11.1	35	86	75 - 125
1941517	Available Cobalt (Co)	2009/09/16	NC	75 - 125	91	75 - 125	ND, RDL=1	mg/kg	3.5	35	96	75 - 125
1941517	Available Copper (Cu)	2009/09/16	NC	75 - 125	91	75 - 125	ND, RDL=2	mg/kg	8.4	35	91	75 - 125
1941517	Available Iron (Fe)	2009/09/16	NC	75 - 125	100	75 - 125	ND, RDL=50	mg/kg	0.8	35	90	75 - 125
1941517	Available Lead (Pb)	2009/09/16	NC	75 - 125	95	75 - 125	ND, RDL=0.5	mg/kg	0.4	35	99	75 - 125
1941517	Available Lithium (Li)	2009/09/16	NC	75 - 125	91	75 - 125	ND, RDL=2	mg/kg	0.4	35		

Intrinsik Environmental Sciences
Maxxam Job #: A9B7570
Client Project #: 055453
Report Date: 2009/09/17
Project name: BELLEDUNE ECO

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**	**% Recovery**	**QC Limits**
1941517	Available Manganese (Mn)	2009/09/16	NC	75 - 125	96	75 - 125	ND, RDL=2	mg/kg	3.0	35	95	75 - 125
1941517	Available Molybdenum (Mo)	2009/09/16	97	75 - 125	92	75 - 125	ND, RDL=2	mg/kg	NC	35		
1941517	Available Nickel (Ni)	2009/09/16	NC	75 - 125	90	75 - 125	ND, RDL=2	mg/kg	0.8	35	99	75 - 125
1941517	Available Rubidium (Rb)	2009/09/16	91	75 - 125	98	75 - 125	ND, RDL=2	mg/kg	NC	35		
1941517	Available Selenium (Se)	2009/09/16	90	75 - 125	84	75 - 125	ND, RDL=2	mg/kg	NC	35		
1941517	Available Silver (Ag)	2009/09/16	101	75 - 125	99	75 - 125	ND, RDL=0.5	mg/kg	NC	35		
1941517	Available Strontium (Sr)	2009/09/16	95	75 - 125	98	75 - 125	ND, RDL=5	mg/kg	NC	35	92	75 - 125
1941517	Available Thallium (Tl)	2009/09/16	96	75 - 125	86	75 - 125	ND, RDL=0.1	mg/kg	NC	35		
1941517	Available Tin (Sn)	2009/09/16	105	75 - 125	93	75 - 125	ND, RDL=2	mg/kg	NC	35		
1941517	Available Uranium (U)	2009/09/16	101	75 - 125	89	75 - 125	ND, RDL=0.1	mg/kg	2.4	35		
1941517	Available Vanadium (V)	2009/09/16	NC	75 - 125	93	75 - 125	ND, RDL=2	mg/kg	1.4	35	107	75 - 125
1941517	Available Zinc (Zn)	2009/09/16	98	75 - 125	94	75 - 125	ND, RDL=5	mg/kg	1.3	35	101	75 - 125

N/A = Not Applicable
RDL = Reportable Detection Limit
RPD = Relative Percent Difference
Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.
Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.
QC Standard: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.
NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.
NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.
(1) - Poor recovery due to sample matrix.
(2) - Poor RPD due to sample inhomogeneity.
(3) - Low recovery due to sample matrix.

Validation Signature Page

Maxxam Job #: A9B7570

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

JERRY ARENOVICH, Inorganics Manager

===

Your Project #: 055453
Site: BELLEDUNE ECO
Your C.O.C. #: B 65312

Attention: Christine Moore
Intrinsik Environmental Sciences
5121 Sackville Street
Suite 506
Halifax, NS
CANADA B3J 1K1

Report Date: 2009/09/17

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: A9B7575
Received: 2009/09/08, 8:46

Sample Matrix: Soil
Samples Received: 23

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Metals Solid Avail. Unified MS - Nper	23	N/A	2009/09/16	ATL SOP 00024 R4	Based on EPA6020A

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
* Results relate only to the items tested.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

MICHELLE HILL, Project Manager
Email: Michelle.Hill.Reports@maxxamanalytics.com
Phone# (902) 420-0203

==

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. SCC and CALA have approved this reporting process and electronic report format.

For Service Group specific validation please refer to the Validation Signature Page

Total cover pages: 1

Maxxam Job #: A9B7575
Report Date: 2009/09/17

Intrinsik Environmental Sciences
Client Project #: 055453
Project name: BELLEDUNE ECO

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		DQ1649	DQ1650	DQ1651		DQ1652	DQ1653			DQ1654	DQ1655	DQ1656		
Sampling Date		2009/07/31 JUL-AUG	2009/07/31 JUL-AUG	2009/07/31 JUL-AUG		2009/07/31 JUL-AUG	2009/07/31 JUL-AUG			2009/07/31 JUL-AUG	2009/07/31 JUL-AUG	2009/07/31 JUL-AUG		
	Units	**S26A**	**S27A**	**S30A**	**RDL**	**S30B**	**S30C**	**RDL**	**QC Batch**	**QA/QC-1**	**S31A**	**S32A**	**RDL**	**QC Batch**
Metals														
Available Aluminum (Al)	mg/kg	18000	25000	6700	10	13000	26000	10	1941517	16000	17000	11000	10	1941518
Available Antimony (Sb)	mg/kg	ND	ND	2	2	ND	ND	2	1941517	ND	ND	14	2	1941518
Available Arsenic (As)	mg/kg	12	240	12	2	6	20	2	1941517	11	7	50	2	1941518
Available Barium (Ba)	mg/kg	160	50	280	5	390	600	5	1941517	150	200	85	5	1941518
Available Beryllium (Be)	mg/kg	ND	ND	ND	2	ND	3	2	1941517	ND	ND	ND	2	1941518
Available Bismuth (Bi)	mg/kg	ND	ND	ND	2	ND	ND	2	1941517	ND	ND	ND	2	1941518
Available Boron (B)	mg/kg	ND	ND	6	5	5	ND	5	1941517	ND	ND	ND	5	1941518
Available Cadmium (Cd)	mg/kg	1.1	5.6	4.3	0.3	4.0	2.7	0.3	1941517	1.3	1.0	5.9	0.3	1941518
Available Chromium (Cr)	mg/kg	40	56	43	2	27	56	2	1941517	37	54	26	2	1941518
Available Cobalt (Co)	mg/kg	13	17	3	1	2	8	1	1941517	13	9	11	1	1941518
Available Copper (Cu)	mg/kg	17	46	40	2	80	86	2	1941517	17	9	77	2	1941518
Available Iron (Fe)	mg/kg	28000	14000	4600	50	5500	20000	50	1941517	28000	29000	33000	50	1941518
Available Lead (Pb)	mg/kg	93	340	260	0.5	24	20	0.5	1941517	98	110	740	0.5	1941518
Available Lithium (Li)	mg/kg	20	ND	3	2	6	30	2	1941517	18	18	13	2	1941518
Available Manganese (Mn)	mg/kg	730	3100	920	2	510	410	2	1941517	940	580	420	2	1941518
Available Molybdenum (Mo)	mg/kg	ND	ND	4	2	5	8	2	1941517	ND	ND	2	2	1941518
Available Nickel (Ni)	mg/kg	40	18	24	2	15	48	2	1941517	41	36	17	2	1941518
Available Rubidium (Rb)	mg/kg	7	ND	2	2	3	12	2	1941517	6	14	10	2	1941518
Available Selenium (Se)	mg/kg	ND	2	4	2	8	5	2	1941517	ND	ND	ND	2	1941518
Available Silver (Ag)	mg/kg	ND	1.7	0.8	0.5	1.0	1.3	0.5	1941517	ND	0.5	1.1	0.5	1941518
Available Strontium (Sr)	mg/kg	9	15	45	5	60	ND(1)	50	1941517	9	14	15	5	1941518
Available Thallium (Tl)	mg/kg	0.5	0.3	0.8	0.1	0.1	0.2	0.1	1941517	0.4	0.4	0.9	0.1	1941518
Available Tin (Sn)	mg/kg	ND	ND	ND	2	ND	ND	2	1941517	ND	ND	26	2	1941518
Available Uranium (U)	mg/kg	0.5	0.8	5.1	0.1	7.9	9.4	0.1	1941517	0.5	0.6	0.4	0.1	1941518
Available Vanadium (V)	mg/kg	64	36	28	2	27	52	2	1941517	45	43	45	2	1941518
Available Zinc (Zn)	mg/kg	90	120	140	5	87	120	5	1941517	84	69	1800	5	1941518

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
(1) - Elevated reporting limit due to matrix interferences.

Maxxam Job #: A9B7575
Report Date: 2009/09/17

Intrinsik Environmental Sciences
Client Project #: 055453
Project name: BELLEDUNE ECO

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		DQ1657	DQ1658	DQ1659	DQ1660	DQ1661	DQ1662	DQ1663	DQ1664	DQ1665		
Sampling Date		2009/07/31	2009/07/31	2009/07/31	2009/07/31	2009/07/31	2009/07/31	2009/07/31	2009/07/31	2009/07/31		
		JUL-AUG	JUL-AUG	JUL-AUG	JUL-AUG	JUL-AUG	JUL-AUG	JUL-AUG	JUL-AUG	JUL-AUG		
	Units	**S32B**	**S32C**	**S33A**	**S33B**	**S33C**	**S34A**	**QA/QC-20**	**S35A**	**S35B**	**RDL**	**QC Batch**
Metals												
Available Aluminum (Al)	mg/kg	15000	19000	9600	12000	13000	13000	19000	14000	16000	10	1941518
Available Antimony (Sb)	mg/kg	ND	ND	3	ND	ND	ND	ND	ND	ND	2	1941518
Available Arsenic (As)	mg/kg	7	8	16	8	6	10	140	22	28	2	1941518
Available Barium (Ba)	mg/kg	48	42	82	77	66	35	34	62	49	5	1941518
Available Beryllium (Be)	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	2	1941518
Available Bismuth (Bi)	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	2	1941518
Available Boron (B)	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	5	1941518
Available Cadmium (Cd)	mg/kg	0.5	ND	3.1	0.6	ND	0.4	4.0	1.2	0.5	0.3	1941518
Available Chromium (Cr)	mg/kg	30	35	19	26	25	22	42	53	44	2	1941518
Available Cobalt (Co)	mg/kg	10	14	7	11	11	4	13	8	9	1	1941518
Available Copper (Cu)	mg/kg	11	15	16	9	8	9	39	16	16	2	1941518
Available Iron (Fe)	mg/kg	31000	28000	19000	23000	22000	34000	8800	33000	44000	50	1941518
Available Lead (Pb)	mg/kg	27	18	170	32	11	36	270	83	34	0.5	1941518
Available Lithium (Li)	mg/kg	18	19	14	20	22	8	ND	13	15	2	1941518
Available Manganese (Mn)	mg/kg	400	540	450	500	530	210	1700	400	370	2	1941518
Available Molybdenum (Mo)	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	2	1941518
Available Nickel (Ni)	mg/kg	29	48	16	25	31	11	10	22	18	2	1941518
Available Rubidium (Rb)	mg/kg	8	6	8	7	5	8	ND	5	5	2	1941518
Available Selenium (Se)	mg/kg	ND	ND	ND	ND	ND	ND	2	ND	ND	2	1941518
Available Silver (Ag)	mg/kg	ND	ND	ND	ND	ND	0.6	1.5	0.7	0.7	0.5	1941518
Available Strontium (Sr)	mg/kg	ND	ND	6	5	6	ND	10	6	ND	5	1941518
Available Thallium (Tl)	mg/kg	0.1	ND	0.8	0.1	ND	0.2	0.2	0.2	0.2	0.1	1941518
Available Tin (Sn)	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	2	1941518
Available Uranium (U)	mg/kg	0.3	0.4	0.6	0.6	0.6	0.3	0.7	0.2	0.3	0.1	1941518
Available Vanadium (V)	mg/kg	44	44	34	38	32	72	25	88	110	2	1941518
Available Zinc (Zn)	mg/kg	100	72	120	54	43	58	83	99	81	5	1941518

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam Job #: A9B7575
Report Date: 2009/09/17

Intrinsik Environmental Sciences
Client Project #: 055453
Project name: BELLEDUNE ECO

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		DQ1666	DQ1666		DQ1667	DQ1668	DQ1669	DQ1680	DQ5416		
Sampling Date		2009/07/31 JUL-AUG	2009/07/31 JUL-AUG		2009/07/31 JUL-AUG	2009/07/31 JUL-AUG	2009/07/31 JUL-AUG	2009/07/31 JUL-AUG	2009/09/08		
	Units	**S35C**	**S35C Lab-Dup**	**RDL**	**S-36A**	**S-38A**	**S-38B**	**S-38C**	**Batch #4 - NIST 2711**	**RDL**	**QC Batch**
Metals											
Available Aluminum (Al)	mg/kg	25000	27000	10	44000	14000	21000	24000	12000	10	1941518
Available Antimony (Sb)	mg/kg	ND	ND	2	ND	ND	ND	ND	15	2	1941518
Available Arsenic (As)	mg/kg	53	69	2	130	11	12	9	87	2	1941518
Available Barium (Ba)	mg/kg	46	55	5	120	160	120	100	180	5	1941518
Available Beryllium (Be)	mg/kg	ND	ND	2	ND	ND	ND	ND	ND	2	1941518
Available Bismuth (Bi)	mg/kg	ND	ND	2	ND	ND	ND	ND	2	2	1941518
Available Boron (B)	mg/kg	ND	ND	5	ND	ND	ND	ND	6	5	1941518
Available Cadmium (Cd)	mg/kg	0.4	0.5	0.3	0.8	1.9	0.3	ND	37	0.3	1941518
Available Chromium (Cr)	mg/kg	73	74	2	91	24	43	49	17	2	1941518
Available Cobalt (Co)	mg/kg	14	15	1	28	9	14	18	8	1	1941518
Available Copper (Cu)	mg/kg	19	21	2	29	15	13	19	100	2	1941518
Available Iron (Fe)	mg/kg	49000	48000	500	41000	25000	36000	37000	18000	50	1941518
Available Lead (Pb)	mg/kg	27	29	0.5	54	130	25	21	1200	0.5	1941518
Available Lithium (Li)	mg/kg	24	26	2	30	21	36	38	11	2	1941518
Available Manganese (Mn)	mg/kg	360	430	2	2300	410	510	680	510	2	1941518
Available Molybdenum (Mo)	mg/kg	7	ND	2	4	ND	ND	ND	ND	2	1941518
Available Nickel (Ni)	mg/kg	35	39	2	89	20	39	51	15	2	1941518
Available Rubidium (Rb)	mg/kg	8	9	2	6	11	11	8	20	2	1941518
Available Selenium (Se)	mg/kg	ND	ND	2	ND	ND	ND	ND	ND	2	1941518
Available Silver (Ag)	mg/kg	ND	0.5	0.5	0.8	ND	ND	ND	4.5	0.5	1941518
Available Strontium (Sr)	mg/kg	ND	ND	5	7	18	9	7	36	5	1941518
Available Thallium (Tl)	mg/kg	0.1	0.2	0.1	0.4	0.4	ND	ND	1.5	0.1	1941518
Available Tin (Sn)	mg/kg	ND	ND	2	ND	ND	ND	ND	ND	2	1941518
Available Uranium (U)	mg/kg	0.3	0.3	0.1	1.0	0.3	0.3	0.5	0.8	0.1	1941518
Available Vanadium (V)	mg/kg	110	100	2	100	41	57	55	38	2	1941518
Available Zinc (Zn)	mg/kg	100	120	5	250	110	80	74	300	5	1941518

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
1941517	Available Aluminum (Al)	2009/09/16	NC	75 - 125	96	75 - 125	ND, RDL=10	mg/kg	2.0	35	81	75 - 125
1941517	Available Antimony (Sb)	2009/09/16	82	75 - 125	106	75 - 125	ND, RDL=2	mg/kg	NC	35		
1941517	Available Arsenic (As)	2009/09/16	101	75 - 125	92	75 - 125	ND, RDL=2	mg/kg	NC	35	109	75 - 125
1941517	Available Barium (Ba)	2009/09/16	NC	75 - 125	96	75 - 125	ND, RDL=5	mg/kg	0.7	35	101	75 - 125
1941517	Available Beryllium (Be)	2009/09/16	91	75 - 125	92	75 - 125	ND, RDL=2	mg/kg	NC	35		
1941517	Available Bismuth (Bi)	2009/09/16	99	75 - 125	95	75 - 125	ND, RDL=2	mg/kg	NC	35		
1941517	Available Boron (B)	2009/09/16	73(1)	75 - 125	96	75 - 125	ND, RDL=5	mg/kg	NC	35		
1941517	Available Cadmium (Cd)	2009/09/16	102	75 - 125	95	75 - 125	ND, RDL=0.3	mg/kg	NC	35		
1941517	Available Chromium (Cr)	2009/09/16	NC	75 - 125	91	75 - 125	ND, RDL=2	mg/kg	11.1	35	86	75 - 125
1941517	Available Cobalt (Co)	2009/09/16	NC	75 - 125	91	75 - 125	ND, RDL=1	mg/kg	3.5	35	96	75 - 125
1941517	Available Copper (Cu)	2009/09/16	NC	75 - 125	91	75 - 125	ND, RDL=2	mg/kg	8.4	35	91	75 - 125
1941517	Available Iron (Fe)	2009/09/16	NC	75 - 125	100	75 - 125	ND, RDL=50	mg/kg	0.8	35	90	75 - 125
1941517	Available Lead (Pb)	2009/09/16	NC	75 - 125	95	75 - 125	ND, RDL=0.5	mg/kg	0.4	35	99	75 - 125
1941517	Available Lithium (Li)	2009/09/16	NC	75 - 125	91	75 - 125	ND, RDL=2	mg/kg	0.4	35		
1941517	Available Manganese (Mn)	2009/09/16	NC	75 - 125	96	75 - 125	ND, RDL=2	mg/kg	3.0	35	95	75 - 125
1941517	Available Molybdenum (Mo)	2009/09/16	97	75 - 125	92	75 - 125	ND, RDL=2	mg/kg	NC	35		
1941517	Available Nickel (Ni)	2009/09/16	NC	75 - 125	90	75 - 125	ND, RDL=2	mg/kg	0.8	35	99	75 - 125
1941517	Available Rubidium (Rb)	2009/09/16	91	75 - 125	98	75 - 125	ND, RDL=2	mg/kg	NC	35		
1941517	Available Selenium (Se)	2009/09/16	90	75 - 125	84	75 - 125	ND, RDL=2	mg/kg	NC	35		
1941517	Available Silver (Ag)	2009/09/16	101	75 - 125	99	75 - 125	ND, RDL=0.5	mg/kg	NC	35		
1941517	Available Strontium (Sr)	2009/09/16	95	75 - 125	98	75 - 125	ND, RDL=5	mg/kg	NC	35	92	75 - 125
1941517	Available Thallium (Tl)	2009/09/16	96	75 - 125	86	75 - 125	ND, RDL=0.1	mg/kg	NC	35		
1941517	Available Tin (Sn)	2009/09/16	105	75 - 125	93	75 - 125	ND, RDL=2	mg/kg	NC	35		
1941517	Available Uranium (U)	2009/09/16	101	75 - 125	89	75 - 125	ND, RDL=0.1	mg/kg	2.4	35		
1941517	Available Vanadium (V)	2009/09/16	NC	75 - 125	93	75 - 125	ND, RDL=2	mg/kg	1.4	35	107	75 - 125
1941517	Available Zinc (Zn)	2009/09/16	98	75 - 125	94	75 - 125	ND, RDL=5	mg/kg	1.3	35	101	75 - 125
1941518	Available Aluminum (Al)	2009/09/16	NC	75 - 125	93	75 - 125	ND, RDL=10	mg/kg	9.3	35	79	75 - 125
1941518	Available Antimony (Sb)	2009/09/16	60(1)	75 - 125	108	75 - 125	ND, RDL=2	mg/kg	NC	35		
1941518	Available Arsenic (As)	2009/09/16	NC	75 - 125	96	75 - 125	ND, RDL=2	mg/kg	25.8	35	117	75 - 125
1941518	Available Barium (Ba)	2009/09/16	NC	75 - 125	93	75 - 125	ND, RDL=5	mg/kg	18.2	35	103	75 - 125
1941518	Available Beryllium (Be)	2009/09/16	95	75 - 125	89	75 - 125	ND, RDL=2	mg/kg	NC	35		
1941518	Available Bismuth (Bi)	2009/09/16	101	75 - 125	92	75 - 125	ND, RDL=2	mg/kg	NC	35		
1941518	Available Boron (B)	2009/09/16	64(1)	75 - 125	91	75 - 125	ND, RDL=5	mg/kg	NC	35		
1941518	Available Cadmium (Cd)	2009/09/16	101	75 - 125	90	75 - 125	ND, RDL=0.3	mg/kg	NC	35		
1941518	Available Chromium (Cr)	2009/09/16	NC	75 - 125	94	75 - 125	ND, RDL=2	mg/kg	1.6	35	77	75 - 125
1941518	Available Cobalt (Co)	2009/09/16	NC	75 - 125	93	75 - 125	ND, RDL=1	mg/kg	6.5	35	95	75 - 125
1941518	Available Copper (Cu)	2009/09/16	NC	75 - 125	91	75 - 125	ND, RDL=2	mg/kg	10.2	35	84	75 - 125
1941518	Available Iron (Fe)	2009/09/16	NC	75 - 125	101	75 - 125	ND, RDL=50	mg/kg	2.9	35	91	75 - 125
1941518	Available Lead (Pb)	2009/09/16	NC	75 - 125	92	75 - 125	ND, RDL=0.5	mg/kg	7.5	35	97	75 - 125
1941518	Available Lithium (Li)	2009/09/16	NC	75 - 125	91	75 - 125	ND, RDL=2	mg/kg	4.5	35		

Maxxam Job #: A9B7575
Report Date: 2009/09/17

Intrinsik Environmental Sciences
Client Project #: 055453
Project name: BELLEDUNE ECO

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**	**% Recovery**	**QC Limits**
1941518	Available Manganese (Mn)	2009/09/16	NC	75 - 125	93	75 - 125	ND, RDL=2	mg/kg	17.9	35	97	75 - 125
1941518	Available Molybdenum (Mo)	2009/09/16	64(1)	75 - 125	87	75 - 125	ND, RDL=2	mg/kg	NC	35		
1941518	Available Nickel (Ni)	2009/09/16	NC	75 - 125	92	75 - 125	ND, RDL=2	mg/kg	11.2	35	96	75 - 125
1941518	Available Rubidium (Rb)	2009/09/16	95	75 - 125	94	75 - 125	ND, RDL=2	mg/kg	NC	35		
1941518	Available Selenium (Se)	2009/09/16	81	75 - 125	90	75 - 125	ND, RDL=2	mg/kg	NC	35		
1941518	Available Silver (Ag)	2009/09/16	108	75 - 125	102	75 - 125	ND, RDL=0.5	mg/kg	NC	35		
1941518	Available Strontium (Sr)	2009/09/16	94	75 - 125	97	75 - 125	ND, RDL=5	mg/kg	NC	35	90	75 - 125
1941518	Available Thallium (Tl)	2009/09/16	89	75 - 125	86	75 - 125	ND, RDL=0.1	mg/kg	NC	35		
1941518	Available Tin (Sn)	2009/09/16	102	75 - 125	91	75 - 125	ND, RDL=2	mg/kg	NC	35		
1941518	Available Uranium (U)	2009/09/16	96	75 - 125	86	75 - 125	ND, RDL=0.1	mg/kg	NC	35		
1941518	Available Vanadium (V)	2009/09/16	NC	75 - 125	99	75 - 125	ND, RDL=2	mg/kg	3.4	35	96	75 - 125
1941518	Available Zinc (Zn)	2009/09/16	99	75 - 125	92	75 - 125	ND, RDL=5	mg/kg	16.9	35	101	75 - 125

N/A = Not Applicable

RDL = Reportable Detection Limit

RPD = Relative Percent Difference

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

QC Standard: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.

Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.

NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

(1) - Low recovery due to sample matrix.

Validation Signature Page

Maxxam Job #: A9B7575

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

JERRY ARENOVICH, Inorganics Manager

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Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. SCC and CALA have approved this reporting process and electronic report format.

Your Project #: 055453
Site: BELLEDUNE ECO
Your C.O.C. #: B 65306

Attention: Christine Moore
Intrinsik Environmental Sciences
5121 Sackville Street
Suite 506
Halifax, NS
CANADA B3J 1K1

Report Date: 2009/09/21

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: A9B7578
Received: 2009/09/08, 8:48

Sample Matrix: Soil
Samples Received: 24

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Metals Solid Avail. Unified MS - Nper	2	N/A	2009/09/16	ATL SOP 00024 R4	Based on EPA6020A
Metals Solid Avail. Unified MS - Nper	22	N/A	2009/09/17	ATL SOP 00024 R4	Based on EPA6020A

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
* Results relate only to the items tested.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

MICHELLE HILL, Project Manager
Email: Michelle.Hill.Reports@maxxamanalytics.com
Phone# (902) 420-0203

==
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. SCC and CALA have approved this reporting process and electronic report format.

For Service Group specific validation please refer to the Validation Signature Page

Total cover pages: 1

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		DQ1682	DQ1683			DQ1684		DQ1685	DQ1686	DQ1687	DQ1688	DQ1688		
Sampling Date		2009/07/31 JUL-AUG	2009/07/31 JUL-AUG			2009/07/31 JUL-AUG		2009/07/31 JUL-AUG	2009/07/31 JUL-AUG	2009/07/31 JUL-AUG	2009/07/31 JUL-AUG	2009/07/31 JUL-AUG		
	Units	**S1A**	**S1B**	**RDL**	**QC Batch**	**S1C**	**RDL**	**S2A**	**S3A**	**S5A**	**S5B**	**S5B Lab-Dup**	**RDL**	**QC Batch**
Metals														
Available Aluminum (Al)	mg/kg	2900	21000	10	1941518	25000	10	20000	7500	8800	15000	15000	10	1942106
Available Antimony (Sb)	mg/kg	ND	ND	2	1941518	ND	2	ND	ND	ND	ND	ND	2	1942106
Available Arsenic (As)	mg/kg	5	16	2	1941518	18	2	15	10	28	37	32	2	1942106
Available Barium (Ba)	mg/kg	25	40	5	1941518	39	5	32	30	86	80	79	5	1942106
Available Beryllium (Be)	mg/kg	ND	ND	2	1941518	ND	2	ND	ND	ND	ND	ND	2	1942106
Available Bismuth (Bi)	mg/kg	ND	ND	2	1941518	ND	2	ND	ND	ND	ND	ND	2	1942106
Available Boron (B)	mg/kg	ND	ND	5	1941518	ND	5	ND	ND	ND	ND	ND	5	1942106
Available Cadmium (Cd)	mg/kg	0.6	ND	0.3	1941518	ND	0.3	ND	1.0	0.6	ND	ND	0.3	1942106
Available Chromium (Cr)	mg/kg	7	36	2	1941518	48	2	25	8	21	43	39	2	1942106
Available Cobalt (Co)	mg/kg	2	14	1	1941518	19	1	5	7	6	11	11	1	1942106
Available Copper (Cu)	mg/kg	12	16	2	1941518	25	2	9	9	5	5	6	2	1942106
Available Iron (Fe)	mg/kg	7100	42000	50	1941518	48000	500	35000	28000	15000	29000	27000	50	1942106
Available Lead (Pb)	mg/kg	56	13	0.5	1941518	10	0.5	26	64	37	21	18	0.5	1942106
Available Lithium (Li)	mg/kg	ND	25	2	1941518	36	2	18	5	12	24	23	2	1942106
Available Manganese (Mn)	mg/kg	69	340	2	1941518	470	2	170	290	510	330	310	2	1942106
Available Molybdenum (Mo)	mg/kg	ND	3	2	1941518	2	2	ND	ND	ND	ND	ND	2	1942106
Available Nickel (Ni)	mg/kg	6	38	2	1941518	60	2	13	7	13	28	29	2	1942106
Available Rubidium (Rb)	mg/kg	2	5	2	1941518	6	2	8	ND	6	8	8	2	1942106
Available Selenium (Se)	mg/kg	ND	ND	2	1941518	ND	2	ND	ND	ND	ND	ND	2	1942106
Available Silver (Ag)	mg/kg	ND	ND	0.5	1941518	ND	0.5	ND	ND	ND	ND	ND	0.5	1942106
Available Strontium (Sr)	mg/kg	7	6	5	1941518	ND	5	ND	ND	10	6	6	5	1942106
Available Thallium (Tl)	mg/kg	0.1	0.1	0.1	1941518	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.1	1942106
Available Tin (Sn)	mg/kg	ND	ND	2	1941518	ND	2	ND	ND	ND	ND	ND	2	1942106
Available Uranium (U)	mg/kg	0.1	0.5	0.1	1941518	0.5	0.1	0.3	ND	0.2	0.2	0.2	0.1	1942106
Available Vanadium (V)	mg/kg	20	75	2	1941518	57	2	70	100	37	51	51	2	1942106
Available Zinc (Zn)	mg/kg	46	45	5	1941518	50	5	59	67	59	60	62	5	1942106

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam Job #: A9B7578
Report Date: 2009/09/21

Intrinsik Environmental Sciences
Client Project #: 055453
Project name: BELLEDUNE ECO

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		DQ1689	DQ1690	DQ1691		DQ1692	DQ1693	DQ1694		DQ1695	DQ1696	DQ1697		
Sampling Date		2009/07/31 JUL-AUG	2009/07/31 JUL-AUG	2009/07/31 JUL-AUG		2009/07/31 JUL-AUG	2009/07/31 JUL-AUG	2009/07/31 JUL-AUG		2009/07/31 JUL-AUG	2009/07/31 JUL-AUG	2009/07/31 JUL-AUG		
	Units	**S5C**	**S6A**	**S7A**	**RDL**	**S8A**	**S8B**	**S8C**	**RDL**	**QA/QC-13**	**S9A**	**S10A**	**RDL**	**QC Batch**
Metals														
Available Aluminum (Al)	mg/kg	17000	4200	18000	10	23000	39000	35000	10	8000	24000	16000	10	1942106
Available Antimony (Sb)	mg/kg	ND	ND	ND	2	ND	ND	ND	2	ND	ND	ND	2	1942106
Available Arsenic (As)	mg/kg	55	ND	17	2	16	16	19	2	24	21	7	2	1942106
Available Barium (Ba)	mg/kg	77	6	110	5	52	36	42	5	37	130	42	5	1942106
Available Beryllium (Be)	mg/kg	ND	ND	ND	2	ND	ND	ND	2	ND	ND	ND	2	1942106
Available Bismuth (Bi)	mg/kg	ND	ND	ND	2	ND	ND	ND	2	ND	ND	ND	2	1942106
Available Boron (B)	mg/kg	ND	ND	ND	5	ND	ND	ND	5	ND	ND	ND	5	1942106
Available Cadmium (Cd)	mg/kg	ND	ND	0.6	0.3	1.7	0.7	0.5	0.3	1.4	0.8	1.5	0.3	1942106
Available Chromium (Cr)	mg/kg	48	46	35	2	25	56	80	2	12	100	98	2	1942106
Available Cobalt (Co)	mg/kg	13	4	12	1	15	34	49	1	6	22	10	1	1942106
Available Copper (Cu)	mg/kg	7	4	15	2	30	35	30	2	11	33	10	2	1942106
Available Iron (Fe)	mg/kg	34000	8400	38000	50	68000	83000	92000	500	35000	39000	30000	50	1942106
Available Lead (Pb)	mg/kg	19	10	47	0.5	110	39	38	0.5	110	42	98	0.5	1942106
Available Lithium (Li)	mg/kg	23	ND	18	2	18	31	35	2	5	24	15	2	1942106
Available Manganese (Mn)	mg/kg	390	72	1500	2	1800	3700	5500	2	300	3100	420	2	1942106
Available Molybdenum (Mo)	mg/kg	ND	ND	ND	2	5	6	5	2	ND	ND	ND	2	1942106
Available Nickel (Ni)	mg/kg	34	23	25	2	11	24	35	2	8	62	28	2	1942106
Available Rubidium (Rb)	mg/kg	7	ND	12	2	3	3	3	2	ND	11	2	2	1942106
Available Selenium (Se)	mg/kg	ND	ND	ND	2	ND	ND	ND	2	ND	3	ND	2	1942106
Available Silver (Ag)	mg/kg	ND	ND	ND	0.5	0.7	ND	ND	0.5	ND	ND	ND	0.5	1942106
Available Strontium (Sr)	mg/kg	5	ND	10	5	10	ND	ND	5	7	9	10	5	1942106
Available Thallium (Tl)	mg/kg	0.1	ND	0.3	0.1	0.5	0.3	0.3	0.1	0.2	0.4	0.4	0.1	1942106
Available Tin (Sn)	mg/kg	ND	ND	ND	2	ND	ND	ND	2	ND	ND	ND	2	1942106
Available Uranium (U)	mg/kg	0.3	ND	0.5	0.1	0.3	0.5	0.5	0.1	ND	0.6	0.2	0.1	1942106
Available Vanadium (V)	mg/kg	56	54	83	2	190	210	190	2	150	85	150	2	1942106
Available Zinc (Zn)	mg/kg	61	17	94	5	340	450	440	5	88	170	75	5	1942106

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		DQ1698	DQ1699	DQ1700	DQ1701	DQ1702		DQ1703	DQ1710		DQ5395		
Sampling Date		2009/07/31 JUL-AUG	2009/07/31 JUL-AUG	2009/07/31 JUL-AUG	2009/07/31 JUL-AUG	2009/07/31 JUL-AUG		2009/07/31 JUL-AUG	2009/07/31 JUL-AUG		2009/09/08		
	Units	**S10B**	**S10C**	**S12A**	**S14A**	**S15A**	**QC Batch**	**QA/QC-11**	**S-17A**	**QC Batch**	**Batch #2 - NIST 2711**	**RDL**	**QC Batch**
Metals													
Available Aluminum (Al)	mg/kg	24000	29000	9900	32000	14000	1942106	32000	12000	1942107	13000	10	1942106
Available Antimony (Sb)	mg/kg	ND	ND	ND	ND	ND	1942106	ND	ND	1942107	17	2	1942106
Available Arsenic (As)	mg/kg	3	2	13	10	4	1942106	12	13	1942107	95	2	1942106
Available Barium (Ba)	mg/kg	30	22	23	160	110	1942106	170	83	1942107	180	5	1942106
Available Beryllium (Be)	mg/kg	ND	ND	ND	ND	ND	1942106	ND	ND	1942107	ND	2	1942106
Available Bismuth (Bi)	mg/kg	ND	ND	ND	ND	ND	1942106	ND	ND	1942107	2	2	1942106
Available Boron (B)	mg/kg	ND	ND	ND	ND	ND	1942106	ND	ND	1942107	6	5	1942106
Available Cadmium (Cd)	mg/kg	0.3	ND	ND	0.6	0.3	1942106	0.7	1.0	1942107	40	0.3	1942106
Available Chromium (Cr)	mg/kg	120	180	18	110	26	1942106	120	20	1942107	17	2	1942106
Available Cobalt (Co)	mg/kg	13	18	4	22	6	1942106	23	6	1942107	8	1	1942106
Available Copper (Cu)	mg/kg	5	4	8	31	4	1942106	31	13	1942107	98	2	1942106
Available Iron (Fe)	mg/kg	34000	41000	31000	36000	13000	1942106	36000	28000	1942107	18000	50	1942106
Available Lead (Pb)	mg/kg	17	7.9	13	39	25	1942106	47	72	1942107	1100	0.5	1942106
Available Lithium (Li)	mg/kg	26	32	6	43	9	1942106	40	10	1942107	12	2	1942106
Available Manganese (Mn)	mg/kg	370	480	120	540	130	1942106	620	290	1942107	500	2	1942106
Available Molybdenum (Mo)	mg/kg	ND	ND	ND	ND	ND	1942106	ND	ND	1942107	ND	2	1942106
Available Nickel (Ni)	mg/kg	39	53	11	76	21	1942106	81	16	1942107	14	2	1942106
Available Rubidium (Rb)	mg/kg	4	3	4	6	4	1942106	5	9	1942107	23	2	1942106
Available Selenium (Se)	mg/kg	ND	ND	ND	ND	ND	1942106	ND	ND	1942107	ND	2	1942106
Available Silver (Ag)	mg/kg	ND	ND	ND	ND	ND	1942106	ND	ND	1942107	4.7	0.5	1942106
Available Strontium (Sr)	mg/kg	ND	ND	ND	11	9	1942106	11	11	1942107	37	5	1942106
Available Thallium (Tl)	mg/kg	ND	ND	0.1	0.3	0.2	1942106	0.4	0.2	1942107	1.3	0.1	1942106
Available Tin (Sn)	mg/kg	ND	ND	ND	ND	ND	1942106	ND	ND	1942107	2	2	1942106
Available Uranium (U)	mg/kg	0.2	0.1	0.3	0.5	0.6	1942106	0.5	0.3	1942107	0.9	0.1	1942106
Available Vanadium (V)	mg/kg	120	120	85	110	32	1942106	110	54	1942107	37	2	1942106
Available Zinc (Zn)	mg/kg	58	54	40	260	40	1942106	250	94	1942107	300	5	1942106

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
1941518	Available Aluminum (Al)	2009/09/16	NC	75 - 125	93	75 - 125	ND, RDL=10	mg/kg	9.3	35	79	75 - 125
1941518	Available Antimony (Sb)	2009/09/16	60(1)	75 - 125	108	75 - 125	ND, RDL=2	mg/kg	NC	35		
1941518	Available Arsenic (As)	2009/09/16	NC	75 - 125	96	75 - 125	ND, RDL=2	mg/kg	25.8	35	117	75 - 125
1941518	Available Barium (Ba)	2009/09/16	NC	75 - 125	93	75 - 125	ND, RDL=5	mg/kg	18.2	35	103	75 - 125
1941518	Available Beryllium (Be)	2009/09/16	95	75 - 125	89	75 - 125	ND, RDL=2	mg/kg	NC	35		
1941518	Available Bismuth (Bi)	2009/09/16	101	75 - 125	92	75 - 125	ND, RDL=2	mg/kg	NC	35		
1941518	Available Boron (B)	2009/09/16	64(1)	75 - 125	91	75 - 125	ND, RDL=5	mg/kg	NC	35		
1941518	Available Cadmium (Cd)	2009/09/16	101	75 - 125	90	75 - 125	ND, RDL=0.3	mg/kg	NC	35		
1941518	Available Chromium (Cr)	2009/09/16	NC	75 - 125	94	75 - 125	ND, RDL=2	mg/kg	1.6	35	77	75 - 125
1941518	Available Cobalt (Co)	2009/09/16	NC	75 - 125	93	75 - 125	ND, RDL=1	mg/kg	6.5	35	95	75 - 125
1941518	Available Copper (Cu)	2009/09/16	NC	75 - 125	91	75 - 125	ND, RDL=2	mg/kg	10.2	35	84	75 - 125
1941518	Available Iron (Fe)	2009/09/16	NC	75 - 125	101	75 - 125	ND, RDL=50	mg/kg	2.9	35	91	75 - 125
1941518	Available Lead (Pb)	2009/09/16	NC	75 - 125	92	75 - 125	ND, RDL=0.5	mg/kg	7.5	35	97	75 - 125
1941518	Available Lithium (Li)	2009/09/16	NC	75 - 125	91	75 - 125	ND, RDL=2	mg/kg	4.5	35		
1941518	Available Manganese (Mn)	2009/09/16	NC	75 - 125	93	75 - 125	ND, RDL=2	mg/kg	17.9	35	97	75 - 125
1941518	Available Molybdenum (Mo)	2009/09/16	64(1)	75 - 125	87	75 - 125	ND, RDL=2	mg/kg	NC	35		
1941518	Available Nickel (Ni)	2009/09/16	NC	75 - 125	92	75 - 125	ND, RDL=2	mg/kg	11.2	35	96	75 - 125
1941518	Available Rubidium (Rb)	2009/09/16	95	75 - 125	94	75 - 125	ND, RDL=2	mg/kg	NC	35		
1941518	Available Selenium (Se)	2009/09/16	81	75 - 125	90	75 - 125	ND, RDL=2	mg/kg	NC	35		
1941518	Available Silver (Ag)	2009/09/16	108	75 - 125	102	75 - 125	ND, RDL=0.5	mg/kg	NC	35		
1941518	Available Strontium (Sr)	2009/09/16	94	75 - 125	97	75 - 125	ND, RDL=5	mg/kg	NC	35	90	75 - 125
1941518	Available Thallium (Tl)	2009/09/16	89	75 - 125	86	75 - 125	ND, RDL=0.1	mg/kg	NC	35		
1941518	Available Tin (Sn)	2009/09/16	102	75 - 125	91	75 - 125	ND, RDL=2	mg/kg	NC	35		
1941518	Available Uranium (U)	2009/09/16	96	75 - 125	86	75 - 125	ND, RDL=0.1	mg/kg	NC	35		
1941518	Available Vanadium (V)	2009/09/16	NC	75 - 125	99	75 - 125	ND, RDL=2	mg/kg	3.4	35	96	75 - 125
1941518	Available Zinc (Zn)	2009/09/16	99	75 - 125	92	75 - 125	ND, RDL=5	mg/kg	16.9	35	101	75 - 125
1942106	Available Aluminum (Al)	2009/09/17	NC	75 - 125	94	75 - 125	ND, RDL=10	mg/kg	2.2	35	78	75 - 125
1942106	Available Antimony (Sb)	2009/09/17	69(1)	75 - 125	103	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942106	Available Arsenic (As)	2009/09/17	NC	75 - 125	83	75 - 125	ND, RDL=2	mg/kg	14.6	35	115	75 - 125
1942106	Available Barium (Ba)	2009/09/17	NC	75 - 125	93	75 - 125	ND, RDL=5	mg/kg	1.6	35	103	75 - 125
1942106	Available Beryllium (Be)	2009/09/17	90	75 - 125	95	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942106	Available Bismuth (Bi)	2009/09/17	90	75 - 125	95	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942106	Available Boron (B)	2009/09/17	81	75 - 125	97	75 - 125	ND, RDL=5	mg/kg	NC	35		
1942106	Available Cadmium (Cd)	2009/09/17	95	75 - 125	90	75 - 125	ND, RDL=0.3	mg/kg	NC	35		
1942106	Available Chromium (Cr)	2009/09/17	NC	75 - 125	102	75 - 125	ND, RDL=2	mg/kg	8.5	35	83	75 - 125
1942106	Available Cobalt (Co)	2009/09/17	NC	75 - 125	98	75 - 125	ND, RDL=1	mg/kg	4.0	35	95	75 - 125
1942106	Available Copper (Cu)	2009/09/17	85	75 - 125	100	75 - 125	ND, RDL=2	mg/kg	NC	35	93	75 - 125
1942106	Available Iron (Fe)	2009/09/17	NC	75 - 125	102	75 - 125	ND, RDL=50	mg/kg	7.4	35	94	75 - 125
1942106	Available Lead (Pb)	2009/09/17	NC	75 - 125	100	75 - 125	ND, RDL=0.5	mg/kg	13.3	35	105	75 - 125
1942106	Available Lithium (Li)	2009/09/17	NC	75 - 125	96	75 - 125	ND, RDL=2	mg/kg	2.9	35		

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
1942106	Available Manganese (Mn)	2009/09/17	NC	75 - 125	94	75 - 125	ND, RDL=2	mg/kg	5.7	35	99	75 - 125
1942106	Available Molybdenum (Mo)	2009/09/17	81	75 - 125	89	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942106	Available Nickel (Ni)	2009/09/17	NC	75 - 125	97	75 - 125	ND, RDL=2	mg/kg	4.1	35	101	75 - 125
1942106	Available Rubidium (Rb)	2009/09/17	77	75 - 125	88	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942106	Available Selenium (Se)	2009/09/17	71(1)	75 - 125	95	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942106	Available Silver (Ag)	2009/09/17	100	75 - 125	97	75 - 125	ND, RDL=0.5	mg/kg	NC	35		
1942106	Available Strontium (Sr)	2009/09/17	92	75 - 125	95	75 - 125	ND, RDL=5	mg/kg	NC	35	96	75 - 125
1942106	Available Thallium (Tl)	2009/09/17	83	75 - 125	96	75 - 125	ND, RDL=0.1	mg/kg	NC	35		
1942106	Available Tin (Sn)	2009/09/17	89	75 - 125	87	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942106	Available Uranium (U)	2009/09/17	85	75 - 125	88	75 - 125	ND, RDL=0.1	mg/kg	NC	35		
1942106	Available Vanadium (V)	2009/09/17	NC	75 - 125	103	75 - 125	ND, RDL=2	mg/kg	0.8	35	101	75 - 125
1942106	Available Zinc (Zn)	2009/09/17	91	75 - 125	90	75 - 125	ND, RDL=5	mg/kg	1.9	35	101	75 - 125
1942107	Available Aluminum (Al)	2009/09/17	NC	75 - 125	103	75 - 125	ND, RDL=10	mg/kg	6.5	35	78	75 - 125
1942107	Available Antimony (Sb)	2009/09/17	65(1)	75 - 125	104	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942107	Available Arsenic (As)	2009/09/17	62(1)	75 - 125	88	75 - 125	ND, RDL=2	mg/kg	NC	35	109	75 - 125
1942107	Available Barium (Ba)	2009/09/17	NC	75 - 125	99	75 - 125	ND, RDL=5	mg/kg	15.1	35	102	75 - 125
1942107	Available Beryllium (Be)	2009/09/17	95	75 - 125	95	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942107	Available Bismuth (Bi)	2009/09/17	90	75 - 125	93	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942107	Available Boron (B)	2009/09/17	82	75 - 125	108	75 - 125	ND, RDL=5	mg/kg	NC	35		
1942107	Available Cadmium (Cd)	2009/09/17	87	75 - 125	88	75 - 125	ND, RDL=0.3	mg/kg	NC	35		
1942107	Available Chromium (Cr)	2009/09/17	NC	75 - 125	99	75 - 125	ND, RDL=2	mg/kg	2.7	35	79	75 - 125
1942107	Available Cobalt (Co)	2009/09/17	NC	75 - 125	95	75 - 125	ND, RDL=1	mg/kg	8.6	35	95	75 - 125
1942107	Available Copper (Cu)	2009/09/17	NC	75 - 125	97	75 - 125	ND, RDL=2	mg/kg	26.8(2)	35	96	75 - 125
1942107	Available Iron (Fe)	2009/09/17	NC	75 - 125	105	75 - 125	ND, RDL=50	mg/kg	4.0	35	89	75 - 125
1942107	Available Lead (Pb)	2009/09/17	NC	75 - 125	96	75 - 125	ND, RDL=0.5	mg/kg	1.9	35	100	75 - 125
1942107	Available Lithium (Li)	2009/09/17	NC	75 - 125	93	75 - 125	ND, RDL=2	mg/kg	4.1	35		
1942107	Available Manganese (Mn)	2009/09/17	NC	75 - 125	97	75 - 125	ND, RDL=2	mg/kg	24.7	35	99	75 - 125
1942107	Available Molybdenum (Mo)	2009/09/17	82	75 - 125	87	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942107	Available Nickel (Ni)	2009/09/17	NC	75 - 125	93	75 - 125	ND, RDL=2	mg/kg	0.8	35	93	75 - 125
1942107	Available Rubidium (Rb)	2009/09/17	72(1)	75 - 125	94	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942107	Available Selenium (Se)	2009/09/17	52(1)	75 - 125	105	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942107	Available Silver (Ag)	2009/09/17	96	75 - 125	97	75 - 125	ND, RDL=0.5	mg/kg	NC	35		
1942107	Available Strontium (Sr)	2009/09/17	81	75 - 125	98	75 - 125	ND, RDL=5	mg/kg	NC	35	91	75 - 125
1942107	Available Thallium (Tl)	2009/09/17	91	75 - 125	86	75 - 125	ND, RDL=0.1	mg/kg	NC	35		
1942107	Available Tin (Sn)	2009/09/17	86	75 - 125	85	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942107	Available Uranium (U)	2009/09/17	86	75 - 125	83	75 - 125	ND, RDL=0.1	mg/kg	NC	35		

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**	**% Recovery**	**QC Limits**
1942107	Available Vanadium (V)	2009/09/17	NC	75 - 125	100	75 - 125	ND, RDL=2	mg/kg	7.1	35	99	75 - 125
1942107	Available Zinc (Zn)	2009/09/17	92	75 - 125	96	75 - 125	ND, RDL=5	mg/kg	2.8	35	105	75 - 125

N/A = Not Applicable

RDL = Reportable Detection Limit

RPD = Relative Percent Difference

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

QC Standard: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.

Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.

NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

(1) - Low recovery due to sample matrix.

(2) - Poor RPD due to sample inhomogeneity.

Validation Signature Page

Maxxam Job #: A9B7578

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

ERIC DEARMAN, Scientific Specialist

JERRY ARENOVICH, Inorganics Manager

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Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. SCC and CALA have approved this reporting process and electronic report format.

Your Project #: 055453
Site#: BATCH #5
Site: BELLEDUNE ECO
Your C.O.C. #: B 65315

Attention: Christine Moore
Intrinsik Environmental Sciences
5121 Sackville Street
Suite 506
Halifax, NS
CANADA B3J 1K1

Report Date: 2009/09/21

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: A9B7632
Received: 2009/09/08, 8:47

Sample Matrix: Soil
Samples Received: 24

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Metals Solid Avail. Unified MS - Nper	24	N/A	2009/09/17	ATL SOP 00024 R4	Based on EPA6020A

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
* Results relate only to the items tested.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

MICHELLE HILL, Project Manager
Email: Michelle.Hill.Reports@maxxamanalytics.com
Phone# (902) 420-0203

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Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. SCC and CALA have approved this reporting process and electronic report format.

For Service Group specific validation please refer to the Validation Signature Page

Total cover pages: 1

Maxxam Job #: A9B7632
Report Date: 2009/09/21

Intrinsik Environmental Sciences
Client Project #: 055453
Project name: BELLEDUNE ECO

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		DQ2014	DQ2031	DQ2033	DQ2034	DQ2035	DQ2036	DQ2037	DQ2038	DQ2039	DQ2040	DQ2041	DQ2041		
	Units	**S39A**	**S41A**	**S42A**	**S43A**	**S44A**	**S45A**	**S46A**	**QA/QC-10**	**S-47A**	**S-47B**	**S-47C**	**S-47C Lab-Dup**	**RDL**	**QC Batch**
Metals															
Available Aluminum (Al)	mg/kg	12000	20000	20000	17000	9300	16000	9700	19000	13000	11000	15000	16000	10	1942107
Available Antimony (Sb)	mg/kg	3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2	1942107
Available Arsenic (As)	mg/kg	20	59	79	9	6	16	8	10	10	7	10	10	2	1942107
Available Barium (Ba)	mg/kg	98	110	31	150	35	120	67	120	160	140	98	110	5	1942107
Available Beryllium (Be)	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2	1942107
Available Bismuth (Bi)	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2	1942107
Available Boron (B)	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5	1942107
Available Cadmium (Cd)	mg/kg	2.6	7.2	1.1	0.4	ND	2.1	1.5	0.7	1.7	0.6	ND	ND	0.3	1942107
Available Chromium (Cr)	mg/kg	22	34	39	29	20	48	15	30	24	23	29	30	2	1942107
Available Cobalt (Co)	mg/kg	9	20	5	13	5	21	5	13	10	10	13	14	1	1942107
Available Copper (Cu)	mg/kg	36	18	15	11	11	24	14	15	18	14	32	42(1)	2	1942107
Available Iron (Fe)	mg/kg	26000	25000	30000	28000	24000	29000	18000	30000	30000	27000	28000	30000	50	1942107
Available Lead (Pb)	mg/kg	200	120	73	32	15	120	150	37	100	35	11	10	0.5	1942107
Available Lithium (Li)	mg/kg	15	8	10	14	8	15	9	15	15	14	18	17	2	1942107
Available Manganese (Mn)	mg/kg	790	5700	230	3500	86	2600	270	4100	410	420	610	780	2	1942107
Available Molybdenum (Mo)	mg/kg	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2	1942107
Available Nickel (Ni)	mg/kg	18	17	16	24	17	30	10	28	23	24	35	35	2	1942107
Available Rubidium (Rb)	mg/kg	9	9	4	12	5	8	5	11	10	8	5	5	2	1942107
Available Selenium (Se)	mg/kg	ND	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2	1942107
Available Silver (Ag)	mg/kg	ND	1.1	ND	ND	ND	0.6	ND	ND	0.6	ND	ND	ND	0.5	1942107
Available Strontium (Sr)	mg/kg	9	17	ND	8	7	37	10	7	9	8	7	7	5	1942107
Available Thallium (Tl)	mg/kg	0.9	0.4	0.2	0.2	0.1	0.6	0.3	0.3	0.5	0.2	ND	ND	0.1	1942107
Available Tin (Sn)	mg/kg	4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2	1942107
Available Uranium (U)	mg/kg	0.6	1.2	0.3	0.3	0.2	0.7	0.3	0.4	0.3	0.3	0.4	0.3	0.1	1942107
Available Vanadium (V)	mg/kg	53	50	79	47	54	40	45	50	53	54	47	44	2	1942107
Available Zinc (Zn)	mg/kg	200	180	110	82	26	170	110	81	100	55	49	48	5	1942107

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
(1) - Poor RPD due to sample inhomogeneity.

Maxxam Job #: A9B7632
Report Date: 2009/09/21

Intrinsik Environmental Sciences
Client Project #: 055453
Project name: BELLEDUNE ECO

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		DQ2042	DQ2043	DQ2044		DQ2045		DQ2046		DQ2047			DQ2048	DQ2049		
	Units	**S-48A**	**S-48B**	**S-48C**	**RDL**	**S-50A**	**RDL**	**QA/QC-4**	**RDL**	**S-51A**	**RDL**	**QC Batch**	**S-52A**	**S-52B**	**RDL**	**QC Batch**
Metals																
Available Aluminum (Al)	mg/kg	10000	10000	9600	10	13000	10	10000	10	26000	10	1942107	13000	13000	10	1942418
Available Antimony (Sb)	mg/kg	4	ND	ND	2	ND	2	2	2	ND	2	1942107	ND	ND	2	1942418
Available Arsenic (As)	mg/kg	42	31	19	2	21	2	11	2	64	2	1942107	10	9	2	1942418
Available Barium (Ba)	mg/kg	220	190	100	5	92	5	100	5	180	5	1942107	64	59	5	1942418
Available Beryllium (Be)	mg/kg	ND	ND	ND	2	ND	2	ND	2	ND	2	1942107	ND	ND	2	1942418
Available Bismuth (Bi)	mg/kg	ND	ND	ND	2	ND	2	ND	2	ND	2	1942107	ND	ND	2	1942418
Available Boron (B)	mg/kg	ND	ND	ND	5	ND	5	ND	5	ND	5	1942107	ND	ND	5	1942418
Available Cadmium (Cd)	mg/kg	3.1	0.7	ND	0.3	2.0	0.3	2.3	0.3	4.1	0.3	1942107	1.1	0.6	0.3	1942418
Available Chromium (Cr)	mg/kg	22	22	19	2	56	2	15	2	51	2	1942107	30	31	2	1942418
Available Cobalt (Co)	mg/kg	9	9	8	1	78	1	5	1	17	1	1942107	8	9	1	1942418
Available Copper (Cu)	mg/kg	23	6	5	2	13	2	20	2	25	2	1942107	14	12	2	1942418
Available Iron (Fe)	mg/kg	15000	16000	15000	50	89000	500	18000	50	27000	50	1942107	29000	27000	50	1942418
Available Lead (Pb)	mg/kg	290	24	7.7	0.5	130	0.5	220	0.5	79	0.5	1942107	64	40	0.5	1942418
Available Lithium (Li)	mg/kg	13	14	14	2	11	2	10	2	19	2	1942107	16	17	2	1942418
Available Manganese (Mn)	mg/kg	1000	2300	580	2	5600	2	270	2	4300	2	1942107	740	670	2	1942418
Available Molybdenum (Mo)	mg/kg	ND	ND	ND	2	ND	2	ND	2	3	2	1942107	ND	ND	2	1942418
Available Nickel (Ni)	mg/kg	19	20	22	2	12	2	12	2	45	2	1942107	24	26	2	1942418
Available Rubidium (Rb)	mg/kg	7	7	6	2	6	2	8	2	9	2	1942107	8	8	2	1942418
Available Selenium (Se)	mg/kg	ND	ND	ND	2	ND	2	ND	2	ND	2	1942107	ND	ND	2	1942418
Available Silver (Ag)	mg/kg	0.6	ND	ND	0.5	ND	0.5	0.8	0.5	0.7	0.5	1942107	ND	ND	0.5	1942418
Available Strontium (Sr)	mg/kg	15	8	7	5	8	5	9	5	ND(1)	50	1942107	5	ND	5	1942418
Available Thallium (Tl)	mg/kg	0.7	0.1	ND	0.1	0.6	0.1	0.4	0.1	0.7	0.1	1942107	0.3	0.2	0.1	1942418
Available Tin (Sn)	mg/kg	7	ND	ND	2	ND	2	ND	2	ND	2	1942107	ND	ND	2	1942418
Available Uranium (U)	mg/kg	2.7	1.3	0.8	0.1	0.2	0.1	0.3	0.1	1.0	0.1	1942107	0.5	0.5	0.1	1942418
Available Vanadium (V)	mg/kg	35	40	25	2	510	2	49	2	45	2	1942107	55	55	2	1942418
Available Zinc (Zn)	mg/kg	310	54	35	5	77	5	170	5	220	5	1942107	92	75	5	1942418

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
(1) - Elevated reporting limits for trace metals due to matrix interferences.

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		DQ2050	DQ2050		DQ2051	DQ2052		DQ2053		DQ5427		
Sampling Date										2009/09/08		
	Units	**S-52C**	**S-52C Lab-Dup**	**RDL**	**S-54A**	**S-54B**	**RDL**	**S-54C**	**QC Batch**	**Batch #5 - NIST 2711**	**RDL**	**QC Batch**
Metals												
Available Aluminum (Al)	mg/kg	19000	21000	10	11000	21000	10	19000	1942418	12000	10	1942107
Available Antimony (Sb)	mg/kg	ND	ND	2	ND	ND	2	ND	1942418	17	2	1942107
Available Arsenic (As)	mg/kg	10	10	2	70	75	2	39	1942418	89	2	1942107
Available Barium (Ba)	mg/kg	44	47	5	170	90	5	60	1942418	160	5	1942107
Available Beryllium (Be)	mg/kg	ND	ND	2	ND	ND	2	ND	1942418	ND	2	1942107
Available Bismuth (Bi)	mg/kg	ND	ND	2	ND	ND	2	ND	1942418	2	2	1942107
Available Boron (B)	mg/kg	ND	ND	5	6	ND	5	ND	1942418	ND	5	1942107
Available Cadmium (Cd)	mg/kg	ND	ND	0.3	7.1	3.8	0.3	2.0	1942418	36	0.3	1942107
Available Chromium (Cr)	mg/kg	39	43	2	34	57	2	54	1942418	16	2	1942107
Available Cobalt (Co)	mg/kg	13	13	1	12	18	1	15	1942418	7	1	1942107
Available Copper (Cu)	mg/kg	9	10	2	38	33	2	14	1942418	94	2	1942107
Available Iron (Fe)	mg/kg	28000	31000	50	21000	43000	50	37000	1942418	17000	50	1942107
Available Lead (Pb)	mg/kg	15	16	0.5	200	110	0.5	54	1942418	1100	0.5	1942107
Available Lithium (Li)	mg/kg	21	24	2	9	25	2	27	1942418	10	2	1942107
Available Manganese (Mn)	mg/kg	430	490	2	1200	690	2	420	1942418	480	2	1942107
Available Molybdenum (Mo)	mg/kg	ND	ND	2	ND	2	2	ND	1942418	ND	2	1942107
Available Nickel (Ni)	mg/kg	49	51	2	22	53	2	55	1942418	14	2	1942107
Available Rubidium (Rb)	mg/kg	7	7	2	5	6	2	4	1942418	20	2	1942107
Available Selenium (Se)	mg/kg	ND	ND	2	ND	ND	2	ND	1942418	ND	2	1942107
Available Silver (Ag)	mg/kg	ND	ND	0.5	1.2	0.5	0.5	ND	1942418	4.1	0.5	1942107
Available Strontium (Sr)	mg/kg	ND	ND	5	ND(1)	ND(1)	50	6	1942418	36	5	1942107
Available Thallium (Tl)	mg/kg	0.2	0.1	0.1	0.4	0.1	0.1	ND	1942418	1.5	0.1	1942107
Available Tin (Sn)	mg/kg	ND	ND	2	ND	ND	2	ND	1942418	2	2	1942107
Available Uranium (U)	mg/kg	0.4	0.4	0.1	0.8	0.9	0.1	0.4	1942418	0.9	0.1	1942107
Available Vanadium (V)	mg/kg	49	51	2	32	60	2	51	1942418	36	2	1942107
Available Zinc (Zn)	mg/kg	76	77	5	360	600	5	540	1942418	280	5	1942107

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
(1) - Elevated reporting limit due to matrix interferences.

Maxxam Job #: A9B7632
Report Date: 2009/09/21

Intrinsik Environmental Sciences
Client Project #: 055453
Project name: BELLEDUNE ECO

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
1942107	Available Aluminum (Al)	2009/09/17	NC	75 - 125	103	75 - 125	ND, RDL=10	mg/kg	6.5	35	78	75 - 125
1942107	Available Antimony (Sb)	2009/09/17	65(1)	75 - 125	104	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942107	Available Arsenic (As)	2009/09/17	62(1)	75 - 125	88	75 - 125	ND, RDL=2	mg/kg	NC	35	109	75 - 125
1942107	Available Barium (Ba)	2009/09/17	NC	75 - 125	99	75 - 125	ND, RDL=5	mg/kg	15.1	35	102	75 - 125
1942107	Available Beryllium (Be)	2009/09/17	95	75 - 125	95	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942107	Available Bismuth (Bi)	2009/09/17	90	75 - 125	93	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942107	Available Boron (B)	2009/09/17	82	75 - 125	108	75 - 125	ND, RDL=5	mg/kg	NC	35		
1942107	Available Cadmium (Cd)	2009/09/17	87	75 - 125	88	75 - 125	ND, RDL=0.3	mg/kg	NC	35		
1942107	Available Chromium (Cr)	2009/09/17	NC	75 - 125	99	75 - 125	ND, RDL=2	mg/kg	2.7	35	79	75 - 125
1942107	Available Cobalt (Co)	2009/09/17	NC	75 - 125	95	75 - 125	ND, RDL=1	mg/kg	8.6	35	95	75 - 125
1942107	Available Copper (Cu)	2009/09/17	NC	75 - 125	97	75 - 125	ND, RDL=2	mg/kg	26.8(2)	35	96	75 - 125
1942107	Available Iron (Fe)	2009/09/17	NC	75 - 125	105	75 - 125	ND, RDL=50	mg/kg	4.0	35	89	75 - 125
1942107	Available Lead (Pb)	2009/09/17	NC	75 - 125	96	75 - 125	ND, RDL=0.5	mg/kg	1.9	35	100	75 - 125
1942107	Available Lithium (Li)	2009/09/17	NC	75 - 125	93	75 - 125	ND, RDL=2	mg/kg	4.1	35		
1942107	Available Manganese (Mn)	2009/09/17	NC	75 - 125	97	75 - 125	ND, RDL=2	mg/kg	24.7	35	99	75 - 125
1942107	Available Molybdenum (Mo)	2009/09/17	82	75 - 125	87	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942107	Available Nickel (Ni)	2009/09/17	NC	75 - 125	93	75 - 125	ND, RDL=2	mg/kg	0.8	35	93	75 - 125
1942107	Available Rubidium (Rb)	2009/09/17	72(1)	75 - 125	94	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942107	Available Selenium (Se)	2009/09/17	52(1)	75 - 125	105	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942107	Available Silver (Ag)	2009/09/17	96	75 - 125	97	75 - 125	ND, RDL=0.5	mg/kg	NC	35		
1942107	Available Strontium (Sr)	2009/09/17	81	75 - 125	98	75 - 125	ND, RDL=5	mg/kg	NC	35	91	75 - 125
1942107	Available Thallium (Tl)	2009/09/17	91	75 - 125	86	75 - 125	ND, RDL=0.1	mg/kg	NC	35		
1942107	Available Tin (Sn)	2009/09/17	86	75 - 125	85	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942107	Available Uranium (U)	2009/09/17	86	75 - 125	83	75 - 125	ND, RDL=0.1	mg/kg	NC	35		
1942107	Available Vanadium (V)	2009/09/17	NC	75 - 125	100	75 - 125	ND, RDL=2	mg/kg	7.1	35	99	75 - 125
1942107	Available Zinc (Zn)	2009/09/17	92	75 - 125	96	75 - 125	ND, RDL=5	mg/kg	2.8	35	105	75 - 125
1942418	Available Aluminum (Al)	2009/09/17	NC	75 - 125	95	75 - 125	ND, RDL=10	mg/kg	9.5	35	84	75 - 125
1942418	Available Antimony (Sb)	2009/09/17	82	75 - 125	109	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942418	Available Arsenic (As)	2009/09/17	82	75 - 125	91	75 - 125	ND, RDL=2	mg/kg	NC	35	112	75 - 125
1942418	Available Barium (Ba)	2009/09/17	NC	75 - 125	91	75 - 125	ND, RDL=5	mg/kg	7.0	35	104	75 - 125
1942418	Available Beryllium (Be)	2009/09/17	87	75 - 125	85	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942418	Available Bismuth (Bi)	2009/09/17	99	75 - 125	94	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942418	Available Boron (B)	2009/09/17	61(1)	75 - 125	77	75 - 125	ND, RDL=5	mg/kg	NC	35		
1942418	Available Cadmium (Cd)	2009/09/17	98	75 - 125	90	75 - 125	ND, RDL=0.3	mg/kg	NC	35		
1942418	Available Chromium (Cr)	2009/09/17	NC	75 - 125	97	75 - 125	ND, RDL=2	mg/kg	8.8	35	85	75 - 125
1942418	Available Cobalt (Co)	2009/09/17	NC	75 - 125	97	75 - 125	ND, RDL=1	mg/kg	3.7	35	96	75 - 125
1942418	Available Copper (Cu)	2009/09/17	84	75 - 125	95	75 - 125	ND, RDL=2	mg/kg	NC	35	92	75 - 125
1942418	Available Iron (Fe)	2009/09/17	NC	75 - 125	98	75 - 125	ND, RDL=50	mg/kg	8.4	35	93	75 - 125
1942418	Available Lead (Pb)	2009/09/17	NC	75 - 125	93	75 - 125	ND, RDL=0.5	mg/kg	7.2	35	105	75 - 125
1942418	Available Lithium (Li)	2009/09/17	NC	75 - 125	88	75 - 125	ND, RDL=2	mg/kg	14.5	35		

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**	**% Recovery**	**QC Limits**
1942418	Available Manganese (Mn)	2009/09/17	NC	75 - 125	92	75 - 125	ND, RDL=2	mg/kg	13.7	35	107	75 - 125
1942418	Available Molybdenum (Mo)	2009/09/17	95	75 - 125	96	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942418	Available Nickel (Ni)	2009/09/17	NC	75 - 125	96	75 - 125	ND, RDL=2	mg/kg	4.9	35	101	75 - 125
1942418	Available Rubidium (Rb)	2009/09/17	83	75 - 125	90	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942418	Available Selenium (Se)	2009/09/17	69(1)	75 - 125	87	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942418	Available Silver (Ag)	2009/09/17	98	75 - 125	95	75 - 125	ND, RDL=0.5	mg/kg	NC	35		
1942418	Available Strontium (Sr)	2009/09/17	85	75 - 125	92	75 - 125	ND, RDL=5	mg/kg	NC	35	85	75 - 125
1942418	Available Thallium (Tl)	2009/09/17	88	75 - 125	96	75 - 125	ND, RDL=0.1	mg/kg	NC	35		
1942418	Available Tin (Sn)	2009/09/17	102	75 - 125	93	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942418	Available Uranium (U)	2009/09/17	105	75 - 125	99	75 - 125	ND, RDL=0.1	mg/kg	NC	35		
1942418	Available Vanadium (V)	2009/09/17	NC	75 - 125	103	75 - 125	ND, RDL=2	mg/kg	3.3	35	101	75 - 125
1942418	Available Zinc (Zn)	2009/09/17	94	75 - 125	91	75 - 125	ND, RDL=5	mg/kg	0.7	35	105	75 - 125

N/A = Not Applicable

RDL = Reportable Detection Limit

RPD = Relative Percent Difference

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

QC Standard: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.

Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.

NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

(1) - Low recovery due to sample matrix.

(2) - Poor RPD due to sample inhomogeneity.

Validation Signature Page

Maxxam Job #: A9B7632

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

JERRY ARENOVICH, Inorganics Manager

==

Your Project #: 055453
Site#: BATCH #6
Site: BELLEDUNE ECO
Your C.O.C. #: B 65319

Attention: Christine Moore
Intrinsik Environmental Sciences
5121 Sackville Street
Suite 506
Halifax, NS
CANADA B3J 1K1

Report Date: 2009/09/18

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: A9B7652
Received: 2009/09/08, 8:47

Sample Matrix: Soil
Samples Received: 24

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Metals Solid Avail. Unified MS - Nper	24	N/A	2009/09/17	ATL SOP 00024 R4	Based on EPA6020A

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
* Results relate only to the items tested.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

MICHELLE HILL, Project Manager
Email: Michelle.Hill.Reports@maxxamanalytics.com
Phone# (902) 420-0203

==

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. SCC and CALA have approved this reporting process and electronic report format.

For Service Group specific validation please refer to the Validation Signature Page

Total cover pages: 1

Intrinsik Environmental Sciences
Maxxam Job #: A9B7652 Client Project #: 055453
Report Date: 2009/09/18 Project name: BELLEDUNE ECO

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		DQ2116		DQ2117	DQ2118	DQ2119	DQ2120		DQ2121		DQ2122	DQ2123	DQ2124	DQ2125		
	Units	**S53A**	**RDL**	**S55A**	**S55B**	**S55C**	**S56A**	**RDL**	**QA/QC-3**	**RDL**	**S57A**	**S58A**	**S59A**	**S59B**	**RDL**	**QC Batch**
Metals																
Available Aluminum (Al)	mg/kg	25000	10	7400	20000	40000	13000	10	28000	10	8500	15000	10000	17000	10	1942418
Available Antimony (Sb)	mg/kg	2	2	ND	ND	ND	ND	2	3	2	ND	ND	2	ND	2	1942418
Available Arsenic (As)	mg/kg	41	2	13	35	180	15	2	45	2	44	31	41	44	2	1942418
Available Barium (Ba)	mg/kg	260	5	51	38	45	58	5	300	5	45	64	88	67	5	1942418
Available Beryllium (Be)	mg/kg	ND	2	ND	ND	ND	ND	2	ND	2	ND	ND	ND	ND	2	1942418
Available Bismuth (Bi)	mg/kg	ND	2	ND	ND	ND	ND	2	ND	2	ND	ND	ND	ND	2	1942418
Available Boron (B)	mg/kg	ND	5	ND	ND	ND	ND	5	ND	5	ND	ND	ND	ND	5	1942418
Available Cadmium (Cd)	mg/kg	3.6	0.3	1.2	0.5	0.6	0.4	0.3	3.9	0.3	0.9	0.5	3.3	0.5	0.3	1942418
Available Chromium (Cr)	mg/kg	35	2	25	41	63	29	2	39	2	25	38	28	46	2	1942418
Available Cobalt (Co)	mg/kg	13	1	6	9	16	9	1	14	1	6	10	7	11	1	1942418
Available Copper (Cu)	mg/kg	31	2	9	10	24	10	2	33	2	9	16	26	17	2	1942418
Available Iron (Fe)	mg/kg	28000	50	19000	35000	42000	32000	50	31000	50	22000	36000	17000	37000	50	1942418
Available Lead (Pb)	mg/kg	230	0.5	74	42	69	28	0.5	240	0.5	65	45	210	27	0.5	1942418
Available Lithium (Li)	mg/kg	27	2	5	16	30	11	2	30	2	6	15	9	19	2	1942418
Available Manganese (Mn)	mg/kg	1900	2	400	450	430	550	2	2100	2	420	320	330	370	2	1942418
Available Molybdenum (Mo)	mg/kg	ND	2	ND	ND	ND	ND	2	ND	2	ND	ND	ND	ND	2	1942418
Available Nickel (Ni)	mg/kg	41	2	11	19	49	16	2	43	2	10	21	20	32	2	1942418
Available Rubidium (Rb)	mg/kg	14	2	4	6	11	7	2	15	2	6	9	6	8	2	1942418
Available Selenium (Se)	mg/kg	ND	2	ND	ND	ND	ND	2	ND	2	ND	ND	ND	ND	2	1942418
Available Silver (Ag)	mg/kg	0.8	0.5	ND	0.6	0.6	ND	0.5	1.0	0.5	ND	ND	0.7	ND	0.5	1942418
Available Strontium (Sr)	mg/kg	ND(1)	50	7	ND	ND	ND	5	ND(1)	50	6	ND	24	12	5	1942418
Available Thallium (Tl)	mg/kg	0.8	0.1	0.2	0.1	0.2	0.1	0.1	0.9	0.1	0.2	0.1	0.4	0.1	0.1	1942418
Available Tin (Sn)	mg/kg	3	2	ND	ND	ND	ND	2	5	2	ND	ND	ND	ND	2	1942418
Available Uranium (U)	mg/kg	1.5	0.1	0.2	0.3	0.5	0.2	0.1	1.8	0.1	0.2	0.3	0.4	0.3	0.1	1942418
Available Vanadium (V)	mg/kg	49	2	71	97	73	72	2	53	2	58	93	38	79	2	1942418
Available Zinc (Zn)	mg/kg	320	5	69	110	240	84	5	340	5	72	84	180	82	5	1942418

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
(1) - Elevated reporting limit due to matrix interferences.

Maxxam Job #: A9B7652
Report Date: 2009/09/18

Intrinsik Environmental Sciences
Client Project #: 055453
Project name: BELLEDUNE ECO

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		DQ2126	DQ2127		DQ2128			DQ2129	DQ2131	DQ2132	DQ2133		DQ2134	DQ2134		
	Units	**S-59C**	**S-61A**	**RDL**	**S-61B**	**RDL**	**QC Batch**	**S-61C**	**R1A**	**R2A**	**R2B**	**RDL**	**R2C**	**R2C Lab-Dup**	**RDL**	**QC Batch**
Metals																
Available Aluminum (Al)	mg/kg	21000	15000	10	21000	10	1942418	24000	21000	6000	16000	10	24000	25000	10	1942837
Available Antimony (Sb)	mg/kg	ND	2	2	ND	2	1942418	2	ND	ND	ND	2	ND	ND	2	1942837
Available Arsenic (As)	mg/kg	41	98	2	120	2	1942418	170	3	3	17	2	3	3	2	1942837
Available Barium (Ba)	mg/kg	76	74	5	64	5	1942418	47	64	52	41	5	34	33	5	1942837
Available Beryllium (Be)	mg/kg	ND	ND	2	ND	2	1942418	ND	ND	ND	ND	2	ND	ND	2	1942837
Available Bismuth (Bi)	mg/kg	ND	ND	2	ND	2	1942418	ND	ND	ND	ND	2	ND	ND	2	1942837
Available Boron (B)	mg/kg	ND	ND	5	ND	5	1942418	ND	ND	ND	ND	5	ND	ND	5	1942837
Available Cadmium (Cd)	mg/kg	ND	1.7	0.3	1.1	0.3	1942418	1.0	ND	0.7	ND	0.3	ND	ND	0.3	1942837
Available Chromium (Cr)	mg/kg	54	52	2	52	2	1942418	60	23	17	29	2	43	41	2	1942837
Available Cobalt (Co)	mg/kg	16	10	1	14	1	1942418	17	11	5	8	1	12	13	1	1942837
Available Copper (Cu)	mg/kg	20	13	2	14	2	1942418	16	7	10	11	2	10	11	2	1942837
Available Iron (Fe)	mg/kg	43000	34000	50	40000	500	1942418	41000	39000	21000	35000	50	42000	44000	500	1942837
Available Lead (Pb)	mg/kg	24	86	0.5	63	0.5	1942418	59	15	40	10	0.5	11	11	0.5	1942837
Available Lithium (Li)	mg/kg	23	17	2	22	2	1942418	26	13	ND	10	2	18	18	2	1942837
Available Manganese (Mn)	mg/kg	690	550	2	680	2	1942418	690	500	170	160	2	350	340	2	1942837
Available Molybdenum (Mo)	mg/kg	ND	ND	2	ND	2	1942418	ND	ND	ND	ND	2	ND	ND	2	1942837
Available Nickel (Ni)	mg/kg	43	26	2	36	2	1942418	54	19	11	18	2	31	31	2	1942837
Available Rubidium (Rb)	mg/kg	7	8	2	8	2	1942418	6	6	3	5	2	6	5	2	1942837
Available Selenium (Se)	mg/kg	ND	ND	2	ND	2	1942418	ND	ND	ND	ND	2	ND	ND	2	1942837
Available Silver (Ag)	mg/kg	ND	0.7	0.5	0.6	0.5	1942418	0.8	ND	ND	ND	0.5	ND	ND	0.5	1942837
Available Strontium (Sr)	mg/kg	9	12	5	8	5	1942418	6	9	22	14	5	8	8	5	1942837
Available Thallium (Tl)	mg/kg	ND	0.3	0.1	0.1	0.1	1942418	0.1	ND	0.2	ND	0.1	0.2	0.1	0.1	1942837
Available Tin (Sn)	mg/kg	ND	ND	2	ND	2	1942418	ND	ND	ND	ND	2	ND	ND	2	1942837
Available Uranium (U)	mg/kg	0.4	0.2	0.1	0.3	0.1	1942418	0.3	0.4	0.2	0.3	0.1	0.4	0.4	0.1	1942837
Available Vanadium (V)	mg/kg	79	74	2	76	2	1942418	71	68	50	69	2	72	68	2	1942837
Available Zinc (Zn)	mg/kg	81	210	5	260	5	1942418	310	59	59	37	5	48	47	5	1942837

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Intrinsik Environmental Sciences
Maxxam Job #: A9B7652
Report Date: 2009/09/18

Client Project #: 055453
Project name: BELLEDUNE ECO

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		DQ2135	DQ2136	DQ2144	DQ2145	DQ2146		DQ5433		
Sampling Date								2009/09/08		
	Units	**R3A**	**R4A**	**QA/QC-22**	**R4B**	**R4C**	**QC Batch**	**Batch #6 - NIST 2711**	**RDL**	**QC Batch**
Metals										
Available Aluminum (Al)	mg/kg	13000	9100	20000	18000	21000	1942837	13000	10	1942418
Available Antimony (Sb)	mg/kg	ND	ND	ND	ND	ND	1942837	18	2	1942418
Available Arsenic (As)	mg/kg	3	4	3	4	3	1942837	97	2	1942418
Available Barium (Ba)	mg/kg	110	120	67	86	41	1942837	180	5	1942418
Available Beryllium (Be)	mg/kg	ND	ND	ND	ND	ND	1942837	ND	2	1942418
Available Bismuth (Bi)	mg/kg	ND	ND	ND	ND	ND	1942837	2	2	1942418
Available Boron (B)	mg/kg	ND	ND	ND	ND	ND	1942837	5	5	1942418
Available Cadmium (Cd)	mg/kg	0.6	1.6	ND	0.3	ND	1942837	42	0.3	1942418
Available Chromium (Cr)	mg/kg	25	13	20	24	30	1942837	17	2	1942418
Available Cobalt (Co)	mg/kg	7	6	10	12	18	1942837	8	1	1942418
Available Copper (Cu)	mg/kg	7	17	7	16	11	1942837	99	2	1942418
Available Iron (Fe)	mg/kg	25000	16000	38000	32000	36000	1942837	18000	50	1942418
Available Lead (Pb)	mg/kg	36	68	14	10	8.1	1942837	1100	0.5	1942418
Available Lithium (Li)	mg/kg	10	5	12	12	15	1942837	12	2	1942418
Available Manganese (Mn)	mg/kg	460	1000	400	1200	420	1942837	510	2	1942418
Available Molybdenum (Mo)	mg/kg	ND	ND	ND	ND	ND	1942837	ND	2	1942418
Available Nickel (Ni)	mg/kg	20	11	15	19	29	1942837	15	2	1942418
Available Rubidium (Rb)	mg/kg	6	7	6	11	6	1942837	23	2	1942418
Available Selenium (Se)	mg/kg	ND	ND	ND	ND	ND	1942837	ND	2	1942418
Available Silver (Ag)	mg/kg	ND	ND	ND	ND	ND	1942837	4.7	0.5	1942418
Available Strontium (Sr)	mg/kg	21	32	10	13	11	1942837	38	5	1942418
Available Thallium (Tl)	mg/kg	0.2	0.3	ND	ND	ND	1942837	1.3	0.1	1942418
Available Tin (Sn)	mg/kg	ND	ND	ND	ND	ND	1942837	2	2	1942418
Available Uranium (U)	mg/kg	0.4	0.6	0.4	1.0	0.5	1942837	0.8	0.1	1942418
Available Vanadium (V)	mg/kg	47	30	70	60	51	1942837	39	2	1942418
Available Zinc (Zn)	mg/kg	57	130	57	66	49	1942837	310	5	1942418

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
1942418	Available Aluminum (Al)	2009/09/17	NC	75 - 125	95	75 - 125	ND, RDL=10	mg/kg	9.5	35	84	75 - 125
1942418	Available Antimony (Sb)	2009/09/17	82	75 - 125	109	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942418	Available Arsenic (As)	2009/09/17	82	75 - 125	91	75 - 125	ND, RDL=2	mg/kg	NC	35	112	75 - 125
1942418	Available Barium (Ba)	2009/09/17	NC	75 - 125	91	75 - 125	ND, RDL=5	mg/kg	7.0	35	104	75 - 125
1942418	Available Beryllium (Be)	2009/09/17	87	75 - 125	85	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942418	Available Bismuth (Bi)	2009/09/17	99	75 - 125	94	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942418	Available Boron (B)	2009/09/17	61(1)	75 - 125	77	75 - 125	ND, RDL=5	mg/kg	NC	35		
1942418	Available Cadmium (Cd)	2009/09/17	98	75 - 125	90	75 - 125	ND, RDL=0.3	mg/kg	NC	35		
1942418	Available Chromium (Cr)	2009/09/17	NC	75 - 125	97	75 - 125	ND, RDL=2	mg/kg	8.8	35	85	75 - 125
1942418	Available Cobalt (Co)	2009/09/17	NC	75 - 125	97	75 - 125	ND, RDL=1	mg/kg	3.7	35	96	75 - 125
1942418	Available Copper (Cu)	2009/09/17	84	75 - 125	95	75 - 125	ND, RDL=2	mg/kg	NC	35	92	75 - 125
1942418	Available Iron (Fe)	2009/09/17	NC	75 - 125	98	75 - 125	ND, RDL=50	mg/kg	8.4	35	93	75 - 125
1942418	Available Lead (Pb)	2009/09/17	NC	75 - 125	93	75 - 125	ND, RDL=0.5	mg/kg	7.2	35	105	75 - 125
1942418	Available Lithium (Li)	2009/09/17	NC	75 - 125	88	75 - 125	ND, RDL=2	mg/kg	14.5	35		
1942418	Available Manganese (Mn)	2009/09/17	NC	75 - 125	92	75 - 125	ND, RDL=2	mg/kg	13.7	35	107	75 - 125
1942418	Available Molybdenum (Mo)	2009/09/17	95	75 - 125	96	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942418	Available Nickel (Ni)	2009/09/17	NC	75 - 125	96	75 - 125	ND, RDL=2	mg/kg	4.9	35	101	75 - 125
1942418	Available Rubidium (Rb)	2009/09/17	83	75 - 125	90	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942418	Available Selenium (Se)	2009/09/17	69(1)	75 - 125	87	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942418	Available Silver (Ag)	2009/09/17	98	75 - 125	95	75 - 125	ND, RDL=0.5	mg/kg	NC	35		
1942418	Available Strontium (Sr)	2009/09/17	85	75 - 125	92	75 - 125	ND, RDL=5	mg/kg	NC	35	85	75 - 125
1942418	Available Thallium (Tl)	2009/09/17	88	75 - 125	96	75 - 125	ND, RDL=0.1	mg/kg	NC	35		
1942418	Available Tin (Sn)	2009/09/17	102	75 - 125	93	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942418	Available Uranium (U)	2009/09/17	105	75 - 125	99	75 - 125	ND, RDL=0.1	mg/kg	NC	35		
1942418	Available Vanadium (V)	2009/09/17	NC	75 - 125	103	75 - 125	ND, RDL=2	mg/kg	3.3	35	101	75 - 125
1942418	Available Zinc (Zn)	2009/09/17	94	75 - 125	91	75 - 125	ND, RDL=5	mg/kg	0.7	35	105	75 - 125
1942837	Available Aluminum (Al)	2009/09/17	NC	75 - 125	93	75 - 125	ND, RDL=10	mg/kg	3.3	35	80	75 - 125
1942837	Available Antimony (Sb)	2009/09/17	76	75 - 125	110	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942837	Available Arsenic (As)	2009/09/17	75	75 - 125	93	75 - 125	ND, RDL=2	mg/kg	NC	35	113	75 - 125
1942837	Available Barium (Ba)	2009/09/17	NC	75 - 125	88	75 - 125	ND, RDL=5	mg/kg	3.3	35	99	75 - 125
1942837	Available Beryllium (Be)	2009/09/17	95	75 - 125	92	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942837	Available Bismuth (Bi)	2009/09/17	95	75 - 125	97	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942837	Available Boron (B)	2009/09/17	76	75 - 125	86	75 - 125	ND, RDL=5	mg/kg	NC	35		
1942837	Available Cadmium (Cd)	2009/09/17	91	75 - 125	91	75 - 125	ND, RDL=0.3	mg/kg	NC	35		
1942837	Available Chromium (Cr)	2009/09/17	NC	75 - 125	101	75 - 125	ND, RDL=2	mg/kg	6.2	35	84	75 - 125
1942837	Available Cobalt (Co)	2009/09/17	NC	75 - 125	99	75 - 125	ND, RDL=1	mg/kg	8.7	35	98	75 - 125
1942837	Available Copper (Cu)	2009/09/17	NC	75 - 125	99	75 - 125	ND, RDL=2	mg/kg	10.4	35	97	75 - 125
1942837	Available Iron (Fe)	2009/09/17	NC	75 - 125	99	75 - 125	ND, RDL=50	mg/kg	5.7	35	93	75 - 125
1942837	Available Lead (Pb)	2009/09/17	NC	75 - 125	96	75 - 125	ND, RDL=0.5	mg/kg	1.3	35	100	75 - 125
1942837	Available Lithium (Li)	2009/09/17	NC	75 - 125	92	75 - 125	ND, RDL=2	mg/kg	4.0	35		

Maxxam Job #: A9B7652
Report Date: 2009/09/18

Intrinsik Environmental Sciences
Client Project #: 055453
Project name: BELLEDUNE ECO

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**	**% Recovery**	**QC Limits**
1942837	Available Manganese (Mn)	2009/09/17	NC	75 - 125	91	75 - 125	ND, RDL=2	mg/kg	1.7	35	101	75 - 125
1942837	Available Molybdenum (Mo)	2009/09/17	84	75 - 125	93	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942837	Available Nickel (Ni)	2009/09/17	NC	75 - 125	100	75 - 125	ND, RDL=2	mg/kg	0.3	35	102	75 - 125
1942837	Available Rubidium (Rb)	2009/09/17	71(1)	75 - 125	90	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942837	Available Selenium (Se)	2009/09/17	75	75 - 125	90	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942837	Available Silver (Ag)	2009/09/17	97	75 - 125	97	75 - 125	ND, RDL=0.5	mg/kg	NC	35		
1942837	Available Strontium (Sr)	2009/09/17	83	75 - 125	91	75 - 125	ND, RDL=5	mg/kg	NC	35	88	75 - 125
1942837	Available Thallium (Tl)	2009/09/17	100	75 - 125	98	75 - 125	ND, RDL=0.1	mg/kg	NC	35		
1942837	Available Tin (Sn)	2009/09/17	94	75 - 125	94	75 - 125	ND, RDL=2	mg/kg	NC	35		
1942837	Available Uranium (U)	2009/09/17	96	75 - 125	98	75 - 125	ND, RDL=0.1	mg/kg	NC	35		
1942837	Available Vanadium (V)	2009/09/17	NC	75 - 125	107	75 - 125	ND, RDL=2	mg/kg	6.0	35	102	75 - 125
1942837	Available Zinc (Zn)	2009/09/17	89	75 - 125	91	75 - 125	ND, RDL=5	mg/kg	0.2	35	98	75 - 125

N/A = Not Applicable

RDL = Reportable Detection Limit

RPD = Relative Percent Difference

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

QC Standard: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.

Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.

NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

(1) - Low recovery due to sample matrix.

Validation Signature Page

Maxxam Job #: A9B7652

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

ERIC DEARMAN, Scientific Specialist

JERRY ARENOVICH, Inorganics Manager

==
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. SCC and CALA have approved this reporting process and electronic report format.

Maxxam Analytics International Corporation

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90 Esplanade Sydney, NS B1P 1A1 Tel: 902-567-1255 Fax: 902-539-6504 Toll Free: 888-535-7770
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MAXXAM Chain of Custody Record

COC #: B 65309

Page 1 of 3

This column for lab use only:

Client Code mc 22319

Maxxam Job # A9B7567

Cooler ID	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp
			16	16	15	

Integrity YES [✓ NO]

Integrity / Checklist by JDW

Labelled by

Location / Bin # Temp T WIF 23

INVOICE INFORMATION:

Company Name: Intrinsik Science
Contact Name: Christine Moore
Address: 5121 Sackville St
Suite 508 Halifax Postal Code B3J 1K1
Email: Cmoore@intrinsikscience.com
Ph: 902-429-0278 Fax: 902-429-0279

REPORT INFORMATION (if differs from invoice):

Company Name: Same
Contact Name: Please Copy Results to
Address:
Postal Code
Email: Nbrodie@craworld.com
Ph: Fax:

PO #
Project # / Phase # 055453
Project Name / Site Location Bellevue EQ0
Quote 09-220KG
Site #
Task Order #
Sampled by Mike Gaines

TURNAROUND TIME

Standard ☒
10 day ☐
If RUSH Specify Date:

Pre-schedule rush work

Charge for # Jars used but not submitted 0

Guideline Requirements / Detection Limits / Special Instructions

Batch #3
Exclude Mercury

*Specify Matrix: Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

Lab ID		Field Sample Identification	Matrix*	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose Total or Diss Metals	RCAP-MS Choose Total or Diss Metals	Metals Water: Total Digest (Default Method) for well water, surface water	Metals Water: Dissolved for ground water	Metals Water: Mercury	Metals Soil: Metals & Mercury Default Available Digest Method	Metals Soil: Metals Total Digest - for Ocean sediments (HNO3/HF/HCLO4)	Metals Soil: Mercury Low level by Cold Vapour AA	Metals Soil: Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Metals Soil: Hot Water soluble Boron (required for CCME Agricultural)	Hydrocarbons: RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons: Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	Hydrocarbons: NB Potable Water BTEX, VPH, Low level T.E.H.	Hydrocarbons: TPH Fractionation	Hydrocarbons: PAH's	Hydrocarbons: PAH's with Acridine, Quinoline	EPA 3050b
DQ1570	1	S16A	Soil	July/09 2009	Baggies								6											
77	2	S18A											✓											
78	3	S18B											✓											
79	4	S18C											6											
80	5	S19A											6											
81	6	S20A											6											
82	7	S20B											6											
83	8	S20C											✓											
84	9	QA/QC-30											6											
85	10	S21A											6											

RELINQUISHED BY: (Signature/Print)	Date	Time	RECEIVED BY: (Signature/Print)	Date	Time
Mario Theriault	Sept 4/09	3:00pm	Jessica Dawson		
			JESS Dawson		

White: Maxxam Yellow : Mail Pink: Client

ATL FCD 00149 / Revision 8/14/08

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90 Esplanade Sydney, NS B1P 1A1 Tel: 902-567-1255 Fax: 902-539-6504 Toll Free: 888-535-7770
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MAXXAM Chain of Custody Record

COC #: B 65310

Page 2 of 3

This column for lab use only:

Client Code

Maxxam Job #

Cooler ID	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp

Integrity YES NO

Integrity / Checklist by

Labelled by

Location / Bin #

INVOICE INFORMATION:

Company Name:
Contact Name:
Address:
Postal Code
Email:
Ph: Fax:

REPORT INFORMATION (if differs from invoice):

Company Name:
Contact Name:
Address:
Postal Code
Email:
Ph: Fax:

PO #
Project # / Phase #
Project Name / Site Location
Quote
Site #
Task Order #
Sampled by

TURNAROUND TIME

Standard ☒
10 day ☐
If RUSH Specify Date:
Pre-schedule rush work
Charge for # Jars used but not submitted

Guideline Requirements / Detection Limits / Special Instructions

Batch #3
Exclude Mercury

*Specify Matrix: Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

									Metals Water			Metals Soil					Hydrocarbons						
Lab	Field Sample Identification	Matrix*	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose Total or Diss Metals	RCAP-MS Choose Total or Diss Metals	Total Digest (Default Method) for well water, surface water	Dissolved for ground water	Mercury	Metals & Mercury Default Available Digest Method	Metals Total Digest - for Ocean sediments (HNO3/HF/HCLO4)	Mercury Low level by Cold Vapour AA	Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Hot Water soluble Boron (required for CCME Agricultural)	RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	NB Potable Water BTEX, VPH, Low level T.E.H.	TPH Fractionation	PAH's	PAH's with Acridine, Quinoline	EPA 3050B
86	1 S22A	Soil	5th (Aug 2009)	baggies								6											
88	2 S23A	〃	〃	〃								6											
89	3 S23B	〃	〃	〃								6											
90	4 S23C	〃	〃	〃								6											
91	5 S24A	〃	〃	〃								6											
92	6 S25A	〃	〃	〃								6											
93	7 S25B	〃	〃	〃								6											
94	8 S25C	〃	〃	〃								6											
95	9 QA/QC-12	〃	〃	〃								6											
96	10 S28A	〃	〃	〃								6											

RELINQUISHED BY: (Signature/Print)	Date	Time	RECEIVED BY: (Signature/Print)	Date	Time
Mario Theriault	Sept 4/09	3:00pm			

White: Maxxam Yellow : Mail Pink: Client

ATL FCD 00149 / Revision 5 11/0

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90 Esplanade Sydney, NS B1P 1A1 Tel: 902-567-1255 Fax: 902-539-6504 Toll Free: 888-535-7770
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MAXXAM Chain of Custody Record

COC #: B 65311

Page 3 of 3

This column for lab use only:

Client Code

Maxxam Job #

Cooler ID	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp

Integrity YES NO	Integrity / Checklist by
Labelled by	Location / Bin #

INVOICE INFORMATION:

Company Name:
Contact Name:
Address:
Postal Code
Email:
Ph:
Fax:

REPORT INFORMATION (if differs from invoice):

Company Name:
Contact Name:
Address:
Postal Code
Email:
Ph:
Fax:

PO #
Project # / Phase #
Project Name / Site Location
Quote
Site #
Task Order #
Sampled by

TURNAROUND TIME

Standard ☑
10 day ☐
If RUSH Specify Date:

Pre-schedule rush work

Charge for # Jars used but not submitted

Guideline Requirements / Detection Limits / Special Instructions

Batch #3
Exclude Mercury

*Specify Matrix: Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

Lab use		Field Sample Identification	Matrix*	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose Total or Diss Metals	RCAP-MS Choose Total or Diss Metals
DQ1597	1	S29A	Soil	July/Aug 2009	Bagies				
	2	[illegible]							
	3								
	4								
	5								
	6								
	7								
	8								
	9								
	10								

	Metals Water			Metals Soil					Hydrocarbons						EPA 3050B			
	Total Digest (Default Method) for well water, surface water	Dissolved for ground water	Mercury	Metals & Mercury Default Available Digest Method	Metals Total Digest - for Ocean sediments (HNO3/HF/HCLO4)	Mercury Low level by Cold Vapour AA	Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Hot Water soluble Boron (required for CCME Agricultural)	RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	NB Potable Water BTEX, VPH, Low level T.E.H.	TPH Fractionation	PAH's	PAH's with Acridine, Quinoline				
1				X														
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		

RELINQUISHED BY: (Signature/Print)	Date	Time	RECEIVED BY: (Signature/Print)	Date	Time
Mario Theriault	Sept 4/09	2:00pm			

White: Maxxam Yellow : Mail Pink: Client

Maxxam Analytics International Corporation

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90 Esplanade Sydney, NS B1P 1A1 Tel: 902-567-1255 Fax: 902-539-6504 Toll Free: 888-535-7770
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MAXXAM Chain of Custody Record

COC #: B 65323

Page 1 of 4

This column for lab use only:

Client Code 22319

Maxxam Job # A9B7570

Cooler ID	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp
			15	15	15	

Integrity YES [✓ NO]

Integrity / Checklist by

Labelled by

Location / Bin # Black Cart wtf 29

INVOICE INFORMATION:

Company Name: Intrinsik Science
Contact Name: Christine Moore
Address: 5121 Sackville St
Halifax NS Postal Code B3J 1K1
Email: Cmoore@intrinsikScience.com
Ph: 902-429-0278 Fax: 902 429-0279

REPORT INFORMATION (if differs from invoice):

Company Name: SAME
Contact Name: Please Copy Results
Address: to Nbradie@oceanworld.com
Postal Code
Email:
Ph: Fax:

PO #
Project # / Phase # 055453
Project Name / Site Location Bellevue ECO
Quote 09-220KG
Site #
Task Order #
Sampled by Mike Gaines (CK)

TURNAROUND TIME

Standard ☒
10 day ☐
If RUSH Specify Date:
Pre-schedule rush work
Charge for # Jars used but not submitted 0

Guideline Requirements / Detection Limits / Special Instructions

Batch #7

Please Exclude Mercury

*Specify Matrix: Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

EPH 30JOB

									Metals Water			Metals Soil					Hydrocarbons					
	Field Sample Identification	Matrix*	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose Total or Diss Metals	RCAP-MS Choose Total or Diss Metals	Total Digest (Default Method) for well water, surface water	Dissolved for ground water	Mercury	Metals & ~~Mercury~~ Default Available Digest Method	Metals Total Digest - for Ocean sediments (HNO3/HF/HCLO4)	Mercury Low level by Cold Vapour AA	Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Hot Water soluble Boron (required for CCME Agricultural)	RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	NB Potable Water BTEX, VPH, Low level T.E.H.	TPH Fractionation	PAH's	PAH's with Acridine, Quinoline
DQ1610	1 R5A	Soil	July/Aug 01	Baggies								X										
DQ1618	2 R6A	|	|	|								X										
DQ1619	3 R6B	|	|	|								X										
DQ1620	4 R6C	|	|	|								X										
DQ1621	5 QA/QC-21	|	|	|								X										
DQ1622	6 R7A	|	|	|								X										
DQ1623	7 R9A	|	|	|								X										
DQ1624	8 R10A	|	|	|								X										
DQ1625	9 R10B	|	|	|								X										
DQ1626	10 R10C	|	|	|								X										

wtf 29

RELINQUISHED BY: (Signature/Print) Mario Theriault Date Time

RECEIVED BY: (Signature/Print) Jess Date Time

White: Maxxam Yellow : Mail Pink: Client

ATL FCD 00149 / Revision 8 11/08

Maxxam Analytics International Corporation
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www.maxxamanalytics.com E-mail: Clientservicesbedford@maxxamanalytics.com

MAXXAM Chain of Custody Record

COC #: B 65324

Page 2 of 4

This column for lab use only:

Client Code 22319 33

Maxxam Job # A9B7570

Cooler ID	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp

Integrity YES NO

Integrity / Checklist by

Labelled by

Location / Bin #

INVOICE INFORMATION:

Company Name:
Contact Name:
Address:
Postal Code
Email:
Ph:
Fax:

REPORT INFORMATION (if differs from invoice):

Company Name:
Contact Name:
Address:
Postal Code
Email:
Ph:
Fax:

PO #
Project # / Phase # 055453
Project Name / Site Location Belledune Eco
Quote 09-220KG
Site #
Task Order #
Sampled by Mike Gaines (CRA)

TURNAROUND TIME

Standard ☒
10 day ☐
If RUSH Specify Date:
Pre-schedule rush work
Charge for # Jars used but not submitted 0

Guideline Requirements / Detection Limits / Special Instructions

Batch #7
Please Exclude Mercury

*Specify Matrix: Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

ERH 30500

	Field Sample Identification	Matrix*	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose Total or Diss Metals	RCAP-MS Choose Total or Diss Metals	Metals Water: Total Digest (Default Method) for well water, surface water	Metals Water: Dissolved for ground water	Metals Water: Mercury	Metals Soil: Metals & ~~Mercury~~ Default Available Digest Method	Metals Soil: Metals Total Digest - for Ocean sediments (HNO3/HF/HCLO4)	Metals Soil: Mercury Low level by Cold Vapour AA	Metals Soil: Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Metals Soil: Hot Water soluble Boron (required for CCME Agricultural)	Hydrocarbons: RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons: Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	Hydrocarbons: NB Potable Water BTEX, VPH, Low level T.E.H.	Hydrocarbons: TPH Fractionation	Hydrocarbons: PAH's	Hydrocarbons: PAH's with Acridine, Quinoline
D01627	1 R11A	Soil	July/Aug 09	Baggies								✓										
D01628	2 R12A											✓										
D01629	3 R14A											✓										
D01630	4 R14B											✓										
D01631	5 R14C											✓										
D01632	6 QA/QC-31											✓										
D01633	7 R15A											✓										
D01634	8 R16A											✓										
D01635	9 R16B											✓										
D01636	10 R16C											✓										

wik 29

RELINQUISHED BY: (Signature/Print)	Date	Time	RECEIVED BY: (Signature/Print)	Date	Time
Mario Theriault	Sept 4/09	3:30pm			

White: Maxxam Yellow : Mail Pink: Client

Maxxam Analytics International Corporation

200 Bluewater Road, Suite 105, Bedford, Nova Scotia B4B 1G9 Tel: 902-420-0203 Fax: 902-420-8612 Toll Free: 1-800-565-7227
90 Esplanade Sydney, NS B1P 1A1 Tel: 902-567-1255 Fax: 902-539-6504 Toll Free: 888-535-7770
www.maxxamanalytics.com E-mail: Clientservicesbedford@maxxamanalytics.com

MAXXAM Chain of Custody Record

COC #: B 65325

Page 3 of 4

This column for lab use only:

Client Code 22319 87

Maxxam Job # A9B7570

Cooler ID	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp

Integrity YES NO

Integrity / Checklist by

Labelled by

Location / Bin #

INVOICE INFORMATION:

Company Name:

Contact Name:

Address:

Postal Code

Email:

Ph: Fax:

REPORT INFORMATION (if differs from invoice):

Company Name:

Contact Name:

Address:

Postal Code

Email:

Ph: Fax:

PO #

Project # / Phase # 055453

Project Name / Site Location Belledune FCO

Quote 09-220KG

Site #

Task Order #

Sampled by Mike Gaines (KRA)

TURNAROUND TIME

Standard ☒

10 day ☐

If RUSH Specify Date:

Pre-schedule rush work

Charge for # Jars used but not submitted 0

Guideline Requirements / Detection Limits / Special Instructions

Batch #7

Please exclude Mercury

*Specify Matrix: Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

									Metals Water			Metals Soil					Hydrocarbons					
	Field Sample Identification	Matrix*	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose Total or Diss Metals	RCAP-MS Choose Total or Diss Metals	Total Digest (Default Method) for well water, surface water	Dissolved for ground water	Mercury	Metals & ~~Mercury~~ Default Available Digest Method	Metals Total Digest - for Ocean sediments (HNO3/HF/HCLO4)	Mercury Low level by Cold Vapour AA	Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Hot Water soluble Boron (required for CCME Agricultural)	RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	NB Potable Water BTEX, VPH, Low level T.E.H.	TPH Fractionation	PAH's	PAH's with Acridine, Quinoline
D01637 wit 29	1 R17A	Soil	July/Aug 09	Baggies								✓										
D01638	2 R18A											✓										
D01639	3 R18B											✓										
D01640	4 R18C											✓										
D01641	5 R19A											✓										
D01642 wit 30	6 QA/QC-23											✓										
D01643	7 R21A											✓										
D01644	8 R22A											✓										
D01645	9 R22B											✓										
D01646.	10 R22C											✓										

RELINQUISHED BY: (Signature/Print)	Date	Time	RECEIVED BY: (Signature/Print)	Date	Time
Mario Theriault	Sept 4/09	3:30pm	Jess		

White: Maxxam Yellow : Mail Pink: Client

ATL FCD 00149 / Revision 8 11/08

Maxxam Analytics International Corporation

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MAXXAM Chain of Custody Record

COC #: B 65326

Page 4 of 4

This column for lab use only:

Client Code 22319 87

Maxxam Job # A9B7570

Cooler ID	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp

Integrity YES NO

Integrity / Checklist by

Labelled by

Location / Bin #

INVOICE INFORMATION:

Company Name:

Contact Name:

Address:

Postal Code

Email:

Ph: **Fax:**

REPORT INFORMATION (if differs from invoice):

Company Name:

Contact Name:

Address:

Postal Code

Email:

Ph: **Fax:**

PO #

Project # / Phase # 055453

Project Name/ Site Location Belledune ECO

Quote 09-220KG

Site #

Task Order #

Sampled by Mike Gaines CRA

TURNAROUND TIME

Standard ☒

10 day ☐

If RUSH Specify Date:

Pre-schedule rush work

Charge for # Jars used but not submitted 0

Guideline Requirements / Detection Limits / Special Instructions

Batch #7

Please Exclude Mercury

***Specify Matrix: Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater**

Lab use		Field Sample Identification	Matrix*	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose Total or Diss Metals	RCAP-MS Choose Total or Diss Metals	Metals Water: Total Digest (Default Method) for well water, surface water	Metals Water: Dissolved for ground water	Metals Water: Mercury	Metals Soil: Metals & ~~Mercury~~ Default Available Digest Method	Metals Soil: Metals Total Digest - for Ocean sediments (HNO3/HF/HCLO4)	Metals Soil: Mercury Low level by Cold Vapour AA	Metals Soil: Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Metals Soil: Hot Water soluble Boron (required for CCME Agricultural)	Hydrocarbons: RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons: Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	Hydrocarbons: NB Potable Water BTEX, VPH, Low level T.E.H.	Hydrocarbons: TPH Fractionation	Hydrocarbons: PAH's	Hydrocarbons: PAH's with Acridine, Quinoline	7050B				
DQ1647. mp wlf	1	R23A	Soil	July 4/09	Baggie								X															
	2																											
	3																											
	4																											
	5																											
	6																											
	7																											
	8																											
	9																											
	10																											

RELINQUISHED BY: (Signature/Print)	Date	Time	RECEIVED BY: (Signature/Print)	Date	Time
Mario Theriault	Sept 4/09	3:30pm	Jess		

White: Maxxam Yellow : Mail Pink: Client

ATL FCD 00149 / Revision 8 11/08

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MAXXAM Chain of Custody Record

COC #: B 65312

Page 1 of 3

This column for lab use only

Client Code: 22319

Maxxam Job #: A9B75

Cooler ID	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp
			16	15	15	

Integrity: YES [✓ NO]

Integrity / Checklist by: [illegible]

Labelled by:

Location / Bin #: Temp Bag Cart WIF 24

INVOICE INFORMATION:

Company Name: Intrinsik Science

Contact Name: Christine Moore

Address: 5121 Sackville St

Suit 506 Halifax Postal Code B3J 1K1

Email: Cmoore@intrinsikscience.com

Ph: 902-429-0278 Fax: 902-429-0279

REPORT INFORMATION (if differs from invoice):

Company Name: Same

Contact Name: Please copy results

Address: to Nbradie@chnworld.com

Postal Code

Email:

Ph: Fax:

PO #

Project # / Phase # 055453

Project Name / Site Location Belledune ECO

Quote 09-220K9

Site #

Task Order #

Sampled by Mike Gaines (CAA)

TURNAROUND TIME

Standard ☒

10 day ☐

If RUSH Specify Date:

Pre-schedule rush work

Charge for # Jars used but not submitted: 0

Guideline Requirements / Detection Limits / Special Instructions

Batch #4

Please Exclude Mercury

EPA 3050B

*Specify Matrix: Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

	Field Sample Identification	Matrix*	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose Total or Diss Metals	RCAP-MS Choose Total or Diss Metals	Metals Water: Total Digest (Default Method) for well water, surface water	Metals Water: Dissolved for ground water	Metals Water: Mercury	Metals Soil: Metals & ~~Mercury~~ Default Available Digest Method	Metals Soil: Metals Total Digest - for Ocean sediments (HNO3/HF/HCLO4)	Metals Soil: Mercury Low level by Cold Vapour AA	Metals Soil: Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Metals Soil: Hot Water soluble Boron (required for CCME Agricultural)	Hydrocarbons: RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons: Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	Hydrocarbons: NB Potable Water BTEX, VPH, Low level T.E.H.	Hydrocarbons: TPH Fractionation	Hydrocarbons: PAH's	Hydrocarbons: PAH's with Acridine, Quinoline
DQ1645	1 S26A	Soil	July/Aug 2009	Baggies								X										
S0	2 S27A											X										
S1	3 S30A											X										
S2	4 S30B											X										
S3	5 S30C											X										
S4	6 QA/QC-1											X										
S5	7 S31A											X										
S6	8 S32A											X										
S7	9 S32B											X										
S8	10 S32C											X										

2009 SEP 8 AM 9:45

RELINQUISHED BY: (Signature/Print)	Date	Time	RECEIVED BY: (Signature/Print)	Date	Time
Mario Theriault	Sept 4/09	7:00pm	Jess Dawson		
			Jess Dawson		

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MAXXAM Chain of Custody Record

COC #: B 65313

Page 2 of 3

This column for lab use only:

Client Code

Maxxam Job #

Cooler ID	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp

Integrity YES NO

Integrity / Checklist by

Labelled by

Location / Bin #

INVOICE INFORMATION:

Company Name:

Contact Name:

Address:

Postal Code

Email:

Ph: Fax:

REPORT INFORMATION (if differs from invoice):

Company Name:

Contact Name:

Address:

Postal Code

Email:

Ph: Fax:

PO #

Project # / Phase #: 055453

Project Name / Site Location: BelleLine Eco

Quote: 09-220 KG

Site #

Task Order #

Sampled by: Mike Gaine

TURNAROUND TIME

Standard ☒

10 day ☐

If RUSH Specify Date:

Pre-schedule rush work

Charge for # Jars used but not submitted

Guideline Requirements / Detection Limits / Special Instructions

Batch #4
Please Exclude Mercury

*Specify Matrix: Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

									Metals Water			Metals Soil					Hydrocarbons						
	Field Sample Identification	Matrix*	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose Total or Diss Metals	RCAP-MS Choose Total or Diss Metals	Total Digest (Default Method) for well water, surface water	Dissolved for ground water	Mercury	Metals & Mercury Default Available Digest Method	Metals Total Digest - for Ocean sediments (HNO3/HF/HCLO4)	Mercury Low level by Cold Vapour AA	Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Hot Water soluble Boron (required for CCME Agricultural)	RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	NB Potable Water BTEX, VPH, Low level T.E.H.	TPH Fractionation	PAH's	PAH's with Acridine, Quinoline	EPA 3050A
DQ1659	1 S33A	Soil	July/Aug 2009	Baggi's								X											
60	2 S33B											X											
61	3 S33C											X											
62	4 S34A											X											
63	5 QA/QC-20											X											
64	6 S35A											X											
65	7 S35B											X											
66	8 S35C											X											
67	9 S-36A											X											
68	10 S-38A											X											

RELINQUISHED BY: (Signature/Print)	Date	Time	RECEIVED BY: (Signature/Print)	Date	Time
Marc Theriault	Sept 7/09	3:00 pm			

xam
Analytics
International Corporation

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MAXXAM Chain of Custody Record

COC #: B 65314

Page 3 of 3

column for lab use only:

ent Code

Maxxam Job #

Cooler ID	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp

Integrity YES NO

Integrity / Checklist by

Labelled by

Location / Bin #

INVOICE INFORMATION:

Company Name:

Contact Name:

Address:

Postal Code

Email:

Ph:

Fax:

REPORT INFORMATION (if differs from invoice):

Company Name:

Contact Name:

Address:

Postal Code

Email:

Ph:

Fax:

PO #

Project # / Phase # 095453

Project Name / Site Location Pollution ECO

Quote 09-220KG

Site #

Task Order #

Sampled by Mike Gaines

TURNAROUND TIME

Standard ☒

10 day ☐

If RUSH Specify Date:

Pre-schedule rush work

Charge for # Jars used but not submitted 0

Guideline Requirements / Detection Limits / Special Instructions

Batch #4

Please Exclude Mercury

*Specify Matrix: Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

Location / Bin #		Field Sample Identification	Matrix*	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose Total or Diss Metals	RCAP-MS Choose Total or Diss Metals	Metals Water: Total Digest (Default Method) for well water, surface water	Metals Water: Dissolved for ground water	Metals Water: Mercury	Metals Soil: Metals & Mercury Default Available Digest Method	Metals Soil: Metals Total Digest - for Ocean sediments (HNO3/HF/HCLO4)	Metals Soil: Mercury Low level by Cold Vapour AA	Metals Soil: Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Metals Soil: Hot Water soluble Boron (required for CCME Agricultural)	Hydrocarbons: RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons: Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	Hydrocarbons: NB Potable Water BTEX, VPH, Low level T.E.H.	Hydrocarbons: TPH Fractionation	Hydrocarbons: PAH's	Hydrocarbons: PAH's with Acridine, Quinoline	EPH 3050B				
DQ1669	1	S-38B	Soil	July/Aug 2009	Baggie								X															
80	2	S-38C	|		〃								X															
	3																											
	4																											
	5																											
	6																											
	7																											
	8																											
	9																											
	10																											

RELINQUISHED BY: (Signature/Print)	Date	Time	RECEIVED BY: (Signature/Print)	Date	Time
Mario Theriault	Sept 4/09	3:00 pm			

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MAXXAM Chain of Custody Record

COC #: B 65306

Page 1 of 3

This column for lab use only:

Client Code 22319

Maxxam Job # A9B7S78

Cooler ID	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp
			15	15	16	

Integrity YES [✓ NO]

Integrity / Checklist by

Labelled by

Location / Bin # Beige cart WJ 25

INVOICE INFORMATION:

Company Name: Intrinsik Science
Contact Name: Christine Moore
Address: 5121 Sackville St
Suite 506 Halifax Postal Code B3J 1K1
Email: Cmoore@intrinsikscience.com
Ph: 902-429-0278 Fax: 902-429-0279

REPORT INFORMATION (if differs from invoice):

Company Name: Same
Contact Name: Please copy Results
Address: to Nbrodie@craworld.com
Postal Code
Email:
Ph: Fax:

PO #
Project # / Phase # 055453
Project Name / Site Location Belledune ECO
Quote 09-220 KG
Site #
Task Order #
Sampled by Mike Gaines (CRA)

TURNAROUND TIME
Standard ☒
10 day ☐
If RUSH Specify Date:
Pre-schedule rush work
Charge for # Jars used but not submitted 0

Guideline Requirements / Detection Limits / Special Instructions

Batch #2

Exclude Mercury

*Specify Matrix: Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

Lab ID	Field Sample Identification	Matrix*	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose Total or Diss Metals	RCAP-MS Choose Total or Diss Metals	Metals Water: Total Digest (Default Method) for well water, surface water	Metals Water: Dissolved for ground water	Metals Water: Mercury	Metals Soil: Metals & Mercury Default Available Digest Method	Metals Soil: Metals Total Digest - for Ocean sediments (HNO3/HF/HCLO4)	Metals Soil: Mercury Low level by Cold Vapour AA	Metals Soil: Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Metals Soil: Hot Water soluble Boron (required for CCME Agricultural)	Hydrocarbons: RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons: Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	Hydrocarbons: NB Potable Water BTEX, VPH, Low level T.E.H.	Hydrocarbons: TPH Fractionation	Hydrocarbons: PAH's	Hydrocarbons: PAH's with Acridine, Quinoline	EPA 3050B
DQ1682	1 ✓S1A	Soil	July/August 2009	Baggies								X											
83	2 ✓S1B											X											
84	3 ✓S1C											X											
85	4 S2A											X											
86	5 ✓S3A											X											
87	6 S5A											X											
88	7 S5B											X											
89	8 ✓S5C											X											
90	9 S6A											X											
91	10 S7A											X											

2009 SEP 8 AM 8:48

RELINQUISHED BY: (Signature/Print) Mario Theriault Date Sept 4/09 Time 2:00pm

RECEIVED BY: (Signature/Print) Jess Dawson Date Time

Maxxam Analytics International Corporation

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MAXXAM Chain of Custody Record

COC #: B 65307

Page 2 of 3

This column for lab use only:
Client Code
Maxxam Job #

Cooler ID	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp

Integrity YES NO
Integrity / Checklist by
Labelled by
Location / Bin #

INVOICE INFORMATION:
Company Name:
Contact Name:
Address:
Postal Code
Email:
Ph:
Fax:

REPORT INFORMATION (if differs from invoice):
Company Name:
Contact Name:
Address:
Postal Code
Email:
Ph:
Fax:

PO #
Project # / Phase #
Project Name / Site Location
Quote
Site #
Task Order #
Sampled by

TURNAROUND TIME
Standard ☒
10 day ☐
If RUSH Specify Date:
Pre-schedule rush work
Charge for # Jars used but not submitted

Guideline Requirements / Detection Limits / Special Instructions

Batch #2
Exclude Mercury

*Specify Matrix: Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

EPA 3050B

	Field Sample Identification	Matrix*	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose Total or Diss Metals	RCAP-MS Choose Total or Diss Metals	Metals Water: Total Digest (Default Method) for well water, surface water	Metals Water: Dissolved for ground water	Metals Water: Mercury	Metals Soil: Metals & ~~Mercury~~ Default Available Digest Method	Metals Soil: Metals Total Digest - for Ocean sediments (HNO3/HF/HCLO4)	Metals Soil: Mercury Low level by Cold Vapour AA	Metals Soil: Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Metals Soil: Hot Water soluble Boron (required for CCME Agricultural)	Hydrocarbons: RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons: Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	Hydrocarbons: NB Potable Water BTEX, VPH, Low level T.E.H.	Hydrocarbons: TPH Fractionation	Hydrocarbons: PAH's	Hydrocarbons: PAH's with Acridine, Quinoline
DQ1092	1 S8A	Soil	July/Aug 2009	Baggies								X										
93	2 S8B											X										
94	3 S8C											X										
95	4 QA/QC-13											X										
96	5 S9A											X										
97	6 S10A											X										
98	7 S10B											X										
99	8 S10C											X										
100	9 S12A											X										
01	10 S14A											X										

RELINQUISHED BY: (Signature/Print)	Date	Time	RECEIVED BY: (Signature/Print)	Date	Time
MArio Theriault	Sept 4/09	2:00pm			

Maxxam Analytics International Corporation

200 Bluewater Road, Suite 105, Bedford, Nova Scotia B4B 1G9 Tel: 902-420-0203 Fax: 902-420-8612 Toll Free: 1-800-565-7227
90 Esplanade Sydney, NS B1P 1A1 Tel: 902-567-1255 Fax: 902-539-6504 Toll Free: 888-535-7770
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MAXXAM Chain of Custody Record

COC #: B 65308

Page 3 of 3

This column for lab use only:

Client Code

Maxxam Job #

Cooler ID	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp

Integrity YES NO

Integrity / Checklist by

Labelled by

Location / Bin #

INVOICE INFORMATION:

Company Name:
Contact Name:
Address:
Postal Code
Email:
Ph:
Fax:

REPORT INFORMATION (if differs from invoice):

Company Name:
Contact Name:
Address:
Postal Code
Email:
Ph:
Fax:

PO #
Project # / Phase #
Project Name / Site Location
Quote
Site #
Task Order #
Sampled by

TURNAROUND TIME

Standard ☑

10 day ☐

If RUSH Specify Date:

Pre-schedule rush work

Charge for # Jars used but not submitted

Guideline Requirements / Detection Limits / Special Instructions

Batch #2
Exclude Mercury

*Specify Matrix: Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

									Metals Water			Metals Soil					Hydrocarbons						
	Field Sample Identification	Matrix*	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose Total or Diss Metals	RCAP-MS Choose Total or Diss Metals	Total Digest (Default Method) for well water, surface water	Dissolved for ground water	Mercury	Metals & Mercury Default Available Digest Method	Metals Total Digest - for Ocean sediments (HNO3/HF/HCLO4)	Mercury Low level by Cold Vapour AA	Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Hot Water soluble Boron (required for CCME Agricultural)	RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	NB Potable Water BTEX, VPH, Low level T.E.H.	TPH Fractionation	PAH's	PAH's with Acridine, Quinoline	EPA 3050B
DQ1702	1 S 15A	Soil	5-4/ Aug 09	Baggie								X											
03	2 QA/QC-11	|	|	|								X											
10	3 S-17A	|	|	|								X											
	4																						
	5																						
	6																						
	7																						SEP 2 PM 3:48
	8																						
	9																						
	10																						

RELINQUISHED BY: (Signature/Print)	Date	Time	RECEIVED BY: (Signature/Print)	Date	Time
Mario Theriault	Sept 4/09	2:00 pm			

ATL FCD 00149 / Revision 8 11/08

Maxxam Analytics International Corporation

200 Bluewater Road, Suite 105, Bedford, Nova Scotia B4B 1G9 Tel: 902-420-0203 Fax: 902-420-8612 Toll Free: 1-800-565-7227
90 Esplanade Sydney, NS B1P 1A1 Tel: 902-567-1255 Fax: 902-539-6504 Toll Free: 888-535-7770
www.maxxamanalytics.com E-mail: Clientservicesbedford@maxxamanalytics.com

MAXXAM Chain of Custody Record

COC #: B 65315

Page 1 of 3

This column for lab use only:

Client Code: 22319 ~~87~~

Maxxam Job #: A9B7632

Cooler ID	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp
			16	15	15	

Integrity: YES [✓ NO]

Integrity / Checklist by:

Labelled by:

Location / Bin #: Black Cart WSF 28

INVOICE INFORMATION:

Company Name: Intrinsik Science
Contact Name: Christine Moore
Address: 5121 Sackville St
Halifax NS Postal Code B3J 1K1
Email: cmoore@intrinsikscience.com
Ph: 902-429-0278 Fax: 902-429-0279

REPORT INFORMATION (if differs from invoice):

Company Name: Same
Contact Name: Please Copy results
Address: to Nbrodie@crawfield.com
Postal Code
Email:
Ph: Fax:

PO #:
Project # / Phase #: 055453
Project Name / Site Location: Belle Lune Ew
Quote: 09-220K9
Site #:
Task Order #:
Sampled by: Mike Grine (CRA)

TURNAROUND TIME
Standard ☒
10 day ☐
If RUSH Specify Date:
Pre-schedule rush work
Charge for # Jars used but not submitted: 0

Guideline Requirements / Detection Limits / Special Instructions

Batch # 5

Please Exclude Mercury

*Specify Matrix: Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

	Field Sample Identification	Matrix*	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose Total or Diss Metals	RCAP-MS Choose Total or Diss Metals	Metals Water: Total Digest (Default Method) for well water, surface water	Metals Water: Dissolved for ground water	Metals Water: Mercury	Metals Soil: Metals & Mercury Default Available Digest Method	Metals Soil: Metals Total Digest - for Ocean sediments (HNO3/HF/HCLO4)	Metals Soil: Mercury Low level by Cold Vapour AA	Metals Soil: Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Metals Soil: Hot Water soluble Boron (required for CCME Agricultural)	Hydrocarbons: RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons: Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	Hydrocarbons: NB Potable Water BTEX, VPH, Low level T.E.H.	Hydrocarbons: TPH Fractionation	Hydrocarbons: PAH's	Hydrocarbons: PAH's with Acridine, Quinoline	EPH 3050B				
DQ2014	1 S39A	Soil	Jly/Aug 09	Bags								✓															
DQ2031	2 S41A											✓															
DQ2033	3 S42A											✓															
DQ2034	4 S43A											✓															
DQ2035	5 S44A											✓															
DQ2036	6 S45A											✓															
DQ2037	7 S46A											✓															
DQ2038	8 QA/QC-10											✓															
DQ2039	9 S-47A											✓															
DQ2040	10 ~~S47B~~ S-47B											✓															

RELINQUISHED BY: (Signature/Print)	Date	Time	RECEIVED BY: (Signature/Print)	Date	Time
Mario Theriault	Sept 4/09	3:00 pm	Jess Davis		

White: Maxxam Yellow : Mail Pink: Client

ATL FCD 00149 / Revision 8 11/08

Maxxam Analytics International Corporation

200 Bluewater Road, Suite 105, Bedford, Nova Scotia B4B 1G9 Tel: 902-420-0203 Fax: 902-420-8612 Toll Free: 1-800-565-7227
90 Esplanade Sydney, NS B1P 1A1 Tel: 902-567-1255 Fax: 902-539-6504 Toll Free: 888-535-7770
www.maxxamanalytics.com E-mail: Clientservicesbedford@maxxamanalytics.com

MAXXAM Chain of Custody Record

COC #: B 65316

Page 2 of 3

This column for lab use only:

Client Code 22319 87.

Maxxam Job # A9B7632

Cooler ID	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp

Integrity YES NO

Integrity / Checklist by

Labelled by

Location / Bin #

INVOICE INFORMATION:

Company Name:

Contact Name:

Address:

Postal Code

Email:

Ph: Fax:

REPORT INFORMATION (if differs from invoice):

Company Name:

Contact Name:

Address:

Postal Code

Email:

Ph: Fax:

PO #

Project # / Phase # 055453

Project Name / Site Location Belledune ECO

Quote 09-220K9

Site #

Task Order #

Sampled by Mike Gaines

TURNAROUND TIME

Standard ☒

10 day ☐

If RUSH Specify Date:

Pre-schedule rush work

Charge for # Jars used but not submitted 0

Guideline Requirements / Detection Limits / Special Instructions

Batch #5

Please Exclude Mercury

*Specify Matrix: Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

	Field Sample Identification	Matrix*	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose Total or Diss Metals	RCAP-MS Choose Total or Diss Metals	Metals Water: Total Digest (Default Method) for well water, surface water	Metals Water: Dissolved for ground water	Metals Water: Mercury	Metals Soil: Metals & ~~Mercury~~ Default Available Digest Method	Metals Soil: Metals Total Digest - for Ocean sediments (HNO3/HF/HCLO4)	Metals Soil: Mercury Low level by Cold Vapour AA	Metals Soil: Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Metals Soil: Hot Water soluble Boron (required for CCME Agricultural)	Hydrocarbons: RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons: Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	Hydrocarbons: NB Potable Water BTEX, VPH, Low level T.E.H.	Hydrocarbons: TPH Fractionation	Hydrocarbons: PAH's	Hydrocarbons: PAH's with Acridine, Quinoline	EPA 3050B			
DQ2041	1 S-47C	Soil	Sep 4/Aug 2009	Baggies								✓														
DQ2042	2 S-48A											✓														
DQ2043	3 S-48B											✓														
DQ2044	4 S-48C											✓														
DQ2045	5 S-50A											✓														
DQ2046	6 QA/QC-4											✓														
DQ2047	7 S-51A											✓														
DQ2048	8 S-52A											✓														
DQ2049	9 S-52B											✓														
DQ2050	10 S-52C											✓														

RELINQUISHED BY: (Signature/Print)	Date	Time	RECEIVED BY: (Signature/Print)	Date	Time
MARIO Theriault	Sept 4/09	3:00 pm			
			J Da S		

White: Maxxam Yellow : Mail Pink: Client

ATL FCD 00149 / Revision 8 11/08

Maxxam Analytics International Corporation

200 Bluewater Road, Suite 105, Bedford, Nova Scotia B4B 1G9 Tel: 902-420-0203 Fax: 902-420-8612 Toll Free: 1-800-565-7227
90 Esplanade Sydney, NS B1P 1A1 Tel: 902-567-1255 Fax: 902-539-6504 Toll Free: 888-535-7770
www.maxxamanalytics.com E-mail: Clientservicesbedford@maxxamanalytics.com

MAXXAM Chain of Custody Record

COC #: B 65317

Page 3 of 3

This column for lab use only:

Client Code 22319 87

Maxxam Job # A9B7632

Cooler ID	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp

Integrity YES NO

Integrity / Checklist by

Labelled by

Location / Bin #

INVOICE INFORMATION:

Company Name:

Contact Name:

Address:

Postal Code

Email:

Ph: **Fax:**

REPORT INFORMATION (if differs from invoice):

Company Name:

Contact Name:

Address:

Postal Code

Email:

Ph: **Fax:**

PO #

Project # / Phase # 055453

Project Name / Site Location Belledune ECO

Quote 09-220 KG

Site #

Task Order #

Sampled by Mike Gaines

TURNAROUND TIME

Standard ☒

10 day ☐

If RUSH Specify Date:

Pre-schedule rush work

Charge for # Jars used but not submitted 0

Guideline Requirements / Detection Limits / Special Instructions

Batch # 5

Please Exclude Mercury

*Specify Matrix: Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

Lab use		Field Sample Identification	Matrix*	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose Total or Diss Metals	RCAP-MS Choose Total or Diss Metals	Metals Water: Total Digest (Default Method) for well water, surface water	Metals Water: Dissolved for ground water	Metals Water: Mercury	Metals Soil: Metals & ~~Mercury~~ Default Available Digest Method	Metals Soil: Metals Total Digest - for Ocean sediments (HNO3/HF/HCLO4)	Metals Soil: Mercury Low level by Cold Vapour AA	Metals Soil: Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Metals Soil: Hot Water soluble Boron (required for CCME Agricultural)	Hydrocarbons: RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons: Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	Hydrocarbons: NB Potable Water BTEX, VPH, Low level T.E.H.	Hydrocarbons: TPH Fractionation	Hydrocarbons: PAH's	Hydrocarbons: PAH's with Acridine, Quinoline	EPA 3050B			
D02051	1	S-54A	Soil	July/Aug 2009	Baggie								8														
D02052	2	S-54B	|	|	|								6														
D02053	3	S-54C	|	|	|																						
	4																										
	5																										
	6																										
	7																										
	8																										
	9																									SEP 8 AM 9:47			
	10																										

RELINQUISHED BY: (Signature/Print)	Date	Time	RECEIVED BY: (Signature/Print)	Date	Time
Mario Theriault	Sept 4/09	3:00pm			

White: Maxxam Yellow : Mail Pink: Client

ATL FCD 00149 / Revision 8 11/08

Maxxam Analytics International Corporation

200 Bluewater Road, Suite 105, Bedford, Nova Scotia B4B 1G9 Tel: 902-420-0203 Fax: 902-420-8612 Toll Free: 1-800-565-7227
90 Esplanade Sydney, NS B1P 1A1 Tel: 902-567-1255 Fax: 902-539-6504 Toll Free: 888-535-7770
www.maxxamanalytics.com E-mail: Clientservicesbedford@maxxamanalytics.com

MAXXAM Chain of Custody Record

COC #: B 65319

Page 1 of 3

This column for lab use only:

Client Code: 22319 JA

Maxxam Job #: A9B7652

Cooler ID	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp
			15	15	15	

Integrity: YES [✓ NO]

Integrity / Checklist by:

Labelled by:

Location / Bin #: Black cart WTF 26

INVOICE INFORMATION:

Company Name: Intrinsik Science
Contact Name: Christine Moore
Address: 5121 Sackville St
Halifax NS Postal Code B3J-1K1
Email: CMoore@intrinsikScience.com
Ph: 902-429-0278 Fax: 902-429-0279

REPORT INFORMATION (if differs from invoice):

Company Name: Same
Contact Name: Please Copy Results
Address: to Nbrodie@crawworld.com
Postal Code:
Email:
Ph:
Fax:

PO #:
Project # / Phase #: 055453
Project Name / Site Location: Belledune EO
Quote: 09-220KG
Site #:
Task Order #:
Sampled by: Mike Gaines (CRA)

TURNAROUND TIME
Standard ☒
10 day ☐
If RUSH Specify Date:
Pre-schedule rush work
Charge for # Jars used but not submitted: 0

Guideline Requirements / Detection Limits / Special Instructions

Batch #6

Please Exclude Mercury

*Specify Matrix: Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

		Field Sample Identification	Matrix*	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose Total or Diss Metals	RCAP-MS Choose Total or Diss Metals	Metals Water: Total Digest (Default Method) for well water, surface water	Metals Water: Dissolved for ground water	Metals Water: Mercury	Metals Soil: Metals & ~~Mercury~~ Default Available Digest Method	Metals Soil: Metals Total Digest - for Ocean sediments (HNO3/HF/HCLO4)	Metals Soil: Mercury Low level by Cold Vapour AA	Metals Soil: Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Metals Soil: Hot Water soluble Boron (required for CCME Agricultural)	Hydrocarbons: RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons: Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	Hydrocarbons: NB Potable Water BTEX, VPH, Low level T.E.H.	Hydrocarbons: TPH Fractionation	Hydrocarbons: PAH's	Hydrocarbons: PAH's with Acridine, Quinoline	EPA 3050B			
D02116	1	S53A	Soil	July/Aug 2009	Baggies								6														
D02117	2	S55A											6														
D02118	3	S55B											6														
D02119	4	S55C											6														
D02120	5	S56A											6														
D02~~122~~ 121 JA	6	QA/QC-3											6														
D021~~23~~ 22 JA	7	S57A											6														
D021~~24~~ 23 JA	8	S58A											6														
D02124	9	S59 A											6														
D03125	10	S59 B											6														

RELINQUISHED BY: (Signature/Print): Mario Thoriault Date: Sept 4/09 Time: 3:30pm

RECEIVED BY: (Signature/Print): Jess Dawson Date: Time:

White: Maxxam Yellow : Mail Pink: Client

ATL FCD 00149 / Revision 8 11/08

Maxxam Analytics International Corporation
200 Bluewater Road, Suite 105, Bedford, Nova Scotia B4B 1G9 Tel: 902-420-0203 Fax: 902-420-8612 Toll Free: 1-800-565-7227
90 Esplanade Sydney, NS B1P 1A1 Tel: 902-567-1255 Fax: 902-539-6504 Toll Free: 888-535-7770
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MAXXAM Chain of Custody Record

COC #: B 65320

Page 2 of 3

This column for lab use only:

Client Code 22319 07

Maxxam Job # A9B7652

Cooler ID	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp

Integrity YES NO

Integrity / Checklist by

Labelled by

Location / Bin #

INVOICE INFORMATION:

Company Name:

Contact Name:

Address:

Postal Code

Email:

Ph:

Fax:

REPORT INFORMATION (if differs from invoice):

Company Name:

Contact Name:

Address:

Postal Code

Email:

Ph:

Fax:

PO #

Project # / Phase # 055453

Project Name / Site Location Belledune ECL

Quote 09-226KG

Site #

Task Order #

Sampled by Mike Gaine

TURNAROUND TIME

Standard ☒

10 day ☐

If RUSH Specify Date:

Pre-schedule rush work

Charge for # Jars used but not submitted 0

Guideline Requirements / Detection Limits / Special Instructions

Batch #6

Please Exclude Mercury

*Specify Matrix: Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

									Metals Water			Metals Soil					Hydrocarbons					
	Field Sample Identification	Matrix*	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose Total or Diss Metals	RCAP-MS Choose Total or Diss Metals	Total Digest (Default Method) for well water, surface water	Dissolved for ground water	Mercury	Metals & ~~Mercury~~ Default Available Digest Method	Metals Total Digest - for Ocean sediments (HNO3/HF/HCLO4)	Mercury Low level by Cold Vapour AA	Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Hot Water soluble Boron (required for CCME Agricultural)	RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	NB Potable Water BTEX, VPH, Low level T.E.H.	TPH Fractionation	PAH's	PAH's with Acridine, Quinoline
D02126	1 5-59C	Soil	Jly/14-9/09	Baggies								X										
D02127	2 5-61A											X										
D02128	3 5-61B											X										
D02129	4 5-61C											X										
D02131	5 R1A											X										
D02132	6 R2A											X										
D02133	7 R2B											X										
D02134	8 R2C											X										
D02135	9 R3A											X										
D02136	10 R4A											X										

RELINQUISHED BY: (Signature/Print)	Date	Time	RECEIVED BY: (Signature/Print)	Date	Time
Mario Theriault	Sept 4/09	3:30pm	J Dawson		

White: Maxxam Yellow : Mail Pink: Client

ATL FCD 00149 / Revision 8 11/08

Maxxam Analytics International Corporation

200 Bluewater Road, Suite 105, Bedford, Nova Scotia B4B 1G9 Tel: 902-420-0203 Fax: 902-420-8612 Toll Free: 1-800-565-7227
90 Esplanade Sydney, NS B1P 1A1 Tel: 902-567-1255 Fax: 902-539-6504 Toll Free: 888-535-7770
www.maxxamanalytics.com E-mail: Clientservicesbedford@maxxamanalytics.com

MAXXAM Chain of Custody Record

COC #: B 65322

Page 3 of 3

This column for lab use only:

Client Code 22319 07

Maxxam Job # A9B7652

Cooler ID	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp

Integrity YES NO

Integrity / Checklist by

Labelled by

Location / Bin #

INVOICE INFORMATION:

Company Name:
Contact Name:
Address:
Postal Code
Email:
Ph: **Fax:**

REPORT INFORMATION (if differs from invoice):

Company Name:
Contact Name:
Address:
Postal Code
Email:
Ph: **Fax:**

PO #
Project # / Phase # 055453
Project Name / Site location Belledune ECO
Quote 09-220KG
Site #
Task Order #
Sampled by Mike Gaines (CRA)

TURNAROUND TIME

Standard ☒
10 day ☐
If RUSH Specify Date:

Pre-schedule rush work

Charge for # Jars used but not submitted 0

Guideline Requirements / Detection Limits / Special Instructions

Batch #6

Please Exclude Mercury

*Specify Matrix: Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

Lab use		Field Sample Identification	Matrix*	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose Total or Diss Metals	RCAP-MS Choose Total or Diss Metals	Metals Water: Total Digest (Default Method) for well water, surface water	Metals Water: Dissolved for ground water	Metals Water: Mercury	Metals Soil: Metals & ~~Mercury~~ Default Available Digest Method	Metals Soil: Metals Total Digest - for Ocean sediments (HNO3/HF/HCLO4)	Metals Soil: Mercury Low level by Cold Vapour AA	Metals Soil: Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Metals Soil: Hot Water soluble Boron (required for CCME Agricultural)	Hydrocarbons: RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons: Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	Hydrocarbons: NB Potable Water BTEX, VPH, Low level T.E.H.	Hydrocarbons: TPH Fractionation	Hydrocarbons: PAH's	Hydrocarbons: PAH's with Acridine, Quinoline	EPA 3050B				
~~D0 41~~ D02144	1	QA/QC-22	Soil	July/Aug 09	Baggies								X															
D02145	2	R4B	│	│	│								X															
D02146	3	R4C	│	│	│								X															
	4																											
	5																											
	6																											
	7																											
	8																											
	9																											
	10																											

RELINQUISHED BY: (Signature/Print)	Date	Time	RECEIVED BY: (Signature/Print)	Date	Time
Marie Theriault	Sept 4/09	3:30 pm			
			J Dawson		

White: Maxxam Yellow : Mail Pink: Client

RPC
921 College Hill Rd,
Fredericton, N.B. E3B 6Z9
Report No.: 97038-IAS

Intrinsik Environmental
5121 Sackville Street, Suite 506
Halifax NS B3J 1K1
Attn: Christine Moore

September 29, 2009

Fax: 902.429.0279

Trace Metals Analysis

Trace Metals Analysis

RPC ID	97038 RB1	NIST 2709aA	SS-2A	97038-01A	97038-01B	**RPC ID**	97038-02	97038-03	97038-04	97038-05
Client ID	QA/QC	CRM	CRM	R3A	Lab Duplicate	**Client ID**	R4A	R19A	S2A	S18A
	Concentration (mg/kg)						Concentration (mg/kg)			
Aluminum	< 1	24800	15300	19600	18200	**Aluminum**	11400	23400	27800	18000
Antimony	< 0.1	< 0.1	0.3	< 0.1	< 0.1	**Antimony**	0.1	< 0.1	< 0.1	0.1
Arsenic	< 1	8	84	3	3	**Arsenic**	5	3	13	14
Barium	< 1	448	274	152	146	**Barium**	124	105	41	108
Beryllium	< 0.1	0.7	0.8	0.5	0.5	**Beryllium**	0.6	0.7	0.5	0.6
Bismuth	< 1	< 1	< 1	< 1	< 1	**Bismuth**	< 1	< 1	< 1	< 1
Boron	< 1	38	14	2	3	**Boron**	4	2	2	3
Cadmium	< 0.01	0.35	1.94	0.76	0.76	**Cadmium**	1.39	0.20	0.22	1.44
Chromium	< 1	74	43	32	29	**Chromium**	13	24	32	27
Cobalt	< 0.1	11.4	12.7	9.1	8.0	**Cobalt**	7.6	18.3	6.2	12.4
Copper	< 1	29	196	9	9	**Copper**	16	7	10	18
Iron	< 20	28300	24800	27900	24500	**Iron**	17800	31200	38300	32500
Lead	< 0.1	11.4	138	40.0	39.9	**Lead**	53.2	20.6	28.9	104
Lithium	< 0.1	35.9	16.6	20.4	18.5	**Lithium**	7.9	17.5	26.3	24.8
Manganese	< 1	465	542	684	592	**Manganese**	890	1800	245	994
Molybdenum	< 0.1	0.6	3.0	0.4	0.4	**Molybdenum**	1.3	0.3	0.8	0.6
Nickel	< 1	73	58	24	24	**Nickel**	12	20	19	16
Rubidium	< 0.1	34.0	29.8	11.9	11.5	**Rubidium**	12.1	15.7	18.1	29.8
Selenium	< 1	< 1	< 1	< 1	< 1	**Selenium**	< 1	< 1	< 1	< 1
Silver	< 0.1	< 0.1	0.4	0.1	< 0.1	**Silver**	< 0.1	< 0.1	< 0.1	0.2
Strontium	< 1	111	245	28	29	**Strontium**	34	8	5	12
Thallium	< 0.1	0.2	0.4	0.3	0.3	**Thallium**	0.3	0.2	0.2	0.6
Tin	2	< 1	< 1	< 1	< 1	**Tin**	< 1	< 1	< 1	< 1
Uranium	< 0.1	1.7	1.2	0.5	0.5	**Uranium**	0.7	0.5	0.5	0.5
Vanadium	< 1	69	45	53	48	**Vanadium**	34	64	81	63
Zinc	< 1	90	510	78	74	**Zinc**	124	55	72	135

Portions of the samples were digested according to EPA Method 3050B. The resulting solutions were analyzed for trace elements by ICP-MS.

A. Ross Kean, M.Sc.
Department Head
Inorganic Analytical Chemistry

Peter Crowhurst, B.Sc., C.Chem.
Analytical Chemist
Inorganic Analytical Chemistry

RPC
921 College Hill Rd,
Fredericton, N.B. E3B 6Z9
Report No.: 97038-IAS

Intrinsik Environmental
5121 Sackville Street, Suite 506
Halifax NS B3J 1K1
Attn: Christine Moore

September 29, 2009

Fax: 902.429.0279

Trace Metals Analysis

RPC ID	97038 RB2	NIST 2709aB	SS-2B	97038-06A	97038-06B
Client ID	QA/QC	CRM	CRM	S19A	Lab Duplicate
	Concentration (mg/kg)				
Aluminum	2	23800	15300	19400	19800
Antimony	< 0.1	< 0.1	0.4	0.5	0.5
Arsenic	< 1	8	86	23	24
Barium	< 1	424	266	93	94
Beryllium	< 0.1	0.7	0.8	0.7	0.7
Bismuth	< 1	< 1	< 1	< 1	< 1
Boron	< 1	36	14	3	3
Cadmium	< 0.01	0.37	1.92	2.75	3.16
Chromium	< 1	70	44	31	31
Cobalt	< 0.1	11.0	12.6	14.4	12.7
Copper	< 1	28	192	38	38
Iron	< 20	27400	24700	33100	32300
Lead	< 0.1	10.8	142	394	422
Lithium	< 0.1	34.7	16.3	26.2	25.3
Manganese	< 1	451	539	831	687
Molybdenum	< 0.1	0.6	2.7	0.4	0.5
Nickel	< 1	70	59	36	33
Rubidium	< 0.1	32.5	29.8	18.9	20.4
Selenium	< 1	< 1	< 1	< 1	< 1
Silver	< 0.1	< 0.1	0.4	0.7	0.7
Strontium	< 1	106	248	9	9
Thallium	< 0.1	0.2	0.4	1.0	1.1
Tin	2	< 1	< 1	< 1	< 1
Uranium	< 0.1	1.7	1.2	0.6	0.6
Vanadium	< 1	66	44	53	53
Zinc	< 1	86	493	427	500

Trace Metals Analysis

RPC ID	97038-07	97038-08	97038-09	97038-10
Client ID	S20A	S30A	S32A	S33A
	Concentration (mg/kg)			
Aluminum	13100	7730	15000	17300
Antimony	< 0.1	1.1	1.4	0.3
Arsenic	7	11	43	14
Barium	28	286	85	97
Beryllium	0.2	0.6	0.5	0.7
Bismuth	< 1	< 1	< 1	< 1
Boron	2	6	4	4
Cadmium	0.83	4.00	5.58	3.03
Chromium	24	16	27	27
Cobalt	5.4	2.7	10.7	9.3
Copper	10	38	70	17
Iron	16000	5540	28900	24000
Lead	66.2	261	768	188
Lithium	7.4	6.2	16.6	27.9
Manganese	203	877	428	542
Molybdenum	0.2	3.8	1.4	0.3
Nickel	16	12	18	24
Rubidium	3.6	3.5	22.6	22.0
Selenium	< 1	4	< 1	< 1
Silver	0.1	0.5	0.4	0.2
Strontium	7	59	13	7
Thallium	0.3	0.8	1.1	1.1
Tin	< 1	< 1	5	< 1
Uranium	0.3	5.4	0.5	0.8
Vanadium	64	27	43	41
Zinc	45	134	1580	137

Portions of the samples were digested according to EPA Method 3050B. The resulting solutions were analyzed for trace elements by ICP-MS.

RPC
921 College Hill Rd,
Fredericton, N.B. E3B 6Z9
Report No.: 97038-IAS

Intrinsik Environmental
5121 Sackville Street, Suite 506
Halifax NS B3J 1K1
Attn: Christine Moore

September 29, 2009

Fax: 902.429.0279

Trace Metals Analysis

Trace Metals Analysis

RPC ID	97038 RB3	NIST 2709aC	SS-2C	97038-11A	97038-11B	**RPC ID**	97038-12	97038-13	97038-14
Client ID	QA/QC	CRM	CRM	S38A	Lab Duplicate	**Client ID**	S48A	S51A	S61A
	Concentration (mg/kg)						Concentration (mg/kg)		
Aluminum	< 1	25700	15600	19400	19000	**Aluminum**	17700	34900	21200
Antimony	< 0.1	< 0.1	0.4	0.2	0.2	**Antimony**	0.6	0.1	0.3
Arsenic	< 1	9	86	12	11	**Arsenic**	41	70	97
Barium	< 1	447	275	183	190	**Barium**	279	228	85
Beryllium	< 0.1	0.8	0.9	0.6	0.6	**Beryllium**	0.7	1.5	0.4
Bismuth	< 1	< 1	< 1	< 1	< 1	**Bismuth**	1	< 1	< 1
Boron	< 1	39	14	5	5	**Boron**	4	6	3
Cadmium	< 0.01	0.36	1.90	2.00	2.13	**Cadmium**	3.55	4.34	1.59
Chromium	< 1	74	44	30	28	**Chromium**	33	62	50
Cobalt	< 0.1	11.4	12.7	9.6	8.8	**Cobalt**	9.8	18.9	11.8
Copper	< 1	29	192	16	16	**Copper**	22	30	15
Iron	< 20	28600	24700	25600	24000	**Iron**	17900	31900	37200
Lead	< 0.1	11.3	138	157	163	**Lead**	292	89.0	87.4
Lithium	< 0.1	36.2	16.6	30.5	30.1	**Lithium**	22.6	36.5	28.0
Manganese	< 1	467	538	444	425	**Manganese**	852	5060	615
Molybdenum	< 0.1	0.6	2.9	0.7	0.6	**Molybdenum**	0.9	2.7	0.4
Nickel	< 1	73	58	22	21	**Nickel**	25	52	31
Rubidium	< 0.1	34.7	30.4	28.0	29.1	**Rubidium**	21.0	17.4	18.3
Selenium	< 1	1	< 1	< 1	< 1	**Selenium**	< 1	2	< 1
Silver	< 0.1	< 0.1	0.4	0.1	0.1	**Silver**	0.2	0.3	0.2
Strontium	< 1	112	258	22	23	**Strontium**	21	36	13
Thallium	< 0.1	0.2	0.4	0.7	0.7	**Thallium**	1.0	0.9	0.4
Tin	2	< 1	< 1	< 1	< 1	**Tin**	< 1	< 1	< 1
Uranium	< 0.1	1.8	1.2	0.4	0.4	**Uranium**	3.3	1.0	0.4
Vanadium	< 1	71	44	50	48	**Vanadium**	42	57	94
Zinc	< 1	89	495	124	126	**Zinc**	352	288	270

Portions of the samples were digested according to EPA Method 3050B. The resulting solutions were analyzed for trace elements by ICP-MS.

Your Project #: 044453-02
Site: BELLEDUNE ECO.
Your C.O.C. #: B 073216

Attention: Christine Moore
Intrinsik Environmental Sciences
5121 Sackville Street
Suite 506
Halifax, NS
CANADA B3J 1K1

Report Date: 2010/08/24

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B0B2321
Received: 2010/08/17, 11:42

Sample Matrix: Water
Samples Received: 2

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Metals Water Diss. Collision Cell MS	2	N/A	2010/08/19	ATL SOP 00058 R2	Based on EPA6020A
Metals Water Total Collision Cell MS	2	2010/08/20	2010/08/20	ATL SOP 00058 R2	Based on EPA6020A

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
* Results relate only to the items tested.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

MICHELLE HILL, Project Manager
Email: Michelle.Hill@maxxamanalytics.com
Phone# (902) 420-0203

==
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Total cover pages: 1

Maxxam Job #: B0B2321
Report Date: 2010/08/24

Intrinsik Environmental Sciences
Client Project #: 044453-02
Project name: BELLEDUNE ECO.

ELEMENTS BY ICP/MS (WATER)

Maxxam ID		GW2179	GW2181		
Sampling Date		2010/08/17	2010/08/17		
	Units	**UNNAMED-SED2-SURFACE WATER (P#GP5749)**	**UNNAMED-SED1-SURFACE WATER (P#GP5743)**	**RDL**	**QC Batch**
Metals					
Dissolved Aluminum (Al)	ug/L	ND	ND	5	2239428
Total Aluminum (Al)	ug/L	8.7	5.7	5.0	2241134
Dissolved Antimony (Sb)	ug/L	ND	ND	1	2239428
Total Antimony (Sb)	ug/L	ND	ND	1.0	2241134
Dissolved Arsenic (As)	ug/L	ND	ND	1	2239428
Total Arsenic (As)	ug/L	1.0	ND	1.0	2241134
Dissolved Barium (Ba)	ug/L	95	150	1	2239428
Total Barium (Ba)	ug/L	111	151	1.0	2241134
Dissolved Beryllium (Be)	ug/L	ND	ND	1	2239428
Total Beryllium (Be)	ug/L	ND	ND	1.0	2241134
Dissolved Bismuth (Bi)	ug/L	ND	ND	2	2239428
Total Bismuth (Bi)	ug/L	ND	ND	2.0	2241134
Dissolved Boron (B)	ug/L	10	13	5	2239428
Total Boron (B)	ug/L	10.9	16.1	5.0	2241134
Dissolved Cadmium (Cd)	ug/L	0.04	0.04	0.02	2239428
Total Cadmium (Cd)	ug/L	0.040	0.040	0.017	2241134
Dissolved Calcium (Ca)	ug/L	73000	140000	100	2239428
Total Calcium (Ca)	ug/L	68500	134000	100	2241134
Dissolved Chromium (Cr)	ug/L	ND	ND	1	2239428
Total Chromium (Cr)	ug/L	ND	ND	1.0	2241134
Dissolved Cobalt (Co)	ug/L	ND	ND	0.4	2239428
Total Cobalt (Co)	ug/L	ND	ND	0.40	2241134
Dissolved Copper (Cu)	ug/L	ND	ND	2	2239428
Total Copper (Cu)	ug/L	ND	ND	2.0	2241134
Dissolved Iron (Fe)	ug/L	ND	ND	50	2239428
Total Iron (Fe)	ug/L	76	82	50	2241134
Dissolved Lead (Pb)	ug/L	ND	ND	0.5	2239428
Total Lead (Pb)	ug/L	ND	0.69	0.50	2241134
Dissolved Magnesium (Mg)	ug/L	4100	7400	100	2239428
Total Magnesium (Mg)	ug/L	3760	6630	100	2241134
Dissolved Manganese (Mn)	ug/L	3200	400	2	2239428
Total Manganese (Mn)	ug/L	3880	429	2.0	2241134
Dissolved Molybdenum (Mo)	ug/L	ND	ND	2	2239428

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam Job #: B0B2321
Report Date: 2010/08/24

Intrinsik Environmental Sciences
Client Project #: 044453-02
Project name: BELLEDUNE ECO.

ELEMENTS BY ICP/MS (WATER)

Maxxam ID		GW2179	GW2181		
Sampling Date		2010/08/17	2010/08/17		
	Units	**UNNAMED-SED2-SURFACE WATER (P#GP5749)**	**UNNAMED-SED1-SURFACE WATER (P#GP5743)**	**RDL**	**QC Batch**
Total Molybdenum (Mo)	ug/L	ND	ND	2.0	2241134
Dissolved Nickel (Ni)	ug/L	ND	ND	2	2239428
Total Nickel (Ni)	ug/L	ND	ND	2.0	2241134
Dissolved Potassium (K)	ug/L	1900	3200	100	2239428
Total Potassium (K)	ug/L	1780	2830	100	2241134
Dissolved Selenium (Se)	ug/L	ND	ND	1	2239428
Total Selenium (Se)	ug/L	ND	ND	1.0	2241134
Dissolved Silver (Ag)	ug/L	ND	ND	0.1	2239428
Total Silver (Ag)	ug/L	ND	ND	0.10	2241134
Dissolved Sodium (Na)	ug/L	9700	7900	100	2239428
Total Sodium (Na)	ug/L	8880	7160	100	2241134
Dissolved Strontium (Sr)	ug/L	170	320	2	2239428
Total Strontium (Sr)	ug/L	168	311	2.0	2241134
Dissolved Thallium (Tl)	ug/L	ND	ND	0.1	2239428
Total Thallium (Tl)	ug/L	ND	ND	0.10	2241134
Dissolved Tin (Sn)	ug/L	ND	ND	2	2239428
Total Tin (Sn)	ug/L	ND	ND	2.0	2241134
Dissolved Titanium (Ti)	ug/L	ND	ND	2	2239428
Total Titanium (Ti)	ug/L	ND	ND	2.0	2241134
Dissolved Uranium (U)	ug/L	0.2	0.1	0.1	2239428
Total Uranium (U)	ug/L	0.24	0.20	0.10	2241134
Dissolved Vanadium (V)	ug/L	ND	ND	2	2239428
Total Vanadium (V)	ug/L	ND	ND	2.0	2241134
Dissolved Zinc (Zn)	ug/L	ND	ND	5	2239428
Total Zinc (Zn)	ug/L	5.0	ND	5.0	2241134

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits
2239428	Dissolved Aluminum (Al)	2010/08/19	129(1, 2)	80 - 120	110	80 - 120	ND, RDL=5	ug/L		
2239428	Dissolved Antimony (Sb)	2010/08/19	110	80 - 120	104	80 - 120	ND, RDL=1	ug/L		
2239428	Dissolved Arsenic (As)	2010/08/19	104	80 - 120	102	80 - 120	ND, RDL=1	ug/L		
2239428	Dissolved Barium (Ba)	2010/08/19	117	80 - 120	102	80 - 120	ND, RDL=1	ug/L		
2239428	Dissolved Beryllium (Be)	2010/08/19	106	80 - 120	104	80 - 120	ND, RDL=1	ug/L		
2239428	Dissolved Bismuth (Bi)	2010/08/19	73(1, 2)	80 - 120	68(1, 3)	80 - 120	ND, RDL=2	ug/L		
2239428	Dissolved Boron (B)	2010/08/19	110	80 - 120	94	80 - 120	ND, RDL=5	ug/L		
2239428	Dissolved Cadmium (Cd)	2010/08/19	103	80 - 120	106	80 - 120	ND, RDL=0.02	ug/L		
2239428	Dissolved Calcium (Ca)	2010/08/19	113	80 - 120	104	80 - 120	ND, RDL=100	ug/L	0.7	25
2239428	Dissolved Chromium (Cr)	2010/08/19	105	80 - 120	101	80 - 120	ND, RDL=1	ug/L		
2239428	Dissolved Cobalt (Co)	2010/08/19	102	80 - 120	101	80 - 120	ND, RDL=0.4	ug/L		
2239428	Dissolved Copper (Cu)	2010/08/19	NC	80 - 120	94	80 - 120	ND, RDL=2	ug/L		
2239428	Dissolved Iron (Fe)	2010/08/19	109	80 - 120	102	80 - 120	ND, RDL=50	ug/L		
2239428	Dissolved Lead (Pb)	2010/08/19	91	80 - 120	91	80 - 120	ND, RDL=0.5	ug/L		
2239428	Dissolved Magnesium (Mg)	2010/08/19	114	80 - 120	108	80 - 120	ND, RDL=100	ug/L		
2239428	Dissolved Manganese (Mn)	2010/08/19	118	80 - 120	101	80 - 120	ND, RDL=2	ug/L		
2239428	Dissolved Molybdenum (Mo)	2010/08/19	109	80 - 120	105	80 - 120	ND, RDL=2	ug/L		
2239428	Dissolved Nickel (Ni)	2010/08/19	104	80 - 120	97	80 - 120	ND, RDL=2	ug/L		
2239428	Dissolved Potassium (K)	2010/08/19	111	80 - 120	104	80 - 120	ND, RDL=100	ug/L		
2239428	Dissolved Selenium (Se)	2010/08/19	110	80 - 120	106	80 - 120	ND, RDL=1	ug/L		
2239428	Dissolved Silver (Ag)	2010/08/19	92	80 - 120	99	80 - 120	ND, RDL=0.1	ug/L		
2239428	Dissolved Sodium (Na)	2010/08/19	NC	80 - 120	105	80 - 120	ND, RDL=100	ug/L		
2239428	Dissolved Strontium (Sr)	2010/08/19	128(1, 2)	80 - 120	99	80 - 120	ND, RDL=2	ug/L		
2239428	Dissolved Thallium (Tl)	2010/08/19	92	80 - 120	92	80 - 120	ND, RDL=0.1	ug/L		
2239428	Dissolved Tin (Sn)	2010/08/19	108	80 - 120	92	80 - 120	ND, RDL=2	ug/L		
2239428	Dissolved Titanium (Ti)	2010/08/19	110	80 - 120	110	80 - 120	ND, RDL=2	ug/L		
2239428	Dissolved Uranium (U)	2010/08/19	83	80 - 120	84	80 - 120	ND, RDL=0.1	ug/L		
2239428	Dissolved Vanadium (V)	2010/08/19	104	80 - 120	104	80 - 120	ND, RDL=2	ug/L		
2239428	Dissolved Zinc (Zn)	2010/08/19	NC	80 - 120	112	80 - 120	ND, RDL=5	ug/L		
2241134	Total Aluminum (Al)	2010/08/20	109	80 - 120	108	80 - 120	ND, RDL=5.0	ug/L	NC	25
2241134	Total Antimony (Sb)	2010/08/20	107	80 - 120	107	80 - 120	ND, RDL=1.0	ug/L	NC	25
2241134	Total Arsenic (As)	2010/08/20	106	80 - 120	101	80 - 120	ND, RDL=1.0	ug/L	NC	25
2241134	Total Barium (Ba)	2010/08/20	104	80 - 120	99	80 - 120	ND, RDL=1.0	ug/L	NC	25
2241134	Total Beryllium (Be)	2010/08/20	105	80 - 120	98	80 - 120	ND, RDL=1.0	ug/L	NC	25
2241134	Total Bismuth (Bi)	2010/08/20	79(1, 4)	80 - 120	89	80 - 120	ND, RDL=2.0	ug/L	NC	25
2241134	Total Boron (B)	2010/08/20	104	80 - 120	95	80 - 120	ND, RDL=5.0	ug/L	NC	25
2241134	Total Cadmium (Cd)	2010/08/20	108	80 - 120	100	80 - 120	ND, RDL=0.017	ug/L	NC	25
2241134	Total Calcium (Ca)	2010/08/20	108	80 - 120	105	80 - 120	ND, RDL=100	ug/L	NC	25
2241134	Total Chromium (Cr)	2010/08/20	104	80 - 120	103	80 - 120	ND, RDL=1.0	ug/L	NC	25
2241134	Total Cobalt (Co)	2010/08/20	102	80 - 120	102	80 - 120	ND, RDL=0.40	ug/L	NC	25

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**
2241134	Total Copper (Cu)	2010/08/20	95	80 - 120	93	80 - 120	ND, RDL=2.0	ug/L	NC	25
2241134	Total Iron (Fe)	2010/08/20	105	80 - 120	104	80 - 120	ND, RDL=50	ug/L	NC	25
2241134	Total Lead (Pb)	2010/08/20	93	80 - 120	94	80 - 120	ND, RDL=0.50	ug/L	NC	25
2241134	Total Magnesium (Mg)	2010/08/20	107	80 - 120	106	80 - 120	ND, RDL=100	ug/L	NC	25
2241134	Total Manganese (Mn)	2010/08/20	NC	80 - 120	103	80 - 120	ND, RDL=2.0	ug/L	NC	25
2241134	Total Molybdenum (Mo)	2010/08/20	109	80 - 120	105	80 - 120	ND, RDL=2.0	ug/L	NC	25
2241134	Total Nickel (Ni)	2010/08/20	94	80 - 120	95	80 - 120	ND, RDL=2.0	ug/L	NC	25
2241134	Total Potassium (K)	2010/08/20	102	80 - 120	99	80 - 120	ND, RDL=100	ug/L	NC	25
2241134	Total Selenium (Se)	2010/08/20	109	80 - 120	101	80 - 120	ND, RDL=1.0	ug/L	NC	25
2241134	Total Silver (Ag)	2010/08/20	95	80 - 120	94	80 - 120	ND, RDL=0.10	ug/L	NC	25
2241134	Total Sodium (Na)	2010/08/20	NC	80 - 120	102	80 - 120	ND, RDL=100	ug/L	0.4	25
2241134	Total Strontium (Sr)	2010/08/20	110	80 - 120	105	80 - 120	ND, RDL=2.0	ug/L	NC	25
2241134	Total Thallium (Tl)	2010/08/20	97	80 - 120	96	80 - 120	ND, RDL=0.10	ug/L	NC	25
2241134	Total Tin (Sn)	2010/08/20	100	80 - 120	106	80 - 120	ND, RDL=2.0	ug/L	NC	25
2241134	Total Titanium (Ti)	2010/08/20	118	80 - 120	110	80 - 120	ND, RDL=2.0	ug/L	NC	25
2241134	Total Uranium (U)	2010/08/20	94	80 - 120	97	80 - 120	ND, RDL=0.10	ug/L	NC	25
2241134	Total Vanadium (V)	2010/08/20	106	80 - 120	101	80 - 120	ND, RDL=2.0	ug/L	NC	25
2241134	Total Zinc (Zn)	2010/08/20	103	80 - 120	99	80 - 120	ND, RDL=5.0	ug/L	NC	25

N/A = Not Applicable
RDL = Reportable Detection Limit
RPD = Relative Percent Difference
Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.
Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.
Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.
NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.
NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.
(1) - Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.
(2) - Violation is not applicable. Parameter not requested in the sample.
(3) - Low recovery due to instrument performance. Minimal impact on data quality.
(4) - Low recovery due to sample matrix.

Validation Signature Page

Maxxam Job #: B0B2321

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Kevin A. MacDonald

KEVIN MACDONALD, Inorganics Supervisor

==

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Maxxam Analytics International Corporation

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MAXXAM Chain of Custody Record

COC #: B 073216 Page 1 of 1

This column for lab use only:
Client Code 22319
Maxxam Job # B0B2321 2.7

Cooler ID	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp
				N/A		

Integrity YES [✓ NO]
Integrity / Checklist by B
Labelled by
Location / Bin #

INVOICE INFORMATION:
Company Name: INTRINSIK
Contact Name: CHRISTINE MOORE
Address: HALIFAX, NS
Postal Code
Email:
Ph: Fax:

REPORT INFORMATION (if differs from invoice):
Company Name:
Contact Name:
Address:
Postal Code
Email:
Ph: Fax:

PO #
Project # / Phase # 044453-02
Project Name / Site Location BELLEDUNE ECO.
Quote B02709
Site #
Task Order #
Sampled by

TURNAROUND TIME
Standard ☑
10 day ☐
If RUSH Specify Date:
Pre-schedule rush work
Charge for # Jars used but not submitted

Guideline Requirements / Detection Limits / Special Instructions

*Specify Matrix: Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

									Metals Water			Metals Soil					Hydrocarbons										
	Field Sample Identification	Matrix*	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose Total or Diss Metals	RCAP-MS Choose Total or Diss Metals	Total Digest (Default Method) for well water, surface water	Dissolved for ground water	Mercury	Metals & Mercury Default Available Digest Method	Metals Total Digest - for Ocean sediments (HNO3/HF/HClO4)	Mercury Low level by Cold Vapour AA	Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Hot Water soluble Boron (required for CCME Agricultural)	RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons Soil (Potable), NB Fuel Oil Soil Policy Low Level BTEX, C6-C32	NB Potable Water BTEX, VPH, Low level T.E.H.	TPH Fractionation	PAH's	PAH's with Acridine, Quinoline					
GW2179	1 UNNAMED-SED2-SURFACE WATER (P# GP5749)								X	X																	
	2 ~~______~~																										
81	3 UNNAMED-SED1-SURFACE WATER (P# GP5743)								X	X																	
	4																										
	5																										
	6																										
	7																										
	8																										
	9																										
	10																										

Please redigest from original tubes
MHL
In RCAp 895.

RELINQUISHED BY: (Signature/Print) by email Date Aug17/10. Time

RECEIVED BY: (Signature/Print) Jason Date 2010 AUG 17 Time AM 11:42

Your Project #: 055453-02
Site: BELLEDUNE ECO
Your C.O.C. #: B 101619

Attention: Neil Brodie
Conestoga-Rovers and Associates Ltd
Fredericton
466 Hodgson Rd
Fredericton , NB
E3C 2G5

Report Date: 2010/07/30

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B098030
Received: 2010/07/23, 8:37

Sample Matrix: Soil
Samples Received: 8

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Metals Solid Avail. Unified MS - Nper	8	2010/07/28	2010/07/28	ATL SOP 00024 R5	Based on EPA6020A

Sample Matrix: Water
Samples Received: 8

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Carbonate, Bicarbonate and Hydroxide	8	N/A	2010/07/29		
Alkalinity	8	N/A	2010/07/29	ATL SOP 00013 R4	Based on EPA310.2
Chloride	8	N/A	2010/07/29	ATL SOP 00014 R6	Based on SM4500-Cl-
Colour	8	N/A	2010/07/29	ATL SOP 00020 R3.	Based on SM2120C
Conductance - water	8	N/A	2010/07/28	ATL SOP 00004 R5/00006 R4	Based on SM2510B
Hardness (calculated as CaCO3)	8	N/A	2010/07/28	ATL SOP 00048	Based on SM2340B
Metals Water Diss. Collision Cell MS	8	N/A	2010/07/28	ATL SOP 00058 R2	Based on EPA6020A
Metals Water Total Collision Cell MS	8	2010/07/27	2010/07/28	ATL SOP 00058 R2	Based on EPA6020A
Ion Balance (% Difference)	8	N/A	2010/07/30		
Anion and Cation Sum	8	N/A	2010/07/29		
Nitrogen Ammonia - water	7	N/A	2010/07/27	ATL SOP 00015 R5	Based on USEPA 350.1
Nitrogen Ammonia - water	1	N/A	2010/07/28	ATL SOP 00015 R5	Based on USEPA 350.1
Nitrogen - Nitrate + Nitrite	8	N/A	2010/07/29	ATL SOP 00016 R4	Based on USGS - Enz.
Nitrogen - Nitrite	8	N/A	2010/07/28	ATL SOP 00017 R4	Based on USEPA 354.1
Nitrogen - Nitrate (as N)	8	N/A	2010/07/29	ATL SOP 00018 R3	Based on ASTMD3867
pH	8	N/A	2010/07/28	ATL SOP 00003 R5/00005 R7	Based on SM4500H+
Phosphorus - ortho	8	N/A	2010/07/29	ATL SOP 00021 R3	Based on USEPA 365.1
Sat. pH and Langelier Index (@ 20C)	8	N/A	2010/07/30		
Sat. pH and Langelier Index (@ 4C)	8	N/A	2010/07/30		
Reactive Silica	8	N/A	2010/07/28	ATL SOP 00022 R3	Based on EPA 366.0
Sulphate	8	N/A	2010/07/28	ATL SOP 00023 R3	Based on EPA 375.4
Total Dissolved Solids (TDS calc)	8	N/A	2010/07/30		
Organic carbon - Total (TOC)	8	N/A	2010/07/29	ATL SOP 00037 R4	Based on SM5310C
Turbidity	1	N/A	2010/07/27	ATL SOP 00011 R4	based on EPA 180.1
Turbidity	7	N/A	2010/07/29	ATL SOP 00011 R4	based on EPA 180.1

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
* Results relate only to the items tested.

../2

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

MICHELLE HILL, Project Manager
Email: Michelle.Hill@maxxamanalytics.com
Phone# (902) 420-0203

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Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Total cover pages: 2

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		GP5872	GP5874	GP5876	GP5878		
Sampling Date		2010/07/20	2010/07/20	2010/07/20	2010/07/20		
	Units	**QA/QC-1 (SED)**	**QA/QC-2 (SED)**	**QA/QC-3 (SED)**	**ARMSTRONG-SED-1 (SED)**	**RDL**	**QC Batch**
Metals							
Available Aluminum (Al)	mg/kg	15000	17000	13000	7700	10	2219522
Available Antimony (Sb)	mg/kg	4	ND	ND	ND	2	2219522
Available Arsenic (As)	mg/kg	16	18	9	8	2	2219522
Available Barium (Ba)	mg/kg	170	140	140	39	5	2219522
Available Beryllium (Be)	mg/kg	ND	ND	ND	ND	2	2219522
Available Bismuth (Bi)	mg/kg	ND	ND	ND	ND	2	2219522
Available Boron (B)	mg/kg	ND	ND	ND	ND	5	2219522
Available Cadmium (Cd)	mg/kg	1.5	2.5	0.6	ND	0.3	2219522
Available Chromium (Cr)	mg/kg	39	26	25	14	2	2219522
Available Cobalt (Co)	mg/kg	18	11	15	8	1	2219522
Available Copper (Cu)	mg/kg	25	21	17	9	2	2219522
Available Iron (Fe)	mg/kg	33000	21000	29000	19000	50	2219522
Available Lead (Pb)	mg/kg	85	150	29	27	0.5	2219522
Available Lithium (Li)	mg/kg	26	22	18	14	2	2219522
Available Manganese (Mn)	mg/kg	2400	1200	1800	420	2	2219522
Available Molybdenum (Mo)	mg/kg	ND	ND	ND	ND	2	2219522
Available Nickel (Ni)	mg/kg	48	32	41	20	2	2219522
Available Rubidium (Rb)	mg/kg	7	9	8	5	2	2219522
Available Selenium (Se)	mg/kg	ND	ND	ND	ND	2	2219522
Available Silver (Ag)	mg/kg	ND	0.5	ND	ND	0.5	2219522
Available Strontium (Sr)	mg/kg	19	13	13	20	5	2219522
Available Thallium (Tl)	mg/kg	0.4	0.6	0.1	ND	0.1	2219522
Available Tin (Sn)	mg/kg	2	3	ND	ND	2	2219522
Available Uranium (U)	mg/kg	0.8	0.7	0.5	0.3	0.1	2219522
Available Vanadium (V)	mg/kg	49	38	31	28	2	2219522
Available Zinc (Zn)	mg/kg	190	300	110	62	5	2219522

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		GP5880	GP5882	GP5884	GP5886		
Sampling Date		2010/07/20	2010/07/20	2010/07/20	2010/07/20		
	Units	**ARMSTRONG-SED-2 (SED)**	**ARMSTRONG-SED-3 (SED)**	**ARMSTRONG-SED-4 (SED)**	**ARMSTRONG-SED-5 (SED)**	**RDL**	**QC Batch**
Metals							
Available Aluminum (Al)	mg/kg	12000	12000	11000	7200	10	2219522
Available Antimony (Sb)	mg/kg	ND	ND	ND	ND	2	2219522
Available Arsenic (As)	mg/kg	9	12	10	8	2	2219522
Available Barium (Ba)	mg/kg	150	100	160	210	5	2219522
Available Beryllium (Be)	mg/kg	ND	ND	ND	ND	2	2219522
Available Bismuth (Bi)	mg/kg	ND	ND	ND	ND	2	2219522
Available Boron (B)	mg/kg	ND	ND	ND	ND	5	2219522
Available Cadmium (Cd)	mg/kg	0.7	0.7	0.4	0.8	0.3	2219522
Available Chromium (Cr)	mg/kg	26	27	26	15	2	2219522
Available Cobalt (Co)	mg/kg	15	17	18	12	1	2219522
Available Copper (Cu)	mg/kg	18	22	18	11	2	2219522
Available Iron (Fe)	mg/kg	30000	34000	36000	23000	50	2219522
Available Lead (Pb)	mg/kg	31	73	23	26	0.5	2219522
Available Lithium (Li)	mg/kg	19	19	14	8	2	2219522
Available Manganese (Mn)	mg/kg	2100	1400	2300	3000	2	2219522
Available Molybdenum (Mo)	mg/kg	ND	ND	ND	ND	2	2219522
Available Nickel (Ni)	mg/kg	44	48	55	26	2	2219522
Available Rubidium (Rb)	mg/kg	9	7	8	8	2	2219522
Available Selenium (Se)	mg/kg	ND	ND	ND	ND	2	2219522
Available Silver (Ag)	mg/kg	ND	ND	ND	ND	0.5	2219522
Available Strontium (Sr)	mg/kg	15	12	11	15	5	2219522
Available Thallium (Tl)	mg/kg	0.2	0.1	0.1	0.2	0.1	2219522
Available Tin (Sn)	mg/kg	ND	2	ND	ND	2	2219522
Available Uranium (U)	mg/kg	0.6	0.4	0.3	0.4	0.1	2219522
Available Vanadium (V)	mg/kg	31	32	29	19	2	2219522
Available Zinc (Zn)	mg/kg	110	230	130	110	5	2219522

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

RESULTS OF ANALYSES OF WATER

Maxxam ID		GP5871	GP5871			GP5873	GP5875	GP5877	GP5879		
Sampling Date		2010/07/20	2010/07/20			2010/07/20	2010/07/20	2010/07/20	2010/07/20		
	Units	**QA/QC-1 (WATER)**	**QA/QC-1 (WATER) Lab-Dup**	**RDL**	**QC Batch**	**QA/QC-2 (WATER)**	**QA/QC-3 (WATER)**	**ARMSTRONG-SED-1 (WATER)**	**ARMSTRONG-SED-2 (WATER)**	**RDL**	**QC Batch**
Calculated Parameters											
Anion Sum	me/L	4.56		N/A	2216531	1.72	1.94	3.77	1.94	N/A	2216531
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	213		1	2216528	68	85	93	85	1	2216528
Calculated TDS	mg/L	234		1	2216536	93	100	205	100	1	2216536
Carb. Alkalinity (calc. as CaCO3)	mg/L	2		1	2216528	ND	ND	1	ND	1	2216528
Cation Sum	me/L	4.22		N/A	2216531	1.66	1.89	3.65	1.89	N/A	2216531
Hardness (CaCO3)	mg/L	190		1	2216529	62	80	100	80	1	2216529
Ion Balance (% Difference)	%	3.87		N/A	2216530	1.78	1.31	1.62	1.31	N/A	2216530
Langelier Index (@ 20C)	N/A	0.670			2216534	-0.184	0.0390	0.132	0.0510		2216534
Langelier Index (@ 4C)	N/A	0.420			2216535	-0.435	-0.212	-0.118	-0.200		2216535
Nitrate (N)	mg/L	0.10		0.05	2216532	0.10	0.15	0.18	0.15	0.05	2216532
Saturation pH (@ 20C)	N/A	7.23			2216534	8.16	8.01	7.96	8.01		2216534
Saturation pH (@ 4C)	N/A	7.48			2216535	8.42	8.26	8.21	8.26		2216535
Inorganics											
Total Alkalinity (Total as CaCO3)	mg/L	210		30	2219096	68	86	94	86	5	2219096
Dissolved Chloride (Cl)	mg/L	10		1	2219101	10	7	59	7	1	2219101
Colour	TCU	20		5	2219106	35	40	30	37	5	2219106
Nitrate + Nitrite	mg/L	0.10		0.05	2219115	0.10	0.15	0.18	0.15	0.05	2219115
Nitrite (N)	mg/L	ND		0.01	2219119	ND	ND	ND	ND	0.01	2219119
Nitrogen (Ammonia Nitrogen)	mg/L	0.19		0.05	2217934	ND	ND	ND	ND	0.05	2217934
Total Organic Carbon (C)	mg/L	7.6	7.3	0.5	2221232	6.4	5.6	5.2	5.7	0.5	2221232
Orthophosphate (P)	mg/L	ND		0.01	2219112	ND	ND	ND	ND	0.01	2219112
pH	pH	7.90		N/A	2220315	7.98	8.05	8.09	8.06	N/A	2220315
Reactive Silica (SiO2)	mg/L	5.1		0.5	2219104	4.5	4.6	4.6	4.5	0.5	2219104
Dissolved Sulphate (SO4)	mg/L	ND		2	2219102	3	ND	10	ND	2	2219102
Turbidity	NTU	0.9	0.8	0.1	2218978	0.8	4.1	1.4	3.5	0.1	2220573
Conductivity	uS/cm	430		1	2220317	170	180	390	180	1	2220317

N/A = Not Applicable
ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

RESULTS OF ANALYSES OF WATER

Maxxam ID		GP5881		GP5883	GP5885	GP5885		
Sampling Date		2010/07/20		2010/07/20	2010/07/20	2010/07/20		
	Units	**ARMSTRONG-SED-3 (WATER)**	**RDL**	**ARMSTRONG-SED-4 (WATER)**	**ARMSTRONG-SED-5 (WATER)**	**ARMSTRONG-SED-5 (WATER) Lab-Dup**	**RDL**	**QC Batch**
Calculated Parameters								
Anion Sum	me/L	1.90	N/A	2.43	2.21		N/A	2216531
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	83	1	107	103		1	2216528
Calculated TDS	mg/L	99	1	128	116		1	2216536
Carb. Alkalinity (calc. as CaCO3)	mg/L	ND	1	1	1		1	2216528
Cation Sum	me/L	1.89	N/A	2.51	2.32		N/A	2216531
Hardness (CaCO3)	mg/L	80	1	110	100		1	2216529
Ion Balance (% Difference)	%	0.260	N/A	1.62	2.43		N/A	2216530
Langelier Index (@ 20C)	N/A	0.0310		0.321	0.228			2216534
Langelier Index (@ 4C)	N/A	-0.220		0.0710	-0.0230			2216535
Nitrate (N)	mg/L	0.15	0.05	0.11	0.06		0.05	2216532
Saturation pH (@ 20C)	N/A	8.02		7.81	7.83			2216534
Saturation pH (@ 4C)	N/A	8.27		8.06	8.08			2216535
Inorganics								
Total Alkalinity (Total as CaCO3)	mg/L	84	5	110	100		10	2219096
Dissolved Chloride (Cl)	mg/L	7	1	9	5		1	2219101
Colour	TCU	41	5	67	65		30	2219106
Nitrate + Nitrite	mg/L	0.15	0.05	0.11	0.06		0.05	2219115
Nitrite (N)	mg/L	ND	0.01	ND	ND		0.01	2219119
Nitrogen (Ammonia Nitrogen)	mg/L	ND	0.05	ND	ND		0.05	2217934
Total Organic Carbon (C)	mg/L	5.7	0.5	5.3	5.7		0.5	2221232
Orthophosphate (P)	mg/L	ND	0.01	ND	ND		0.01	2219112
pH	pH	8.05	N/A	8.13	8.06	8.09	N/A	2220315
Reactive Silica (SiO2)	mg/L	4.6	0.5	5.2	5.1		0.5	2219104
Dissolved Sulphate (SO4)	mg/L	ND	2	ND	ND		2	2219102
Turbidity	NTU	4.5	0.1	9.2	20		0.1	2220573
Conductivity	uS/cm	180	1	240	210	210	1	2220317

N/A = Not Applicable
ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

ELEMENTS BY ICP/MS (WATER)

Maxxam ID		GP5871	GP5871	GP5873	GP5875	GP5877		
Sampling Date		2010/07/20	2010/07/20	2010/07/20	2010/07/20	2010/07/20		
	Units	**QA/QC-1 (WATER)**	**QA/QC-1 (WATER) Lab-Dup**	**QA/QC-2 (WATER)**	**QA/QC-3 (WATER)**	**ARMSTRONG-SED-1 (WATER)**	**RDL**	**QC Batch**
Metals								
Dissolved Aluminum (Al)	ug/L	10	11	40	32	17	5	2218985
Total Aluminum (Al)	ug/L	10.2		79.3	107	29.3	5.0	2217822
Dissolved Antimony (Sb)	ug/L	ND	ND	ND	ND	ND	1	2218985
Total Antimony (Sb)	ug/L	ND		ND	ND	ND	1.0	2217822
Dissolved Arsenic (As)	ug/L	1	1	ND	ND	ND	1	2218985
Total Arsenic (As)	ug/L	1.3		ND	ND	ND	1.0	2217822
Dissolved Barium (Ba)	ug/L	190	190	35	31	37	1	2218985
Total Barium (Ba)	ug/L	184		38.0	34.6	38.8	1.0	2217822
Dissolved Beryllium (Be)	ug/L	ND	ND	ND	ND	ND	1	2218985
Total Beryllium (Be)	ug/L	ND		ND	ND	ND	1.0	2217822
Dissolved Bismuth (Bi)	ug/L	ND	ND	ND	ND	ND	2	2218985
Total Bismuth (Bi)	ug/L	ND		ND	ND	ND	2.0	2217822
Dissolved Boron (B)	ug/L	11	11	5	6	22	5	2218985
Total Boron (B)	ug/L	9.7		5.2	6.4	22.0	5.0	2217822
Dissolved Cadmium (Cd)	ug/L	0.10	0.10	0.03	ND	ND	0.02	2218985
Total Cadmium (Cd)	ug/L	0.066		0.027	0.022	ND	0.017	2217822
Dissolved Calcium (Ca)	ug/L	69000	69000	22000	25000	29000	100	2218985
Total Calcium (Ca)	ug/L	68100		21900	25500	28200	100	2217822
Dissolved Chromium (Cr)	ug/L	ND	ND	ND	ND	ND	1	2218985
Total Chromium (Cr)	ug/L	ND		ND	ND	ND	1.0	2217822
Dissolved Cobalt (Co)	ug/L	1.1	1.0	ND	ND	ND	0.4	2218985
Total Cobalt (Co)	ug/L	1.17		ND	ND	ND	0.40	2217822
Dissolved Copper (Cu)	ug/L	ND	ND	ND	ND	ND	2	2218985
Total Copper (Cu)	ug/L	ND		ND	ND	ND	2.0	2217822
Dissolved Iron (Fe)	ug/L	190	190	71	260	200	50	2218985
Total Iron (Fe)	ug/L	213		107	432	251	50	2217822
Dissolved Lead (Pb)	ug/L	8.0	7.7	0.8	ND	ND	0.5	2218985
Total Lead (Pb)	ug/L	ND		0.65	0.74	ND	0.50	2217822
Dissolved Magnesium (Mg)	ug/L	3700	3700	1800	4200	7600	100	2218985
Total Magnesium (Mg)	ug/L	3540		1750	4190	7210	100	2217822
Dissolved Manganese (Mn)	ug/L	6400	6400	17	38	64	2	2218985
Total Manganese (Mn)	ug/L	7750		26.2	70.0	71.1	2.0	2217822
Dissolved Molybdenum (Mo)	ug/L	ND	ND	ND	ND	ND	2	2218985

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

ELEMENTS BY ICP/MS (WATER)

Maxxam ID		GP5871	GP5871	GP5873	GP5875	GP5877		
Sampling Date		2010/07/20	2010/07/20	2010/07/20	2010/07/20	2010/07/20		
	Units	**QA/QC-1 (WATER)**	**QA/QC-1 (WATER) Lab-Dup**	**QA/QC-2 (WATER)**	**QA/QC-3 (WATER)**	**ARMSTRONG-SED-1 (WATER)**	**RDL**	**QC Batch**
Total Molybdenum (Mo)	ug/L	ND		ND	ND	ND	2.0	2217822
Dissolved Nickel (Ni)	ug/L	2	ND	ND	ND	ND	2	2218985
Total Nickel (Ni)	ug/L	2.1		ND	ND	ND	2.0	2217822
Total Phosphorus (P)	ug/L	ND		ND	ND	ND	100	2217822
Dissolved Potassium (K)	ug/L	1800	1800	510	600	1700	100	2218985
Total Potassium (K)	ug/L	1770		539	633	1790	100	2217822
Dissolved Selenium (Se)	ug/L	ND	ND	ND	ND	ND	1	2218985
Total Selenium (Se)	ug/L	ND		ND	ND	ND	1.0	2217822
Dissolved Silver (Ag)	ug/L	ND	ND	ND	ND	ND	0.1	2218985
Total Silver (Ag)	ug/L	ND		ND	ND	ND	0.10	2217822
Dissolved Sodium (Na)	ug/L	8900	8900	9300	6100	35000	100	2218985
Total Sodium (Na)	ug/L	8290		9150	5930	33700	100	2217822
Dissolved Strontium (Sr)	ug/L	170	170	51	62	89	2	2218985
Total Strontium (Sr)	ug/L	172		54.7	65.6	91.4	2.0	2217822
Dissolved Thallium (Tl)	ug/L	0.1	0.1	ND	ND	ND	0.1	2218985
Total Thallium (Tl)	ug/L	0.11		ND	ND	ND	0.10	2217822
Dissolved Tin (Sn)	ug/L	ND	ND	ND	ND	ND	2	2218985
Total Tin (Sn)	ug/L	ND		ND	ND	ND	2.0	2217822
Dissolved Titanium (Ti)	ug/L	ND	ND	ND	ND	ND	2	2218985
Total Titanium (Ti)	ug/L	ND		ND	ND	ND	2.0	2217822
Dissolved Uranium (U)	ug/L	0.3	0.2	ND	ND	ND	0.1	2218985
Total Uranium (U)	ug/L	0.24		ND	ND	ND	0.10	2217822
Dissolved Vanadium (V)	ug/L	ND	ND	ND	ND	ND	2	2218985
Total Vanadium (V)	ug/L	ND		ND	ND	ND	2.0	2217822
Dissolved Zinc (Zn)	ug/L	8	8	ND	ND	ND	5	2218985
Total Zinc (Zn)	ug/L	8.1		5.1	ND	ND	5.0	2217822

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

ELEMENTS BY ICP/MS (WATER)

Maxxam ID		GP5879	GP5881	GP5883	GP5885		
Sampling Date		2010/07/20	2010/07/20	2010/07/20	2010/07/20		
	Units	**ARMSTRONG-SED-2 (WATER)**	**ARMSTRONG-SED-3 (WATER)**	**ARMSTRONG-SED-4 (WATER)**	**ARMSTRONG-SED-5 (WATER)**	**RDL**	**QC Batch**
Metals							
Dissolved Aluminum (Al)	ug/L	23	31	16	24	5	2218985
Total Aluminum (Al)	ug/L	104	181	89.5	347	5.0	2217822
Dissolved Antimony (Sb)	ug/L	ND	ND	ND	ND	1	2218985
Total Antimony (Sb)	ug/L	ND	ND	ND	ND	1.0	2217822
Dissolved Arsenic (As)	ug/L	ND	ND	ND	ND	1	2218985
Total Arsenic (As)	ug/L	ND	ND	1.0	1.1	1.0	2217822
Dissolved Barium (Ba)	ug/L	31	31	34	40	1	2218985
Total Barium (Ba)	ug/L	34.9	35.5	40.4	55.7	1.0	2217822
Dissolved Beryllium (Be)	ug/L	ND	ND	ND	ND	1	2218985
Total Beryllium (Be)	ug/L	ND	ND	ND	ND	1.0	2217822
Dissolved Bismuth (Bi)	ug/L	ND	ND	ND	ND	2	2218985
Total Bismuth (Bi)	ug/L	ND	ND	ND	ND	2.0	2217822
Dissolved Boron (B)	ug/L	5	5	6	ND	5	2218985
Total Boron (B)	ug/L	6.2	6.9	6.6	5.1	5.0	2217822
Dissolved Cadmium (Cd)	ug/L	ND	0.02	ND	ND	0.02	2218985
Total Cadmium (Cd)	ug/L	0.033	0.061	0.029	0.053	0.017	2217822
Dissolved Calcium (Ca)	ug/L	25000	25000	33000	32000	100	2218985
Total Calcium (Ca)	ug/L	25400	25600	34200	32100	100	2217822
Dissolved Chromium (Cr)	ug/L	ND	ND	ND	ND	1	2218985
Total Chromium (Cr)	ug/L	ND	ND	ND	ND	1.0	2217822
Dissolved Cobalt (Co)	ug/L	ND	ND	ND	ND	0.4	2218985
Total Cobalt (Co)	ug/L	ND	ND	ND	0.65	0.40	2217822
Dissolved Copper (Cu)	ug/L	ND	ND	ND	ND	2	2218985
Total Copper (Cu)	ug/L	ND	ND	ND	ND	2.0	2217822
Dissolved Iron (Fe)	ug/L	250	260	850	600	50	2218985
Total Iron (Fe)	ug/L	412	531	1230	1680	50	2217822
Dissolved Lead (Pb)	ug/L	ND	0.8	0.7	0.5	0.5	2218985
Total Lead (Pb)	ug/L	0.82	2.85	0.97	1.49	0.50	2217822
Dissolved Magnesium (Mg)	ug/L	4200	4200	6200	6000	100	2218985
Total Magnesium (Mg)	ug/L	4100	4270	6280	5790	100	2217822
Dissolved Manganese (Mn)	ug/L	31	32	62	140	2	2218985
Total Manganese (Mn)	ug/L	73.5	79.2	193	478	2.0	2217822
Dissolved Molybdenum (Mo)	ug/L	ND	ND	ND	ND	2	2218985

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

ELEMENTS BY ICP/MS (WATER)

Maxxam ID		GP5879	GP5881	GP5883	GP5885		
Sampling Date		2010/07/20	2010/07/20	2010/07/20	2010/07/20		
	Units	**ARMSTRONG-SED-2 (WATER)**	**ARMSTRONG-SED-3 (WATER)**	**ARMSTRONG-SED-4 (WATER)**	**ARMSTRONG-SED-5 (WATER)**	**RDL**	**QC Batch**
Total Molybdenum (Mo)	ug/L	ND	ND	ND	ND	2.0	2217822
Dissolved Nickel (Ni)	ug/L	ND	ND	ND	ND	2	2218985
Total Nickel (Ni)	ug/L	ND	ND	ND	ND	2.0	2217822
Total Phosphorus (P)	ug/L	ND	ND	ND	ND	100	2217822
Dissolved Potassium (K)	ug/L	590	630	670	630	100	2218985
Total Potassium (K)	ug/L	657	684	710	645	100	2217822
Dissolved Selenium (Se)	ug/L	ND	ND	ND	ND	1	2218985
Total Selenium (Se)	ug/L	ND	ND	ND	ND	1.0	2217822
Dissolved Silver (Ag)	ug/L	ND	ND	ND	ND	0.1	2218985
Total Silver (Ag)	ug/L	ND	ND	ND	ND	0.10	2217822
Dissolved Sodium (Na)	ug/L	6100	6100	7000	4300	100	2218985
Total Sodium (Na)	ug/L	5930	6120	6910	4060	100	2217822
Dissolved Strontium (Sr)	ug/L	61	61	65	63	2	2218985
Total Strontium (Sr)	ug/L	64.9	67.1	71.1	65.5	2.0	2217822
Dissolved Thallium (Tl)	ug/L	ND	ND	ND	ND	0.1	2218985
Total Thallium (Tl)	ug/L	ND	ND	ND	ND	0.10	2217822
Dissolved Tin (Sn)	ug/L	ND	ND	ND	ND	2	2218985
Total Tin (Sn)	ug/L	ND	ND	ND	ND	2.0	2217822
Dissolved Titanium (Ti)	ug/L	ND	ND	ND	ND	2	2218985
Total Titanium (Ti)	ug/L	ND	2.1	ND	2.9	2.0	2217822
Dissolved Uranium (U)	ug/L	ND	ND	ND	ND	0.1	2218985
Total Uranium (U)	ug/L	ND	ND	ND	ND	0.10	2217822
Dissolved Vanadium (V)	ug/L	ND	ND	ND	ND	2	2218985
Total Vanadium (V)	ug/L	ND	ND	ND	ND	2.0	2217822
Dissolved Zinc (Zn)	ug/L	ND	11	ND	ND	5	2218985
Total Zinc (Zn)	ug/L	6.6	9.1	5.8	9.2	5.0	2217822

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

GENERAL COMMENTS

Sample GP5881-01: RCAp Ion Balance acceptable. Anion/cation agreement within 0.2 meq/L.

Conestoga-Rovers and Associates Ltd
Maxxam Job #: B098030
Report Date: 2010/07/30

Client Project #: 055453-02
Project name: BELLEDUNE ECO

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**	**% Recovery**	**QC Limits**
2217822	Total Aluminum (Al)	2010/07/28	98	80 - 120	102	80 - 120	ND, RDL=5.0	ug/L				
2217822	Total Antimony (Sb)	2010/07/28	101	80 - 120	106	80 - 120	ND, RDL=1.0	ug/L				
2217822	Total Arsenic (As)	2010/07/28	102	80 - 120	101	80 - 120	ND, RDL=1.0	ug/L	NC	25		
2217822	Total Barium (Ba)	2010/07/28	99	80 - 120	100	80 - 120	ND, RDL=1.0	ug/L				
2217822	Total Beryllium (Be)	2010/07/28	107	80 - 120	104	80 - 120	ND, RDL=1.0	ug/L				
2217822	Total Bismuth (Bi)	2010/07/28	82	80 - 120	96	80 - 120	ND, RDL=2.0	ug/L				
2217822	Total Boron (B)	2010/07/28	104	80 - 120	97	80 - 120	ND, RDL=5.0	ug/L				
2217822	Total Cadmium (Cd)	2010/07/28	104	80 - 120	105	80 - 120	ND, RDL=0.017	ug/L				
2217822	Total Calcium (Ca)	2010/07/28	NC	80 - 120	100	80 - 120	ND, RDL=100	ug/L				
2217822	Total Chromium (Cr)	2010/07/28	99	80 - 120	102	80 - 120	ND, RDL=1.0	ug/L				
2217822	Total Cobalt (Co)	2010/07/28	99	80 - 120	101	80 - 120	ND, RDL=0.40	ug/L				
2217822	Total Copper (Cu)	2010/07/28	NC	80 - 120	97	80 - 120	ND, RDL=2.0	ug/L				
2217822	Total Iron (Fe)	2010/07/28	NC	80 - 120	102	80 - 120	ND, RDL=50	ug/L				
2217822	Total Lead (Pb)	2010/07/28	97	80 - 120	100	80 - 120	ND, RDL=0.50	ug/L				
2217822	Total Magnesium (Mg)	2010/07/28	93	80 - 120	97	80 - 120	ND, RDL=100	ug/L				
2217822	Total Manganese (Mn)	2010/07/28	NC	80 - 120	103	80 - 120	ND, RDL=2.0	ug/L				
2217822	Total Molybdenum (Mo)	2010/07/28	104	80 - 120	108	80 - 120	ND, RDL=2.0	ug/L				
2217822	Total Nickel (Ni)	2010/07/28	93	80 - 120	98	80 - 120	ND, RDL=2.0	ug/L				
2217822	Total Phosphorus (P)	2010/07/28	106	80 - 120	105	80 - 120	ND, RDL=100	ug/L				
2217822	Total Potassium (K)	2010/07/28	95	80 - 120	96	80 - 120	ND, RDL=100	ug/L				
2217822	Total Selenium (Se)	2010/07/28	102	80 - 120	107	80 - 120	ND, RDL=1.0	ug/L				
2217822	Total Silver (Ag)	2010/07/28	96	80 - 120	97	80 - 120	ND, RDL=0.10	ug/L				
2217822	Total Sodium (Na)	2010/07/28	90	80 - 120	92	80 - 120	ND, RDL=100	ug/L				
2217822	Total Strontium (Sr)	2010/07/28	NC	80 - 120	109	80 - 120	ND, RDL=2.0	ug/L				
2217822	Total Thallium (Tl)	2010/07/28	99	80 - 120	101	80 - 120	ND, RDL=0.10	ug/L				
2217822	Total Tin (Sn)	2010/07/28	94	80 - 120	105	80 - 120	ND, RDL=2.0	ug/L				
2217822	Total Titanium (Ti)	2010/07/28	116	80 - 120	118	80 - 120	ND, RDL=2.0	ug/L				
2217822	Total Uranium (U)	2010/07/28	102	80 - 120	107	80 - 120	ND, RDL=0.10	ug/L				
2217822	Total Vanadium (V)	2010/07/28	104	80 - 120	106	80 - 120	ND, RDL=2.0	ug/L				
2217822	Total Zinc (Zn)	2010/07/28	96	80 - 120	104	80 - 120	ND, RDL=5.0	ug/L				
2217934	Nitrogen (Ammonia Nitrogen)	2010/07/28	97	80 - 120	98	80 - 120	ND, RDL=0.05	mg/L	NC	25	111	80 - 120
2218978	Turbidity	2010/07/27					ND, RDL=0.1	NTU	11.5	25	97	80 - 120
2218985	Dissolved Aluminum (Al)	2010/07/28	104	80 - 120	104	80 - 120	ND, RDL=5	ug/L	NC	25		
2218985	Dissolved Antimony (Sb)	2010/07/28	103	80 - 120	108	80 - 120	ND, RDL=1	ug/L	NC	25		
2218985	Dissolved Arsenic (As)	2010/07/28	105	80 - 120	102	80 - 120	ND, RDL=1	ug/L	NC	25		
2218985	Dissolved Barium (Ba)	2010/07/28	NC	80 - 120	98	80 - 120	ND, RDL=1	ug/L	0.9	25		
2218985	Dissolved Beryllium (Be)	2010/07/28	106	80 - 120	106	80 - 120	ND, RDL=1	ug/L	NC	25		
2218985	Dissolved Bismuth (Bi)	2010/07/28	64(1, 2)	80 - 120	98	80 - 120	ND, RDL=2	ug/L	NC	25		
2218985	Dissolved Boron (B)	2010/07/28	110	80 - 120	105	80 - 120	ND, RDL=5	ug/L	NC	25		
2218985	Dissolved Cadmium (Cd)	2010/07/28	104	80 - 120	100	80 - 120	ND, RDL=0.02	ug/L	6.5	25		

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**	**% Recovery**	**QC Limits**
2218985	Dissolved Calcium (Ca)	2010/07/28	NC	80 - 120	103	80 - 120	120, RDL=100	ug/L	1.2	25		
2218985	Dissolved Chromium (Cr)	2010/07/28	105	80 - 120	108	80 - 120	ND, RDL=1	ug/L	NC	25		
2218985	Dissolved Cobalt (Co)	2010/07/28	105	80 - 120	105	80 - 120	ND, RDL=0.4	ug/L	NC	25		
2218985	Dissolved Copper (Cu)	2010/07/28	101	80 - 120	100	80 - 120	ND, RDL=2	ug/L	NC	25		
2218985	Dissolved Iron (Fe)	2010/07/28	102	80 - 120	104	80 - 120	ND, RDL=50	ug/L	NC	25		
2218985	Dissolved Lead (Pb)	2010/07/28	96	80 - 120	94	80 - 120	ND, RDL=0.5	ug/L	3.7	25		
2218985	Dissolved Magnesium (Mg)	2010/07/28	102	80 - 120	103	80 - 120	ND, RDL=100	ug/L	0.7	25		
2218985	Dissolved Manganese (Mn)	2010/07/28	NC	80 - 120	105	80 - 120	ND, RDL=2	ug/L	1	25		
2218985	Dissolved Molybdenum (Mo)	2010/07/28	108	80 - 120	114	80 - 120	ND, RDL=2	ug/L	NC	25		
2218985	Dissolved Nickel (Ni)	2010/07/28	104	80 - 120	104	80 - 120	ND, RDL=2	ug/L	NC	25		
2218985	Dissolved Potassium (K)	2010/07/28	96	80 - 120	96	80 - 120	ND, RDL=100	ug/L	0.1	25		
2218985	Dissolved Selenium (Se)	2010/07/28	108	80 - 120	103	80 - 120	ND, RDL=1	ug/L	NC	25		
2218985	Dissolved Silver (Ag)	2010/07/28	97	80 - 120	97	80 - 120	ND, RDL=0.1	ug/L	NC	25		
2218985	Dissolved Sodium (Na)	2010/07/28	98	80 - 120	99	80 - 120	ND, RDL=100	ug/L	0.3	25		
2218985	Dissolved Strontium (Sr)	2010/07/28	NC	80 - 120	104	80 - 120	ND, RDL=2	ug/L	2.0	25		
2218985	Dissolved Thallium (Tl)	2010/07/28	103	80 - 120	103	80 - 120	ND, RDL=0.1	ug/L	NC	25		
2218985	Dissolved Tin (Sn)	2010/07/28	100	80 - 120	108	80 - 120	ND, RDL=2	ug/L	NC	25		
2218985	Dissolved Titanium (Ti)	2010/07/28	128(1, 3)	80 - 120	133(1, 3)	80 - 120	ND, RDL=2	ug/L	NC	25		
2218985	Dissolved Uranium (U)	2010/07/28	103	80 - 120	101	80 - 120	ND, RDL=0.1	ug/L	NC	25		
2218985	Dissolved Vanadium (V)	2010/07/28	110	80 - 120	111	80 - 120	ND, RDL=2	ug/L	NC	25		
2218985	Dissolved Zinc (Zn)	2010/07/28	118	80 - 120	112	80 - 120	ND, RDL=5	ug/L	NC	25		
2219096	Total Alkalinity (Total as CaCO3)	2010/07/29	NC	80 - 120	109	80 - 120	ND, RDL=5	mg/L	NC	25	102	80 - 120
2219101	Dissolved Chloride (Cl)	2010/07/29	97	80 - 120	106	80 - 120	ND, RDL=1	mg/L	1.0	25	100	80 - 120
2219102	Dissolved Sulphate (SO4)	2010/07/28	107	80 - 120	111	80 - 120	ND, RDL=2	mg/L	0.9	25	110	80 - 120
2219104	Reactive Silica (SiO2)	2010/07/28	NC	80 - 120	101	80 - 120	ND, RDL=0.5	mg/L	0.7	25	99	75 - 125
2219106	Colour	2010/07/29					ND, RDL=5	TCU	NC	25	104	80 - 120
2219112	Orthophosphate (P)	2010/07/29	92	80 - 120	105	80 - 120	ND, RDL=0.01	mg/L	NC	25	98	80 - 120
2219115	Nitrate + Nitrite	2010/07/29	100	80 - 120	106	80 - 120	ND, RDL=0.05	mg/L	1	25	100	80 - 120
2219119	Nitrite (N)	2010/07/28	99	80 - 120	102	80 - 120	ND, RDL=0.01	mg/L	NC	25	103	80 - 120
2219522	Available Aluminum (Al)	2010/07/28	NC	75 - 125	100	75 - 125	ND, RDL=10	mg/kg	1.7	35	81	75 - 125
2219522	Available Antimony (Sb)	2010/07/28	77	75 - 125	110	75 - 125	ND, RDL=2	mg/kg	NC	35		
2219522	Available Arsenic (As)	2010/07/28	NC	75 - 125	100	75 - 125	ND, RDL=2	mg/kg	2.2	35	112	75 - 125
2219522	Available Barium (Ba)	2010/07/28	NC	75 - 125	101	75 - 125	ND, RDL=5	mg/kg	0.6	35	106	75 - 125
2219522	Available Beryllium (Be)	2010/07/28	105	75 - 125	99	75 - 125	ND, RDL=2	mg/kg	NC	35		
2219522	Available Bismuth (Bi)	2010/07/28	104	75 - 125	103	75 - 125	ND, RDL=2	mg/kg	NC	35		
2219522	Available Boron (B)	2010/07/28	75	75 - 125	98	75 - 125	ND, RDL=5	mg/kg	NC	35		
2219522	Available Cadmium (Cd)	2010/07/28	112	75 - 125	103	75 - 125	ND, RDL=0.3	mg/kg	NC	35		
2219522	Available Chromium (Cr)	2010/07/28	NC	75 - 125	102	75 - 125	ND, RDL=2	mg/kg	5.2	35	86	75 - 125
2219522	Available Cobalt (Co)	2010/07/28	NC	75 - 125	101	75 - 125	ND, RDL=1	mg/kg	1.5	35	94	75 - 125
2219522	Available Copper (Cu)	2010/07/28	NC	75 - 125	101	75 - 125	ND, RDL=2	mg/kg	1.9	35	93	75 - 125

Maxxam Job #: B098030
Report Date: 2010/07/30

Conestoga-Rovers and Associates Ltd
Client Project #: 055453-02
Project name: BELLEDUNE ECO

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**	**% Recovery**	**QC Limits**
2219522	Available Iron (Fe)	2010/07/28	NC	75 - 125	101	75 - 125	ND, RDL=50	mg/kg	1.2	35	94	75 - 125
2219522	Available Lead (Pb)	2010/07/28	NC	75 - 125	103	75 - 125	ND, RDL=0.5	mg/kg	3.8	35	102	75 - 125
2219522	Available Lithium (Li)	2010/07/28	NC	75 - 125	97	75 - 125	ND, RDL=2	mg/kg	2.4	35		
2219522	Available Manganese (Mn)	2010/07/28	NC	75 - 125	105	75 - 125	ND, RDL=2	mg/kg	1.4	35	101	75 - 125
2219522	Available Molybdenum (Mo)	2010/07/28	102	75 - 125	95	75 - 125	ND, RDL=2	mg/kg	NC	35		
2219522	Available Nickel (Ni)	2010/07/28	NC	75 - 125	99	75 - 125	ND, RDL=2	mg/kg	2.7	35	99	75 - 125
2219522	Available Rubidium (Rb)	2010/07/28	NC	75 - 125	103	75 - 125	ND, RDL=2	mg/kg	0.8	35		
2219522	Available Selenium (Se)	2010/07/28	102	75 - 125	109	75 - 125	ND, RDL=2	mg/kg	NC	35		
2219522	Available Silver (Ag)	2010/07/28	106	75 - 125	102	75 - 125	ND, RDL=0.5	mg/kg	NC	35		
2219522	Available Strontium (Sr)	2010/07/28	NC	75 - 125	99	75 - 125	ND, RDL=5	mg/kg	NC	35	86	75 - 125
2219522	Available Thallium (Tl)	2010/07/28	98	75 - 125	100	75 - 125	ND, RDL=0.1	mg/kg	NC	35		
2219522	Available Tin (Sn)	2010/07/28	100	75 - 125	96	75 - 125	ND, RDL=2	mg/kg	NC	35		
2219522	Available Uranium (U)	2010/07/28	103	75 - 125	101	75 - 125	ND, RDL=0.1	mg/kg	9.7	35		
2219522	Available Vanadium (V)	2010/07/28	NC	75 - 125	102	75 - 125	ND, RDL=2	mg/kg	6.1	35	101	75 - 125
2219522	Available Zinc (Zn)	2010/07/28	108	75 - 125	104	75 - 125	ND, RDL=5	mg/kg	2.5	35	108	75 - 125
2220315	pH	2010/07/28					5.65, RDL=N/A	pH	0.4	25	101	80 - 120
2220317	Conductivity	2010/07/28					1, RDL=1	uS/cm	0	25	103	80 - 120
2220573	Turbidity	2010/07/29					ND, RDL=0.1	NTU	NC	25	100	80 - 120
2221232	Total Organic Carbon (C)	2010/07/29	NC	80 - 120	98	80 - 120	ND, RDL=0.5	mg/L	4.0	25	101	80 - 120

N/A = Not Applicable

RDL = Reportable Detection Limit

RPD = Relative Percent Difference

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

QC Standard: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.

Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.

NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

(1) - Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.

(2) - Low recovery due to sample matrix.

(3) - Elevated recovery due to spiking solution artifact. No impact on sample data quality.

Validation Signature Page

Maxxam Job #: B098030

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Kevin A. MacDonald

KEVIN MACDONALD, Inorganics Supervisor

==

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Analytics International Corporation

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MAXXAM Chain of Custody Record

COC #: B 101619 Page 1 of 1

This column for lab use only:

Client Code: 16274

Maxxam Job #: B098030 MW

Cooler ID	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp
			8	8	9	
			7	3	1	

Integrity: [✓ YES] NO

Integrity / Checklist by: MW

Labelled by:

Location / Bin #:

INVOICE INFORMATION:

Company Name: CRA FREDERICTON
Contact Name: NEIL BRODIE
Address:
Postal Code:
Email:
Ph:
Fax:

REPORT INFORMATION (if differs from invoice):

Company Name: INTRANSIK
Contact Name: CHRISTINE MOORE
Address:
Postal Code:
Email:
Ph:
Fax:

PO #:
Project # / Phase #: 055453-02
Project Name / Site Location: BELLEDUNE ECO
Quote: B02709
Site #:
Task Order #:
Sampled by: HM & JG

TURNAROUND TIME

Standard ☑
10 day ☐
If RUSH Specify Date:
Pre-schedule rush work
Charge for # Jars used but not submitted

Guideline Requirements / Detection Limits / Special Instructions

*FWAL guidelines required
*Please do not dispose before talking to C.Moore

*Specify Matrix: Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

Analysis columns: Field Filtered & Preserved; Lab Filtration Required; RCAP-30 Choose Total or Diss Metals; RCAP-MS Choose Total or Diss Metals; Metals Water: Total Digest (Default Method) for well water, surface water; Dissolved for ground water; Mercury; Metals Soil: Metals & [redacted] Default Available Digest Method; Metals Total Digest - for Ocean sediments (HNO3/HF/HCLO4); Mercury Low level by Cold Vapour AA; Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural; Hot Water soluble Boron (required for CCME Agricultural); Hydrocarbons: RBCA Hydrocarbons (BTEX, C6-C32); Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32; NB Potable Water BTEX, VPH, Low level T.E.H.; TPH Fractionation; PAH's; PAH's with Acridine, Quinoline

	Field Sample Identification	Matrix*	Date/Time Sampled	# & type of bottles
1	QA/QC - [redacted] 1		July 20	
2	QA/QC - 2			
3	QA/QC - 3			
4	ARMSTRONG - SED - 1			
5	ARMSTRONNG - SED - 2			
6	ARMISTRONG - SED - 3			
7	ARMSTRONG - SED - 4			
8	ARMSTRONG - SED - 5			
9				
10				

SAME ANALYSES AS COOLER 1 & OTHER COCs (B101620, B101616 - B101618)
(RAN OUT OF FORMS - CAN SEND FORMS FRIDAY JULY 23/010)

RELINQUISHED BY: (Signature/Print)	Date	Time	RECEIVED BY: (Signature/Print)	Date	Time
HEATHER MACDONALD	JULY 22/010	2pm			
A MacDonald					
COOLER 2 of 2			Matthew White	2010 JUL 23 AM 9:37	

White: Maxxam Yellow: Mail Pink: Client

ATL FCD 00149 / Revision 10

Your Project #: 044453-02
Site: BELLEDUNE ECO
Your C.O.C. #: B 101620, B 101616, B 101617, B 101618

Attention: Neil Brodie
Conestoga-Rovers and Associates Ltd
Fredericton
466 Hodgson Rd
Fredericton , NB
E3C 2G5

Report Date: 2010/07/30

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B099031
Received: 2010/07/23, 9:01

Sample Matrix: Soil
Samples Received: 9

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Metals Solid Avail. Unified MS - Nper	7	2010/07/28	2010/07/28	ATL SOP 00024 R5	Based on EPA6020A
Metals Solid Avail. Unified MS - Nper	2	2010/07/28	2010/07/29	ATL SOP 00024 R5	Based on EPA6020A

Sample Matrix: Water
Samples Received: 9

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Carbonate, Bicarbonate and Hydroxide	9	N/A	2010/07/29		
Alkalinity	5	N/A	2010/07/28	ATL SOP 00013 R4	Based on EPA310.2
Alkalinity	4	N/A	2010/07/29	ATL SOP 00013 R4	Based on EPA310.2
Chloride	9	N/A	2010/07/29	ATL SOP 00014 R6	Based on SM4500-Cl-
Colour	9	N/A	2010/07/29	ATL SOP 00020 R3.	Based on SM2120C
Conductance - water	9	N/A	2010/07/28	ATL SOP 00004 R5/00006 R4	Based on SM2510B
Hardness (calculated as CaCO3)	9	N/A	2010/07/29	ATL SOP 00048	Based on SM2340B
Metals Water Diss. Collision Cell MS	9	N/A	2010/07/29	ATL SOP 00058 R2	Based on EPA6020A
Metals Water Total Collision Cell MS	9	2010/07/27	2010/07/28	ATL SOP 00058 R2	Based on EPA6020A
Ion Balance (% Difference)	9	N/A	2010/07/30		
Anion and Cation Sum	9	N/A	2010/07/29		
Nitrogen Ammonia - water	9	N/A	2010/07/27	ATL SOP 00015 R5	Based on USEPA 350.1
Nitrogen - Nitrate + Nitrite	9	N/A	2010/07/29	ATL SOP 00016 R4	Based on USGS - Enz.
Nitrogen - Nitrite	9	N/A	2010/07/28	ATL SOP 00017 R4	Based on USEPA 354.1
Nitrogen - Nitrate (as N)	9	N/A	2010/07/29	ATL SOP 00018 R3	Based on ASTMD3867
pH	9	N/A	2010/07/28	ATL SOP 00003 R5/00005 R7	Based on SM4500H+
Phosphorus - ortho	9	N/A	2010/07/29	ATL SOP 00021 R3	Based on USEPA 365.1
Sat. pH and Langelier Index (@ 20C)	9	N/A	2010/07/30		
Sat. pH and Langelier Index (@ 4C)	9	N/A	2010/07/30		
Reactive Silica	9	N/A	2010/07/29	ATL SOP 00022 R3	Based on EPA 366.0
Sulphate	9	N/A	2010/07/28	ATL SOP 00023 R3	Based on EPA 375.4
Total Dissolved Solids (TDS calc)	9	N/A	2010/07/30		
Organic carbon - Total (TOC)	9	N/A	2010/07/29	ATL SOP 00037 R4	Based on SM5310C
Turbidity	9	N/A	2010/07/27	ATL SOP 00011 R4	based on EPA 180.1

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
* Results relate only to the items tested.

../2

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

MICHELLE HILL, Project Manager
Email: Michelle.Hill@maxxamanalytics.com
Phone# (902) 420-0203

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Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Total cover pages: 2

Conestoga-Rovers and Associates Ltd
Maxxam Job #: B099031 Client Project #: 044453-02
Report Date: 2010/07/30 Project name: BELLEDUNE ECO

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		GP5736		GP5748	GP5794	GP5798		GP5820		
Sampling Date		2010/07/20		2010/07/20	2010/07/20	2010/07/20		2010/07/20		
	Units	**UNNAMED-SED-1 SEDIMENT**	**RDL**	**UNNAMED-SED-2 SEDIMENT**	**HENDRY-SED-1 SEDIMENT**	**HENDRY-SED-2 SEDIMENT**	**RDL**	**HENDRY-SED-3 SEDIMENT**	**RDL**	**QC Batch**
Metals										
Available Aluminum (Al)	mg/kg	8300	10	14000	16000	17000	10	18000	10	2219522
Available Antimony (Sb)	mg/kg	4	2	5	ND	ND	2	ND	2	2219522
Available Arsenic (As)	mg/kg	43	2	13	24	19	2	20	2	2219522
Available Barium (Ba)	mg/kg	1600	5	130	130	140	5	180	5	2219522
Available Beryllium (Be)	mg/kg	ND	2	ND	ND	ND	2	ND	2	2219522
Available Bismuth (Bi)	mg/kg	ND	2	ND	ND	ND	2	ND	2	2219522
Available Boron (B)	mg/kg	ND	5	ND	ND	ND	5	ND	5	2219522
Available Cadmium (Cd)	mg/kg	4.4	0.3	1.2	2.1	2.8	0.3	2.2	0.3	2219522
Available Chromium (Cr)	mg/kg	22	2	33	25	28	2	30	2	2219522
Available Cobalt (Co)	mg/kg	34	1	18	11	12	1	10	1	2219522
Available Copper (Cu)	mg/kg	39	2	23	20	21	2	23	2	2219522
Available Iron (Fe)	mg/kg	75000	500	32000	21000	22000	50	22000	50	2219522
Available Lead (Pb)	mg/kg	140	0.5	59	160	160	0.5	87	0.5	2219522
Available Lithium (Li)	mg/kg	14	2	24	22	23	2	20	2	2219522
Available Manganese (Mn)	mg/kg	26000	20	1700	900	1300	2	1600	2	2219522
Available Molybdenum (Mo)	mg/kg	2	2	ND	ND	ND	2	ND	2	2219522
Available Nickel (Ni)	mg/kg	35	2	48	30	34	2	29	2	2219522
Available Rubidium (Rb)	mg/kg	5	2	6	10	10	2	9	2	2219522
Available Selenium (Se)	mg/kg	2	2	ND	ND	ND	2	2	2	2219522
Available Silver (Ag)	mg/kg	ND	0.5	ND	0.5	ND	0.5	0.6	0.5	2219522
Available Strontium (Sr)	mg/kg	39	5	14	14	14	5	ND(1)	50	2219522
Available Thallium (Tl)	mg/kg	1.4	0.1	0.3	0.5	0.6	0.1	0.4	0.1	2219522
Available Tin (Sn)	mg/kg	7	2	ND	3	3	2	ND	2	2219522
Available Uranium (U)	mg/kg	0.6	0.1	0.8	0.7	0.7	0.1	1.1	0.1	2219522
Available Vanadium (V)	mg/kg	38	2	47	40	41	2	37	2	2219522
Available Zinc (Zn)	mg/kg	760	5	130	280	310	5	260	5	2219522

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
(1) - Elevated reporting limit due to sample matrix.

Maxxam Job #: B099031
Report Date: 2010/07/30

Conestoga-Rovers and Associates Ltd
Client Project #: 044453-02
Project name: BELLEDUNE ECO

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		GP5823	GP5823	GP5841	GP5844	GP5866		
Sampling Date		2010/07/21	2010/07/21	2010/07/21	2010/07/21	2010/07/21		
	Units	**HENDRY-SED-4 SEDIMENT**	**HENDRY-SED-4 SEDIMENT Lab-Dup**	**HENDRY-SED-5 SEDIMENT**	**HENDRY-SED-6 SEDIMENT**	**HENDRY-SED-7 SEDIMENT**	**RDL**	**QC Batch**
Metals								
Available Aluminum (Al)	mg/kg	24000	24000	17000	26000	15000	10	2219522
Available Antimony (Sb)	mg/kg	ND	ND	ND	ND	ND	2	2219522
Available Arsenic (As)	mg/kg	15	14	11	5	10	2	2219522
Available Barium (Ba)	mg/kg	140	140	79	120	69	5	2219522
Available Beryllium (Be)	mg/kg	ND	ND	ND	ND	ND	2	2219522
Available Bismuth (Bi)	mg/kg	ND	ND	ND	ND	ND	2	2219522
Available Boron (B)	mg/kg	ND	ND	ND	ND	ND	5	2219522
Available Cadmium (Cd)	mg/kg	0.6	0.6	0.5	ND	0.5	0.3	2219522
Available Chromium (Cr)	mg/kg	43	41	51	66	30	2	2219522
Available Cobalt (Co)	mg/kg	14	13	15	22	13	1	2219522
Available Copper (Cu)	mg/kg	17	17	19	5	22	2	2219522
Available Iron (Fe)	mg/kg	26000	26000	30000	42000	28000	50	2219522
Available Lead (Pb)	mg/kg	19	18	36	6.9	36	0.5	2219522
Available Lithium (Li)	mg/kg	34	34	27	51	19	2	2219522
Available Manganese (Mn)	mg/kg	410	410	920	430	390	2	2219522
Available Molybdenum (Mo)	mg/kg	ND	ND	ND	ND	ND	2	2219522
Available Nickel (Ni)	mg/kg	46	45	48	49	37	2	2219522
Available Rubidium (Rb)	mg/kg	11	11	7	10	6	2	2219522
Available Selenium (Se)	mg/kg	ND	ND	ND	ND	ND	2	2219522
Available Silver (Ag)	mg/kg	0.5	0.5	ND	ND	ND	0.5	2219522
Available Strontium (Sr)	mg/kg	11	10	7	8	7	5	2219522
Available Thallium (Tl)	mg/kg	0.3	0.3	0.2	0.1	0.2	0.1	2219522
Available Tin (Sn)	mg/kg	ND	ND	ND	ND	ND	2	2219522
Available Uranium (U)	mg/kg	0.8	0.8	0.3	0.2	0.4	0.1	2219522
Available Vanadium (V)	mg/kg	42	40	54	80	38	2	2219522
Available Zinc (Zn)	mg/kg	190	190	150	74	100	5	2219522

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

RESULTS OF ANALYSES OF WATER

Maxxam ID		GP5743	GP5749		GP5796	GP5799	GP5821	GP5838		
Sampling Date		2010/07/20	2010/07/20		2010/07/20	2010/07/20	2010/07/20	2010/07/21		
	Units	**UNNAMED-SED-1 SURFACE WATER**	**UNNAMED-SED-2 SURFACE WATER**	**RDL**	**HENDRY-SED-1 SURFACE WATER**	**HENDRY-SED-2 SURFACE WATER**	**HENDRY-SED-3 SURFACE WATER**	**HENDRY-SED-4 SURFACE WATER**	**RDL**	**QC Batch**
Calculated Parameters										
Anion Sum	me/L	7.77	4.59	N/A	1.79	1.74	1.70	1.62	N/A	2216531
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	354	214	1	71	69	65	62	1	2216528
Calculated TDS	mg/L	401	232	1	95	92	91	87	1	2216536
Carb. Alkalinity (calc. as CaCO3)	mg/L	3	2	1	ND	ND	ND	ND	1	2216528
Cation Sum	me/L	7.54	4.11	N/A	1.67	1.61	1.60	1.50	N/A	2216531
Hardness (CaCO3)	mg/L	360	180	1	63	61	58	53	1	2216529
Ion Balance (% Difference)	%	1.50	5.52	N/A	3.47	3.88	3.03	3.85	N/A	2216530
Langelier Index (@ 20C)	N/A	1.15	0.682		-0.0780	-0.187	-0.272	-0.350		2216534
Langelier Index (@ 4C)	N/A	0.905	0.432		-0.329	-0.438	-0.523	-0.601		2216535
Nitrate (N)	mg/L	1.8	0.06	0.05	0.10	0.10	0.10	0.11	0.05	2216532
Saturation pH (@ 20C)	N/A	6.78	7.24		8.14	8.17	8.22	8.28		2216534
Saturation pH (@ 4C)	N/A	7.03	7.49		8.39	8.42	8.47	8.53		2216535
Inorganics										
Total Alkalinity (Total as CaCO3)	mg/L	360	220	30	72	69	66	62	5	2219163
Dissolved Chloride (Cl)	mg/L	7	10	1	10	10	11	11	1	2219165
Colour	TCU	15	20	5	33	34	32	30	5	2219173
Nitrate + Nitrite	mg/L	1.8	0.06	0.05	0.10	0.10	0.10	0.11	0.05	2219178
Nitrite (N)	mg/L	0.01	ND	0.01	ND	ND	ND	ND	0.01	2219180
Nitrogen (Ammonia Nitrogen)	mg/L	0.48	0.22	0.05	ND	ND	ND	ND	0.05	2217942
Total Organic Carbon (C)	mg/L	12	7.2	0.5	6.2	6.2	6.2	6.6	0.5	2221232
Orthophosphate (P)	mg/L	ND	ND	0.01	ND	ND	ND	ND	0.01	2219174
pH	pH	7.93	7.92	N/A	8.06	7.98	7.95	7.93	N/A	2220302
Reactive Silica (SiO2)	mg/L	7.6	5.2	0.5	4.5	4.6	4.6	4.5	0.5	2219172
Dissolved Sulphate (SO4)	mg/L	15	ND	2	3	3	3	2	2	2219169
Turbidity	NTU	1.7	0.7	0.1	0.7	0.7	0.7	0.7	0.1	2218978
Conductivity	uS/cm	680	420	1	170	170	170	160	1	2220313

N/A = Not Applicable
ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

RESULTS OF ANALYSES OF WATER

Maxxam ID		GP5842	GP5845			GP5867	GP5867		
Sampling Date		2010/07/21	2010/07/21			2010/07/21	2010/07/21		
	Units	**HENDRY-SED-5 SURFACE WATER**	**HENDRY-SED-6 SURFACE WATER**	**RDL**	**QC Batch**	**HENDRY-SED-7 SURFACE WATER**	**HENDRY-SED-7 SURFACE WATER Lab-Dup**	**RDL**	**QC Batch**
Calculated Parameters									
Anion Sum	me/L	1.39	2.63	N/A	2216531	1.80		N/A	2216531
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	51	92	1	2216528	56		1	2216528
Calculated TDS	mg/L	75	141	1	2216536	98		1	2216536
Carb. Alkalinity (calc. as CaCO3)	mg/L	ND	ND	1	2216528	ND		1	2216528
Cation Sum	me/L	1.32	2.38	N/A	2216531	1.68		N/A	2216531
Hardness (CaCO3)	mg/L	44	85	1	2216529	45		1	2216529
Ion Balance (% Difference)	%	2.58	4.99	N/A	2216530	3.45		N/A	2216530
Langelier Index (@ 20C)	N/A	-0.492	0.0450		2216534	-0.687			2216534
Langelier Index (@ 4C)	N/A	-0.744	-0.205		2216535	-0.938			2216535
Nitrate (N)	mg/L	0.09	0.23	0.05	2216532	ND		0.05	2216532
Saturation pH (@ 20C)	N/A	8.43	7.94		2216534	8.40			2216534
Saturation pH (@ 4C)	N/A	8.68	8.19		2216535	8.65			2216535
Inorganics									
Total Alkalinity (Total as CaCO3)	mg/L	52	93	5	2219163	57	57	5	2219163
Dissolved Chloride (Cl)	mg/L	12	14	1	2219165	23	24	1	2219165
Colour	TCU	35	27	5	2219173	75	74	30	2219173
Nitrate + Nitrite	mg/L	0.09	0.23	0.05	2219178	ND	ND	0.05	2219178
Nitrite (N)	mg/L	ND	ND	0.01	2219180	ND	ND	0.01	2219180
Nitrogen (Ammonia Nitrogen)	mg/L	ND	ND	0.05	2217942	ND		0.05	2217942
Total Organic Carbon (C)	mg/L	7.1	6.5	0.5	2221232	11		0.5	2221235
Orthophosphate (P)	mg/L	ND	ND	0.01	2219174	ND	ND	0.01	2219174
pH	pH	7.94	7.98	N/A	2220302	7.71		N/A	2220315
Reactive Silica (SiO2)	mg/L	4.3	4.8	0.5	2219172	5.1	5.1	0.5	2219172
Dissolved Sulphate (SO4)	mg/L	ND	18	2	2219169	ND	ND	2	2219169
Turbidity	NTU	0.7	1.8	0.1	2218978	1.2		0.1	2218978
Conductivity	uS/cm	140	250	1	2220313	180		1	2220317

N/A = Not Applicable
ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

ELEMENTS BY ICP/MS (WATER)

Maxxam ID		GP5743	GP5749	GP5796	GP5799		
Sampling Date		2010/07/20	2010/07/20	2010/07/20	2010/07/20		
	Units	**UNNAMED-SED-1 SURFACE WATER**	**UNNAMED-SED-2 SURFACE WATER**	**HENDRY-SED-1 SURFACE WATER**	**HENDRY-SED-2 SURFACE WATER**	**RDL**	**QC Batch**
Metals							
Dissolved Aluminum (Al)	ug/L	9	8	41	40	5	2218988
Total Aluminum (Al)	ug/L	10.5	10.0	70.5	81.4	5.0	2218164
Dissolved Antimony (Sb)	ug/L	ND	ND	ND	ND	1	2218988
Total Antimony (Sb)	ug/L	ND	ND	ND	ND	1.0	2218164
Dissolved Arsenic (As)	ug/L	1	1	1	ND	1	2218988
Total Arsenic (As)	ug/L	1.4	1.4	1.2	1.0	1.0	2218164
Dissolved Barium (Ba)	ug/L	160	190	40	36	1	2218988
Total Barium (Ba)	ug/L	167	186	42.9	39.1	1.0	2218164
Dissolved Beryllium (Be)	ug/L	ND	ND	ND	ND	1	2218988
Total Beryllium (Be)	ug/L	ND	ND	ND	ND	1.0	2218164
Dissolved Bismuth (Bi)	ug/L	ND	ND	ND	ND	2	2218988
Total Bismuth (Bi)	ug/L	ND	ND	ND	ND	2.0	2218164
Dissolved Boron (B)	ug/L	18	12	8	8	5	2218988
Total Boron (B)	ug/L	13.7	10.0	6.9	6.6	5.0	2218164
Dissolved Cadmium (Cd)	ug/L	0.16	0.04	0.04	0.03	0.02	2218988
Total Cadmium (Cd)	ug/L	0.267	0.076	0.059	0.053	0.017	2218164
Dissolved Calcium (Ca)	ug/L	130000	67000	22000	22000	100	2218988
Total Calcium (Ca)	ug/L	131000	67000	25000	23100	100	2218164
Dissolved Chromium (Cr)	ug/L	ND	ND	ND	ND	1	2218988
Total Chromium (Cr)	ug/L	ND	ND	ND	ND	1.0	2218164
Dissolved Cobalt (Co)	ug/L	ND	1.0	ND	ND	0.4	2218988
Total Cobalt (Co)	ug/L	0.41	0.92	ND	ND	0.40	2218164
Dissolved Copper (Cu)	ug/L	3	ND	ND	ND	2	2218988
Total Copper (Cu)	ug/L	2.9	ND	ND	ND	2.0	2218164
Dissolved Iron (Fe)	ug/L	130	180	62	68	50	2218988
Total Iron (Fe)	ug/L	312	186	93	109	50	2218164
Dissolved Lead (Pb)	ug/L	24	0.6	0.9	0.9	0.5	2218988
Total Lead (Pb)	ug/L	34.1	1.28	0.92	1.19	0.50	2218164
Dissolved Magnesium (Mg)	ug/L	6600	3600	1700	1700	100	2218988
Total Magnesium (Mg)	ug/L	6260	3470	1870	1800	100	2218164
Dissolved Manganese (Mn)	ug/L	660	5700	6	17	2	2218988
Total Manganese (Mn)	ug/L	662	7740	13.9	27.2	2.0	2218164
Dissolved Molybdenum (Mo)	ug/L	ND	ND	ND	ND	2	2218988

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

ELEMENTS BY ICP/MS (WATER)

Maxxam ID		GP5743	GP5749	GP5796	GP5799		
Sampling Date		2010/07/20	2010/07/20	2010/07/20	2010/07/20		
	Units	**UNNAMED-SED-1 SURFACE WATER**	**UNNAMED-SED-2 SURFACE WATER**	**HENDRY-SED-1 SURFACE WATER**	**HENDRY-SED-2 SURFACE WATER**	**RDL**	**QC Batch**
Total Molybdenum (Mo)	ug/L	ND	ND	ND	ND	2.0	2218164
Dissolved Nickel (Ni)	ug/L	ND	ND	ND	ND	2	2218988
Total Nickel (Ni)	ug/L	ND	ND	ND	ND	2.0	2218164
Total Phosphorus (P)	ug/L	ND	ND	ND	ND	100	2218164
Dissolved Potassium (K)	ug/L	2800	1700	510	500	100	2218988
Total Potassium (K)	ug/L	2750	1750	574	549	100	2218164
Dissolved Selenium (Se)	ug/L	ND	ND	ND	ND	1	2218988
Total Selenium (Se)	ug/L	ND	ND	ND	ND	1.0	2218164
Dissolved Silver (Ag)	ug/L	ND	ND	ND	ND	0.1	2218988
Total Silver (Ag)	ug/L	ND	ND	ND	ND	0.10	2218164
Dissolved Sodium (Na)	ug/L	6900	8600	9000	8900	100	2218988
Total Sodium (Na)	ug/L	6580	8480	9800	9540	100	2218164
Dissolved Strontium (Sr)	ug/L	300	170	53	50	2	2218988
Total Strontium (Sr)	ug/L	324	173	61.5	56.8	2.0	2218164
Dissolved Thallium (Tl)	ug/L	ND	ND	ND	ND	0.1	2218988
Total Thallium (Tl)	ug/L	ND	ND	ND	ND	0.10	2218164
Dissolved Tin (Sn)	ug/L	ND	ND	ND	ND	2	2218988
Total Tin (Sn)	ug/L	ND	ND	ND	ND	2.0	2218164
Dissolved Titanium (Ti)	ug/L	ND	ND	ND	ND	2	2218988
Total Titanium (Ti)	ug/L	ND	ND	ND	ND	2.0	2218164
Dissolved Uranium (U)	ug/L	0.2	0.3	ND	ND	0.1	2218988
Total Uranium (U)	ug/L	0.21	0.27	ND	ND	0.10	2218164
Dissolved Vanadium (V)	ug/L	ND	ND	ND	ND	2	2218988
Total Vanadium (V)	ug/L	ND	ND	ND	ND	2.0	2218164
Dissolved Zinc (Zn)	ug/L	8	6	5	ND	5	2218988
Total Zinc (Zn)	ug/L	6.5	8.0	5.3	6.3	5.0	2218164

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

ELEMENTS BY ICP/MS (WATER)

Maxxam ID		GP5821	GP5838	GP5842	GP5845	GP5867		
Sampling Date		2010/07/20	2010/07/21	2010/07/21	2010/07/21	2010/07/21		
	Units	**HENDRY-SED-3 SURFACE WATER**	**HENDRY-SED-4 SURFACE WATER**	**HENDRY-SED-5 SURFACE WATER**	**HENDRY-SED-6 SURFACE WATER**	**HENDRY-SED-7 SURFACE WATER**	**RDL**	**QC Batch**
Metals								
Dissolved Aluminum (Al)	ug/L	33	36	91	10	35	5	2218988
Total Aluminum (Al)	ug/L	63.9	77.2	139	30.5	136	5.0	2218164
Dissolved Antimony (Sb)	ug/L	ND	ND	ND	ND	ND	1	2218988
Total Antimony (Sb)	ug/L	ND	ND	ND	ND	ND	1.0	2218164
Dissolved Arsenic (As)	ug/L	ND	1	1	1	1	1	2218988
Total Arsenic (As)	ug/L	ND	1.1	1.5	1.2	1.8	1.0	2218164
Dissolved Barium (Ba)	ug/L	30	26	20	33	28	1	2218988
Total Barium (Ba)	ug/L	31.1	28.6	21.5	34.5	31.4	1.0	2218164
Dissolved Beryllium (Be)	ug/L	ND	ND	ND	ND	ND	1	2218988
Total Beryllium (Be)	ug/L	ND	ND	ND	ND	ND	1.0	2218164
Dissolved Bismuth (Bi)	ug/L	ND	ND	ND	ND	ND	2	2218988
Total Bismuth (Bi)	ug/L	ND	ND	ND	ND	ND	2.0	2218164
Dissolved Boron (B)	ug/L	6	7	6	12	5	5	2218988
Total Boron (B)	ug/L	5.8	5.3	5.1	9.5	5.2	5.0	2218164
Dissolved Cadmium (Cd)	ug/L	0.04	0.03	ND	0.02	0.06	0.02	2218988
Total Cadmium (Cd)	ug/L	0.034	0.036	0.040	0.037	0.095	0.017	2218164
Dissolved Calcium (Ca)	ug/L	20000	18000	15000	29000	16000	100	2218988
Total Calcium (Ca)	ug/L	20900	19300	16800	29800	16800	100	2218164
Dissolved Chromium (Cr)	ug/L	ND	ND	ND	ND	ND	1	2218988
Total Chromium (Cr)	ug/L	ND	ND	ND	ND	ND	1.0	2218164
Dissolved Cobalt (Co)	ug/L	ND	ND	ND	ND	ND	0.4	2218988
Total Cobalt (Co)	ug/L	ND	ND	ND	ND	ND	0.40	2218164
Dissolved Copper (Cu)	ug/L	ND	ND	ND	ND	ND	2	2218988
Total Copper (Cu)	ug/L	ND	ND	2.4	ND	ND	2.0	2218164
Dissolved Iron (Fe)	ug/L	57	73	110	96	250	50	2218988
Total Iron (Fe)	ug/L	86	110	153	166	482	50	2218164
Dissolved Lead (Pb)	ug/L	1.0	0.7	ND	1.0	1.2	0.5	2218988
Total Lead (Pb)	ug/L	0.72	0.99	1.55	1.37	4.66	0.50	2218164
Dissolved Magnesium (Mg)	ug/L	1900	1700	1400	3100	1600	100	2218988
Total Magnesium (Mg)	ug/L	1850	1770	1530	3120	1680	100	2218164
Dissolved Manganese (Mn)	ug/L	6	10	22	41	34	2	2218988
Total Manganese (Mn)	ug/L	13.8	20.5	41.7	86.6	54.6	2.0	2218164
Dissolved Molybdenum (Mo)	ug/L	ND	ND	ND	ND	ND	2	2218988

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

ELEMENTS BY ICP/MS (WATER)

Maxxam ID		GP5821	GP5838	GP5842	GP5845	GP5867		
Sampling Date		2010/07/20	2010/07/21	2010/07/21	2010/07/21	2010/07/21		
	Units	**HENDRY-SED-3 SURFACE WATER**	**HENDRY-SED-4 SURFACE WATER**	**HENDRY-SED-5 SURFACE WATER**	**HENDRY-SED-6 SURFACE WATER**	**HENDRY-SED-7 SURFACE WATER**	**RDL**	**QC Batch**
Total Molybdenum (Mo)	ug/L	ND	ND	ND	ND	ND	2.0	2218164
Dissolved Nickel (Ni)	ug/L	ND	ND	ND	ND	ND	2	2218988
Total Nickel (Ni)	ug/L	ND	ND	ND	ND	ND	2.0	2218164
Total Phosphorus (P)	ug/L	ND	ND	ND	ND	ND	100	2218164
Dissolved Potassium (K)	ug/L	560	480	380	910	240	100	2218988
Total Potassium (K)	ug/L	553	525	430	936	372	100	2218164
Dissolved Selenium (Se)	ug/L	ND	ND	ND	ND	ND	1	2218988
Total Selenium (Se)	ug/L	ND	ND	ND	ND	ND	1.0	2218164
Dissolved Silver (Ag)	ug/L	ND	ND	ND	ND	ND	0.1	2218988
Total Silver (Ag)	ug/L	ND	ND	ND	ND	ND	0.10	2218164
Dissolved Sodium (Na)	ug/L	10000	9900	9800	15000	17000	100	2218988
Total Sodium (Na)	ug/L	10200	10000	10400	15100	18800	100	2218164
Dissolved Strontium (Sr)	ug/L	49	44	35	88	41	2	2218988
Total Strontium (Sr)	ug/L	52.6	47.9	38.3	92.2	45.6	2.0	2218164
Dissolved Thallium (Tl)	ug/L	ND	ND	ND	ND	ND	0.1	2218988
Total Thallium (Tl)	ug/L	ND	ND	ND	ND	ND	0.10	2218164
Dissolved Tin (Sn)	ug/L	ND	ND	ND	ND	ND	2	2218988
Total Tin (Sn)	ug/L	ND	ND	ND	ND	ND	2.0	2218164
Dissolved Titanium (Ti)	ug/L	ND	ND	ND	ND	ND	2	2218988
Total Titanium (Ti)	ug/L	ND	ND	ND	ND	2.9	2.0	2218164
Dissolved Uranium (U)	ug/L	ND	ND	ND	ND	ND	0.1	2218988
Total Uranium (U)	ug/L	ND	ND	ND	ND	ND	0.10	2218164
Dissolved Vanadium (V)	ug/L	ND	ND	ND	ND	ND	2	2218988
Total Vanadium (V)	ug/L	ND	ND	ND	ND	ND	2.0	2218164
Dissolved Zinc (Zn)	ug/L	ND	5	ND	6	7	5	2218988
Total Zinc (Zn)	ug/L	ND	8.0	33.8	7.4	10.5	5.0	2218164

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

GENERAL COMMENTS

Sample	GP5749-01: Poor RCAp Ion Balance due to sample matrix.
Sample	GP5796-01: RCAp Ion Balance acceptable. Anion/cation agreement within 0.2 meq/L.
Sample	GP5799-01: RCAp Ion Balance acceptable. Anion/cation agreement within 0.2 meq/L.
Sample	GP5838-01: RCAp Ion Balance acceptable. Anion/cation agreement within 0.2 meq/L.

Maxxam Job #: B099031
Report Date: 2010/07/30

Conestoga-Rovers and Associates Ltd
Client Project #: 044453-02
Project name: BELLEDUNE ECO

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
2217942	Nitrogen (Ammonia Nitrogen)	2010/07/28	95	80 - 120	96	80 - 120	ND, RDL=0.05	mg/L	NC	25	110	80 - 120
2218164	Total Aluminum (Al)	2010/07/28	101	80 - 120	102	80 - 120	ND, RDL=5.0	ug/L	NC	25		
2218164	Total Antimony (Sb)	2010/07/28	114	80 - 120	110	80 - 120	ND, RDL=1.0	ug/L	NC	25		
2218164	Total Arsenic (As)	2010/07/28	100	80 - 120	99	80 - 120	ND, RDL=1.0	ug/L	NC	25		
2218164	Total Barium (Ba)	2010/07/28	NC	80 - 120	103	80 - 120	ND, RDL=1.0	ug/L	1.3	25		
2218164	Total Beryllium (Be)	2010/07/28	104	80 - 120	98	80 - 120	ND, RDL=1.0	ug/L	NC	25		
2218164	Total Bismuth (Bi)	2010/07/28	82	80 - 120	94	80 - 120	ND, RDL=2.0	ug/L	NC	25		
2218164	Total Boron (B)	2010/07/28	92	80 - 120	95	80 - 120	ND, RDL=5.0	ug/L	NC	25		
2218164	Total Cadmium (Cd)	2010/07/28	107	80 - 120	104	80 - 120	ND, RDL=0.017	ug/L	NC	25		
2218164	Total Calcium (Ca)	2010/07/28	NC	80 - 120	101	80 - 120	ND, RDL=100	ug/L	2.1	25		
2218164	Total Chromium (Cr)	2010/07/28	94	80 - 120	96	80 - 120	ND, RDL=1.0	ug/L	NC	25		
2218164	Total Cobalt (Co)	2010/07/28	93	80 - 120	94	80 - 120	ND, RDL=0.40	ug/L	NC	25		
2218164	Total Copper (Cu)	2010/07/28	NC	80 - 120	91	80 - 120	ND, RDL=2.0	ug/L	NC	25		
2218164	Total Iron (Fe)	2010/07/28	94	80 - 120	97	80 - 120	ND, RDL=50	ug/L	NC	25		
2218164	Total Lead (Pb)	2010/07/28	98	80 - 120	98	80 - 120	ND, RDL=0.50	ug/L	NC	25		
2218164	Total Magnesium (Mg)	2010/07/28	NC	80 - 120	96	80 - 120	ND, RDL=100	ug/L	2.6	25		
2218164	Total Manganese (Mn)	2010/07/28	NC	80 - 120	101	80 - 120	ND, RDL=2.0	ug/L	0.4	25		
2218164	Total Molybdenum (Mo)	2010/07/28	NC	80 - 120	106	80 - 120	ND, RDL=2.0	ug/L	NC	25		
2218164	Total Nickel (Ni)	2010/07/28	88	80 - 120	90	80 - 120	ND, RDL=2.0	ug/L	NC	25		
2218164	Total Phosphorus (P)	2010/07/28	107	80 - 120	105	80 - 120	ND, RDL=100	ug/L	NC	25		
2218164	Total Potassium (K)	2010/07/28	94	80 - 120	95	80 - 120	ND, RDL=100	ug/L	1.4	25		
2218164	Total Selenium (Se)	2010/07/28	106	80 - 120	104	80 - 120	ND, RDL=1.0	ug/L	NC	25		
2218164	Total Silver (Ag)	2010/07/28	96	80 - 120	93	80 - 120	ND, RDL=0.10	ug/L	NC	25		
2218164	Total Sodium (Na)	2010/07/28	92	80 - 120	92	80 - 120	ND, RDL=100	ug/L	1.8	25		
2218164	Total Strontium (Sr)	2010/07/28	NC	80 - 120	109	80 - 120	ND, RDL=2.0	ug/L	0.6	25		
2218164	Total Thallium (Tl)	2010/07/28	98	80 - 120	99	80 - 120	ND, RDL=0.10	ug/L	NC	25		
2218164	Total Tin (Sn)	2010/07/28	103	80 - 120	110	80 - 120	ND, RDL=2.0	ug/L	NC	25		
2218164	Total Titanium (Ti)	2010/07/28	116	80 - 120	122(1, 2)	80 - 120	ND, RDL=2.0	ug/L	NC	25		
2218164	Total Uranium (U)	2010/07/28	102	80 - 120	108	80 - 120	ND, RDL=0.10	ug/L	NC	25		
2218164	Total Vanadium (V)	2010/07/28	100	80 - 120	99	80 - 120	ND, RDL=2.0	ug/L	NC	25		
2218164	Total Zinc (Zn)	2010/07/28	98	80 - 120	100	80 - 120	ND, RDL=5.0	ug/L	NC	25		
2218978	Turbidity	2010/07/27					ND, RDL=0.1	NTU	11.5	25	97	80 - 120
2218988	Dissolved Aluminum (Al)	2010/07/29	97	80 - 120	105	80 - 120	ND, RDL=5	ug/L				
2218988	Dissolved Antimony (Sb)	2010/07/29	104	80 - 120	112	80 - 120	ND, RDL=1	ug/L				
2218988	Dissolved Arsenic (As)	2010/07/29	103	80 - 120	104	80 - 120	ND, RDL=1	ug/L				
2218988	Dissolved Barium (Ba)	2010/07/29	98	80 - 120	101	80 - 120	ND, RDL=1	ug/L				
2218988	Dissolved Beryllium (Be)	2010/07/29	105	80 - 120	108	80 - 120	ND, RDL=1	ug/L				
2218988	Dissolved Bismuth (Bi)	2010/07/29	71(1, 3)	80 - 120	99	80 - 120	ND, RDL=2	ug/L				
2218988	Dissolved Boron (B)	2010/07/29	107	80 - 120	104	80 - 120	ND, RDL=5	ug/L				
2218988	Dissolved Cadmium (Cd)	2010/07/29	106	80 - 120	103	80 - 120	ND, RDL=0.02	ug/L				

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**	**% Recovery**	**QC Limits**
2218988	Dissolved Calcium (Ca)	2010/07/29	100	80 - 120	106	80 - 120	ND, RDL=100	ug/L	1.1	25		
2218988	Dissolved Chromium (Cr)	2010/07/29	103	80 - 120	109	80 - 120	ND, RDL=1	ug/L				
2218988	Dissolved Cobalt (Co)	2010/07/29	103	80 - 120	107	80 - 120	ND, RDL=0.4	ug/L				
2218988	Dissolved Copper (Cu)	2010/07/29	NC	80 - 120	103	80 - 120	ND, RDL=2	ug/L				
2218988	Dissolved Iron (Fe)	2010/07/29	99	80 - 120	106	80 - 120	ND, RDL=50	ug/L				
2218988	Dissolved Lead (Pb)	2010/07/29	98	80 - 120	96	80 - 120	ND, RDL=0.5	ug/L				
2218988	Dissolved Magnesium (Mg)	2010/07/29	97	80 - 120	106	80 - 120	ND, RDL=100	ug/L				
2218988	Dissolved Manganese (Mn)	2010/07/29	102	80 - 120	108	80 - 120	ND, RDL=2	ug/L				
2218988	Dissolved Molybdenum (Mo)	2010/07/29	114	80 - 120	115	80 - 120	ND, RDL=2	ug/L				
2218988	Dissolved Nickel (Ni)	2010/07/29	97	80 - 120	107	80 - 120	ND, RDL=2	ug/L	0.9	25		
2218988	Dissolved Potassium (K)	2010/07/29	91	80 - 120	98	80 - 120	ND, RDL=100	ug/L				
2218988	Dissolved Selenium (Se)	2010/07/29	106	80 - 120	107	80 - 120	ND, RDL=1	ug/L				
2218988	Dissolved Silver (Ag)	2010/07/29	97	80 - 120	101	80 - 120	ND, RDL=0.1	ug/L				
2218988	Dissolved Sodium (Na)	2010/07/29	94	80 - 120	102	80 - 120	ND, RDL=100	ug/L				
2218988	Dissolved Strontium (Sr)	2010/07/29	NC	80 - 120	107	80 - 120	ND, RDL=2	ug/L				
2218988	Dissolved Thallium (Tl)	2010/07/29	105	80 - 120	103	80 - 120	ND, RDL=0.1	ug/L				
2218988	Dissolved Tin (Sn)	2010/07/29	101	80 - 120	111	80 - 120	ND, RDL=2	ug/L				
2218988	Dissolved Titanium (Ti)	2010/07/29	122(1, 4)	80 - 120	134(1, 2)	80 - 120	ND, RDL=2	ug/L				
2218988	Dissolved Uranium (U)	2010/07/29	109	80 - 120	103	80 - 120	ND, RDL=0.1	ug/L				
2218988	Dissolved Vanadium (V)	2010/07/29	105	80 - 120	113	80 - 120	ND, RDL=2	ug/L				
2218988	Dissolved Zinc (Zn)	2010/07/29	107	80 - 120	114	80 - 120	ND, RDL=5	ug/L				
2219163	Total Alkalinity (Total as CaCO3)	2010/07/28	NC	80 - 120	106	80 - 120	ND, RDL=5	mg/L	0.2	25	102	80 - 120
2219165	Dissolved Chloride (Cl)	2010/07/29	92	80 - 120	99	80 - 120	ND, RDL=1	mg/L	0.4	25	97	80 - 120
2219169	Dissolved Sulphate (SO4)	2010/07/28	115	80 - 120	105	80 - 120	ND, RDL=2	mg/L	NC	25	107	80 - 120
2219172	Reactive Silica (SiO2)	2010/07/29	NC	80 - 120	103	80 - 120	ND, RDL=0.5	mg/L	0.4	25	100	75 - 125
2219173	Colour	2010/07/29					ND, RDL=5	TCU	NC	25	102	80 - 120
2219174	Orthophosphate (P)	2010/07/29	91	80 - 120	103	80 - 120	ND, RDL=0.01	mg/L	NC	25	99	80 - 120
2219178	Nitrate + Nitrite	2010/07/29	101	80 - 120	102	80 - 120	ND, RDL=0.05	mg/L	NC	25	98	80 - 120
2219180	Nitrite (N)	2010/07/28	90	80 - 120	102	80 - 120	ND, RDL=0.01	mg/L	NC	25	104	80 - 120
2219522	Available Aluminum (Al)	2010/07/28	NC	75 - 125	100	75 - 125	ND, RDL=10	mg/kg	1.7	35	81	75 - 125
2219522	Available Antimony (Sb)	2010/07/28	77	75 - 125	110	75 - 125	ND, RDL=2	mg/kg	NC	35		
2219522	Available Arsenic (As)	2010/07/28	NC	75 - 125	100	75 - 125	ND, RDL=2	mg/kg	2.2	35	112	75 - 125
2219522	Available Barium (Ba)	2010/07/28	NC	75 - 125	101	75 - 125	ND, RDL=5	mg/kg	0.6	35	106	75 - 125
2219522	Available Beryllium (Be)	2010/07/28	105	75 - 125	99	75 - 125	ND, RDL=2	mg/kg	NC	35		
2219522	Available Bismuth (Bi)	2010/07/28	104	75 - 125	103	75 - 125	ND, RDL=2	mg/kg	NC	35		
2219522	Available Boron (B)	2010/07/28	75	75 - 125	98	75 - 125	ND, RDL=5	mg/kg	NC	35		
2219522	Available Cadmium (Cd)	2010/07/28	112	75 - 125	103	75 - 125	ND, RDL=0.3	mg/kg	NC	35		
2219522	Available Chromium (Cr)	2010/07/28	NC	75 - 125	102	75 - 125	ND, RDL=2	mg/kg	5.2	35	86	75 - 125
2219522	Available Cobalt (Co)	2010/07/28	NC	75 - 125	101	75 - 125	ND, RDL=1	mg/kg	1.5	35	94	75 - 125
2219522	Available Copper (Cu)	2010/07/28	NC	75 - 125	101	75 - 125	ND, RDL=2	mg/kg	1.9	35	93	75 - 125

Maxxam Job #: B099031
Report Date: 2010/07/30

Conestoga-Rovers and Associates Ltd
Client Project #: 044453-02
Project name: BELLEDUNE ECO

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**	**% Recovery**	**QC Limits**
2219522	Available Iron (Fe)	2010/07/28	NC	75 - 125	101	75 - 125	ND, RDL=50	mg/kg	1.2	35	94	75 - 125
2219522	Available Lead (Pb)	2010/07/28	NC	75 - 125	103	75 - 125	ND, RDL=0.5	mg/kg	3.8	35	102	75 - 125
2219522	Available Lithium (Li)	2010/07/28	NC	75 - 125	97	75 - 125	ND, RDL=2	mg/kg	2.4	35		
2219522	Available Manganese (Mn)	2010/07/28	NC	75 - 125	105	75 - 125	ND, RDL=2	mg/kg	1.4	35	101	75 - 125
2219522	Available Molybdenum (Mo)	2010/07/28	102	75 - 125	95	75 - 125	ND, RDL=2	mg/kg	NC	35		
2219522	Available Nickel (Ni)	2010/07/28	NC	75 - 125	99	75 - 125	ND, RDL=2	mg/kg	2.7	35	99	75 - 125
2219522	Available Rubidium (Rb)	2010/07/28	NC	75 - 125	103	75 - 125	ND, RDL=2	mg/kg	0.8	35		
2219522	Available Selenium (Se)	2010/07/28	102	75 - 125	109	75 - 125	ND, RDL=2	mg/kg	NC	35		
2219522	Available Silver (Ag)	2010/07/28	106	75 - 125	102	75 - 125	ND, RDL=0.5	mg/kg	NC	35		
2219522	Available Strontium (Sr)	2010/07/28	NC	75 - 125	99	75 - 125	ND, RDL=5	mg/kg	NC	35	86	75 - 125
2219522	Available Thallium (Tl)	2010/07/28	98	75 - 125	100	75 - 125	ND, RDL=0.1	mg/kg	NC	35		
2219522	Available Tin (Sn)	2010/07/28	100	75 - 125	96	75 - 125	ND, RDL=2	mg/kg	NC	35		
2219522	Available Uranium (U)	2010/07/28	103	75 - 125	101	75 - 125	ND, RDL=0.1	mg/kg	9.7	35		
2219522	Available Vanadium (V)	2010/07/28	NC	75 - 125	102	75 - 125	ND, RDL=2	mg/kg	6.1	35	101	75 - 125
2219522	Available Zinc (Zn)	2010/07/28	108	75 - 125	104	75 - 125	ND, RDL=5	mg/kg	2.5	35	108	75 - 125
2220302	pH	2010/07/28					5.78, RDL=N/A	pH	2.4	25	101	80 - 120
2220313	Conductivity	2010/07/28					ND, RDL=1	uS/cm	0.7	25	103	80 - 120
2220315	pH	2010/07/28					5.65, RDL=N/A	pH	0.4	25	101	80 - 120
2220317	Conductivity	2010/07/28					1, RDL=1	uS/cm	0	25	103	80 - 120
2221232	Total Organic Carbon (C)	2010/07/29	NC	80 - 120	98	80 - 120	ND, RDL=0.5	mg/L	4.0	25	101	80 - 120
2221235	Total Organic Carbon (C)	2010/07/29	99	80 - 120	100	80 - 120	ND, RDL=0.5	mg/L	NC	25	98	80 - 120

N/A = Not Applicable
RDL = Reportable Detection Limit
RPD = Relative Percent Difference
Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.
Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.
QC Standard: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.
NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.
NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.
(1) - Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.
(2) - Elevated recovery due to spiking solution artifact. No impact on sample data quality.
(3) - Low recovery due to sample matrix.
(4) - Recovery within acceptance limits.

Validation Signature Page

Maxxam Job #: B099031

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Mike Mac Gillivray

MIKE MACGILLIVRAY, Bedford Inorg Spvsr

==

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

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49 Elizabeth Ave., St John's, NL A1A 1W9 Tel: 709-754-0203 Fax: 709-754-8612 Toll Free: 1-888-492-7227
90 Esplanade Sydney, NS B1P 1A1 Tel: 902-567-1255 Fax: 902-539-6504 Toll Free: 1-888-535-7770
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MAXXAM Chain of Custody Record

COC #: B 101620

Page 1 of 4

This column for lab use only:

Client Code: 16279

Maxxam Job #: B099031

Cooler ID	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp
			7	3	1	
			8	8	9	

Integrity: YES NO
Integrity / Checklist by:
Labelled by:
Location / Bin #:

INVOICE INFORMATION:

Company Name: CRA FREDERICTON
Contact Name: NEIL BRODIE
Address: 466 HODGSON RD.
FREDERICTON, NB Postal Code: E3C 2G5
Email: nbrodie@craworld.com
Ph: 506-458-1248 Fax: 506-462-7646

REPORT INFORMATION (if differs from invoice):

Company Name: INTRINSIK ENV. SER.
Contact Name: CHRISTINE MOORE
Address: 5121 SACKVILLE ST.
HALIFAX Postal Code: B3J 1K1
Email:
Ph: 902-429-0278 Fax:

PO #:
Project # / Phase #: 055453-02
Project Name / Site Location: BELLEDUNE ECO
Quote: B02709
Site #:
Task Order #:
Sampled by: HM & JG

TURNAROUND TIME
Standard ☑
10 day ☐
If RUSH Specify Date:
Pre-schedule rush work
Charge for # Jars used but not submitted

Guideline Requirements / Detection Limits / Special Instructions

* CCME FWAL guidelines required
* Do not dispose of samples without permission from C. MOORE

*Specify Matrix: Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

Lab use	#	Field Sample Identification	Matrix*	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose Total or Diss Metals	RCAP-MS Choose Total or Diss Metals	Metals Water: Total Digest (Default Method) for well water, surface water	Metals Water: Dissolved for ground water	Metals Water: Mercury	Metals Soil: Metals & ~~Mercury~~ Default Available Digest Method	Metals Soil: Metals Total Digest - for Ocean sediments (HNO3/HF/HCLO4)	Metals Soil: Mercury Low level by Cold Vapour AA	Metals Soil: Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Metals Soil: Hot Water soluble Boron (required for CCME Agricultural)	Hydrocarbons: RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons: Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	Hydrocarbons: NB Potable Water BTEX, VPH, Low level T.E.H.	Hydrocarbons: TPH Fractionation	Hydrocarbons: PAH's	Hydrocarbons: PAH's with Acridine, Quinoline				
GP5736	1	UNNAMED - SED - 1	SED	JULY 20	250mL	N							X					as per 3050B & 6020A						(no mercury)			
GP5743-01,02	2	↓	SURFACE WATER	↓	1x50mL	P				X																	
	3	↓	↓	↓	1x50mL	F+P					X																
	4	↓	↓	↓	1x200mL	N			X																		
GP5748	5	UNNAMED - SED - 2	SED	JULY 20	250mL	N							X											(no mercury)			
GP5749-01,02	6	↓	SURFACE WATER	↓	1x50mL	P				X																	
	7	↓	↓	↓	1x50mL	F+P					X																
	8	↓	↓	↓	1x200mL	N			X																		
GP5794	9	HENDRY - SED - 1	SED	JULY 20	1x250mL	N							X											(no mercury)			
GP5796-01,02	10	↓	SURFACE WATER	↓	1x50mL	P				X																	

RELINQUISHED BY: (Signature/Print) HEATHER MACDONALD H MacDonald Date: JULY 22/010 Time: 2pm

RECEIVED BY: (Signature/Print) Date Time

2010 JUL 23 AM 9:01

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MAXXAM Chain of Custody Record

COC #: B 101616

Page 2 of 4

This column for lab use only:
Client Code 16279
Maxxam Job # B099631 87

Cooler ID	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp

Integrity YES NO
Integrity / Checklist by
Labelled by
Location / Bin #

INVOICE INFORMATION:
Company Name:
Contact Name:
Address:
Postal Code
Email:
Ph:
Fax:

REPORT INFORMATION (if differs from invoice):
Company Name:
Contact Name:
Address:
Postal Code
Email:
Ph:
Fax:

PO #
Project # / Phase # 055453-02
Project Name / Site Location BELLEDUNE ECO
Quote B02709
Site #
Task Order #
Sampled by HM & JG

TURNAROUND TIME
Standard ☑
10 day ☐
If RUSH Specify Date:
Pre-schedule rush work
Charge for # Jars used but not submitted

Guideline Requirements / Detection Limits / Special Instructions

*Specify Matrix: Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

Lab use		Field Sample Identification	Matrix*	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose Total or Diss Metals	RCAP-MS Choose Total or Diss Metals	Metals Water: Total Digest (Default Method) for well water, surface water	Metals Water: Dissolved for ground water	Metals Water: Mercury	Metals Soil: Metals & ~~Mercury~~ Default Available Digest Method	Metals Soil: Metals Total Digest - for Ocean sediments (HNO3/HF/HCLO4)	Metals Soil: Mercury Low level by Cold Vapour AA	Metals Soil: Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Metals Soil: Hot Water soluble Boron (required for CCME Agricultural)	Hydrocarbons: RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons: Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	Hydrocarbons: NB Potable Water BTEX, VPH, Low level T.E.H.	Hydrocarbons: TPH Fractionation	Hydrocarbons: PAH's	Hydrocarbons: PAH's with Acridine, Quinoline	
GP5796-01,02	1	HENDRY-SED-1	SURFACE WATER	JULY 20	1x50mL	F+P					X													
	2	↓	↓	↓	1x200mL	N			X															
GP5798	3	HENDRY-SED-2	SED	JULY 20	1x250mL	N							X											(no mercury)
GP5799-01,02	4		SURFACE WATER		1x50mL	P				X														
	5				1x50mL	F+P					X													
	6	↓	↓	↓	1x200mL	N			X															
GP5820	7	HENDRY-SED-3	SED	JULY 20	1x250	N							X											(no mercury)
GP5821-01,02	8		SURFACE WATER		1x50mL	P				X														
	9				1x50mL	F+P					X													2010 JUL 23 AM 9:01
	10	↓	↓	↓	1x200mL	N			X															

RELINQUISHED BY: (Signature/Print)	Date	Time	RECEIVED BY: (Signature/Print)	Date	Time
HEATHER MACDONALD	JULY 22/010	2pm			

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90 Esplanade Sydney, NS B1P 1A1 Tel: 902-567-1255 Fax: 902-539-6504 Toll Free: 1-888-535-7770
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MAXXAM Chain of Custody Record

COC #: B 101617

Page 3 of 4

This column for lab use only:

Client Code 16279

Maxxam Job # B099D31 83

Cooler ID	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp

Integrity YES NO

Integrity / Checklist by

Labelled by

Location / Bin #

INVOICE INFORMATION:

Company Name:
Contact Name:
Address:
Postal Code
Email:
Ph:
Fax:

REPORT INFORMATION (if differs from invoice):

Company Name:
Contact Name:
Address:
Postal Code
Email:
Ph:
Fax:

PO #
Project # / Phase # 055453 - 02
Project Name / Site Location BELLEDUNE ECO
Quote B02709
Site #
Task Order #
Sampled by HM & JG

TURNAROUND TIME
Standard ☑
10 day ☐
If RUSH Specify Date:
Pre-schedule rush work
Charge for # Jars used but not submitted

Guideline Requirements / Detection Limits / Special Instructions

*Specify Matrix: Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

Lab use	#	Field Sample Identification	Matrix*	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose Total or Diss Metals	RCAP-MS Choose Total or Diss Metals	Metals Water: Total Digest (Default Method) for well water, surface water	Metals Water: Dissolved for ground water	Metals Water: Mercury	Metals Soil: Metals & ~~Mercury~~ Default Available Digest Method	Metals Soil: Metals Total Digest - for Ocean sediments (HNO3/HF/HCLO4)	Metals Soil: Mercury Low level by Cold Vapour AA	Metals Soil: Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Metals Soil: Hot Water soluble Boron (required for CCME Agricultural)	Hydrocarbons: RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons: Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	Hydrocarbons: NB Potable Water BTEX, VPH, Low level T.E.H.	Hydrocarbons: TPH Fractionation	Hydrocarbons: PAH's	Hydrocarbons: PAH's with Acridine, Quinoline	
GP5823	1	HENDRY-SED-4	SED	JULY 21	1x250mL	N							X											(no mercury)
GP5838-01,02	2	↓	SURFACE WATER	↓	1x50mL	P				X														
	3		↓		1x50mL	F+P					X													
	4				1x200mL	N			X															
GP5841	5	HENDRY-SED-5	SED	↓	1x250mL	N							X											(no mercury)
GP5842-01,02	6	↓	SURFACE WATER		1x50mL	P				X														
	7		↓		1x50mL	F+P					X													
	8				1x200mL	N			X															
GP5844	9	HENDRY-SED-6	SED		1x250mL	N							X											(no mercury)
GP5845	10	↓	SURFACE WATER		1x50mL	P				X														

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MAXXAM Chain of Custody Record

COC #: B 101618

Page 4 of 4

This column for lab use only:

Client Code 16279

Maxxam Job # B099031

Cooler ID	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp

Integrity YES NO

Integrity / Checklist by

Labelled by

Location / Bin #

INVOICE INFORMATION:

Company Name:
Contact Name:
Address:
Postal Code
Email:
Ph: Fax:

REPORT INFORMATION (if differs from invoice):

Company Name:
Contact Name:
Address:
Postal Code
Email:
Ph: Fax:

PO #
Project # / Phase # 055453-02
Project Name / Site Location BELLEDUNE ECO
Quote B02709
Site #
Task Order #
Sampled by HM & JG

TURNAROUND TIME

Standard ☑
10 day ☐
If RUSH Specify Date:
Pre-schedule rush work
Charge for # Jars used but not submitted

Guideline Requirements / Detection Limits / Special Instructions

*Specify Matrix: Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

		Field Sample Identification	Matrix*	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose Total or Diss Metals	RCAP-MS Choose Total or Diss Metals	Metals Water: Total Digest (Default Method) for well water, surface water	Metals Water: Dissolved for ground water	Metals Water: Mercury	Metals Soil: Metals & ~~Mercury~~ Default Available Digest Method	Metals Soil: Metals Total Digest - for Ocean sediments (HNO3/HF/HCLO4)	Metals Soil: Mercury Low level by Cold Vapour AA	Metals Soil: Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Metals Soil: Hot Water soluble Boron (required for CCME Agricultural)	Hydrocarbons: RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons: Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	Hydrocarbons: NB Potable Water BTEX, VPH, Low level T.E.H.	Hydrocarbons: TPH Fractionation	Hydrocarbons: PAH's	Hydrocarbons: PAH's with Acridine, Quinoline	
GP5845-01,02	1	HENDRY-SED-6	SURFACE WATER	July 21	1x50mL	F+P					X													
	2	↓	↓	↓	1x200mL	N			X															
GP5866	3	HENDRY-SED-7	SED		1x250mL	N							X											(no mercury)
GP5867-01,02	4		SURFACE WATER		1x50mL	P				X														
	5				1x50mL	F+P																		
	6	↓	↓	↓	1x200mL	N																		
	7																							
	8																							
	9																							
	10																							

RELINQUISHED BY: (Signature/Print)	Date	Time	RECEIVED BY: (Signature/Print)	Date	Time
HEATHER MACDONALD	July 22/010	2pm		2010 JUL 23 AM 9:01	

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ATL FCD 00149 / Revision 10

Intrinsik Environmental Sciences
Maxxam Job #: B0B4390 — Client Project #: 30075
Report Date: 2010/09/10 — Project name: BELLEDUNE SMELTER ERA
Sampler Initials:

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		GX6124	GX6134	GX6135	GX6136
Sampling Date		8/10/2010	8/10/2010	8/10/2010	8/10/2010
COC Number		B 100986	B 100986	B 100986	B 100986
	Units	**BS-T1-1 SOIL**	**BS-T1-2 SOIL**	**BS-T1-3 SOIL**	**BS-T1-4 SOIL**
Metals					
Available Aluminum (Al)	mg/kg	14000	12000	13000	16000
Available Antimony (Sb)	mg/kg	11	ND	ND	3
Available Arsenic (As)	mg/kg	50	15	16	26
Available Barium (Ba)	mg/kg	70	110	66	83
Available Beryllium (Be)	mg/kg	ND	ND	ND	ND
Available Bismuth (Bi)	mg/kg	7	ND	ND	ND
Available Boron (B)	mg/kg	ND	ND	ND	ND
Available Cadmium (Cd)	mg/kg	16	2.7	2.2	2.6
Available Chromium (Cr)	mg/kg	31	31	28	28
Available Cobalt (Co)	mg/kg	12	10	9	17
Available Copper (Cu)	mg/kg	99	30	25	30
Available Iron (Fe)	mg/kg	27000	25000	28000	39000
Available Lead (Pb)	mg/kg	1600	180	160	160
Available Lithium (Li)	mg/kg	18	14	16	17
Available Manganese (Mn)	mg/kg	680	990	410	1300
Available Molybdenum (Mo)	mg/kg	ND	ND	ND	ND
Available Nickel (Ni)	mg/kg	29	23	22	37
Available Rubidium (Rb)	mg/kg	7	8	8	10
Available Selenium (Se)	mg/kg	ND	ND	ND	ND
Available Silver (Ag)	mg/kg	2.9	ND	ND	ND
Available Strontium (Sr)	mg/kg	11	7	6	12
Available Thallium (Tl)	mg/kg	4.8	0.8	0.6	0.8
Available Tin (Sn)	mg/kg	10	ND	ND	ND
Available Uranium (U)	mg/kg	0.6	0.7	0.6	0.6
Available Vanadium (V)	mg/kg	52	54	55	61
Available Zinc (Zn)	mg/kg	440	130	110	140

ND = Not detected
RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
EDL = Estimated Detection Limit
QC Batch = Quality Control Batch
(1) Elevated reporting limit due to sample matrix.

GX6137	GX6138	GX6139	GX6140	GX6141	GX6142	
8/11/2010	8/11/2010	8/11/2010	8/11/2010	8/12/2010	8/12/2010	
B 100986	B 100986	B 100986	B 100986	B 100986	B 100986	
BS-T2-1 SOIL	**BS-T2-2 SOIL**	**BS-T2-3 SOIL**	**BS-T2-4 SOIL**	**BS-T3-1 SOIL**	**BS-T3-2 SOIL**	**RDL**
9800	6000	7500	14000	1900	8000	10
3	4	3	3	2	4	2
23	20	19	18	7	19	2
140	63	31	110	230	57	5
ND	ND	ND	ND	ND	ND	2
2	ND	ND	ND	ND	ND	2
ND	ND	ND	ND	6	ND	5
9.3	7.2	2.4	1.6	6.4	3.4	0.3
27	13	14	23	6	15	2
8	5	4	11	1	5	1
29	30	13	23	23	22	2
16000	16000	24000	31000	3100	21000	50
490	480	140	120	270	380	0.5
11	5	8	19	2	8	2
380	1300	210	940	100	310	2
ND	ND	ND	ND	ND	ND	2
21	7	10	23	4	9	2
5	6	8	10	ND	8	2
ND	ND	ND	ND	ND	ND	2
0.9	0.6	ND	ND	0.6	0.6	0.5
22	7	ND	6	48	6	5
2.7	1.7	0.4	0.5	1.2	1.3	0.1
2	7	3	ND	ND	5	2
0.8	0.4	0.3	0.6	9.0	0.4	0.1
47	27	72	60	17	44	2
270	480	230	120	170	220	5

GX6231		GX6236	GX6237	GX6238	GX6239	GX6240
8/12/2010		8/12/2010	8/13/2010	8/13/2010	8/13/2010	8/13/2010
B 100987		B 100987	B 100987	B 100987	B 100987	B 100987
BS-T3-3-SOIL	**RDL**	**BS-T3-4-SOIL**	**BS-T4-1-SOIL**	**BS-T4-2-SOIL**	**BS-T4-3-SOIL**	**BS-T5-1-SOIL**
12000	10	4000	12000	12000	9600	12000
2	2	ND	ND	4	2	5
14	2	5	14	21	13	31
120	5	22	44	170	48	59
ND	2	ND	ND	ND	ND	ND
ND	2	ND	ND	2	ND	2
ND	5	ND	ND	ND	ND	ND
1.6	0.3	1.0	2.6	6.7	1.5	5.5
29	2	9	23	23	19	26
10	1	2	7	9	7	9
19	2	6	15	27	14	38
22000	50	14000	25000	27000	24000	25000
110	0.5	51	110	430	150	610
17	2	ND	16	15	13	15
800	2	56	290	780	540	520
ND	2	ND	ND	ND	ND	ND
27	2	4	18	16	13	20
9	2	5	9	11	8	8
ND	2	ND	ND	ND	ND	ND
ND	0.5	ND	ND	0.8	ND	1.0
ND (1)	50	ND	ND	8	ND	ND
0.4	0.1	0.3	0.8	1.8	0.6	6.2
4	2	ND	ND	2	ND	2
0.7	0.1	0.2	0.4	0.6	0.3	0.4
42	2	32	45	44	36	53
200	5	35	74	150	100	120

GX6241	GX6241	GX6242	GX6243	GX6244		
8/12/2010	8/12/2010	8/14/2010	8/14/2010	8/14/2010		
B 100987	B 100987	B 100987	B 100987	B 100987		
BS-T5-2-SOIL	**BS-T5-2-SOIL Lab-Dup**	**BS-REF-1-SOIL**	**BS-REF2-SOIL**	**BS-REF3-SOIL**	**RDL**	**QC Batch**
4600	4400	6800	4900	13000	10	2246759
8	8	ND	ND	ND	2	2246759
40	34	3	ND	3	2	2246759
29	29	51	48	43	5	2246759
ND	ND	ND	ND	ND	2	2246759
5	5	ND	ND	ND	2	2246759
ND	ND	ND	ND	ND	5	2246759
8.9	8.1	ND	ND	ND	0.3	2246759
11	12	13	9	17	2	2246759
3	3	4	2	6	1	2246759
43	44	8	5	6	2	2246759
17000	16000	25000	17000	33000	50	2246759
1100	1000	36	30	16	0.5	2246759
3	3	3	2	9	2	2246759
100	100	600	200	910	2	2246759
ND	ND	ND	ND	ND	2	2246759
6	6	5	4	9	2	2246759
7	6	4	3	6	2	2246759
ND	ND	ND	ND	ND	2	2246759
1.9	1.7	ND	ND	ND	0.5	2246759
ND	ND	5	7	ND	5	2246759
6.0	5.7	0.1	0.1	ND	0.1	2246759
3	3	ND	ND	ND	2	2246759
0.4	0.4	0.3	0.3	0.3	0.1	2246759
41	41	54	32	58	2	2246759
130	120	33	27	48	5	2246759

GX6984		GX6985	GX6986			GY2620	
8/14/2010		8/14/2010	8/14/2010			8/20/2010	
B 100988		B 100988	B 100988			B 100986	
BS-REF4-SOIL	**RDL**	**QA/QCA**	**QA/QCB**	**RDL**	**QC Batch**	**ERA Sample #1**	**QC Batch**
18000	10	8800	11000	10	2246778	9000	2246759
ND	2	2	6	2	2246778	230	2246759
ND	2	16	36	2	2246778	130	2246759
78	5	38	57	5	2246778	260	2246759
ND	2	ND	ND	2	2246778	150	2246759
ND	2	ND	3	2	2246778	ND	2246759
ND	5	ND	ND	5	2246778	90	2246759
ND	0.3	3.1	7.7	0.3	2246778	71	2246759
20	2	19	25	2	2246778	110	2246759
27	1	6	9	1	2246778	140	2246759
25	2	17	36	2	2246778	110	2246759
50000	500	22000	24000	50	2246778	17000	2246759
4.6	0.5	180	710	0.5	2246778	140	2246759
12	2	11	14	2	2246778	9	2246759
1400	2	300	680	2	2246778	540	2246759
ND	2	ND	ND	2	2246778	100	2246759
22	2	13	18	2	2246778	140	2246759
ND	2	8	8	2	2246778	24	2246759
ND	2	ND	ND	2	2246778	200	2246759
ND	0.5	ND	1.1	0.5	2246778	46	2246759
81	50	ND	ND	5	2246778	220	2246759
0.2	0.1	1.0	5.9	0.1	2246778	160	2246759
ND	2	ND	2	2	2246778	170	2246759
0.2	0.1	0.3	0.4	0.1	2246778	1.7	2246759
84	2	43	48	2	2246778	70	2246759
78	5	80	130	5	2246778	230	2246759

GY2621		
8/20/2010		
B 100986		
ERA Sample #2	**RDL**	**QC Batch**
8100	10	2246778
220	2	2246778
130	2	2246778
250	5	2246778
150	2	2246778
ND	2	2246778
82	5	2246778
71	0.3	2246778
100	2	2246778
140	1	2246778
100	2	2246778
16000	50	2246778
140	0.5	2246778
8	2	2246778
550	2	2246778
100	2	2246778
130	2	2246778
23	2	2246778
200	2	2246778
49	5	2246778
220	5	2246778
160	0.1	2246778
170	2	2246778
1.7	0.1	2246778
63	2	2246778
220	5	2246778

Maxxam Job #: B0B4390
Report Date: 2010/09/10

Intrinsik Environmental Sciences
Client Project #: 30075
Project name: BELLEDUNE SMELTER ERA
Sampler Initials:

ELEMENTS BY ICP/MS (TISSUE)

Maxxam ID		GX6918		GX6995	HA9049
Sampling Date		8/16/2010		8/12/2010	8/20/2010
COC Number		B 100980		B 100988	B 100986
	Units	**REF-4**	**RDL**	**T1-1**	**COMPOSITE-REF-1, REF-2, & REF-3**
Metals					
Aluminum (Al)	mg/kg	49.3	5.0	306	382
Antimony (Sb)	mg/kg	ND	1.0	ND	ND
Arsenic (As)	mg/kg	ND	1.0	2.93	ND
Barium (Ba)	mg/kg	24.3	3.0	29.7	107
Beryllium (Be)	mg/kg	ND	1.0	ND	ND
Boron (B)	mg/kg	4.0	3.0	5.1	3.2
Cadmium (Cd)	mg/kg	0.46	0.10	3.55	6.86
Chromium (Cr)	mg/kg	ND	1.0	1.38	ND
Cobalt (Co)	mg/kg	ND	0.40	0.48	ND
Copper (Cu)	mg/kg	50.9	1.0	60.5	26.1
Iron (Fe)	mg/kg	115	30	478	405
Lead (Pb)	mg/kg	1.32	0.36	0.96	3.40
Lithium (Li)	mg/kg	ND	1.0	ND	ND
Manganese (Mn)	mg/kg	61.8	1.0	28.2	2760
Molybdenum (Mo)	mg/kg	ND	1.0	ND	ND
Nickel (Ni)	mg/kg	ND	1.0	0.96	ND
Selenium (Se)	mg/kg	ND	1.0	2.70	1.03
Silver (Ag)	mg/kg	ND	0.24	0.80	0.47
Strontium (Sr)	mg/kg	14.2	3.0	10.3	19.9
Thallium (Tl)	mg/kg	ND	0.040	0.543	0.111
Tin (Sn)	mg/kg	ND	1.0	2.31	0.54
Uranium (U)	mg/kg	ND	0.040	0.025	ND
Vanadium (V)	mg/kg	ND	1.0	0.74	0.79
Zinc (Zn)	mg/kg	164	3.0	332	247

ND = Not detected
RDL = Reportable Detection Limit
EDL = Estimated Detection Limit
QC Batch = Quality Control Batch

HA9076	HA9077	HA9078
8/20/2010	8/20/2010	8/20/2010
B 100986	B 100986	B 100986
COMPOSITE-T2-1, T3-1, T4-1, & T5-1	**COMPOSITE-T1-2, T3-2, T4-2, & T5-2**	**COMPOSITE-T1-3 & T2-3**
85.4	511	1440
1.65	0.52	1.54
31.9	13.5	14.1
21.6	27.1	38.6
ND	ND	ND
7.5	3.6	3.9
59.8	26.3	64.1
0.62	1.52	2.65
0.37	0.73	1.38
55.4	19.6	42.1
330	743	2240
254	395	116
ND	0.55	1.77
71.0	108	92.9
ND	ND	ND
ND	0.88	2.55
2.79	4.72	4.05
2.21	0.27	3.83
11.6	5.9	14.8
3.85	0.688	1.03
3.07	2.44	ND
0.071	0.051	0.074
0.68	1.48	4.86
1640	296	933

HA9079	HA9080		
8/20/2010	8/20/2010		
B 100986	B 100986		
COMPOSITE-T3-3 & T4-3	**COMPOSITE-T1-4, T2-4, & T3-4**	**RDL**	**QC Batch**
35.9	699	2.5	2257659
ND	ND	0.50	2257659
5.29	4.48	0.50	2257659
3.6	10.6	1.5	2257659
ND	ND	0.50	2257659
2.1	3.6	1.5	2257659
9.27	17.1	0.050	2257659
ND	1.09	0.50	2257659
ND	0.71	0.20	2257659
14.5	28.3	0.50	2257659
107	1270	15	2257659
4.52	18.8	0.18	2257659
ND	0.62	0.50	2257659
20.1	329	0.50	2257659
0.50	ND	0.50	2257659
ND	1.37	0.50	2257659
2.46	1.33	0.50	2257659
0.12	0.76	0.12	2257659
2.8	4.4	1.5	2257659
0.213	0.284	0.020	2257659
0.57	1.74	0.50	2257659
ND	0.021	0.020	2257659
ND	1.95	0.50	2257659
167	345	1.5	2257659

GENERAL COMMENTS

Sample GX6918-01: Elevated reporting limits for trace metals due to a low sample weight used for digestion.

Intrinsik Environmental Sciences
Attention: Christine Moore
Client Project #: 30075
P.O. #:
Project name: BELLEDUNE SMELTER ERA

Quality Assurance Report
Maxxam Job Number: DB0B4390

QA/QC Batch Num	Init	QC Type	Date Analyzed Parameter	yyyy/mm/dd	Value	Recovery	Units	QC Limits
2246759	MPT	Matrix Spike	Available Aluminum (Al)	8/26/2010		NC	%	75 - 125
			Available Antimony (Sb)	8/26/2010		78	%	75 - 125
			Available Arsenic (As)	8/26/2010		NC	%	75 - 125
			Available Barium (Ba)	8/26/2010		NC	%	75 - 125
			Available Beryllium (Be)	8/26/2010		103	%	75 - 125
			Available Bismuth (Bi)	8/26/2010		103	%	75 - 125
			Available Boron (B)	8/26/2010		87	%	75 - 125
			Available Cadmium (Cd)	8/26/2010		104	%	75 - 125
			Available Chromium (Cr)	8/26/2010		NC	%	75 - 125
			Available Cobalt (Co)	8/26/2010		109	%	75 - 125
			Available Copper (Cu)	8/26/2010		NC	%	75 - 125
			Available Iron (Fe)	8/26/2010		NC	%	75 - 125
			Available Lead (Pb)	8/26/2010		NC	%	75 - 125
			Available Lithium (Li)	8/26/2010		111	%	75 - 125
			Available Manganese (Mn)	8/26/2010		NC	%	75 - 125
			Available Molybdenum (Mo)	8/26/2010		105	%	75 - 125
			Available Nickel (Ni)	8/26/2010		108	%	75 - 125
			Available Rubidium (Rb)	8/26/2010		94	%	75 - 125
			Available Selenium (Se)	8/26/2010		105	%	75 - 125
			Available Silver (Ag)	8/26/2010		106	%	75 - 125
			Available Strontium (Sr)	8/26/2010		104	%	75 - 125
			Available Thallium (Tl)	8/26/2010		101	%	75 - 125
			Available Tin (Sn)	8/26/2010		110	%	75 - 125
			Available Uranium (U)	8/26/2010		110	%	75 - 125
			Available Vanadium (V)	8/26/2010		NC	%	75 - 125
			Available Zinc (Zn)	8/26/2010		101	%	75 - 125
		QC Standard	Available Aluminum (Al)	8/26/2010		85	%	75 - 125
			Available Arsenic (As)	8/26/2010		114	%	75 - 125
			Available Barium (Ba)	8/26/2010		114	%	75 - 125
			Available Chromium (Cr)	8/26/2010		90	%	75 - 125
			Available Cobalt (Co)	8/26/2010		109	%	75 - 125
			Available Copper (Cu)	8/26/2010		91	%	75 - 125
			Available Iron (Fe)	8/26/2010		94	%	75 - 125
			Available Lead (Pb)	8/26/2010		102	%	75 - 125
			Available Manganese (Mn)	8/26/2010		102	%	75 - 125
			Available Nickel (Ni)	8/26/2010		102	%	75 - 125
			Available Strontium (Sr)	8/26/2010		87	%	75 - 125
			Available Vanadium (V)	8/26/2010		109	%	75 - 125
			Available Zinc (Zn)	8/26/2010		104	%	75 - 125
		Spiked Blank	Available Aluminum (Al)	8/26/2010		98	%	75 - 125

	Available Antimony (Sb)	8/26/2010	96		%	75 - 125
	Available Arsenic (As)	8/26/2010	98		%	75 - 125
	Available Barium (Ba)	8/26/2010	98		%	75 - 125
	Available Beryllium (Be)	8/26/2010	93		%	75 - 125
	Available Bismuth (Bi)	8/26/2010	100		%	75 - 125
	Available Boron (B)	8/26/2010	93		%	75 - 125
	Available Cadmium (Cd)	8/26/2010	97		%	75 - 125
	Available Chromium (Cr)	8/26/2010	99		%	75 - 125
	Available Cobalt (Co)	8/26/2010	98		%	75 - 125
	Available Copper (Cu)	8/26/2010	95		%	75 - 125
	Available Iron (Fe)	8/26/2010	98		%	75 - 125
	Available Lead (Pb)	8/26/2010	99		%	75 - 125
	Available Lithium (Li)	8/26/2010	94		%	75 - 125
	Available Manganese (Mn)	8/26/2010	97		%	75 - 125
	Available Molybdenum (Mo)	8/26/2010	95		%	75 - 125
	Available Nickel (Ni)	8/26/2010	98		%	75 - 125
	Available Rubidium (Rb)	8/26/2010	97		%	75 - 125
	Available Selenium (Se)	8/26/2010	100		%	75 - 125
	Available Silver (Ag)	8/26/2010	97		%	75 - 125
	Available Strontium (Sr)	8/26/2010	97		%	75 - 125
	Available Thallium (Tl)	8/26/2010	96		%	75 - 125
	Available Tin (Sn)	8/26/2010	104		%	75 - 125
	Available Uranium (U)	8/26/2010	100		%	75 - 125
	Available Vanadium (V)	8/26/2010	101		%	75 - 125
	Available Zinc (Zn)	8/26/2010	95		%	75 - 125
Method Blank	Available Aluminum (Al)	8/26/2010	ND	RDL=10	mg/kg	
	Available Antimony (Sb)	8/26/2010	ND	RDL=2	mg/kg	
	Available Arsenic (As)	8/26/2010	ND	RDL=2	mg/kg	
	Available Barium (Ba)	8/26/2010	ND	RDL=5	mg/kg	
	Available Beryllium (Be)	8/26/2010	ND	RDL=2	mg/kg	
	Available Bismuth (Bi)	8/26/2010	ND	RDL=2	mg/kg	
	Available Boron (B)	8/26/2010	ND	RDL=5	mg/kg	
	Available Cadmium (Cd)	8/26/2010	ND	RDL=0.3	mg/kg	
	Available Chromium (Cr)	8/26/2010	ND	RDL=2	mg/kg	
	Available Cobalt (Co)	8/26/2010	ND	RDL=1	mg/kg	
	Available Copper (Cu)	8/26/2010	ND	RDL=2	mg/kg	
	Available Iron (Fe)	8/26/2010	ND	RDL=50	mg/kg	
	Available Lead (Pb)	8/26/2010	ND	RDL=0.5	mg/kg	
	Available Lithium (Li)	8/26/2010	ND	RDL=2	mg/kg	
	Available Manganese (Mn)	8/26/2010	ND	RDL=2	mg/kg	
	Available Molybdenum (Mo)	8/26/2010	ND	RDL=2	mg/kg	
	Available Nickel (Ni)	8/26/2010	ND	RDL=2	mg/kg	
	Available Rubidium (Rb)	8/26/2010	ND	RDL=2	mg/kg	
	Available Selenium (Se)	8/26/2010	ND	RDL=2	mg/kg	
	Available Silver (Ag)	8/26/2010	ND	RDL=0.5	mg/kg	
	Available Strontium (Sr)	8/26/2010	ND	RDL=5	mg/kg	
	Available Thallium (Tl)	8/26/2010	ND	RDL=0.1	mg/kg	
	Available Tin (Sn)	8/26/2010	ND	RDL=2	mg/kg	
	Available Uranium (U)	8/26/2010	ND	RDL=0.1	mg/kg	
	Available Vanadium (V)	8/26/2010	ND	RDL=2	mg/kg	
	Available Zinc (Zn)	8/26/2010	ND	RDL=5	mg/kg	
RPD	Available Aluminum (Al)	8/26/2010	4		%	35
	Available Antimony (Sb)	8/26/2010	NC		%	35

			Available Arsenic (As)	8/26/2010	17		%	35
			Available Barium (Ba)	8/26/2010	1.7		%	35
			Available Beryllium (Be)	8/26/2010	NC		%	35
			Available Bismuth (Bi)	8/26/2010	NC		%	35
			Available Boron (B)	8/26/2010	NC		%	35
			Available Cadmium (Cd)	8/26/2010	9.9		%	35
			Available Chromium (Cr)	8/26/2010	9.7		%	35
			Available Cobalt (Co)	8/26/2010	NC		%	35
			Available Copper (Cu)	8/26/2010	3.1		%	35
			Available Iron (Fe)	8/26/2010	4.8		%	35
			Available Lead (Pb)	8/26/2010	8.1		%	35
			Available Lithium (Li)	8/26/2010	NC		%	35
			Available Manganese (Mn)	8/26/2010	0.2		%	35
			Available Molybdenum (Mo)	8/26/2010	NC		%	35
			Available Nickel (Ni)	8/26/2010	NC		%	35
			Available Rubidium (Rb)	8/26/2010	NC		%	35
			Available Selenium (Se)	8/26/2010	NC		%	35
			Available Silver (Ag)	8/26/2010	NC		%	35
			Available Strontium (Sr)	8/26/2010	NC		%	35
			Available Thallium (Tl)	8/26/2010	4.9		%	35
			Available Tin (Sn)	8/26/2010	NC		%	35
			Available Uranium (U)	8/26/2010	NC		%	35
			Available Vanadium (V)	8/26/2010	1.9		%	35
			Available Zinc (Zn)	8/26/2010	8.7		%	35
2246778	MPT	QC Standard	Available Aluminum (Al)	8/26/2010		83	%	75 - 125
			Available Arsenic (As)	8/26/2010		101	%	75 - 125
			Available Barium (Ba)	8/26/2010		108	%	75 - 125
			Available Chromium (Cr)	8/26/2010		95	%	75 - 125
			Available Cobalt (Co)	8/26/2010		95	%	75 - 125
			Available Copper (Cu)	8/26/2010		92	%	75 - 125
			Available Iron (Fe)	8/26/2010		95	%	75 - 125
			Available Lead (Pb)	8/26/2010		105	%	75 - 125
			Available Manganese (Mn)	8/26/2010		107	%	75 - 125
			Available Nickel (Ni)	8/26/2010		98	%	75 - 125
			Available Strontium (Sr)	8/26/2010		91	%	75 - 125
			Available Vanadium (V)	8/26/2010		111	%	75 - 125
			Available Zinc (Zn)	8/26/2010		104	%	75 - 125
		Spiked Blank	Available Aluminum (Al)	8/26/2010		99	%	75 - 125
			Available Antimony (Sb)	8/26/2010		93	%	75 - 125
			Available Arsenic (As)	8/26/2010		93	%	75 - 125
			Available Barium (Ba)	8/26/2010		101	%	75 - 125
			Available Beryllium (Be)	8/26/2010		92	%	75 - 125
			Available Bismuth (Bi)	8/26/2010		100	%	75 - 125
			Available Boron (B)	8/26/2010		92	%	75 - 125
			Available Cadmium (Cd)	8/26/2010		98	%	75 - 125
			Available Chromium (Cr)	8/26/2010		99	%	75 - 125
			Available Cobalt (Co)	8/26/2010		96	%	75 - 125
			Available Copper (Cu)	8/26/2010		96	%	75 - 125
			Available Iron (Fe)	8/26/2010		101	%	75 - 125
			Available Lead (Pb)	8/26/2010		101	%	75 - 125
			Available Lithium (Li)	8/26/2010		95	%	75 - 125
			Available Manganese (Mn)	8/26/2010		104	%	75 - 125
			Available Molybdenum (Mo)	8/26/2010		96	%	75 - 125

			Available Nickel (Ni)	8/26/2010		93	%	75 - 125
			Available Rubidium (Rb)	8/26/2010		100	%	75 - 125
			Available Selenium (Se)	8/26/2010		99	%	75 - 125
			Available Silver (Ag)	8/26/2010		101	%	75 - 125
			Available Strontium (Sr)	8/26/2010		101	%	75 - 125
			Available Thallium (Tl)	8/26/2010		98	%	75 - 125
			Available Tin (Sn)	8/26/2010		102	%	75 - 125
			Available Uranium (U)	8/26/2010		99	%	75 - 125
			Available Vanadium (V)	8/26/2010		97	%	75 - 125
			Available Zinc (Zn)	8/26/2010		97	%	75 - 125
		Method Blank	Available Aluminum (Al)	8/26/2010	ND	RDL=10	mg/kg	
			Available Antimony (Sb)	8/26/2010	ND	RDL=2	mg/kg	
			Available Arsenic (As)	8/26/2010	ND	RDL=2	mg/kg	
			Available Barium (Ba)	8/26/2010	ND	RDL=5	mg/kg	
			Available Beryllium (Be)	8/26/2010	ND	RDL=2	mg/kg	
			Available Bismuth (Bi)	8/26/2010	ND	RDL=2	mg/kg	
			Available Boron (B)	8/26/2010	ND	RDL=5	mg/kg	
			Available Cadmium (Cd)	8/26/2010	ND	RDL=0.3	mg/kg	
			Available Chromium (Cr)	8/26/2010	ND	RDL=2	mg/kg	
			Available Cobalt (Co)	8/26/2010	ND	RDL=1	mg/kg	
			Available Copper (Cu)	8/26/2010	ND	RDL=2	mg/kg	
			Available Iron (Fe)	8/26/2010	ND	RDL=50	mg/kg	
			Available Lead (Pb)	8/26/2010	ND	RDL=0.5	mg/kg	
			Available Lithium (Li)	8/26/2010	ND	RDL=2	mg/kg	
			Available Manganese (Mn)	8/26/2010	ND	RDL=2	mg/kg	
			Available Molybdenum (Mo)	8/26/2010	ND	RDL=2	mg/kg	
			Available Nickel (Ni)	8/26/2010	ND	RDL=2	mg/kg	
			Available Rubidium (Rb)	8/26/2010	ND	RDL=2	mg/kg	
			Available Selenium (Se)	8/26/2010	ND	RDL=2	mg/kg	
			Available Silver (Ag)	8/26/2010	ND	RDL=0.5	mg/kg	
			Available Strontium (Sr)	8/26/2010	ND	RDL=5	mg/kg	
			Available Thallium (Tl)	8/26/2010	ND	RDL=0.1	mg/kg	
			Available Tin (Sn)	8/26/2010	ND	RDL=2	mg/kg	
			Available Uranium (U)	8/26/2010	ND	RDL=0.1	mg/kg	
			Available Vanadium (V)	8/26/2010	ND	RDL=2	mg/kg	
			Available Zinc (Zn)	8/26/2010	ND	RDL=5	mg/kg	
2257659	KGU	QC Standard	Arsenic (As)	9/7/2010		89	%	75 - 125
			Cadmium (Cd)	9/7/2010		96	%	75 - 125
			Chromium (Cr)	9/7/2010		105	%	75 - 125
			Copper (Cu)	9/7/2010		101	%	75 - 125
			Iron (Fe)	9/7/2010		95	%	75 - 125
			Lead (Pb)	9/7/2010		49 (1)	%	75 - 125
			Zinc (Zn)	9/7/2010		93	%	75 - 125
		Spiked Blank	Aluminum (Al)	9/7/2010		103	%	75 - 125
			Antimony (Sb)	9/7/2010		98	%	75 - 125
			Arsenic (As)	9/7/2010		97	%	75 - 125
			Barium (Ba)	9/7/2010		102	%	75 - 125
			Beryllium (Be)	9/7/2010		87	%	75 - 125
			Boron (B)	9/7/2010		92	%	75 - 125
			Cadmium (Cd)	9/7/2010		94	%	75 - 125
			Chromium (Cr)	9/7/2010		106	%	75 - 125
			Cobalt (Co)	9/7/2010		109	%	75 - 125
			Copper (Cu)	9/7/2010		112	%	75 - 125

	Iron (Fe)	9/7/2010	108		%	75 - 125
	Lead (Pb)	9/7/2010	110		%	75 - 125
	Lithium (Li)	9/7/2010	89		%	75 - 125
	Manganese (Mn)	9/7/2010	98		%	75 - 125
	Molybdenum (Mo)	9/7/2010	103		%	75 - 125
	Nickel (Ni)	9/7/2010	109		%	75 - 125
	Selenium (Se)	9/7/2010	103		%	75 - 125
	Silver (Ag)	9/7/2010	98		%	75 - 125
	Strontium (Sr)	9/7/2010	97		%	75 - 125
	Thallium (Tl)	9/7/2010	109		%	75 - 125
	Tin (Sn)	9/7/2010	104		%	75 - 125
	Uranium (U)	9/7/2010	111		%	75 - 125
	Vanadium (V)	9/7/2010	108		%	75 - 125
	Zinc (Zn)	9/7/2010	93		%	75 - 125
Method Blank	Aluminum (Al)	9/7/2010	ND	RDL=2.5	mg/kg	
	Antimony (Sb)	9/7/2010	ND	RDL=0.50	mg/kg	
	Arsenic (As)	9/7/2010	ND	RDL=0.50	mg/kg	
	Barium (Ba)	9/7/2010	ND	RDL=1.5	mg/kg	
	Beryllium (Be)	9/7/2010	ND	RDL=0.50	mg/kg	
	Boron (B)	9/7/2010	ND	RDL=1.5	mg/kg	
	Cadmium (Cd)	9/7/2010	ND	RDL=0.050	mg/kg	
	Chromium (Cr)	9/7/2010	ND	RDL=0.50	mg/kg	
	Cobalt (Co)	9/7/2010	ND	RDL=0.20	mg/kg	
	Copper (Cu)	9/7/2010	0.75	RDL=0.50	mg/kg	
	Iron (Fe)	9/7/2010	ND	RDL=15	mg/kg	
	Lead (Pb)	9/7/2010	ND	RDL=0.18	mg/kg	
	Lithium (Li)	9/7/2010	ND	RDL=0.50	mg/kg	
	Manganese (Mn)	9/7/2010	ND	RDL=0.50	mg/kg	
	Molybdenum (Mo)	9/7/2010	ND	RDL=0.50	mg/kg	
	Nickel (Ni)	9/7/2010	ND	RDL=0.50	mg/kg	
	Selenium (Se)	9/7/2010	ND	RDL=0.50	mg/kg	
	Silver (Ag)	9/7/2010	ND	RDL=0.12	mg/kg	
	Strontium (Sr)	9/7/2010	ND	RDL=1.5	mg/kg	
	Thallium (Tl)	9/7/2010	ND	RDL=0.020	mg/kg	
	Tin (Sn)	9/7/2010	ND	RDL=0.50	mg/kg	
	Uranium (U)	9/7/2010	ND	RDL=0.020	mg/kg	
	Vanadium (V)	9/7/2010	ND	RDL=0.50	mg/kg	
	Zinc (Zn)	9/7/2010	ND	RDL=1.5	mg/kg	

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

QC Standard: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.

Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.

NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

(1)   Recovery typical for RM matrix.

Intrinsik Environmental Sciences
Maxxam Job #: B1G7201
Client Project #: 30075-MAMMAL
Report Date: 2011/11/28
Site Location: X STRATA
This report supersedes all previous reports
Sampler Initials:

RESULTS OF ANALYSES OF SOIL

Maxxam ID		LK1288		LK1290		LK1291	LK1291		LK1292	LK1293		LK1294	LK1295		
Sampling Date		10/1/2011		10/1/2011		10/1/2011	10/1/2011		10/1/2011	10/1/2011		10/1/2011	10/1/2011		
COC Number		N/A		N/A		N/A	N/A		N/A	N/A		N/A	N/A		
	Units	**A-SOIL**	**RDL**	**B-SOIL**	**RDL**	**D-SOIL**	**D-SOIL Lab-Dup**	**RDL**	**F-SOIL**	**G-SOIL**	**RDL**	**BP-SOIL**	**FOR REF-SOIL**	**RDL**	**QC Batch**
Inorganics															
Organic Carbon (TOC)	g/kg	40	0.5	130	2	37		0.5	86	72	1	120	190	2	2668777
Soluble (5:1) pH	pH	4.82	N/A	5.73	N/A	5.64	5.64	N/A	4.20	5.45	N/A	7.18	4.18	N/A	2669863

N/A = Not Applicable
RDL = Reportable Detection Limit
Lab-Dup = Laboratory Initiated Duplicate
EDL = Estimated Detection Limit
QC Batch = Quality Control Batch

Intrinsik Environmental Sciences

Maxxam Job #: B1G7201
Client Project #: 30075-MAMMAL

Report Date: 2011/11/28
Site Location: X STRATA

This report supersedes all previous reports with th
Sampler Initials:

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		LK1288	LK1290	LK1291	LK1292	LK1293	LK1295
Sampling Date		10/1/2011	10/1/2011	10/1/2011	10/1/2011	10/1/2011	10/1/2011
COC Number		N/A	N/A	N/A	N/A	N/A	N/A
	Units	**A-SOIL**	**B-SOIL**	**D-SOIL**	**F-SOIL**	**G-SOIL**	**FOR REF-SOIL**
Metals							
Available Aluminum (Al)	mg/kg	18000	13000	30000	13000	9200	6900
Available Antimony (Sb)	mg/kg	3	9	4	19	13	2
Available Arsenic (As)	mg/kg	25	45	25	64	110	4
Available Barium (Ba)	mg/kg	71	240	51	90	130	96
Available Beryllium (Be)	mg/kg	2	2	2	2	2	2
Available Bismuth (Bi)	mg/kg	2	6	2	13	4	2
Available Boron (B)	mg/kg	5	5	5	5	5	5
Available Cadmium (Cd)	mg/kg	6.4	28	5.1	17	17	1.1
Available Chromium (Cr)	mg/kg	34	24	67	31	20	12
Available Cobalt (Co)	mg/kg	11	8	22	10	13	3
Available Copper (Cu)	mg/kg	36	66	39	130	93	9
Available Iron (Fe)	mg/kg	32000	19000	45000	30000	28000	21000
Available Lead (Pb)	mg/kg	360	1600	440	2900	1900	110
Available Lithium (Li)	mg/kg	21	19	31	16	11	4
Available Manganese (Mn)	mg/kg	770	370	530	610	600	470
Available Mercury (Hg)	mg/kg	0.1	0.4	1.7	0.5	0.3	0.2
Available Molybdenum (Mo)	mg/kg	2	2	2	2	2	2
Available Nickel (Ni)	mg/kg	26	22	58	23	11	6
Available Rubidium (Rb)	mg/kg	13	10	9	12	12	4
Available Selenium (Se)	mg/kg	2	2	2	2	2	2
Available Silver (Ag)	mg/kg	0.8	3.0	0.8	5.6	1.7	0.5
Available Strontium (Sr)	mg/kg	6	28	8	7	29	17
Available Thallium (Tl)	mg/kg	1.9	6.8	2.9	14	4.0	0.3
Available Tin (Sn)	mg/kg	3	7	4	13	51	4
Available Uranium (U)	mg/kg	0.6	1.4	0.5	0.7	0.6	0.2
Available Vanadium (V)	mg/kg	58	46	110	62	39	41
Available Zinc (Zn)	mg/kg	150	470	230	270	1600	63

ND = Not detected

N/A = Not Applicable

RDL = Reportable Detection Limit

EDL = Estimated Detection Limit

QC Batch = Quality Control Batch

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MAXXAM Chain of Custody Record

COC#:
Page 1 of 3

This column for lab use only:
Client Code
Maxxam Job#

Cooler Id	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp
			7	8	6	

Integrity [✓ YES] NO
Integrity/Checklist by: GK
Labelled by:
Location/Bin#

INVOICE INFORMATION:
Company Name: Intrinsik Enviro Sciences
Contact Name: Christine Moore.
Address: Suite 506, 5121 Sackville St,
Halifax, NS, B3J 1K1
Postal Code
Email: cmoore@intrinsikscience.com
Ph: 902 429 0278 Fax: 902 478 0395

REPORT INFORMATION (if differs from invoice):
Company Name:
Contact Name:
Address:
Postal Code
Email:
Ph:
Fax:

PO#
Project # / Phase# 30075 -mammal
Project Name/Site Location Xstrata.
Quote B14952-R1.
Site #
Task Order#
Sampled by

TURNAROUND TIME
Standard ☐
10 day ☐
If RUSH Specify Date:
Pre-schedule rush work
Charge for # Jars used but not submitted

Guideline Requirements/ Detection Limits/ Special Instructions
submit for available metals analysis (3050), soil PH (soil: DH water), total organic carbon (lbs, CLECO method), homogenization of tissues, Please use best effort for low detection limits
*Please call to discuss how to process bodies
**

* Specify Matrix; Surface/Salt/Ground/Tapwater/Sewage/Effluent/ Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

Choose ☐ Total or Diss Metals (RCAP-30)
Choose ☐ Total or Diss Metals (RCAP-MS)

Lab use		Field Sample Identification	Matrix *	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30	RCAP-MS	Metals Water: Total Digest(Default Method) for well water, surface water	Metals Water: Dissolved for ground water	Metals Water: Mercury	Metals Soil: Metals & Mercury Default Available Digest Method	Metals Soil: Metals Total Digest-for Ocean sediments (HNO3/HF/HCLO4)	Metals Soil: Mercury Low level by Cold Vapour AA	Metals Soil: Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Metals Soil: Hot Water soluble Boron (required for CCME Agricultural)	Hydrocarbons: RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons: Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	Hydrocarbons: NB Potable Water	Hydrocarbons: BTEX, VPH, Low level T.E.H	Hydrocarbons: TPH Fractionation	Hydrocarbons: PAH's	Hydrocarbons: PAH's with Acridine,Quinoline	soil PH (soil: DH water)	available metals analysis	soil organic carbon		
	1	BP-PEMA-Kidney	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐
	2	BP-MIPE-liver	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐
	3	BP-PEMA-liver	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐
	4	BP-MIPE Kidney	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐
	5	A-F-PEMA-MIPE	Kidney tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐
	6	A-MIPE-liver	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐
	7	F-PEMA-liver	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐
*	8	F-SOCI-bodies	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐
	9	F-BLBR-liver	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐
*	10	F-BLBR-bodies	tissues	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐

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MAXXAM Chain of Custody Record

COC#:

Page 2 of 3

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Client Code

Maxxam Job#

Cooler Id	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp
			7	8	6	

Integrity: [✓ YES] ~~NO~~

Integrity/Checklist by: GLe GLe

Labelled by:

Location/Bin#

INVOICE INFORMATION:

Company Name: Intrinsik Enviro Sciences.
Contact Name: Christine Moore.
Address: Suite 506, 5121 Sackville St
Halifax, NS, B3J 1K1
Postal Code
Email: cmoore@intrinsikscience.com
Ph: 9024290278 Fax: 9024780395

REPORT INFORMATION (if differs from invoice):

Company Name:
Contact Name:
Address:
Postal Code
Email:
Ph: Fax:

PO#:
Project # / Phase#: 30075 mammal
Project Name/Site Location: Xstrata.
Quote: B14952 -R1
Site #:
Task Order#:
Sampled by:

TURNAROUND TIME

Standard ☐
10 day ☐
If RUSH Specify Date:

Pre-schedule rush work

Charge for # Jars used but not submitted

Guideline Requirements/ Detection Limits/ Special Instructions

Submit for available metals analysis (3050 lbs), homogenization of tissues, Please use best effort for low detection limits *Please call to discuss how to process bodies **

* Specify Matrix; Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

	Field Sample Identification	Matrix *	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose ☐ Total or Diss Metals ☐	RCAP-MS Choose ☐ Total or Diss Metals ☐	Metals Water: Total Digest(Default Method) for well water, surface water	Metals Water: Dissolved for ground water	Metals Water: Mercury	Metals Soil: Metals & Mercury Default Available Digest Method	Metals Soil: Metals Total Digest-for Ocean sediments (HNO3/HF/HCLO4)	Metals Soil: Mercury Low level by Cold Vapour AA	Metals Soil: Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Metals Soil: Hot Water soluble Boron (required for CCME Agricultural)	Hydrocarbons: RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons: Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	Hydrocarbons: NB Potable Water BTEX, VPH, Low level T.E.H	Hydrocarbons: TPH Fractionation	Hydrocarbons: PAH's	Hydrocarbons: PAH's with Acridine,Quinoline	available metals analysis				
*	1 A-SOCI-bodies	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐
	2 A-PEMA-liver	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐
	3 FOR REF-PEMA-liver	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐
	4 FOR REF-MYGA-liver	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐
	5 FOR REF-MYGA-PEMA kidney	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐
	6 FOR REF-SOCI-body	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐
*	7 D-SOCI-bodies	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐
	8 G-MYGA-liver	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐
	9 B-MYGA-PEMA liver	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐
	10 G-B-MYGA-PEMA kidney	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐

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			Ryan		

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2011 OCT 26

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MAXXAM Chain of Custody Record

COC#:

Page 3 of 3

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Client Code:

Maxxam Job#:

Cooler Id	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp
			7	8	6	

Integrity: [✓ YES] ~~NO~~

Integrity/Checklist by: GK

Labelled by:

Location/Bin#:

INVOICE INFORMATION:

Company Name: Intrinsik Enviro Sciences
Contact Name: Christine Moore.
Address: Suite 506, 5121 Sackville St.
Halifax, NS, B3J 1K1 · Postal Code
Email: cmoore@intrinsikscience.com
Ph: 902 429 0278 Fax: 902 478 0395.

REPORT INFORMATION (if differs from invoice):

Company Name:
Contact Name:
Address:
Postal Code
Email:
Ph:
Fax:

PO#:
Project # / Phase#: 30075 - mammal.
Project Name/Site Location: Xstrata.
Quote: B14952 - R1.
Site #:
Task Order#:
Sampled by:

TURNAROUND TIME

Standard ☐
10 day ☐
If RUSH Specify Date:
Pre-schedule rush work

Charge for # Jars used but not submitted:

Guideline Requirements/ Detection Limits/ Special Instructions

Available metals analysis (3050lbs)
~~In~~ total organic carbon (LECO method)
soil pH (soil: DH water).

* Specify Matrix; Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

	Field Sample Identification	Matrix *	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose ☐ Total or Diss Metals ☐	RCAP-MS Choose ☐ Total or Diss Metals ☐	Metals Water: Total Digest (Default Method) for well water, surface water	Metals Water: Dissolved for ground water	Metals Water: Mercury	Metals Soil: Metals & Mercury Default Available Digest Method	Metals Soil: Metals Total Digest-for Ocean sediments (HNO3/HF/HCLO4)	Metals Soil: Mercury Low level by Cold Vapour AA	Metals Soil: Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Metals Soil: Hot Water soluble Boron (required for CCME Agricultural)	Hydrocarbons: RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons: Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	Hydrocarbons: NB Potable Water BTEX, VPH, Low level T.E.H	Hydrocarbons: TPH Fractionation	Hydrocarbons: PAH's	Hydrocarbons: PAH's with Acridine, Quinoline	soil pH (soil: DH water)	soil total organic carbon			
	1 A - SOIL	soil		1	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☒	☐	☐	☐
	2 B - SOIL	soil		1	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☒	☐	☐	☐
	3 D - SOIL	soil		1	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☒	☐	☐	☐
	4 F - SOIL	soil		1	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☒	☐	☐	☐
	5 G - SOIL	soil		1	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☒	☐	☐	☐
	6 BP - SOIL	soil		1	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☒	☐	☐	☐
	7 FOR REF - SOIL	soil		1	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☒	☐	☐	☐
	8				☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	~~☒~~	~~☒~~	☐	☐	☐
	9				☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	10				☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

RELINQUISHED BY: (Signature/Print)	Date	Time	RECEIVED BY: (Signature/Print)	Date	Time

White : Maxxam Yellow : Mail Pink : Client

ATL FCD 00149 / Revision 11

[illegible] OCT 25 [illegible]

Your Project #: 30075-MAMMAL
Site Location: X STRATA
Your C.O.C. #: N/A

Attention: Christine Moore
Intrinsik Environmental Sciences
5121 Sackville Street
Suite 506
Halifax, NS
CANADA B3J 1K1

Report Date: 2011/11/22

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B1G7201
Received: 2011/10/26, 10:51

Sample Matrix: Soil
Samples Received: 7

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
pH (5:1 DI Water Extract)	7	2011/11/02	2011/11/03	ATL SOP 00003	Based on SM4500H+B
Total Organic Carbon in Soil	7	2011/11/02	2011/11/02	ATL SOP 00044/00045	LECO 203-601-224

Sample Matrix: TISSUE
Samples Received: 20

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Metals Tissue MS - Nitric	20	2011/11/15	2011/11/15	ATL SOP 00024	Based on EPA6020A

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
* Results relate only to the items tested.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

MICHELLE HILL, Project Manager
Email: MHill@maxxam.ca
Phone# (902) 420-0203

==
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Total cover pages: 1

RESULTS OF ANALYSES OF SOIL

Maxxam ID		LK1288		LK1290		LK1291	LK1291		LK1292	LK1293		LK1294	LK1295		
Sampling Date		2011/10/01		2011/10/01		2011/10/01	2011/10/01		2011/10/01	2011/10/01		2011/10/01	2011/10/01		
	Units	**A-SOIL**	**RDL**	**B-SOIL**	**RDL**	**D-SOIL**	**D-SOIL Lab-Dup**	**RDL**	**F-SOIL**	**G-SOIL**	**RDL**	**BP-SOIL**	**FOR REF-SOIL**	**RDL**	**QC Batch**
Inorganics															
Organic Carbon (TOC)	g/kg	40	0.5	130	2	37		0.5	86	72	1	120	190	2	2668777
Soluble (5:1) pH	pH	4.82	N/A	5.73	N/A	5.64	5.64	N/A	4.20	5.45	N/A	7.18	4.18	N/A	2669863

N/A = Not Applicable
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

ELEMENTS BY ICP/MS (TISSUE)

Maxxam ID		LK1255		LK1256	LK1257	LK1258	LK1259	LK1260		
Sampling Date		2011/10/01		2011/10/01	2011/10/01	2011/10/01	2011/10/01	2011/10/01		
	Units	**BP-PEMA-KIDNEY**	**RDL**	**BP-MIPE-LIVER**	**BP-PEMA-LIVER**	**BP-MIPE KIDNEY**	**A-F-PEMA-MIPE KIDNEY**	**A-MIPE-LIVER**	**RDL**	**QC Batch**
Metals										
Aluminum (Al)	mg/kg	ND	5.0	ND	ND	ND	ND	ND	2.5	2682554
Antimony (Sb)	mg/kg	ND	1.0	ND	ND	ND	ND	ND	0.50	2682554
Arsenic (As)	mg/kg	ND	1.0	ND	1.07	ND	ND	ND	0.50	2682554
Barium (Ba)	mg/kg	ND	3.0	ND	ND	ND	ND	ND	1.5	2682554
Beryllium (Be)	mg/kg	ND	1.0	ND	ND	ND	ND	ND	0.50	2682554
Boron (B)	mg/kg	ND	3.0	ND	ND	ND	ND	ND	1.5	2682554
Cadmium (Cd)	mg/kg	1.94	0.10	0.242	0.710	1.08	5.06	1.44	0.050	2682554
Chromium (Cr)	mg/kg	ND	1.0	ND	ND	ND	ND	ND	0.50	2682554
Cobalt (Co)	mg/kg	ND	0.40	ND	ND	ND	ND	ND	0.20	2682554
Copper (Cu)	mg/kg	5.4	1.0	8.46	7.53	4.58	5.49	5.09	0.50	2682554
Iron (Fe)	mg/kg	73	30	283	175	97	102	243	15	2682554
Lead (Pb)	mg/kg	15.9	0.36	1.86	6.25	6.98	14.1	3.27	0.18	2682554
Lithium (Li)	mg/kg	ND	1.0	ND	ND	ND	ND	ND	0.50	2682554
Manganese (Mn)	mg/kg	1.1	1.0	2.28	2.60	1.35	1.49	2.13	0.50	2682554
Molybdenum (Mo)	mg/kg	ND	1.0	0.79	1.45	ND	ND	0.54	0.50	2682554
Nickel (Ni)	mg/kg	ND	1.0	ND	ND	ND	ND	ND	0.50	2682554
Selenium (Se)	mg/kg	2.7	1.0	0.60	1.31	0.77	3.60	0.76	0.50	2682554
Silver (Ag)	mg/kg	ND	0.24	ND	ND	ND	ND	ND	0.12	2682554
Strontium (Sr)	mg/kg	ND	3.0	ND	ND	ND	ND	ND	1.5	2682554
Thallium (Tl)	mg/kg	6.23	0.040	0.241	2.01	1.28	3.73	1.43	0.020	2682554
Tin (Sn)	mg/kg	ND	1.0	ND	ND	ND	ND	ND	0.50	2682554
Uranium (U)	mg/kg	ND	0.040	ND	ND	ND	ND	ND	0.020	2682554
Vanadium (V)	mg/kg	ND	1.0	ND	ND	ND	ND	ND	0.50	2682554
Zinc (Zn)	mg/kg	23.5	3.0	23.5	28.4	18.2	21.0	25.7	1.5	2682554

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam Job #: B1G7201
Report Date: 2011/11/22

Intrinsik Environmental Sciences
Client Project #: 30075-MAMMAL
Site Location: X STRATA

ELEMENTS BY ICP/MS (TISSUE)

Maxxam ID		LK1261		LK1262	LK1263	LK1264	LK1265	LK1266		
Sampling Date		2011/10/01		2011/10/01	2011/10/01	2011/10/01	2011/10/01	2011/10/01		
	Units	**F-PEMA-LIVER**	**RDL**	**F-SOCI-BODIES**	**F-BLBR-LIVER**	**F-BLBR-BODIES**	**A-SOCI-BODIES**	**A-PEMA-LIVER**	**RDL**	**QC Batch**
Metals										
Aluminum (Al)	mg/kg	ND	5.0	101	ND	23.1	33.5	ND	2.5	2682554
Antimony (Sb)	mg/kg	ND	1.0	ND	ND	ND	ND	ND	0.50	2682554
Arsenic (As)	mg/kg	ND	1.0	0.91	0.82	2.81	1.08	ND	0.50	2682554
Barium (Ba)	mg/kg	ND	3.0	4.5	ND	2.3	2.6	ND	1.5	2682554
Beryllium (Be)	mg/kg	ND	1.0	ND	ND	ND	ND	ND	0.50	2682554
Boron (B)	mg/kg	ND	3.0	ND	ND	ND	ND	ND	1.5	2682554
Cadmium (Cd)	mg/kg	ND	0.10	2.89	23.5	0.885	2.65	1.28	0.050	2682554
Chromium (Cr)	mg/kg	ND	1.0	ND	ND	ND	ND	ND	0.50	2682554
Cobalt (Co)	mg/kg	ND	0.40	ND	ND	ND	ND	ND	0.20	2682554
Copper (Cu)	mg/kg	4.3	1.0	3.83	9.22	2.85	3.93	4.46	0.50	2682554
Iron (Fe)	mg/kg	87	30	169	442	64	139	118	15	2682554
Lead (Pb)	mg/kg	ND	0.36	27.3	6.45	18.5	30.8	0.82	0.18	2682554
Lithium (Li)	mg/kg	ND	1.0	ND	ND	ND	ND	ND	0.50	2682554
Manganese (Mn)	mg/kg	2.1	1.0	10.4	4.54	1.48	6.30	2.19	0.50	2682554
Molybdenum (Mo)	mg/kg	1.2	1.0	ND	1.20	ND	ND	1.10	0.50	2682554
Nickel (Ni)	mg/kg	ND	1.0	ND	ND	ND	ND	ND	0.50	2682554
Selenium (Se)	mg/kg	ND	1.0	0.91	2.11	0.77	1.05	0.82	0.50	2682554
Silver (Ag)	mg/kg	ND	0.24	ND	ND	ND	ND	ND	0.12	2682554
Strontium (Sr)	mg/kg	ND	3.0	3.8	ND	1.9	1.9	ND	1.5	2682554
Thallium (Tl)	mg/kg	0.081	0.040	1.56	1.32	1.40	4.11	0.270	0.020	2682554
Tin (Sn)	mg/kg	ND	1.0	1.08	ND	ND	2.94	ND	0.50	2682554
Uranium (U)	mg/kg	ND	0.040	ND	ND	ND	ND	ND	0.020	2682554
Vanadium (V)	mg/kg	ND	1.0	ND	ND	ND	ND	ND	0.50	2682554
Zinc (Zn)	mg/kg	16.5	3.0	36.7	39.4	35.2	31.3	19.1	1.5	2682554

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam Job #: B1G7201
Report Date: 2011/11/22

Intrinsik Environmental Sciences
Client Project #: 30075-MAMMAL
Site Location: X STRATA

ELEMENTS BY ICP/MS (TISSUE)

Maxxam ID		LK1267	LK1268	LK1268	LK1269		
Sampling Date		2011/10/01	2011/10/01	2011/10/01	2011/10/01		
	Units	**FOR REF-PEMA-LIVER**	**FOR REF-MYGA-LIVER**	**FOR REF-MYGA-LIVER Lab-Dup**	**FOR REF-MYGA-PEMA KIDNEY**	**RDL**	**QC Batch**
Metals							
Aluminum (Al)	mg/kg	ND	ND	ND	ND	2.5	2682554
Antimony (Sb)	mg/kg	ND	ND	ND	ND	0.50	2682554
Arsenic (As)	mg/kg	ND	ND	ND	ND	0.50	2682554
Barium (Ba)	mg/kg	ND	ND	ND	ND	1.5	2682554
Beryllium (Be)	mg/kg	ND	ND	ND	ND	0.50	2682554
Boron (B)	mg/kg	ND	ND	ND	ND	1.5	2682554
Cadmium (Cd)	mg/kg	0.180	1.16	2.06(1)	3.09	0.050	2682554
Chromium (Cr)	mg/kg	ND	ND	ND	ND	0.50	2682554
Cobalt (Co)	mg/kg	ND	ND	ND	ND	0.20	2682554
Copper (Cu)	mg/kg	4.78	4.76	5.20	5.21	0.50	2682554
Iron (Fe)	mg/kg	91	199	144(2)	99	15	2682554
Lead (Pb)	mg/kg	ND	0.39	0.32	1.02	0.18	2682554
Lithium (Li)	mg/kg	ND	ND	ND	ND	0.50	2682554
Manganese (Mn)	mg/kg	2.62	3.75	3.79	2.03	0.50	2682554
Molybdenum (Mo)	mg/kg	1.20	0.93	0.92	0.56	0.50	2682554
Nickel (Ni)	mg/kg	ND	ND	ND	ND	0.50	2682554
Selenium (Se)	mg/kg	0.53	0.62	0.65	1.14	0.50	2682554
Silver (Ag)	mg/kg	ND	ND	ND	ND	0.12	2682554
Strontium (Sr)	mg/kg	ND	ND	ND	ND	1.5	2682554
Thallium (Tl)	mg/kg	ND	ND	ND	0.058	0.020	2682554
Tin (Sn)	mg/kg	ND	ND	ND	ND	0.50	2682554
Uranium (U)	mg/kg	ND	ND	ND	ND	0.020	2682554
Vanadium (V)	mg/kg	ND	ND	ND	ND	0.50	2682554
Zinc (Zn)	mg/kg	19.5	21.4	23.0	23.3	1.5	2682554

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
(1) - Poor RPD due to sample inhomogeneity.
(2) - Violation is not applicable.

ELEMENTS BY ICP/MS (TISSUE)

Maxxam ID		LK1270	LK1271	LK1272	LK1273	LK1274		
Sampling Date		2011/10/01	2011/10/01	2011/10/01	2011/10/01	2011/10/01		
	Units	**FOR REF-SOCI-BODY**	**D-SOCI-BODIES**	**G-MYGA-LIVER**	**B-MYGA-PEMA LIVER**	**G-B-MYGA-PEMA KIDNEY**	**RDL**	**QC Batch**
Metals								
Aluminum (Al)	mg/kg	123	132	ND	ND	ND	2.5	2682554
Antimony (Sb)	mg/kg	ND	ND	ND	ND	ND	0.50	2682554
Arsenic (As)	mg/kg	ND	1.06	ND	ND	ND	0.50	2682554
Barium (Ba)	mg/kg	3.9	3.7	ND	ND	ND	1.5	2682554
Beryllium (Be)	mg/kg	ND	ND	ND	ND	ND	0.50	2682554
Boron (B)	mg/kg	ND	ND	ND	ND	ND	1.5	2682554
Cadmium (Cd)	mg/kg	0.275	2.41	9.18	5.05	9.28	0.050	2682554
Chromium (Cr)	mg/kg	ND	ND	ND	ND	ND	0.50	2682554
Cobalt (Co)	mg/kg	ND	ND	ND	ND	ND	0.20	2682554
Copper (Cu)	mg/kg	3.29	3.05	4.34	5.65	5.74	0.50	2682554
Iron (Fe)	mg/kg	252	182	177	148	95	15	2682554
Lead (Pb)	mg/kg	5.67	23.9	1.29	0.86	7.11	0.18	2682554
Lithium (Li)	mg/kg	ND	ND	ND	ND	ND	0.50	2682554
Manganese (Mn)	mg/kg	120	5.10	3.24	2.78	2.06	0.50	2682554
Molybdenum (Mo)	mg/kg	ND	ND	0.95	0.99	ND	0.50	2682554
Nickel (Ni)	mg/kg	ND	ND	ND	ND	ND	0.50	2682554
Selenium (Se)	mg/kg	0.65	0.92	0.69	0.60	1.27	0.50	2682554
Silver (Ag)	mg/kg	ND	ND	ND	ND	ND	0.12	2682554
Strontium (Sr)	mg/kg	3.3	2.4	ND	ND	ND	1.5	2682554
Thallium (Tl)	mg/kg	0.098	1.24	0.155	0.220	1.12	0.020	2682554
Tin (Sn)	mg/kg	0.50	0.66	ND	ND	ND	0.50	2682554
Uranium (U)	mg/kg	ND	ND	ND	ND	ND	0.020	2682554
Vanadium (V)	mg/kg	ND	ND	ND	ND	ND	0.50	2682554
Zinc (Zn)	mg/kg	33.0	32.5	25.5	24.6	26.8	1.5	2682554

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Package 1	7.0°C

Each temperature is the average of up to three cooler temperatures taken at receipt

GENERAL COMMENTS

Maxxam Job #: B1G7201
Report Date: 2011/11/22

Intrinsik Environmental Sciences
Client Project #: 30075-MAMMAL
Site Location: X STRATA

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**	**% Recovery**	**QC Limits**
2668777	Organic Carbon (TOC)	2011/11/02					ND, RDL=0.2	g/kg	0.2	35	95	75 - 125
2669863	Soluble (5:1) pH	2011/11/03							0	N/A		
2682554	Aluminum (Al)	2011/11/15	NC	75 - 125	112	75 - 125	ND, RDL=2.5	mg/kg	NC	25		
2682554	Antimony (Sb)	2011/11/15	86	75 - 125	91	75 - 125	ND, RDL=0.50	mg/kg	NC	25		
2682554	Arsenic (As)	2011/11/15	NC	75 - 125	99	75 - 125	ND, RDL=0.50	mg/kg	NC	25	88	75 - 125
2682554	Barium (Ba)	2011/11/15	NC	75 - 125	99	75 - 125	ND, RDL=1.5	mg/kg	NC	25		
2682554	Beryllium (Be)	2011/11/15	86	75 - 125	93	75 - 125	ND, RDL=0.50	mg/kg	NC	25		
2682554	Boron (B)	2011/11/15	78	75 - 125	83	75 - 125	ND, RDL=1.5	mg/kg	NC	25		
2682554	Cadmium (Cd)	2011/11/15	NC	75 - 125	99	75 - 125	ND, RDL=0.050	mg/kg	55.9(1, 2)	25	98	75 - 125
2682554	Chromium (Cr)	2011/11/15	131(1, 3)	75 - 125	101	75 - 125	ND, RDL=0.50	mg/kg	NC	25	96	75 - 125
2682554	Cobalt (Co)	2011/11/15	96	75 - 125	101	75 - 125	ND, RDL=0.20	mg/kg	NC	25		
2682554	Copper (Cu)	2011/11/15	NC	75 - 125	96	75 - 125	ND, RDL=0.50	mg/kg	8.8	25	94	75 - 125
2682554	Iron (Fe)	2011/11/15	NC	75 - 125	109	75 - 125	ND, RDL=15	mg/kg	32.2(1, 4)	25	111	75 - 125
2682554	Lead (Pb)	2011/11/15	NC	75 - 125	87	75 - 125	ND, RDL=0.18	mg/kg	NC	25	48(1, 5)	75 - 125
2682554	Lithium (Li)	2011/11/15	96	75 - 125	89	75 - 125	ND, RDL=0.50	mg/kg	NC	25		
2682554	Manganese (Mn)	2011/11/15	NC	75 - 125	95	75 - 125	ND, RDL=0.50	mg/kg	1	25		
2682554	Molybdenum (Mo)	2011/11/15	103	75 - 125	105	75 - 125	ND, RDL=0.50	mg/kg	NC	25		
2682554	Nickel (Ni)	2011/11/15	52(1, 6)	75 - 125	104	75 - 125	ND, RDL=0.50	mg/kg	NC	25		
2682554	Selenium (Se)	2011/11/15	NC	75 - 125	97	75 - 125	ND, RDL=0.50	mg/kg	NC	25		
2682554	Silver (Ag)	2011/11/15	94	75 - 125	106	75 - 125	ND, RDL=0.12	mg/kg	NC	25		
2682554	Strontium (Sr)	2011/11/15	NC	75 - 125	97	75 - 125	ND, RDL=1.5	mg/kg	NC	25		
2682554	Thallium (Tl)	2011/11/15	NC	75 - 125	83	75 - 125	ND, RDL=0.020	mg/kg	NC	25		
2682554	Tin (Sn)	2011/11/15	81	75 - 125	106	75 - 125	ND, RDL=0.50	mg/kg	NC	25		
2682554	Uranium (U)	2011/11/15	80	75 - 125	90	75 - 125	ND, RDL=0.020	mg/kg	NC	25		

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
2682554	Vanadium (V)	2011/11/15	94	75 - 125	102	75 - 125	ND, RDL=0.50	mg/kg	NC	25		
2682554	Zinc (Zn)	2011/11/15	NC	75 - 125	92	75 - 125	ND, RDL=1.5	mg/kg	7.1	25	87	75 - 125

N/A = Not Applicable
RDL = Reportable Detection Limit
RPD = Relative Percent Difference
Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.
Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.
QC Standard: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.
NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.
NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.
(1) - Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.
(2) - Poor RPD due to sample inhomogeneity.
(3) - Elevated recovery due to sample matrix.
(4) - Violation is not applicable.
(5) - Typical recovery for RM matrix. Secondary RM is acceptable.
(6) - Low recovery due to sample matrix.

Validation Signature Page

Maxxam Job #: B1G7201

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

CAcker

COLLEEN ACKER

Kevin A. MacDonald

KEVIN MACDONALD, Inorganics Supervisor

Mike MacGillivray

MIKE MACGILLIVRAY, Scientific Specialist (Inorganics)

==

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam

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MAXXAM Chain of Custody Record

COC#:

Page 1 of 3

This column for lab use only:

Client Code

Maxxam Job#

Cooler Id	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp
			7	8	6	

Integrity [✓ YES] ~~NO~~

Integrity/Checklist by: Gk

Labelled by:

Location/Bin#

INVOICE INFORMATION:

Company Name: Intrinsik Enviro Sciences
Contact Name: Christine Moore.
Address: Suite 506, 5121 Sackville St,
Halifax, NS, B3J 1K1 Postal Code
Email: cmoore@intrinsikscience.com
Ph: 902 429 0278 Fax: 902 478 0395

REPORT INFORMATION (if differs from invoice):

Company Name:
Contact Name:
Address:
Postal Code
Email:
Ph: Fax:

PO#
Project # / Phase# 30075 -mammal
Project Name/Site Location Xstrata.
Quote B14952-R1.
Site #
Task Order#
Sampled by

TURNAROUND TIME

Standard ☐
10 day ☐
If RUSH Specify Date:

Pre-schedule rush work

Charge for # Jars used but not submitted

Guideline Requirements/ Detection Limits/ Special Instructions

submit for available metals analysis (3050), soil PH (soil: DH water), total organic carbon (LECO method), homogenization of tissues. Please use best effort for low detection limits
*Please call to discuss how to process bodies
**

* Specify Matrix; Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

	Field Sample Identification	Matrix *	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose ☐ Total or Diss Metals ☐	RCAP-MS Choose ☐ Total or Diss Metals ☐	Metals Water: Total Digest(Default Method) for well water, surface water	Metals Water: Dissolved for ground water	Metals Water: Mercury	Metals Soil: Metals & Mercury Default Available Digest Method	Metals Soil: Metals Total Digest-for Ocean sediments (HNO3/HF/HCLO4)	Metals Soil: Mercury Low level by Cold Vapour AA	Metals Soil: Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Metals Soil: Hot Water soluble Boron (required for CCME Agricultural)	Hydrocarbons: RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons: Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	Hydrocarbons: NB Potable Water	Hydrocarbons: BTEX, VPH, Low level T.E.H	Hydrocarbons: TPH Fractionation	Hydrocarbons: PAH's	Hydrocarbons: PAH's with Acridine,Quinoline	soil PH (soil: DH water)	available metals analysis	soil organic carbon		
	1 BP-PEMA-Kidney	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐
	2 BP-MIPE-liver	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐
	3 BP-PEMA-liver	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐
	4 BP-MIPE Kidney	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐
	5 A-F-PEMA-MIPE	Kidney tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐
	6 A-MIPE-liver	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐
	7 F-PEMA-liver	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐
*	8 F-SOCI-bodies	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐
	9 F-BLBR-liver	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐
*	10 F-BLBR-bodies	tissues	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐

RELINQUISHED BY: (Signature/Print)	Date	Time	RECEIVED BY: (Signature/Print)	Date	Time
			X		

White : Maxxam Yellow : Mail Pink : Client

ATL FCD 00149 / Revision 11

[illegible] OCT 26 AM 9:01

Maxxam

200 Bluewater Road, Suite 105, Bedford, Nova Scotia B4B 1G9 Tel: 902-420-0203 Fax: 902-420-8612 Toll Free: 1-800-565-7227
49 Elizabeth Ave., St John's, NL A1A 1W9 Tel: 709-754-0203 Fax: 709-754-8612 Toll Free: 1-888-492-7227
90 Esplanade, Sydney, NS B1P 1A1 Tel: 902-567-1255 Fax: 902-539-6504 Toll Free: 1-888-535-7770
www.maxxamanalytics.com E-mail: Clientservicesbedford@maxxamanalytics.com

MAXXAM Chain of Custody Record

COC#:

Page 2 of 3

This column for lab use only

Client Code:

Maxxam Job#:

Cooler Id	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp
			7	8	6	

Integrity [✓ YES] ~~NO~~

Integrity/Checklist by: Cle

Labelled by:

Location/Bin#:

INVOICE INFORMATION:

Company Name: Intrinsik Enviro Sciences.
Contact Name: Christine Moore.
Address: Suite 506, 5121 Sackville St.
Halifax, NS, B3J 1K1 Postal Code
Email: cmoore@intrinsikscience.com
Ph: 902 429 0278 Fax: 902 478 0395

REPORT INFORMATION (if differs from invoice):

Company Name:
Contact Name:
Address:
Postal Code
Email:
Ph: Fax:

PO#:
Project # / Phase#: 30075 mammal
Project Name/Site Location: Xstrata.
Quote: B14952 -R1
Site #:
Task Order#:
Sampled by:

TURNAROUND TIME

Standard ☐
10 day ☐
If RUSH Specify Date:

Pre-schedule rush work

Charge for # Jars used but not submitted

Guideline Requirements/ Detection Limits/ Special Instructions

Submit for available metals analysis (3050 lbs), homogenization of tissues. Please use best effort for low detection limits. *Please call to discuss how to process bodies**

* Specify Matrix; Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

	Field Sample Identification	Matrix *	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose ☐ Total or Diss Metals ☐	RCAP-MS Choose ☐ Total or Diss Metals ☐	Metals Water: Total Digest(Default Method) for well water, surface water	Metals Water: Dissolved for ground water	Metals Water: Mercury	Metals Soil: Metals & Mercury Default Available Digest Method	Metals Soil: Metals Total Digest-for Ocean sediments (HNO3/HF/HCLO4)	Metals Soil: Mercury Low level by Cold Vapour AA	Metals Soil: Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Metals Soil: Hot Water soluble Boron (required for CCME Agricultural)	Hydrocarbons: RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons: Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	Hydrocarbons: NB Potable Water BTEX, VPH, Low level T.E.H	Hydrocarbons: TPH Fractionation	Hydrocarbons: PAH's	Hydrocarbons: PAH's with Acridine,Quinoline	available metals analysis				
*	1 A-SOCI - bodies	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐
	2 A-PEMA - liver	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐
	3 FOR REF- PEMA-liver	tissue	OCT 201	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐
	4 FOR REF-MYGA-liver	tissue	OCT 201	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐
	5 FOR REF-MYGA-PEMA kidney	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐
	6 FOR REF- SOCI -body	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐
*	7 D-SOCI -bodies	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐
	8 G - MYGA - liver	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐
	9 B - MYGA - PEMA liver	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐
	10 G - B -MYGA - PEMA kidney	tissue	OCT 2011	1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐

RELINQUISHED BY: (Signature/Print)	Date	Time	RECEIVED BY: (Signature/Print)	Date	Time
			X Ryan		

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Maxxam

200 Bluewater Road, Suite 105, Bedford, Nova Scotia B4B 1G9 Tel: 902-420-0203 Fax: 902-420-8612 Toll Free: 1-800-565-7227
49 Elizabeth Ave., St John's, NL A1A 1W9 Tel: 709-754-0203 Fax: 709-754-8612 Toll Free: 1-888-492-7227
90 Esplanade, Sydney, NS B1P 1A1 Tel: 902-567-1255 Fax: 902-539-6504 Toll Free: 1-888-535-7770
www.maxxamanalytics.com E-mail: Clientservicesbedford@maxxamanalytics.com

MAXXAM Chain of Custody Record

COC#:
Page 3 of 3

This column for lab use only
Client Code:
Maxxam Job#:

Cooler Id	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp
			7	8	6	

Integrity: [✓ YES] ~~NO~~ GK
Integrity/Checklist by: GK
Labelled by:
Location/Bin#:

INVOICE INFORMATION:
Company Name: Intrinsik Enviro Sciences
Contact Name: Christine Moore.
Address: Suite 506, 5121 Sackville St.
Halifax, NS, B3J 1K1.
Postal Code:
Email: cmoore@intrinsikscience.com.
Ph: 902 429 0278 Fax: 902 478 0395

REPORT INFORMATION (if differs from invoice):
Company Name:
Contact Name:
Address:
Postal Code:
Email:
Ph:
Fax:

PO#:
Project # / Phase#: 30075 - mammal.
Project Name/Site Location: Xstrata.
Quote: B14952 - R1.
Site #:
Task Order#:
Sampled by:

TURNAROUND TIME
Standard ☐
10 day ☐
If RUSH Specify Date:
Pre-schedule rush work
Charge for # Jars used but not submitted:

Guideline Requirements/ Detection Limits/ Special Instructions
Available metals analysis (3050 lbs)
total organic carbon (LECO method)
soil pH (soil: DH water).

* Specify Matrix; Surface/Salt/Ground/Tapwater/Sewage/Effluent/ Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

	Field Sample Identification	Matrix *	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose ☐ Total or Diss Metals ☐	RCAP-MS Choose ☐ Total or Diss Metals ☐	Metals Water: Total Digest (Default Method) for well water, surface water	Metals Water: Dissolved for ground water	Metals Water: Mercury	Metals Soil: Metals & Mercury Default Available Digest Method	Metals Soil: Metals Total Digest-for Ocean sediments (HNO3/HF/HCLO4)	Metals Soil: Mercury Low level by Cold Vapour AA	Metals Soil: Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Metals Soil: Hot Water soluble Boron (required for CCME Agricultural)	Hydrocarbons: RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons: Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	Hydrocarbons: NB Potable Water BTEX, VPH, Low level T.E.H	Hydrocarbons: TPH Fractionation	Hydrocarbons: PAH's	Hydrocarbons: PAH's with Acridine, Quinoline	soil pH (soil: DH water)	soil total organic carbon			
1	A - SOIL	soil		1								X											X	X			
2	B - SOIL	soil		1								X											X	X			
3	D - SOIL	soil		1								X											X	X			
4	F - SOIL	soil		1								X											X	X			
5	G - SOIL	soil		1								X											X	X			
6	BP - SOIL	soil		1								X											X	X			
7	FOR REF - SOIL	soil		1								X											X	X			
8																							~~X~~	~~X~~			
9																											
10																											

RELINQUISHED BY: (Signature/Print)	Date	Time	RECEIVED BY: (Signature/Print)	Date	Time

White : Maxxam Yellow : Mail Pink : Client

ATL FCD 00149 / Revision 11

[illegible] OCT 25 [illegible]

Your Project #: 30075-MAMMAL
Site Location: X STRATA
Your C.O.C. #: N/A

Attention: Christine Moore
Intrinsik Environmental Sciences
5121 Sackville Street
Suite 506
Halifax, NS
CANADA B3J 1K1

Report Date: 2011/11/28
This report supersedes all previous reports with the same Maxxam job number

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B1G7201
Received: 2011/10/26, 10:51

Sample Matrix: Soil
Samples Received: 7

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Metals Solid Avail. Unified MS - Nper	7	2011/11/25	2011/11/25	ATL SOP 00024	Based on EPA6020A
pH (5:1 DI Water Extract)	7	2011/11/02	2011/11/03	ATL SOP 00003	Based on SM4500H+B
Total Organic Carbon in Soil	7	2011/11/02	2011/11/02	ATL SOP 00044/00045	LECO 203-601-224

Sample Matrix: TISSUE
Samples Received: 20

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Metals Tissue MS - Nitric	20	2011/11/15	2011/11/15	ATL SOP 00024	Based on EPA6020A

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
* Results relate only to the items tested.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

MICHELLE HILL, Project Manager
Email: MHill@maxxam.ca
Phone# (902) 420-0203

==
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Total cover pages: 1

RESULTS OF ANALYSES OF SOIL

Maxxam ID		LK1288		LK1290		LK1291	LK1291		LK1292	LK1293		LK1294	LK1295		
Sampling Date		2011/10/01		2011/10/01		2011/10/01	2011/10/01		2011/10/01	2011/10/01		2011/10/01	2011/10/01		
	Units	**A-SOIL**	**RDL**	**B-SOIL**	**RDL**	**D-SOIL**	**D-SOIL Lab-Dup**	**RDL**	**F-SOIL**	**G-SOIL**	**RDL**	**BP-SOIL**	**FOR REF-SOIL**	**RDL**	**QC Batch**
Inorganics															
Organic Carbon (TOC)	g/kg	40	0.5	130	2	37		0.5	86	72	1	120	190	2	2668777
Soluble (5:1) pH	pH	4.82	N/A	5.73	N/A	5.64	5.64	N/A	4.20	5.45	N/A	7.18	4.18	N/A	2669863

N/A = Not Applicable
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam Job #: B1G7201
Report Date: 2011/11/28

Intrinsik Environmental Sciences
Client Project #: 30075-MAMMAL
Site Location: X STRATA

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		LK1288	LK1290		LK1291		LK1292	LK1293		LK1294		LK1295		
Sampling Date		2011/10/01	2011/10/01		2011/10/01		2011/10/01	2011/10/01		2011/10/01		2011/10/01		
	Units	**A-SOIL**	**B-SOIL**	**RDL**	**D-SOIL**	**RDL**	**F-SOIL**	**G-SOIL**	**RDL**	**BP-SOIL**	**RDL**	**FOR REF-SOIL**	**RDL**	**QC Batch**
Metals														
Available Aluminum (Al)	mg/kg	18000	13000	10	30000	10	13000	9200	10	14000	10	6900	10	2693862
Available Antimony (Sb)	mg/kg	3	9	2	4	2	19	13	2	32	2	ND	2	2693862
Available Arsenic (As)	mg/kg	25	45	2	25	2	64	110	2	140	2	4	2	2693862
Available Barium (Ba)	mg/kg	71	240	5	51	5	90	130	5	51	5	96	5	2693862
Available Beryllium (Be)	mg/kg	ND	ND	2	ND	2	ND	ND	2	ND	2	ND	2	2693862
Available Bismuth (Bi)	mg/kg	2	6	2	ND	2	13	4	2	25	2	ND	2	2693862
Available Boron (B)	mg/kg	ND	ND	5	ND	5	ND	ND	5	7	5	ND	5	2693862
Available Cadmium (Cd)	mg/kg	6.4	28	0.3	5.1	0.3	17	17	0.3	18	0.3	1.1	0.3	2693862
Available Chromium (Cr)	mg/kg	34	24	2	67	2	31	20	2	47	2	12	2	2693862
Available Cobalt (Co)	mg/kg	11	8	1	22	1	10	13	1	22	1	3	1	2693862
Available Copper (Cu)	mg/kg	36	66	2	39	2	130	93	2	450	2	9	2	2693862
Available Iron (Fe)	mg/kg	32000	19000	50	45000	500	30000	28000	50	34000	50	21000	50	2693862
Available Lead (Pb)	mg/kg	360	1600	0.5	440	0.5	2900	1900	0.5	7000	5	110	0.5	2693862
Available Lithium (Li)	mg/kg	21	19	2	31	2	16	11	2	20	2	4	2	2693862
Available Manganese (Mn)	mg/kg	770	370	2	530	2	610	600	2	720	2	470	2	2693862
Available Mercury (Hg)	mg/kg	ND	0.4	0.1	1.7	0.1	0.5	0.3	0.1	1.0	0.1	0.2	0.1	2693862
Available Molybdenum (Mo)	mg/kg	ND	ND	2	ND	2	ND	ND	2	2	2	ND	2	2693862
Available Nickel (Ni)	mg/kg	26	22	2	58	2	23	11	2	38	2	6	2	2693862
Available Rubidium (Rb)	mg/kg	13	10	2	9	2	12	12	2	9	2	4	2	2693862
Available Selenium (Se)	mg/kg	ND	ND	2	ND	2	ND	ND	2	3	2	ND	2	2693862
Available Silver (Ag)	mg/kg	0.8	3.0	0.5	0.8	0.5	5.6	1.7	0.5	13	5	ND	0.5	2693862
Available Strontium (Sr)	mg/kg	6	28	5	8	5	7	29	5	53	5	17	5	2693862
Available Thallium (Tl)	mg/kg	1.9	6.8	0.1	2.9	0.1	14	4.0	0.1	9.1	0.1	0.3	0.1	2693862
Available Tin (Sn)	mg/kg	3	7	2	4	2	13	51	2	50	2	4	2	2693862
Available Uranium (U)	mg/kg	0.6	1.4	0.1	0.5	0.1	0.7	0.6	0.1	4.6	0.1	0.2	0.1	2693862
Available Vanadium (V)	mg/kg	58	46	2	110	2	62	39	2	72	2	41	2	2693862
Available Zinc (Zn)	mg/kg	150	470	5	230	5	270	1600	5	3600	5	63	5	2693862

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

ELEMENTS BY ICP/MS (TISSUE)

Maxxam ID		LK1255		LK1256	LK1257	LK1258	LK1259	LK1260		
Sampling Date		2011/10/01		2011/10/01	2011/10/01	2011/10/01	2011/10/01	2011/10/01		
	Units	**BP-PEMA-KIDNEY**	**RDL**	**BP-MIPE-LIVER**	**BP-PEMA-LIVER**	**BP-MIPE KIDNEY**	**A-F-PEMA-MIPE KIDNEY**	**A-MIPE-LIVER**	**RDL**	**QC Batch**
Metals										
Aluminum (Al)	mg/kg	ND	5.0	ND	ND	ND	ND	ND	2.5	2682554
Antimony (Sb)	mg/kg	ND	1.0	ND	ND	ND	ND	ND	0.50	2682554
Arsenic (As)	mg/kg	ND	1.0	ND	1.07	ND	ND	ND	0.50	2682554
Barium (Ba)	mg/kg	ND	3.0	ND	ND	ND	ND	ND	1.5	2682554
Beryllium (Be)	mg/kg	ND	1.0	ND	ND	ND	ND	ND	0.50	2682554
Boron (B)	mg/kg	ND	3.0	ND	ND	ND	ND	ND	1.5	2682554
Cadmium (Cd)	mg/kg	1.94	0.10	0.242	0.710	1.08	5.06	1.44	0.050	2682554
Chromium (Cr)	mg/kg	ND	1.0	ND	ND	ND	ND	ND	0.50	2682554
Cobalt (Co)	mg/kg	ND	0.40	ND	ND	ND	ND	ND	0.20	2682554
Copper (Cu)	mg/kg	5.4	1.0	8.46	7.53	4.58	5.49	5.09	0.50	2682554
Iron (Fe)	mg/kg	73	30	283	175	97	102	243	15	2682554
Lead (Pb)	mg/kg	15.9	0.36	1.86	6.25	6.98	14.1	3.27	0.18	2682554
Lithium (Li)	mg/kg	ND	1.0	ND	ND	ND	ND	ND	0.50	2682554
Manganese (Mn)	mg/kg	1.1	1.0	2.28	2.60	1.35	1.49	2.13	0.50	2682554
Molybdenum (Mo)	mg/kg	ND	1.0	0.79	1.45	ND	ND	0.54	0.50	2682554
Nickel (Ni)	mg/kg	ND	1.0	ND	ND	ND	ND	ND	0.50	2682554
Selenium (Se)	mg/kg	2.7	1.0	0.60	1.31	0.77	3.60	0.76	0.50	2682554
Silver (Ag)	mg/kg	ND	0.24	ND	ND	ND	ND	ND	0.12	2682554
Strontium (Sr)	mg/kg	ND	3.0	ND	ND	ND	ND	ND	1.5	2682554
Thallium (Tl)	mg/kg	6.23	0.040	0.241	2.01	1.28	3.73	1.43	0.020	2682554
Tin (Sn)	mg/kg	ND	1.0	ND	ND	ND	ND	ND	0.50	2682554
Uranium (U)	mg/kg	ND	0.040	ND	ND	ND	ND	ND	0.020	2682554
Vanadium (V)	mg/kg	ND	1.0	ND	ND	ND	ND	ND	0.50	2682554
Zinc (Zn)	mg/kg	23.5	3.0	23.5	28.4	18.2	21.0	25.7	1.5	2682554

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

ELEMENTS BY ICP/MS (TISSUE)

Maxxam ID		LK1261		LK1262	LK1263	LK1264	LK1265	LK1266		
Sampling Date		2011/10/01		2011/10/01	2011/10/01	2011/10/01	2011/10/01	2011/10/01		
	Units	**F-PEMA-LIVER**	**RDL**	**F-SOCI-BODIES**	**F-BLBR-LIVER**	**F-BLBR-BODIES**	**A-SOCI-BODIES**	**A-PEMA-LIVER**	**RDL**	**QC Batch**
Metals										
Aluminum (Al)	mg/kg	ND	5.0	101	ND	23.1	33.5	ND	2.5	2682554
Antimony (Sb)	mg/kg	ND	1.0	ND	ND	ND	ND	ND	0.50	2682554
Arsenic (As)	mg/kg	ND	1.0	0.91	0.82	2.81	1.08	ND	0.50	2682554
Barium (Ba)	mg/kg	ND	3.0	4.5	ND	2.3	2.6	ND	1.5	2682554
Beryllium (Be)	mg/kg	ND	1.0	ND	ND	ND	ND	ND	0.50	2682554
Boron (B)	mg/kg	ND	3.0	ND	ND	ND	ND	ND	1.5	2682554
Cadmium (Cd)	mg/kg	ND	0.10	2.89	23.5	0.885	2.65	1.28	0.050	2682554
Chromium (Cr)	mg/kg	ND	1.0	ND	ND	ND	ND	ND	0.50	2682554
Cobalt (Co)	mg/kg	ND	0.40	ND	ND	ND	ND	ND	0.20	2682554
Copper (Cu)	mg/kg	4.3	1.0	3.83	9.22	2.85	3.93	4.46	0.50	2682554
Iron (Fe)	mg/kg	87	30	169	442	64	139	118	15	2682554
Lead (Pb)	mg/kg	ND	0.36	27.3	6.45	18.5	30.8	0.82	0.18	2682554
Lithium (Li)	mg/kg	ND	1.0	ND	ND	ND	ND	ND	0.50	2682554
Manganese (Mn)	mg/kg	2.1	1.0	10.4	4.54	1.48	6.30	2.19	0.50	2682554
Molybdenum (Mo)	mg/kg	1.2	1.0	ND	1.20	ND	ND	1.10	0.50	2682554
Nickel (Ni)	mg/kg	ND	1.0	ND	ND	ND	ND	ND	0.50	2682554
Selenium (Se)	mg/kg	ND	1.0	0.91	2.11	0.77	1.05	0.82	0.50	2682554
Silver (Ag)	mg/kg	ND	0.24	ND	ND	ND	ND	ND	0.12	2682554
Strontium (Sr)	mg/kg	ND	3.0	3.8	ND	1.9	1.9	ND	1.5	2682554
Thallium (Tl)	mg/kg	0.081	0.040	1.56	1.32	1.40	4.11	0.270	0.020	2682554
Tin (Sn)	mg/kg	ND	1.0	1.08	ND	ND	2.94	ND	0.50	2682554
Uranium (U)	mg/kg	ND	0.040	ND	ND	ND	ND	ND	0.020	2682554
Vanadium (V)	mg/kg	ND	1.0	ND	ND	ND	ND	ND	0.50	2682554
Zinc (Zn)	mg/kg	16.5	3.0	36.7	39.4	35.2	31.3	19.1	1.5	2682554

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

ELEMENTS BY ICP/MS (TISSUE)

Maxxam ID		LK1267	LK1268	LK1268	LK1269		
Sampling Date		2011/10/01	2011/10/01	2011/10/01	2011/10/01		
	Units	**FOR REF-PEMA-LIVER**	**FOR REF-MYGA-LIVER**	**FOR REF-MYGA-LIVER Lab-Dup**	**FOR REF-MYGA-PEMA KIDNEY**	**RDL**	**QC Batch**
Metals							
Aluminum (Al)	mg/kg	ND	ND	ND	ND	2.5	2682554
Antimony (Sb)	mg/kg	ND	ND	ND	ND	0.50	2682554
Arsenic (As)	mg/kg	ND	ND	ND	ND	0.50	2682554
Barium (Ba)	mg/kg	ND	ND	ND	ND	1.5	2682554
Beryllium (Be)	mg/kg	ND	ND	ND	ND	0.50	2682554
Boron (B)	mg/kg	ND	ND	ND	ND	1.5	2682554
Cadmium (Cd)	mg/kg	0.180	1.16	2.06(1)	3.09	0.050	2682554
Chromium (Cr)	mg/kg	ND	ND	ND	ND	0.50	2682554
Cobalt (Co)	mg/kg	ND	ND	ND	ND	0.20	2682554
Copper (Cu)	mg/kg	4.78	4.76	5.20	5.21	0.50	2682554
Iron (Fe)	mg/kg	91	199	144(2)	99	15	2682554
Lead (Pb)	mg/kg	ND	0.39	0.32	1.02	0.18	2682554
Lithium (Li)	mg/kg	ND	ND	ND	ND	0.50	2682554
Manganese (Mn)	mg/kg	2.62	3.75	3.79	2.03	0.50	2682554
Molybdenum (Mo)	mg/kg	1.20	0.93	0.92	0.56	0.50	2682554
Nickel (Ni)	mg/kg	ND	ND	ND	ND	0.50	2682554
Selenium (Se)	mg/kg	0.53	0.62	0.65	1.14	0.50	2682554
Silver (Ag)	mg/kg	ND	ND	ND	ND	0.12	2682554
Strontium (Sr)	mg/kg	ND	ND	ND	ND	1.5	2682554
Thallium (Tl)	mg/kg	ND	ND	ND	0.058	0.020	2682554
Tin (Sn)	mg/kg	ND	ND	ND	ND	0.50	2682554
Uranium (U)	mg/kg	ND	ND	ND	ND	0.020	2682554
Vanadium (V)	mg/kg	ND	ND	ND	ND	0.50	2682554
Zinc (Zn)	mg/kg	19.5	21.4	23.0	23.3	1.5	2682554

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
(1) - Poor RPD due to sample inhomogeneity.
(2) - Violation is not applicable.

ELEMENTS BY ICP/MS (TISSUE)

Maxxam ID		LK1270	LK1271	LK1272	LK1273	LK1274		
Sampling Date		2011/10/01	2011/10/01	2011/10/01	2011/10/01	2011/10/01		
	Units	**FOR REF-SOCI-BODY**	**D-SOCI-BODIES**	**G-MYGA-LIVER**	**B-MYGA-PEMA LIVER**	**G-B-MYGA-PEMA KIDNEY**	**RDL**	**QC Batch**
Metals								
Aluminum (Al)	mg/kg	123	132	ND	ND	ND	2.5	2682554
Antimony (Sb)	mg/kg	ND	ND	ND	ND	ND	0.50	2682554
Arsenic (As)	mg/kg	ND	1.06	ND	ND	ND	0.50	2682554
Barium (Ba)	mg/kg	3.9	3.7	ND	ND	ND	1.5	2682554
Beryllium (Be)	mg/kg	ND	ND	ND	ND	ND	0.50	2682554
Boron (B)	mg/kg	ND	ND	ND	ND	ND	1.5	2682554
Cadmium (Cd)	mg/kg	0.275	2.41	9.18	5.05	9.28	0.050	2682554
Chromium (Cr)	mg/kg	ND	ND	ND	ND	ND	0.50	2682554
Cobalt (Co)	mg/kg	ND	ND	ND	ND	ND	0.20	2682554
Copper (Cu)	mg/kg	3.29	3.05	4.34	5.65	5.74	0.50	2682554
Iron (Fe)	mg/kg	252	182	177	148	95	15	2682554
Lead (Pb)	mg/kg	5.67	23.9	1.29	0.86	7.11	0.18	2682554
Lithium (Li)	mg/kg	ND	ND	ND	ND	ND	0.50	2682554
Manganese (Mn)	mg/kg	120	5.10	3.24	2.78	2.06	0.50	2682554
Molybdenum (Mo)	mg/kg	ND	ND	0.95	0.99	ND	0.50	2682554
Nickel (Ni)	mg/kg	ND	ND	ND	ND	ND	0.50	2682554
Selenium (Se)	mg/kg	0.65	0.92	0.69	0.60	1.27	0.50	2682554
Silver (Ag)	mg/kg	ND	ND	ND	ND	ND	0.12	2682554
Strontium (Sr)	mg/kg	3.3	2.4	ND	ND	ND	1.5	2682554
Thallium (Tl)	mg/kg	0.098	1.24	0.155	0.220	1.12	0.020	2682554
Tin (Sn)	mg/kg	0.50	0.66	ND	ND	ND	0.50	2682554
Uranium (U)	mg/kg	ND	ND	ND	ND	ND	0.020	2682554
Vanadium (V)	mg/kg	ND	ND	ND	ND	ND	0.50	2682554
Zinc (Zn)	mg/kg	33.0	32.5	25.5	24.6	26.8	1.5	2682554

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Package 1	7.0°C

Each temperature is the average of up to three cooler temperatures taken at receipt

GENERAL COMMENTS

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**	**% Recovery**	**QC Limits**
2668777	Organic Carbon (TOC)	2011/11/02					ND, RDL=0.2	g/kg	0.2	35	95	75 - 125
2669863	Soluble (5:1) pH	2011/11/03							0	N/A		
2682554	Aluminum (Al)	2011/11/15	NC	75 - 125	112	75 - 125	ND, RDL=2.5	mg/kg	NC	25		
2682554	Antimony (Sb)	2011/11/15	86	75 - 125	91	75 - 125	ND, RDL=0.50	mg/kg	NC	25		
2682554	Arsenic (As)	2011/11/15	NC	75 - 125	99	75 - 125	ND, RDL=0.50	mg/kg	NC	25	88	75 - 125
2682554	Barium (Ba)	2011/11/15	NC	75 - 125	99	75 - 125	ND, RDL=1.5	mg/kg	NC	25		
2682554	Beryllium (Be)	2011/11/15	86	75 - 125	93	75 - 125	ND, RDL=0.50	mg/kg	NC	25		
2682554	Boron (B)	2011/11/15	78	75 - 125	83	75 - 125	ND, RDL=1.5	mg/kg	NC	25		
2682554	Cadmium (Cd)	2011/11/15	NC	75 - 125	99	75 - 125	ND, RDL=0.050	mg/kg	55.9(1, 2)	25	98	75 - 125
2682554	Chromium (Cr)	2011/11/15	131(1, 3)	75 - 125	101	75 - 125	ND, RDL=0.50	mg/kg	NC	25	96	75 - 125
2682554	Cobalt (Co)	2011/11/15	96	75 - 125	101	75 - 125	ND, RDL=0.20	mg/kg	NC	25		
2682554	Copper (Cu)	2011/11/15	NC	75 - 125	96	75 - 125	ND, RDL=0.50	mg/kg	8.8	25	94	75 - 125
2682554	Iron (Fe)	2011/11/15	NC	75 - 125	109	75 - 125	ND, RDL=15	mg/kg	32.2(1, 4)	25	111	75 - 125
2682554	Lead (Pb)	2011/11/15	NC	75 - 125	87	75 - 125	ND, RDL=0.18	mg/kg	NC	25	48(1, 5)	75 - 125
2682554	Lithium (Li)	2011/11/15	96	75 - 125	89	75 - 125	ND, RDL=0.50	mg/kg	NC	25		
2682554	Manganese (Mn)	2011/11/15	NC	75 - 125	95	75 - 125	ND, RDL=0.50	mg/kg	1	25		
2682554	Molybdenum (Mo)	2011/11/15	103	75 - 125	105	75 - 125	ND, RDL=0.50	mg/kg	NC	25		
2682554	Nickel (Ni)	2011/11/15	52(1, 6)	75 - 125	104	75 - 125	ND, RDL=0.50	mg/kg	NC	25		
2682554	Selenium (Se)	2011/11/15	NC	75 - 125	97	75 - 125	ND, RDL=0.50	mg/kg	NC	25		
2682554	Silver (Ag)	2011/11/15	94	75 - 125	106	75 - 125	ND, RDL=0.12	mg/kg	NC	25		
2682554	Strontium (Sr)	2011/11/15	NC	75 - 125	97	75 - 125	ND, RDL=1.5	mg/kg	NC	25		
2682554	Thallium (Tl)	2011/11/15	NC	75 - 125	83	75 - 125	ND, RDL=0.020	mg/kg	NC	25		
2682554	Tin (Sn)	2011/11/15	81	75 - 125	106	75 - 125	ND, RDL=0.50	mg/kg	NC	25		
2682554	Uranium (U)	2011/11/15	80	75 - 125	90	75 - 125	ND, RDL=0.020	mg/kg	NC	25		
2682554	Vanadium (V)	2011/11/15	94	75 - 125	102	75 - 125	ND, RDL=0.50	mg/kg	NC	25		
2682554	Zinc (Zn)	2011/11/15	NC	75 - 125	92	75 - 125	ND, RDL=1.5	mg/kg	7.1	25	87	75 - 125
2693862	Available Antimony (Sb)	2011/11/25	84	75 - 125	90	75 - 125	ND, RDL=2	mg/kg	NC	35		
2693862	Available Arsenic (As)	2011/11/25	95	75 - 125	90	75 - 125	ND, RDL=2	mg/kg	NC	35		
2693862	Available Barium (Ba)	2011/11/25	105	75 - 125	97	75 - 125	ND, RDL=5	mg/kg	NC	35		
2693862	Available Beryllium (Be)	2011/11/25	103	75 - 125	94	75 - 125	ND, RDL=2	mg/kg	NC	35		
2693862	Available Bismuth (Bi)	2011/11/25	97	75 - 125	95	75 - 125	ND, RDL=2	mg/kg	NC	35		
2693862	Available Boron (B)	2011/11/25	67(1, 6)	75 - 125	96	75 - 125	ND, RDL=5	mg/kg	NC	35		
2693862	Available Cadmium (Cd)	2011/11/25	104	75 - 125	96	75 - 125	ND, RDL=0.3	mg/kg	NC	35		
2693862	Available Chromium (Cr)	2011/11/25	115	75 - 125	95	75 - 125	ND, RDL=2	mg/kg	3.5	35		
2693862	Available Cobalt (Co)	2011/11/25	106	75 - 125	94	75 - 125	ND, RDL=1	mg/kg	10.2	35		
2693862	Available Copper (Cu)	2011/11/25	102	75 - 125	92	75 - 125	ND, RDL=2	mg/kg	NC	35		
2693862	Available Lead (Pb)	2011/11/25	105	75 - 125	101	75 - 125	ND, RDL=0.5	mg/kg	3.7	35		
2693862	Available Lithium (Li)	2011/11/25	106	75 - 125	91	75 - 125	ND, RDL=2	mg/kg	NC	35		
2693862	Available Manganese (Mn)	2011/11/25	NC	75 - 125	102	75 - 125	ND, RDL=2	mg/kg	1.1	35		
2693862	Available Mercury (Hg)	2011/11/25	110	75 - 125	106	75 - 125	ND, RDL=0.1	mg/kg	NC	35		

Maxxam Job #: B1G7201
Report Date: 2011/11/28

Intrinsik Environmental Sciences
Client Project #: 30075-MAMMAL
Site Location: X STRATA

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**	**% Recovery**	**QC Limits**
2693862	Available Molybdenum (Mo)	2011/11/25	106	75 - 125	99	75 - 125	ND, RDL=2	mg/kg	NC	35		
2693862	Available Nickel (Ni)	2011/11/25	104	75 - 125	93	75 - 125	ND, RDL=2	mg/kg	NC	35		
2693862	Available Rubidium (Rb)	2011/11/25	99	75 - 125	98	75 - 125	ND, RDL=2	mg/kg	NC	35		
2693862	Available Selenium (Se)	2011/11/25	96	75 - 125	95	75 - 125	ND, RDL=2	mg/kg	NC	35		
2693862	Available Silver (Ag)	2011/11/25	102	75 - 125	100	75 - 125	ND, RDL=0.5	mg/kg	NC	35		
2693862	Available Strontium (Sr)	2011/11/25	102	75 - 125	99	75 - 125	ND, RDL=5	mg/kg	NC	35		
2693862	Available Thallium (Tl)	2011/11/25	101	75 - 125	90	75 - 125	ND, RDL=0.1	mg/kg	NC	35		
2693862	Available Tin (Sn)	2011/11/25	109	75 - 125	104	75 - 125	ND, RDL=2	mg/kg	NC	35		
2693862	Available Uranium (U)	2011/11/25	109	75 - 125	99	75 - 125	ND, RDL=0.1	mg/kg	NC	35		
2693862	Available Vanadium (V)	2011/11/25	NC	75 - 125	96	75 - 125	ND, RDL=2	mg/kg	2.0	35		
2693862	Available Zinc (Zn)	2011/11/25	NC	75 - 125	90	75 - 125	ND, RDL=5	mg/kg	0.5	35		
2693862	Available Aluminum (Al)	2011/11/25					ND, RDL=10	mg/kg	0.7	35		
2693862	Available Iron (Fe)	2011/11/25					ND, RDL=50	mg/kg	1.1	35		

N/A = Not Applicable
RDL = Reportable Detection Limit
RPD = Relative Percent Difference
Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.
Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.
QC Standard: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.
NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.
NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.
(1) - Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.
(2) - Poor RPD due to sample inhomogeneity.
(3) - Elevated recovery due to sample matrix.
(4) - Violation is not applicable.
(5) - Typical recovery for RM matrix. Secondary RM is acceptable.
(6) - Low recovery due to sample matrix.

Validation Signature Page

Maxxam Job #: B1G7201

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

C Acker

COLLEEN ACKER

Kevin A. MacDonald

KEVIN MACDONALD, Inorganics Supervisor

Mike MacGillivray

MIKE MACGILLIVRAY, Scientific Specialist (Inorganics)

==

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam

Maxxam ID: KX4271-01

HESED-1

Percent Coarser than 75 µm (PHI = 3.737)	Percent Coarser than 50 µm (PHI = 4.322)
98.1 %	98.2 %

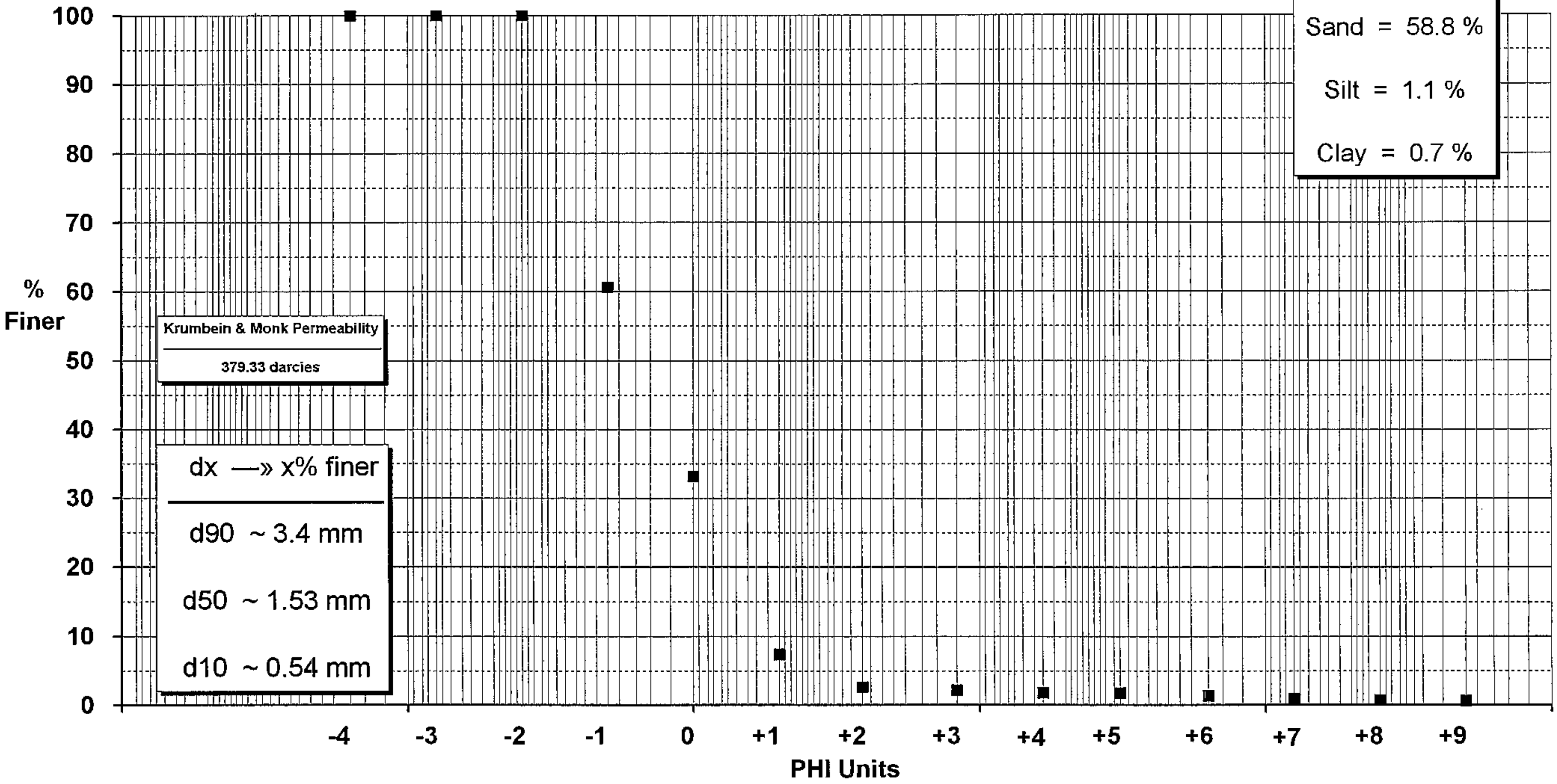
Wentworth

Gravel = 39.4 %

Sand = 58.8 %

Silt = 1.1 %

Clay = 0.7 %



Krumbein & Monk Permeability

379.33 darcies

dx —» x% finer

d90 ~ 3.4 mm

d50 ~ 1.53 mm

d10 ~ 0.54 mm

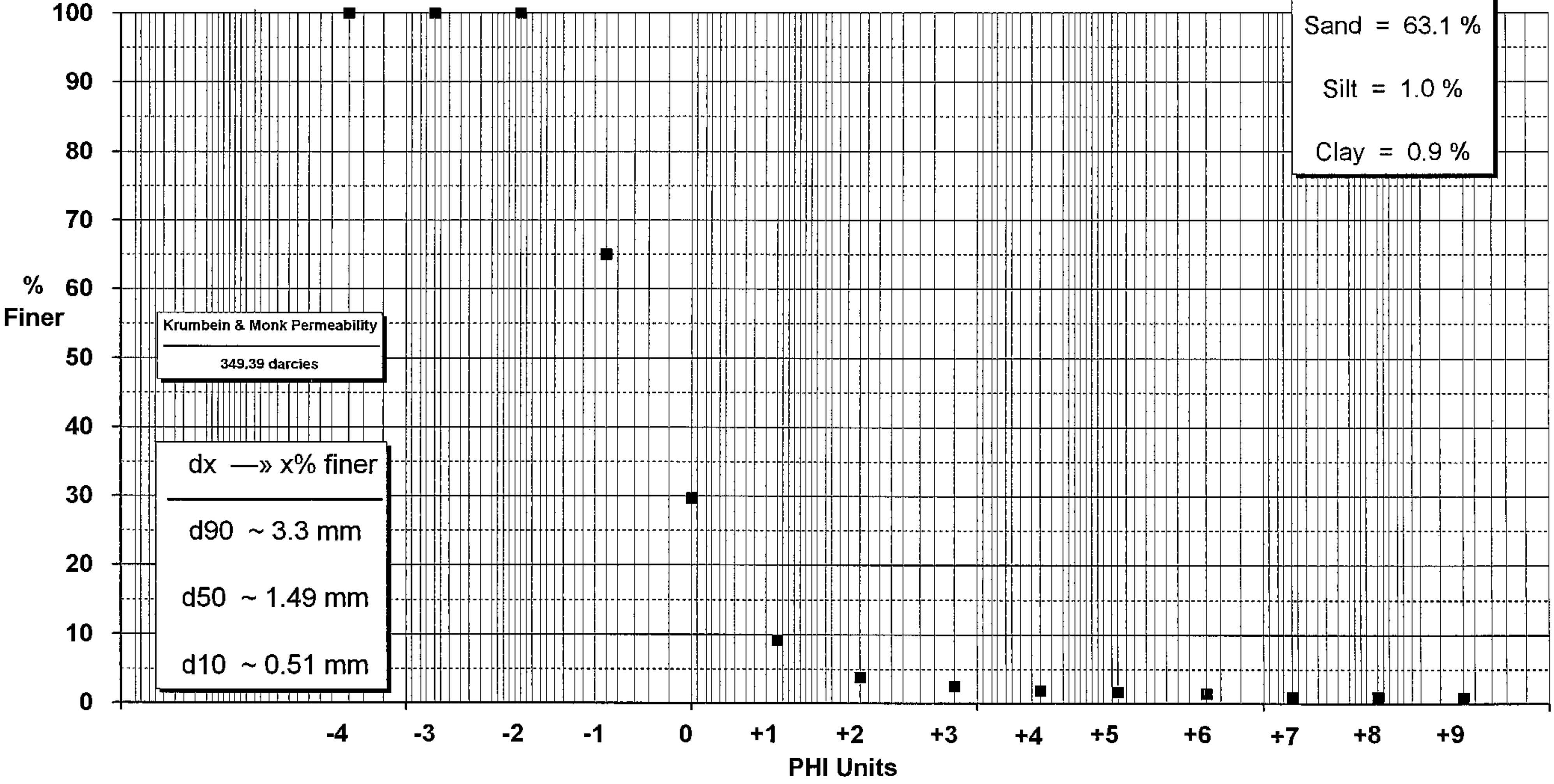
Approved

Maxxam

Maxxam ID: KX4273-01

HESED-2

Percent Coarser than 75 µm (PHI = 3.737)	Percent Coarser than 50 µm (PHI = 4.322)
97.9 %	98.2 %



Wentworth

Gravel = 35.0 %

Sand = 63.1 %

Silt = 1.0 %

Clay = 0.9 %

Krumbein & Monk Permeability

349.39 darcies

dx —» x% finer

d90 ~ 3.3 mm

d50 ~ 1.49 mm

d10 ~ 0.51 mm

Approved

Maxxam

Maxxam ID: KX4274-01

HESED-3

Percent Coarser than 75 µm (PHI = 3.737)	Percent Coarser than 50 µm (PHI = 4.322)
93.2 %	93.8 %

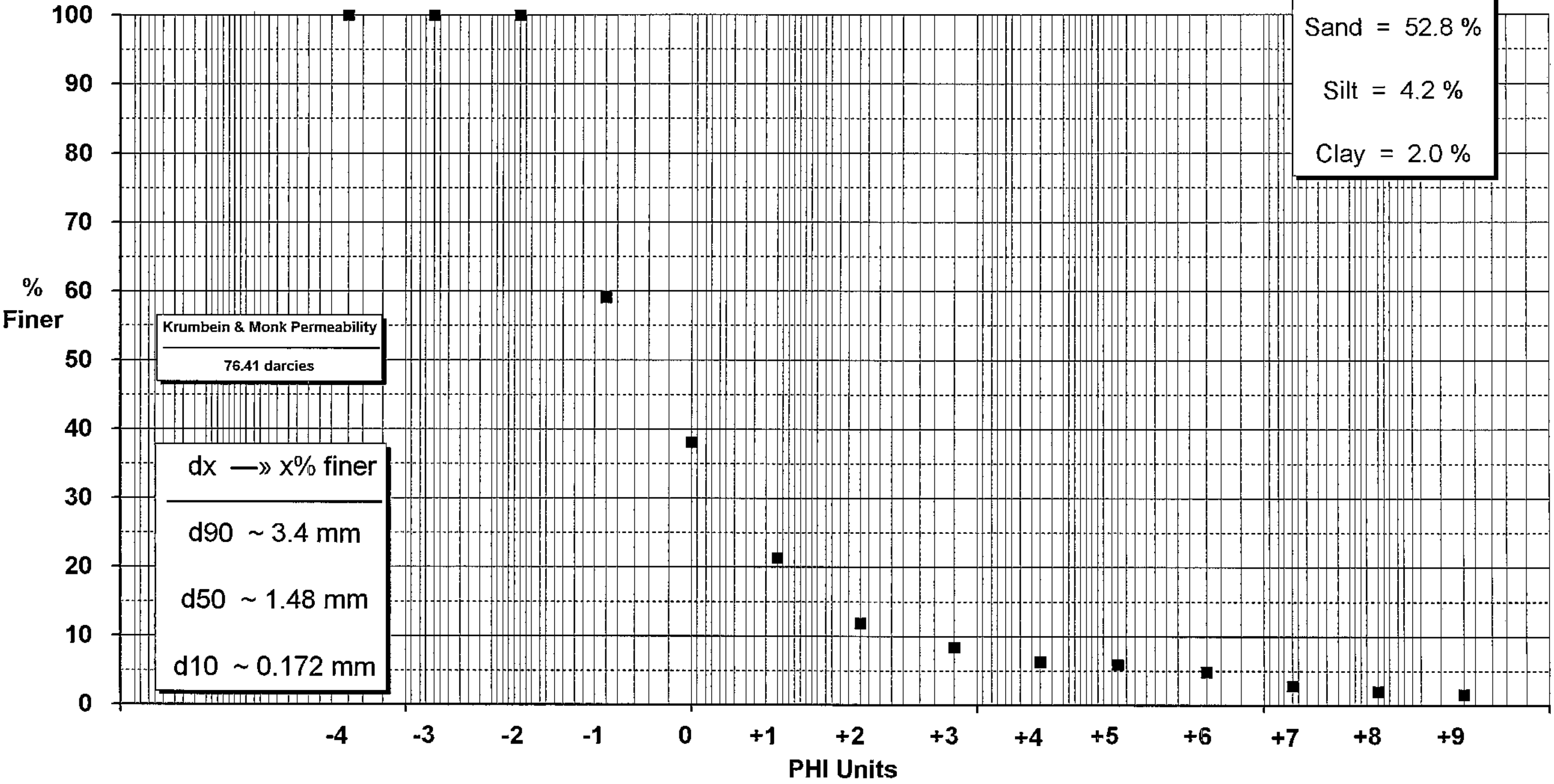
Wentworth

Gravel = 40.9 %

Sand = 52.8 %

Silt = 4.2 %

Clay = 2.0 %



Krumbein & Monk Permeability

76.41 darcies

dx —» x% finer

d90 ~ 3.4 mm

d50 ~ 1.48 mm

d10 ~ 0.172 mm

Approved

Maxxam ID: KX4275-01

Maxxam

HESED-4

Percent Coarser than 75 μm (PHI = 3.737)	Percent Coarser than 50 μm (PHI = 4.322)
94.4 %	95.1 %

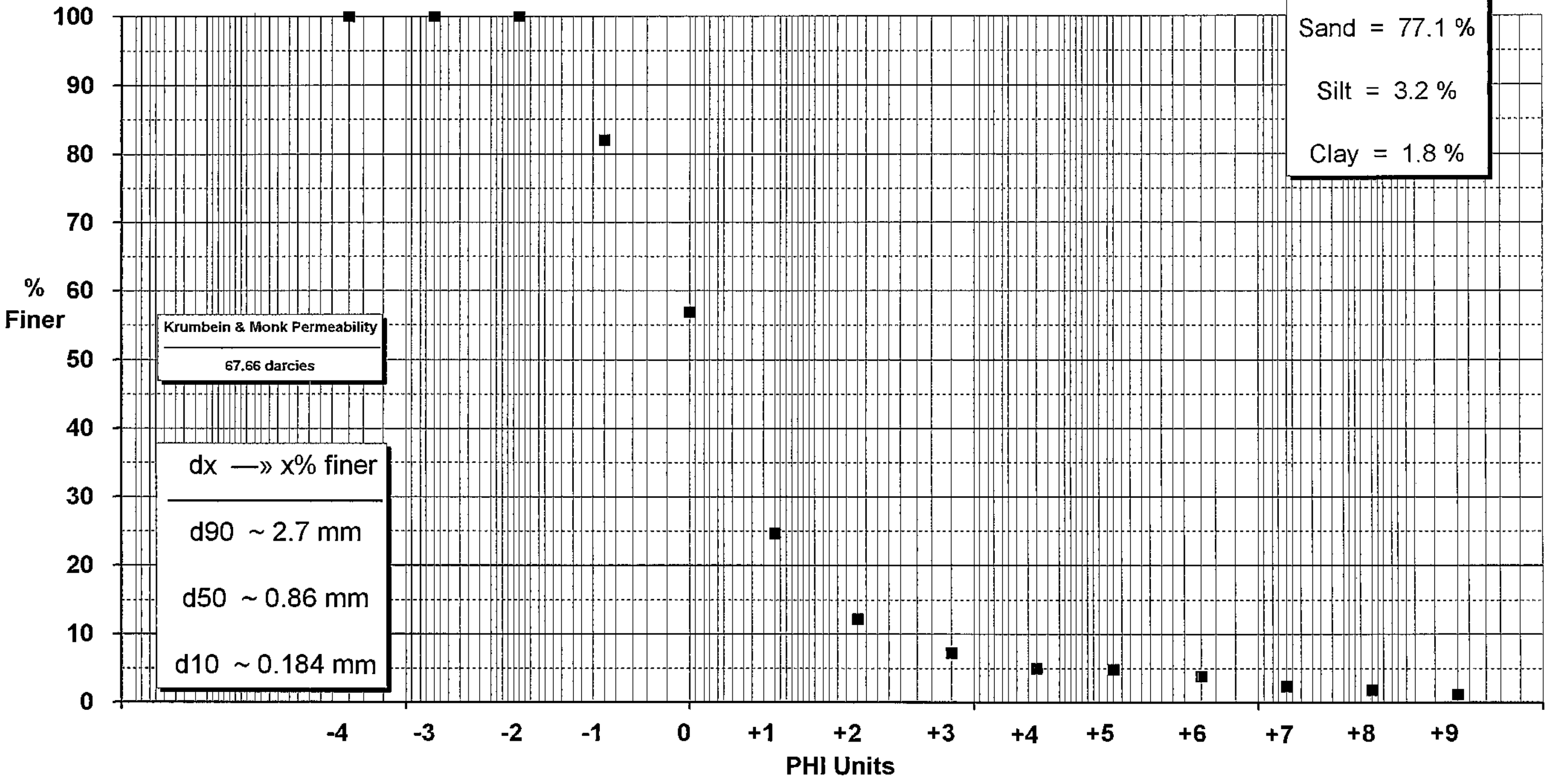
Wentworth

Gravel = 18.0 %

Sand = 77.1 %

Silt = 3.2 %

Clay = 1.8 %



Krumbein & Monk Permeability

67.66 darcies

dx —» x% finer

d90 ~ 2.7 mm

d50 ~ 0.86 mm

d10 ~ 0.184 mm

Approved

Maxxam

Maxxam ID: KX4276-01

HESED-5

Percent Coarser than 75 μm (PHI = 3.737)	Percent Coarser than 50 μm (PHI = 4.322)
96.6 %	97.0 %

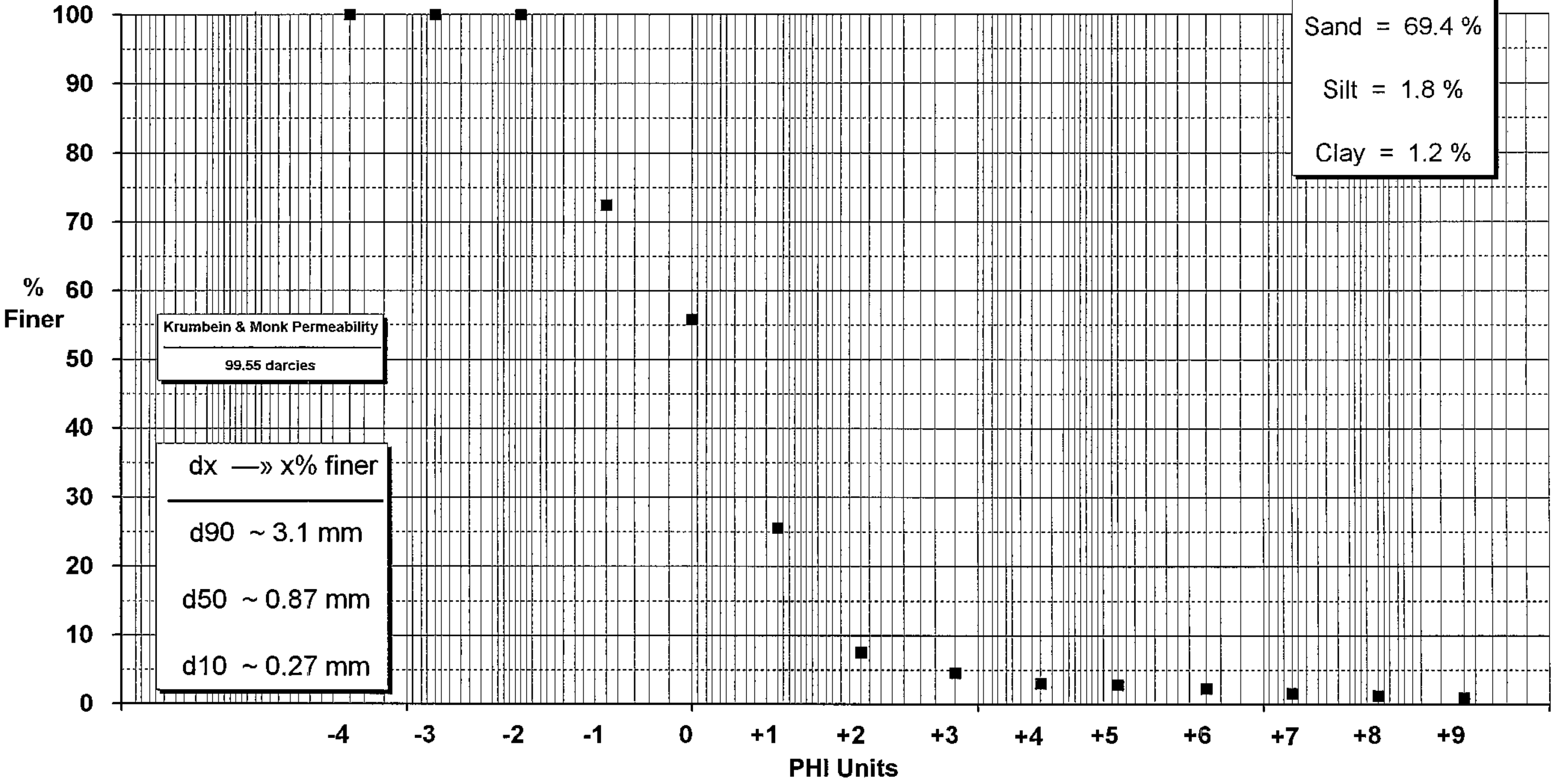
Wentworth

Gravel = 27.5 %

Sand = 69.4 %

Silt = 1.8 %

Clay = 1.2 %



Krumbein & Monk Permeability
99.55 darcies

dx —» x% finer

d90 ~ 3.1 mm

d50 ~ 0.87 mm

d10 ~ 0.27 mm

Approved

Maxxam

Maxxam ID: KX4277-01

HESED-6

Percent Coarser than 75 µm (PHI = 3.737)	Percent Coarser than 50 µm (PHI = 4.322)
87.0 %	88.6 %

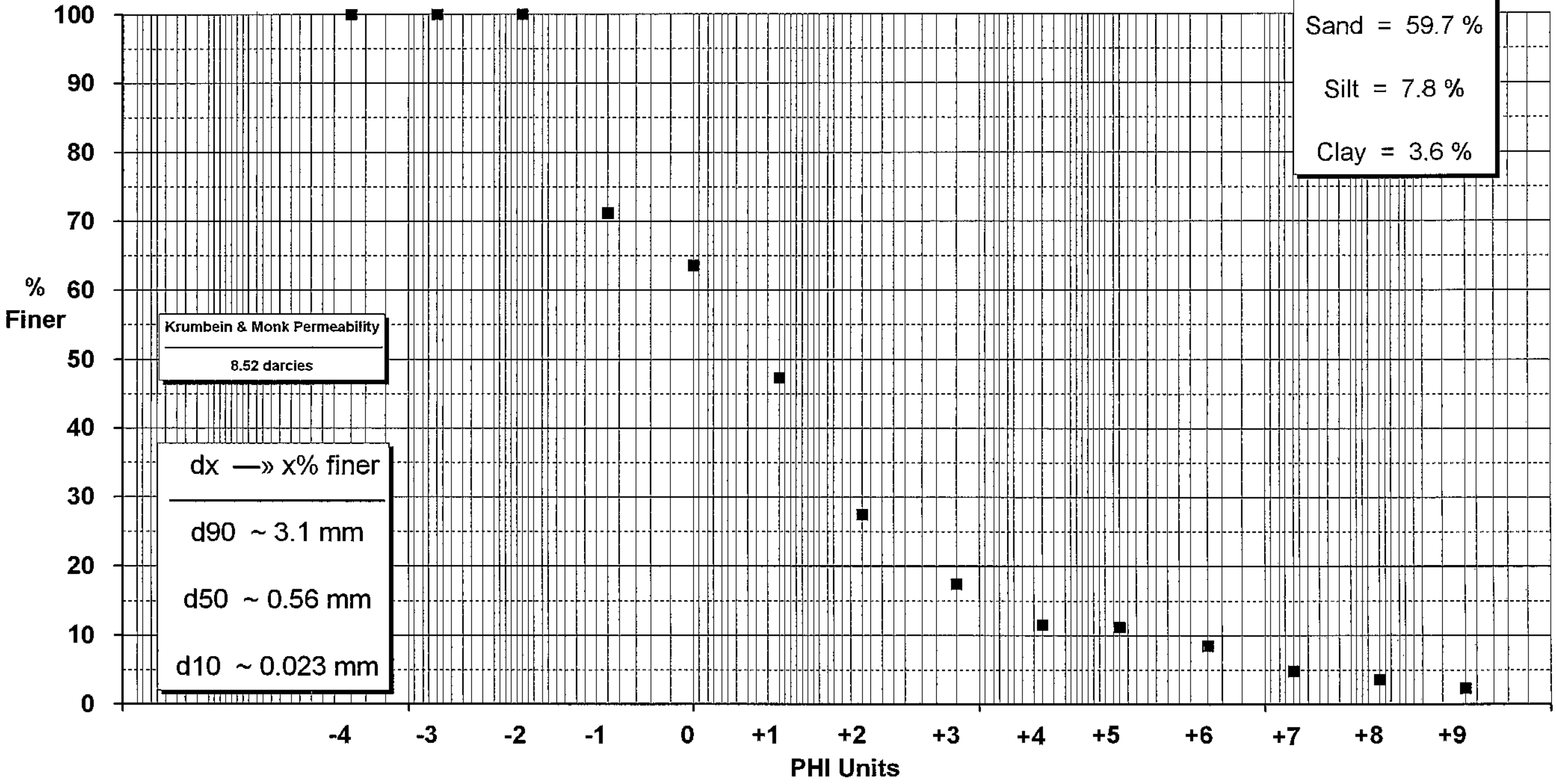
Wentworth

Gravel = 28.8 %

Sand = 59.7 %

Silt = 7.8 %

Clay = 3.6 %



Krumbein & Monk Permeability

8.52 darcies

dx —» x% finer

d90 ~ 3.1 mm

d50 ~ 0.56 mm

d10 ~ 0.023 mm

Approved

Maxxam ID: KX4278-01

HESED-7

Percent Coarser than 75 μm (PHI = 3.737)	Percent Coarser than 50 μm (PHI = 4.322)
97.3 %	97.5 %

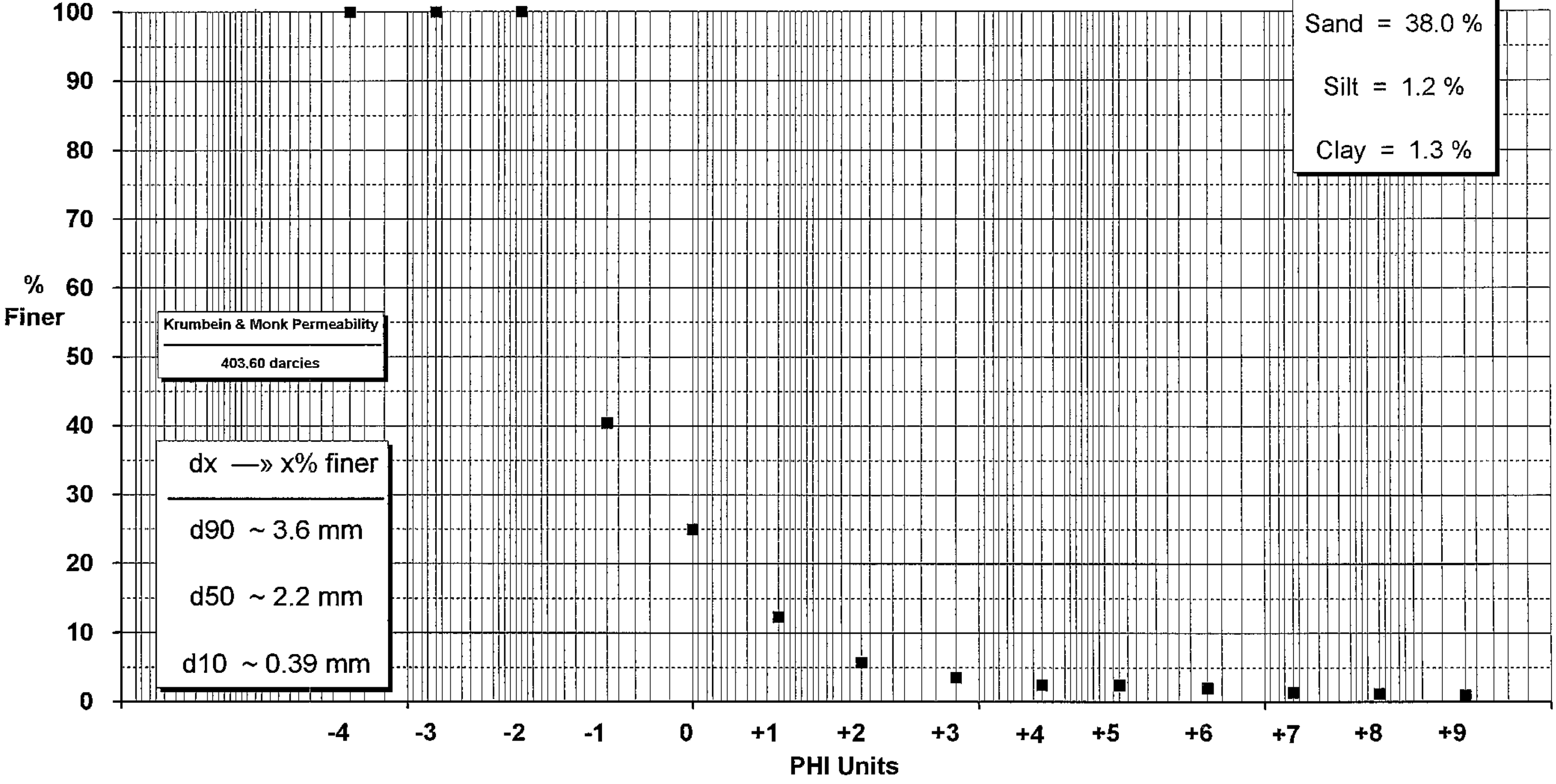
Wentworth

Gravel = 59.6 %

Sand = 38.0 %

Silt = 1.2 %

Clay = 1.3 %



Krumbein & Monk Permeability

403.60 darcies

dx —» x% finer

d90 ~ 3.6 mm

d50 ~ 2.2 mm

d10 ~ 0.39 mm

Approved

Maxxam ID: KX4279-01

UNSED-1

Percent Coarser than 75 µm (PHI = 3.737)	Percent Coarser than 50 µm (PHI = 4.322)
94.9 %	95.2 %

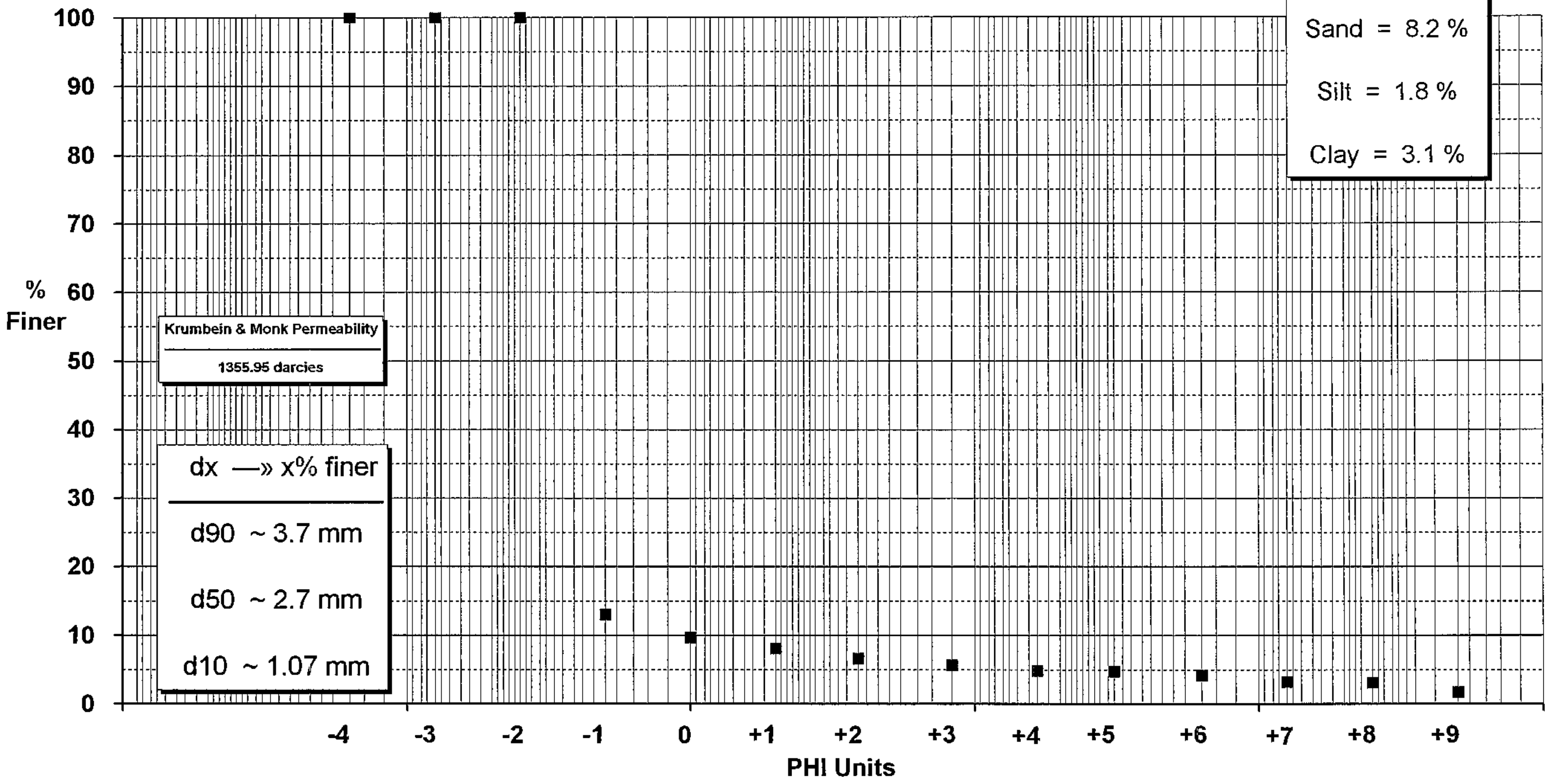
Wentworth

Gravel = 87.0 %

Sand = 8.2 %

Silt = 1.8 %

Clay = 3.1 %



Krumbein & Monk Permeability
1355.95 darcies

dx —» x% finer

d90 ~ 3.7 mm

d50 ~ 2.7 mm

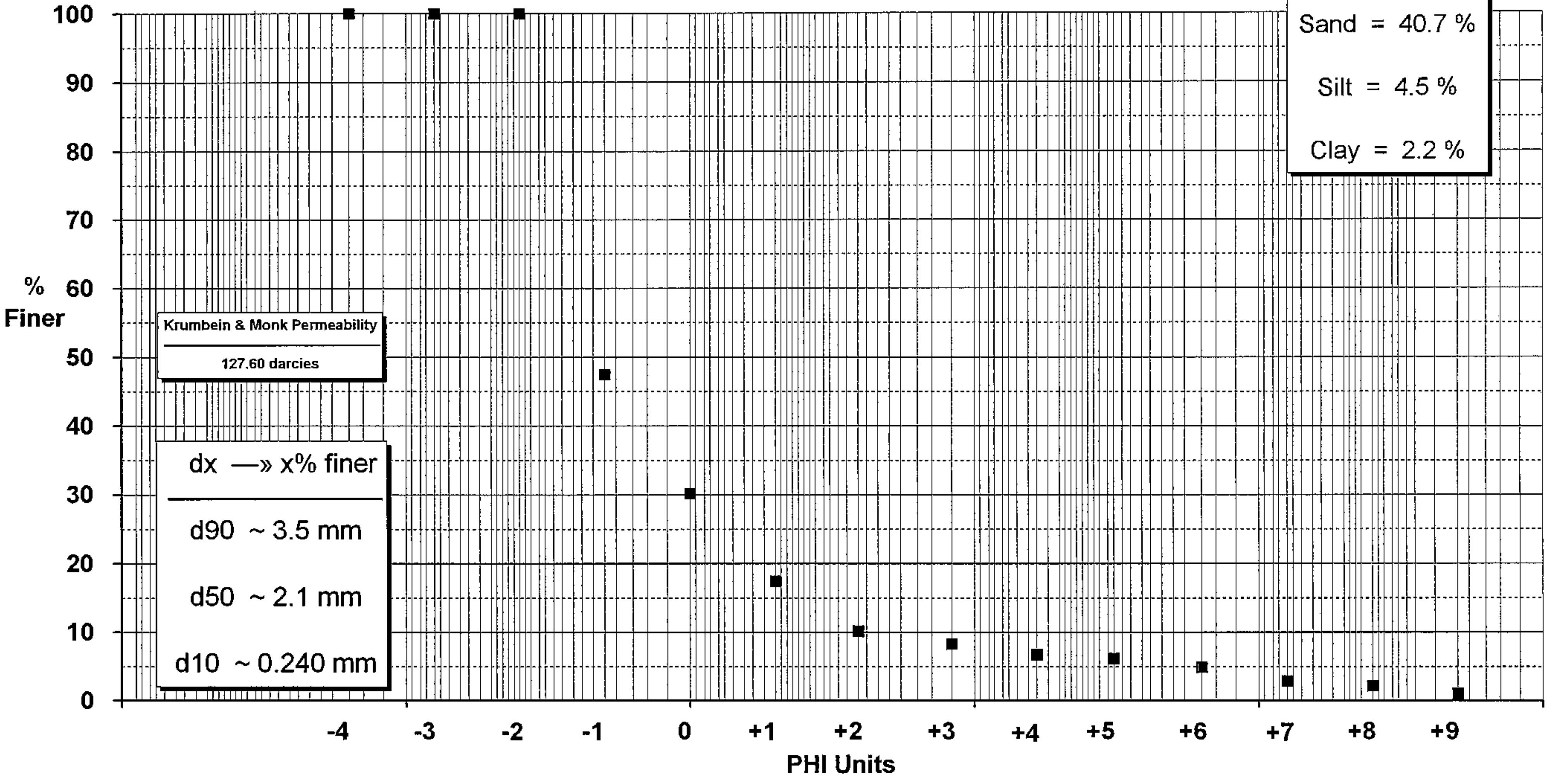
d10 ~ 1.07 mm

Approved

Maxxam ID: KX4280-01

UNSED-2

Percent Coarser than 75 µm (PHI = 3.737)	Percent Coarser than 50 µm (PHI = 4.322)
92.9 %	93.5 %



Wentworth

Gravel = 52.6 %

Sand = 40.7 %

Silt = 4.5 %

Clay = 2.2 %

Krumbein & Monk Permeability
127.60 darcies

dx —» x% finer

d90 ~ 3.5 mm

d50 ~ 2.1 mm

d10 ~ 0.240 mm

Approved

Maxxam ID: KX4281-01

Maxxam

UNSED-3

Percent Coarser than 75 µm (PHI = 3.737)	Percent Coarser than 50 µm (PHI = 4.322)
94.3 %	94.9 %

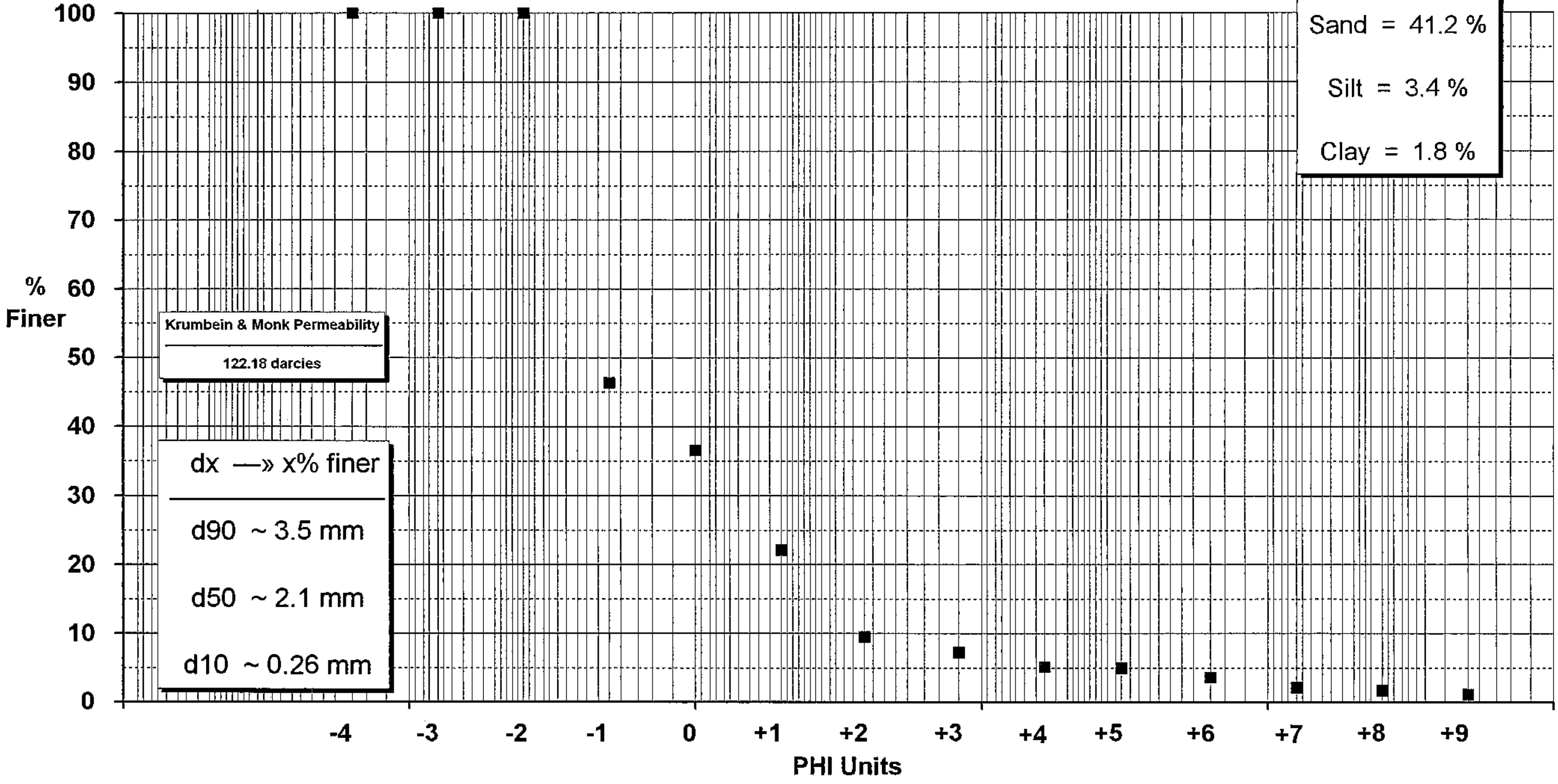
Wentworth

Gravel = 53.7 %

Sand = 41.2 %

Silt = 3.4 %

Clay = 1.8 %



Krumbein & Monk Permeability

122.18 darcies

dx —» x% finer

d90 ~ 3.5 mm

d50 ~ 2.1 mm

d10 ~ 0.26 mm

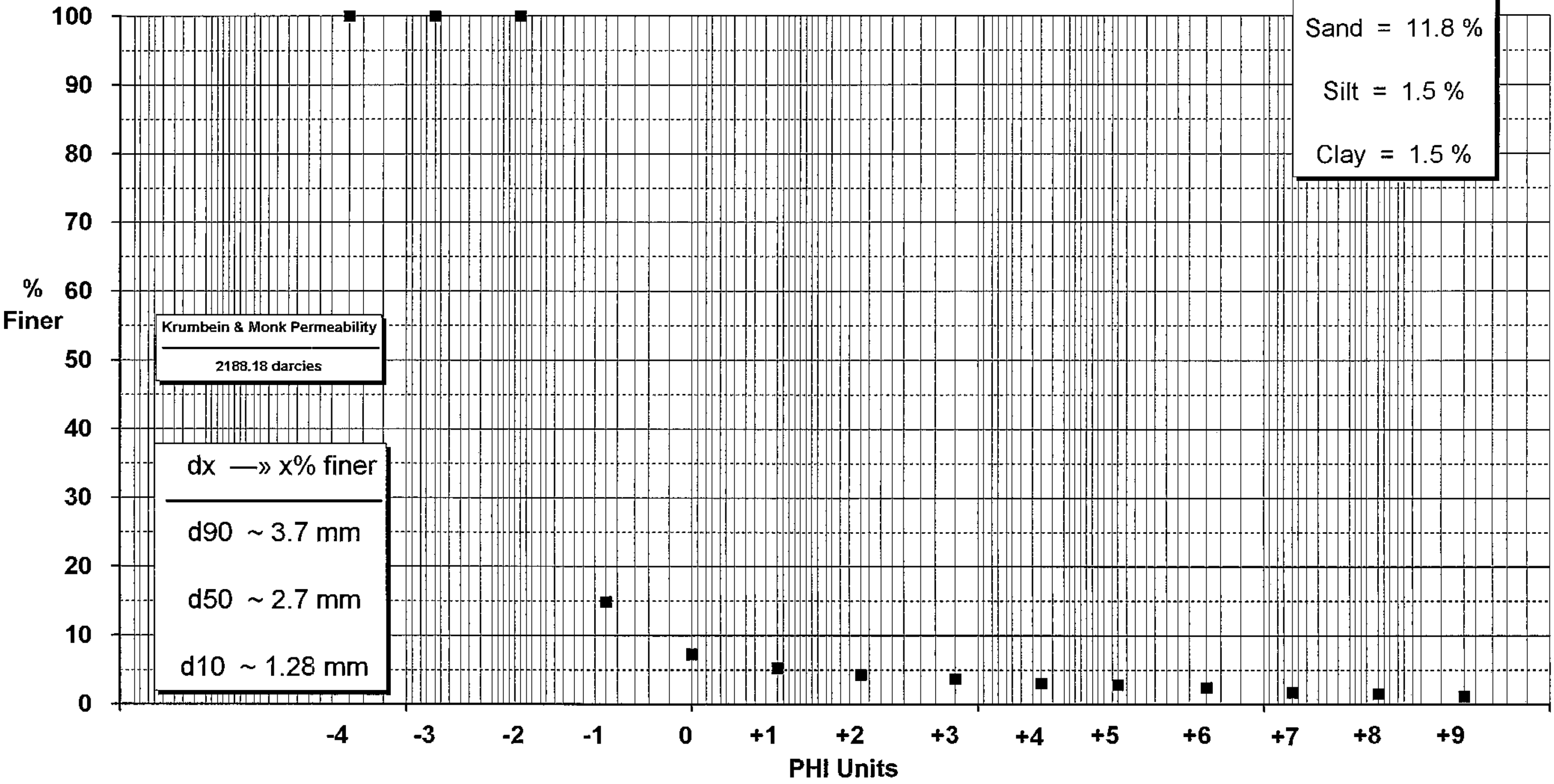
Approved

Maxxam

Maxxam ID: KX4283-01

POND-1

Percent Coarser than 75 µm (PHI = 3.737)	Percent Coarser than 50 µm (PHI = 4.322)
96.8 %	97.0 %



Wentworth

Gravel = 85.1 %

Sand = 11.8 %

Silt = 1.5 %

Clay = 1.5 %

Krumbein & Monk Permeability
2188.18 darcies

dx —» x% finer

d90 ~ 3.7 mm

d50 ~ 2.7 mm

d10 ~ 1.28 mm

Approved

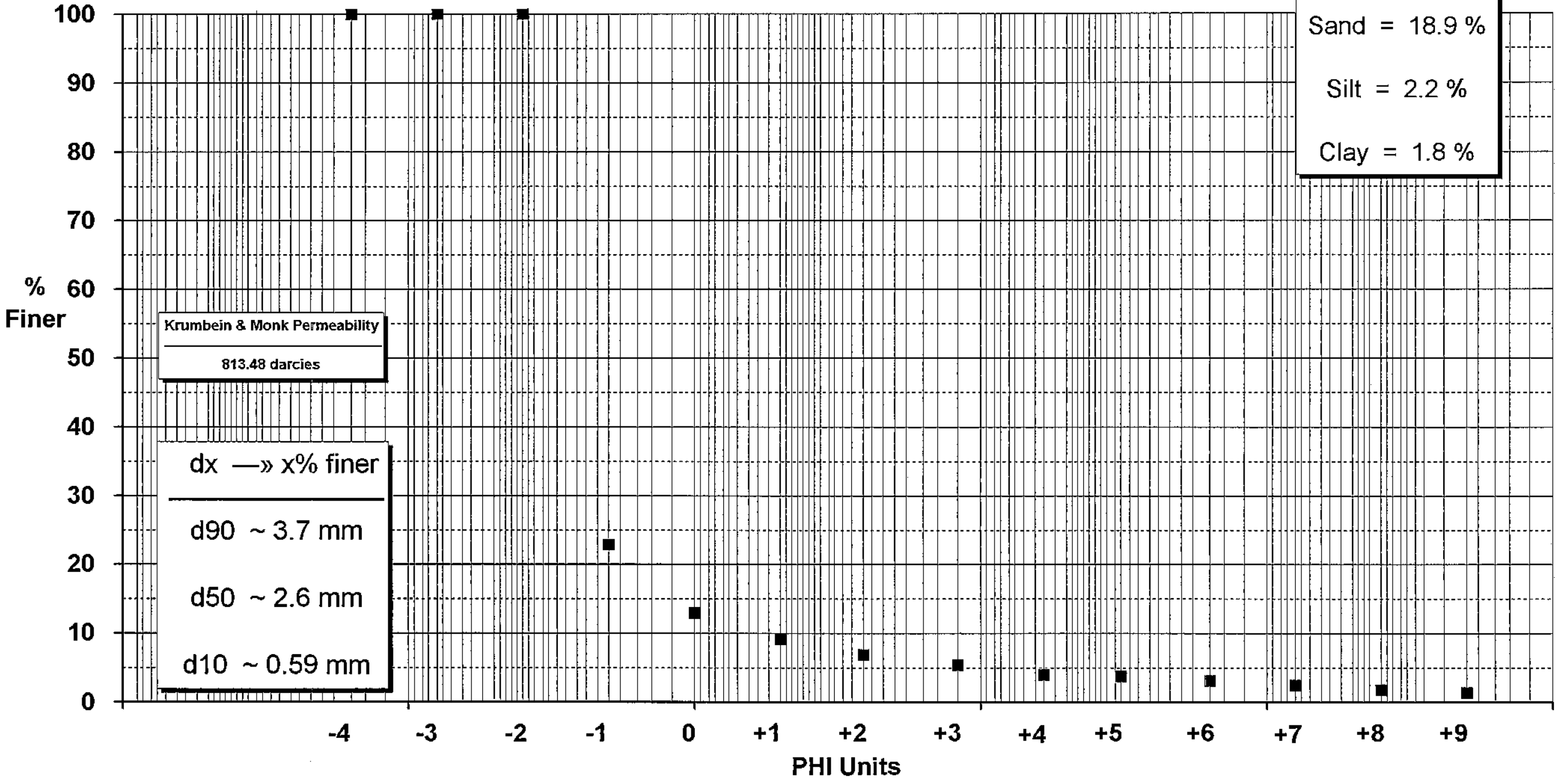
Maxxam

Maxxam ID: KX4283-01:D1

POND-1 :D1

Percent Coarser than 75 µm (PHI = 3.737)	Percent Coarser than 50 µm (PHI = 4.322)
95.6 %	96.1 %

Wentworth
Gravel = 77.1 %
Sand = 18.9 %
Silt = 2.2 %
Clay = 1.8 %



Krumbein & Monk Permeability
813.48 darcies

dx —» x% finer
d90 ~ 3.7 mm
d50 ~ 2.6 mm
d10 ~ 0.59 mm

Approved

Maxxam ID: **KX4284-01**

Maxxam

ARMSED-1

Percent Coarser than 75 µm (PHI = 3.737)	Percent Coarser than 50 µm (PHI = 4.322)
96.7 %	97.1 %

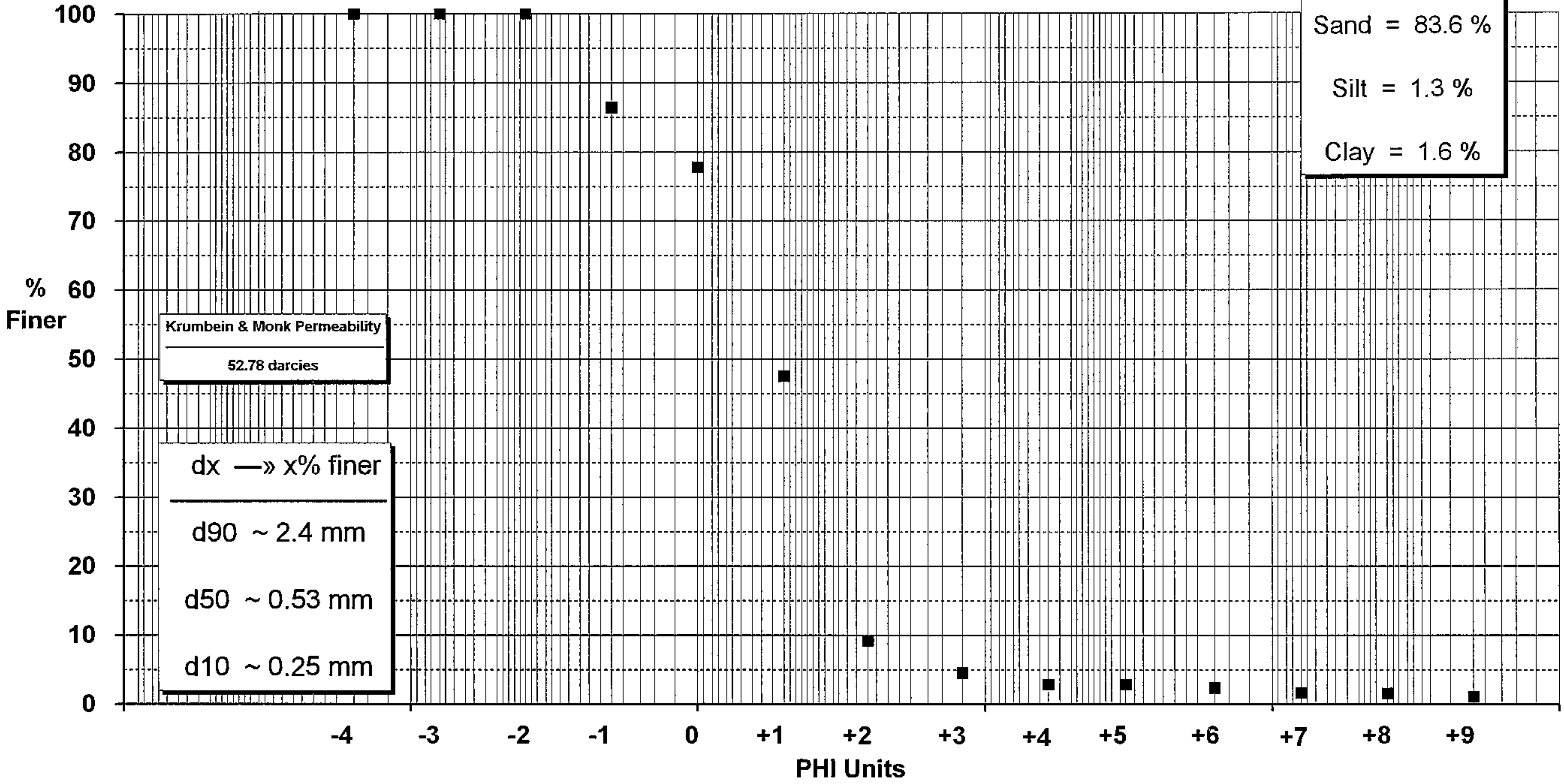
Wentworth

Gravel = 13.5 %

Sand = 83.6 %

Silt = 1.3 %

Clay = 1.6 %



Krumbein & Monk Permeability

52.78 darcies

dx —» x% finer

d90 ~ 2.4 mm

d50 ~ 0.53 mm

d10 ~ 0.25 mm

Approved

Maxxam

Maxxam ID: KX4285-01

ARMSED-2

Percent Coarser than 75 µm (PHI = 3.737)	Percent Coarser than 50 µm (PHI = 4.322)
90.2 %	92.3 %

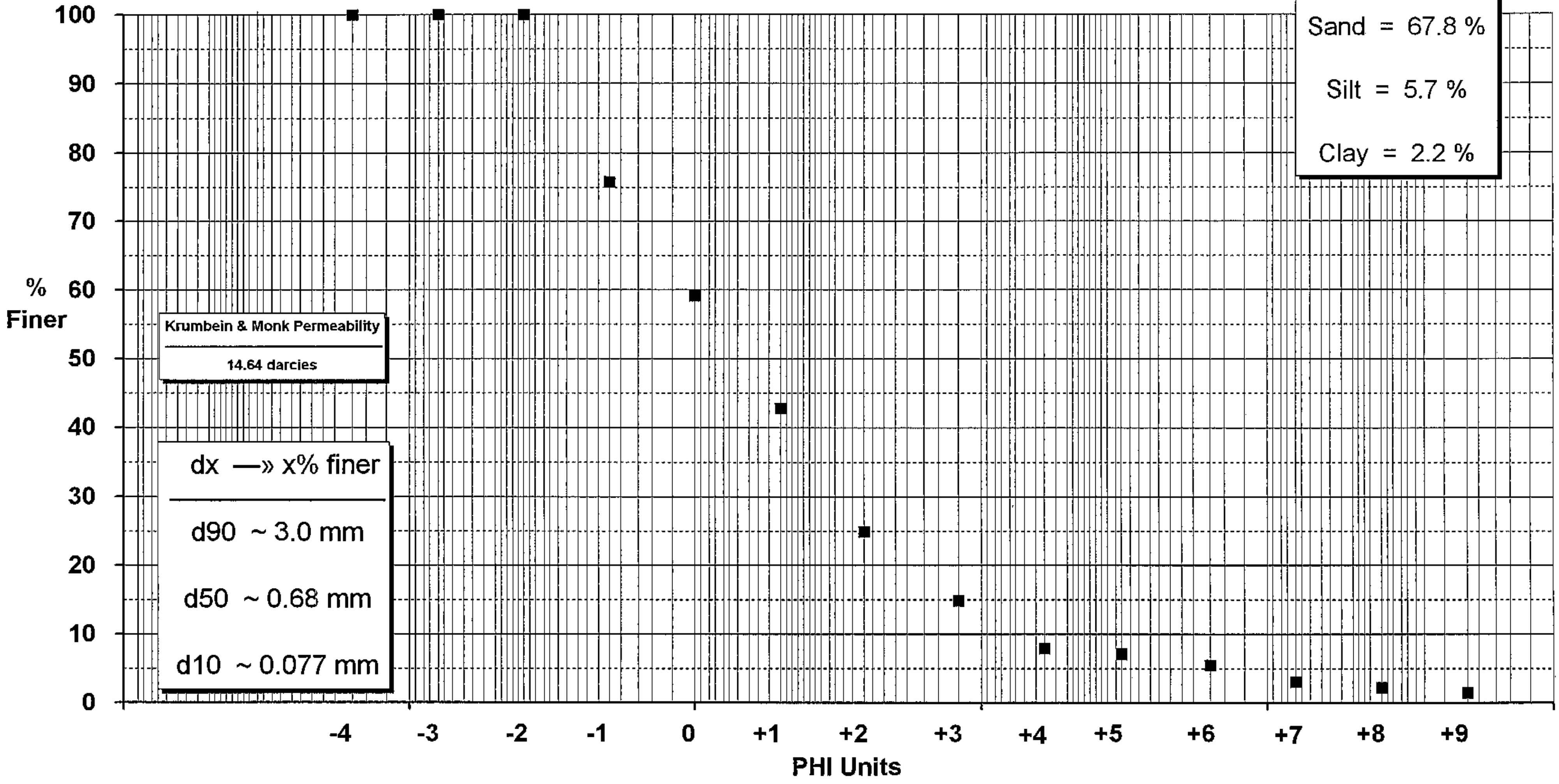
Wentworth

Gravel = 24.2 %

Sand = 67.8 %

Silt = 5.7 %

Clay = 2.2 %



Krumbein & Monk Permeability

14.64 darcies

dx —» x% finer

d90 ~ 3.0 mm

d50 ~ 0.68 mm

d10 ~ 0.077 mm

Approved

Maxxam

Maxxam ID: KX4285-01:D1

ARMSED-2 :D1

Percent Coarser than 75 µm (PHI = 3.737)	Percent Coarser than 50 µm (PHI = 4.322)
89.0 %	90.0 %

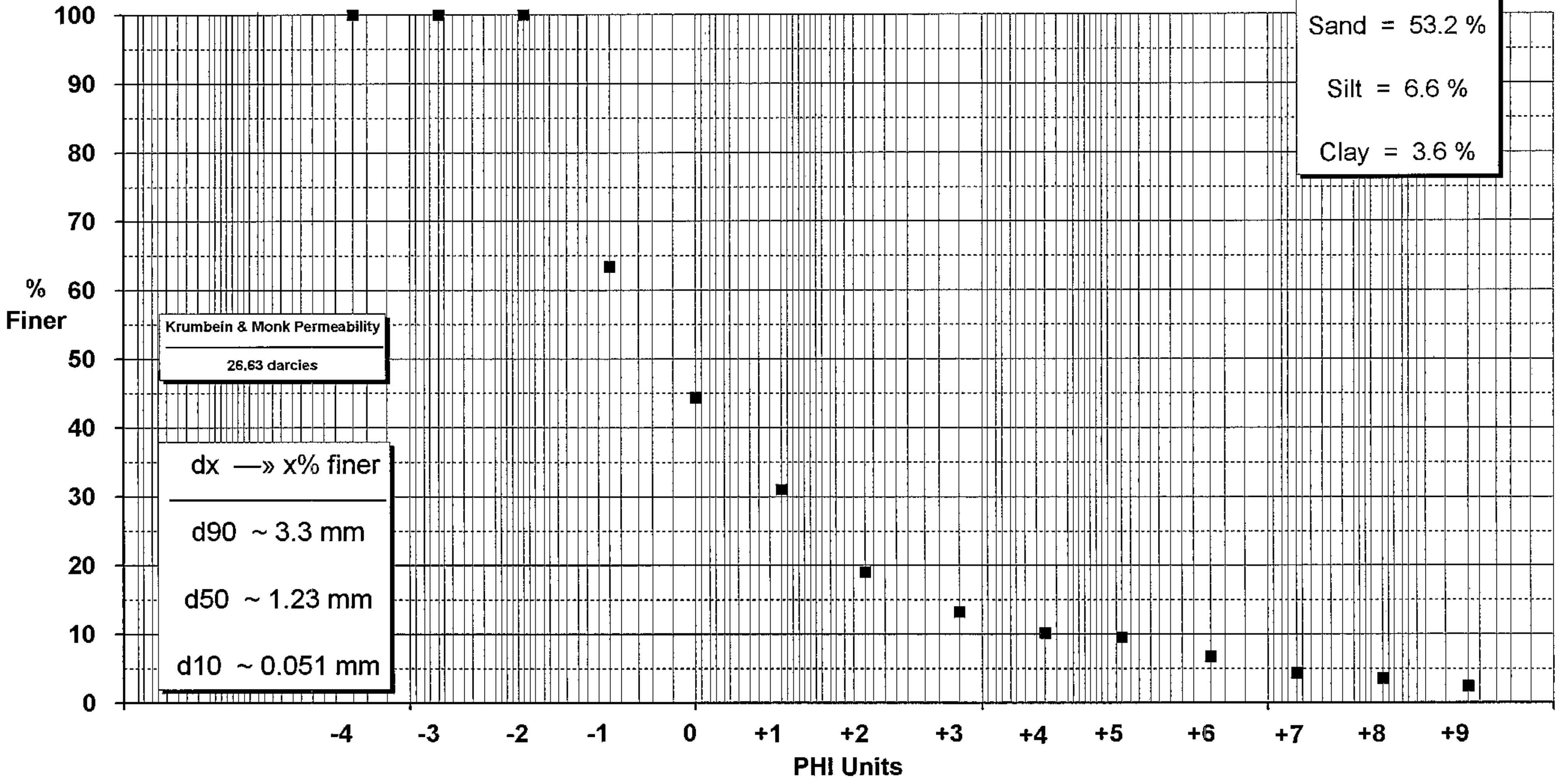
Wentworth

Gravel = 36.6 %

Sand = 53.2 %

Silt = 6.6 %

Clay = 3.6 %



Krumbein & Monk Permeability
26.63 darcies

dx —» x% finer

d90 ~ 3.3 mm

d50 ~ 1.23 mm

d10 ~ 0.051 mm

Approved

Maxxam ID: KX4286-01

ARMSED-3

Percent Coarser than 75 µm (PHI = 3.737)	Percent Coarser than 50 µm (PHI = 4.322)
81.5 %	84.7 %

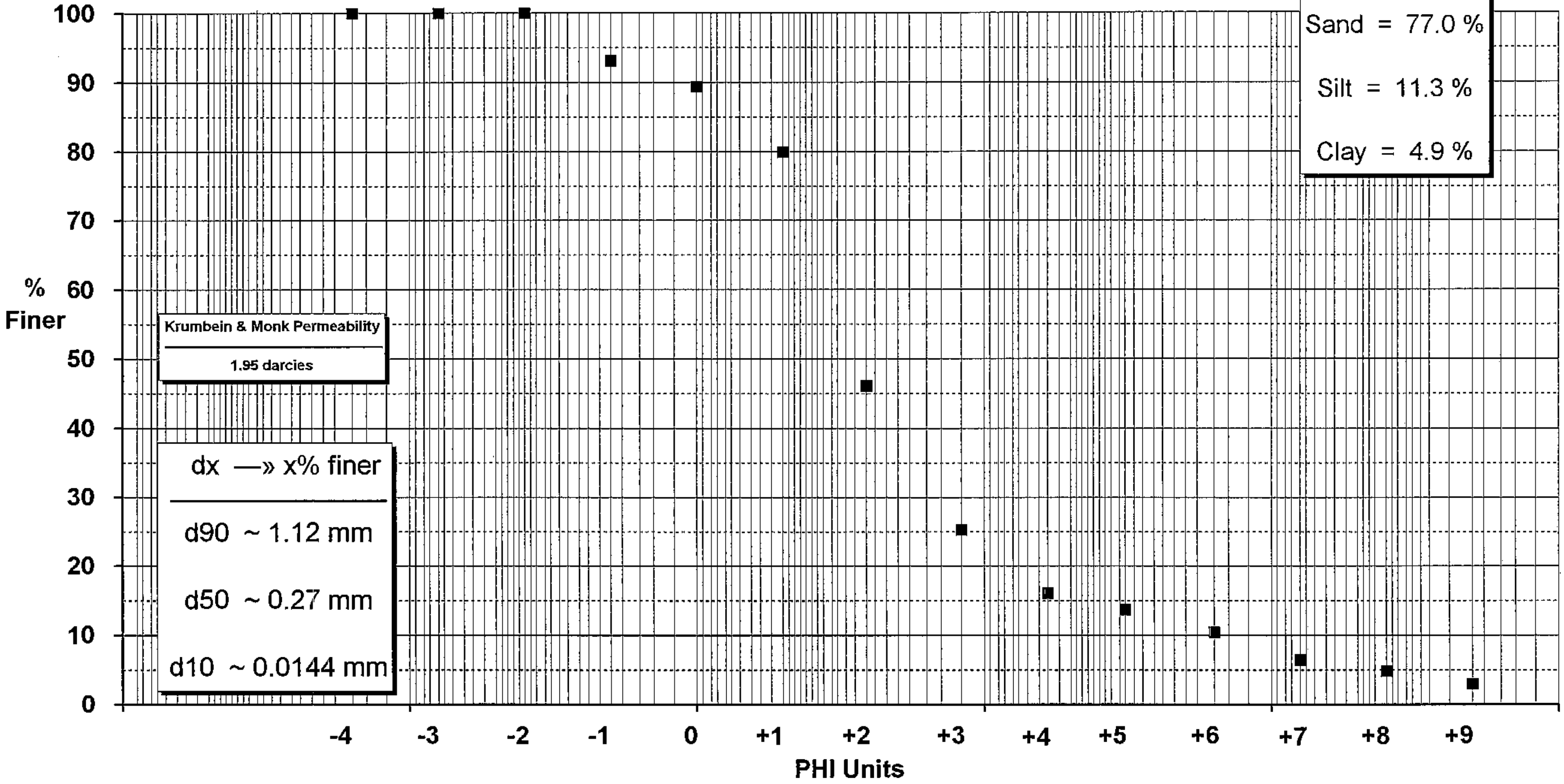
Wentworth

Gravel = 6.9 %

Sand = 77.0 %

Silt = 11.3 %

Clay = 4.9 %



Krumbein & Monk Permeability
1.95 darcies

dx —» x% finer

d90 ~ 1.12 mm

d50 ~ 0.27 mm

d10 ~ 0.0144 mm

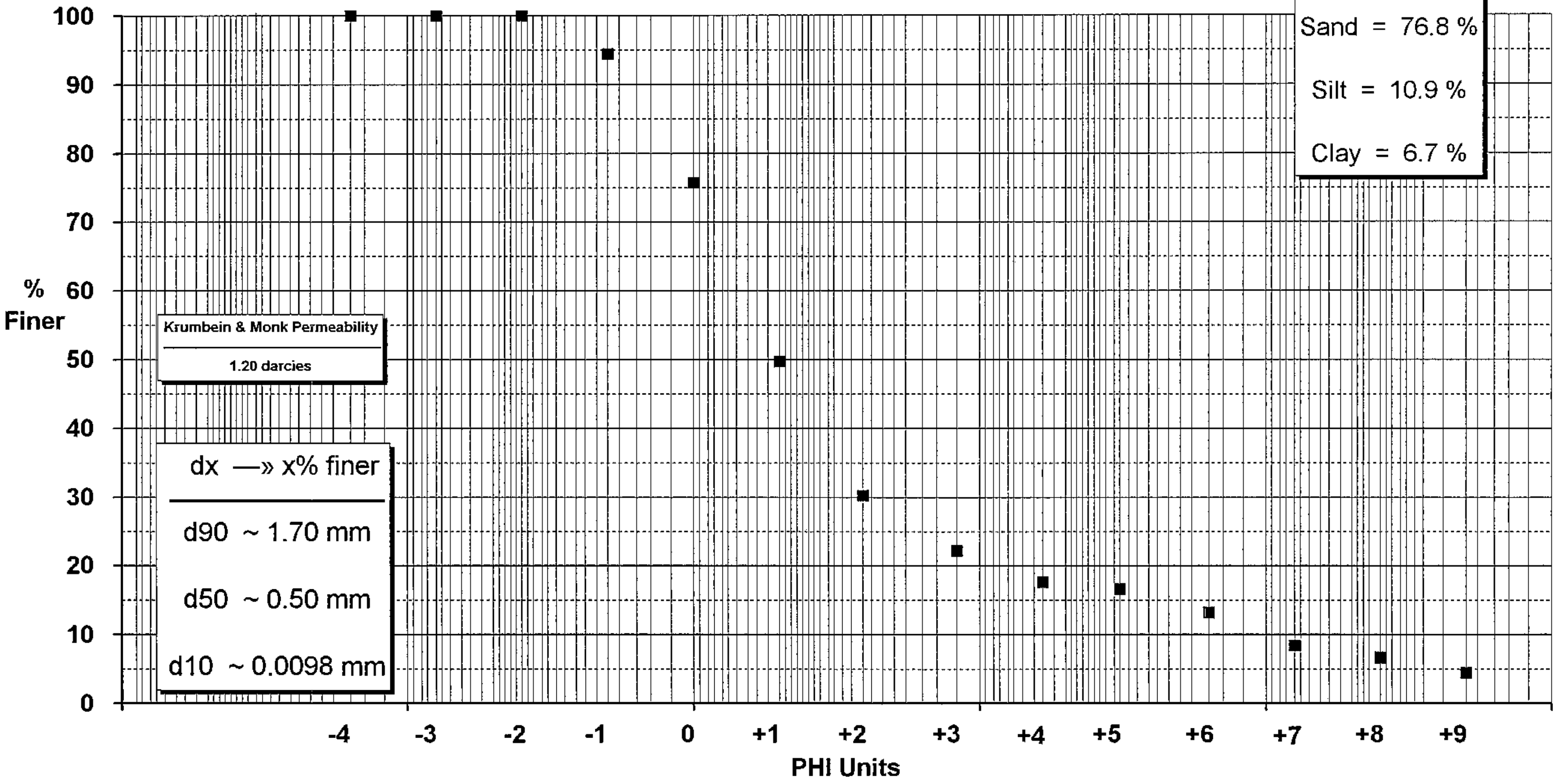
Approved

Maxxam ID: KX4287-01

Maxxam

ARMSED-4

Percent Coarser than 75 µm (PHI = 3.737)	Percent Coarser than 50 µm (PHI = 4.322)
81.2 %	82.7 %



Wentworth

Gravel = 5.6 %

Sand = 76.8 %

Silt = 10.9 %

Clay = 6.7 %

Krumbein & Monk Permeability
1.20 darcies

dx —» x% finer

d90 ~ 1.70 mm

d50 ~ 0.50 mm

d10 ~ 0.0098 mm

Approved

Maxxam ID: KX4288-01

ARMSED-5

Percent Coarser than 75 µm (PHI = 3.737)	Percent Coarser than 50 µm (PHI = 4.322)
89.9 %	90.6 %

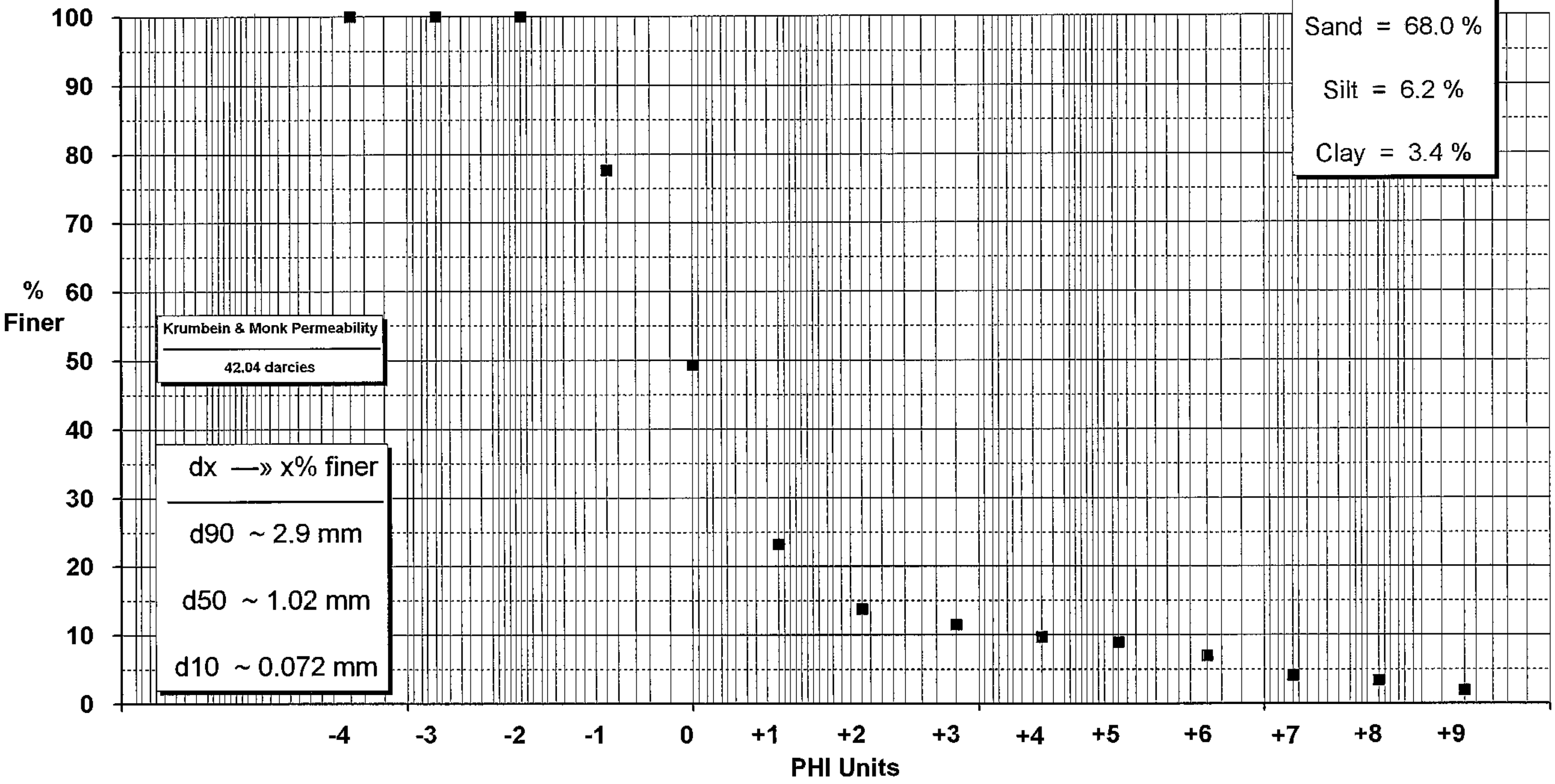
Wentworth

Gravel = 22.3 %

Sand = 68.0 %

Silt = 6.2 %

Clay = 3.4 %



Krumbein & Monk Permeability
42.04 darcies

dx —» x% finer

d90 ~ 2.9 mm

d50 ~ 1.02 mm

d10 ~ 0.072 mm

Approved

Maxxam ID: **KX4289-01**

Maxxam

QA/QC-1

Percent Coarser than 75 µm (PHI = 3.737)	Percent Coarser than 50 µm (PHI = 4.322)
97.6 %	98.2 %

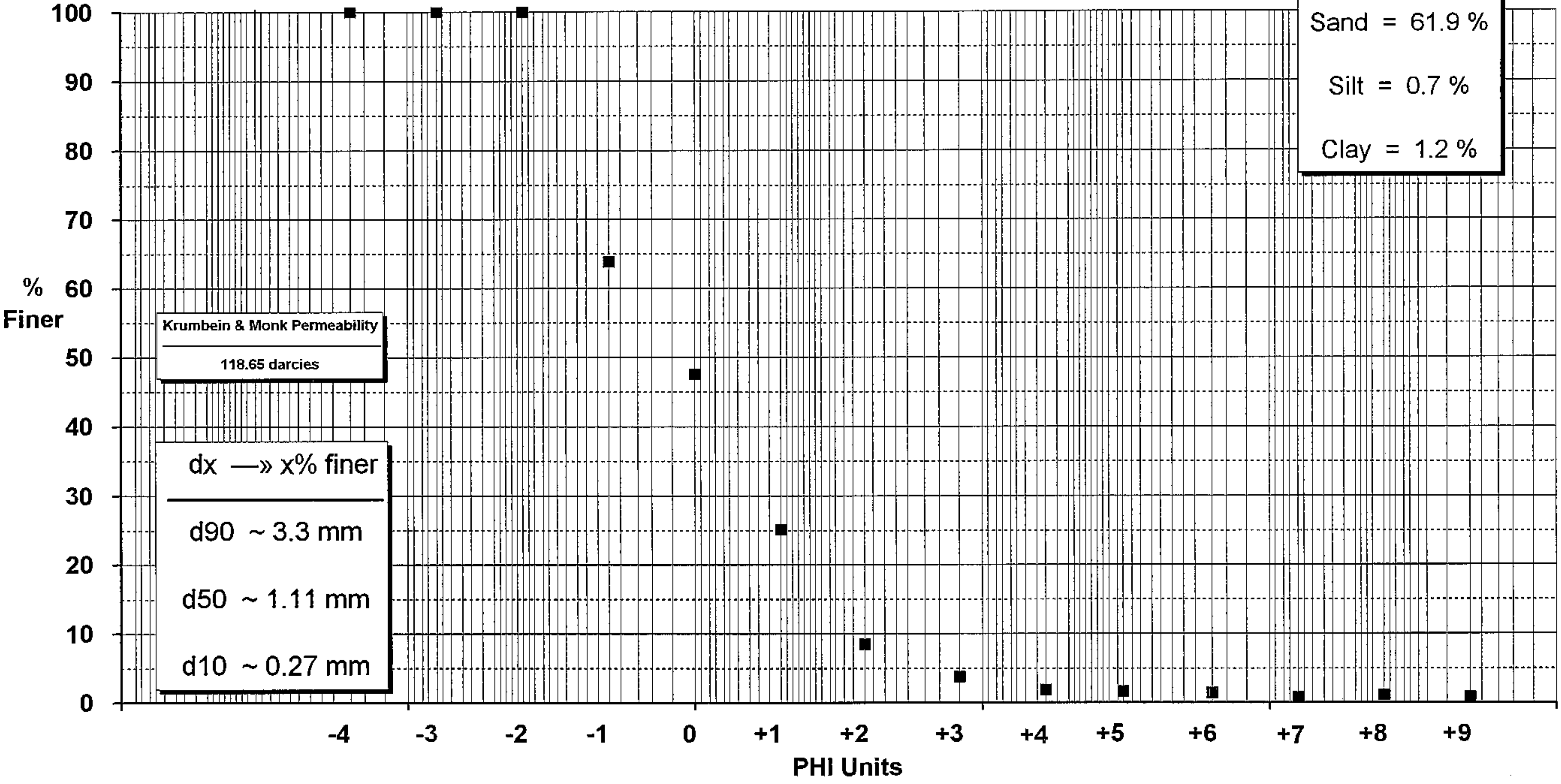
Wentworth

Gravel = 36.2 %

Sand = 61.9 %

Silt = 0.7 %

Clay = 1.2 %



Krumbein & Monk Permeability
118.65 darcies

dx —» x% finer

d90 ~ 3.3 mm

d50 ~ 1.11 mm

d10 ~ 0.27 mm

Approved

Maxxam

Maxxam ID: KX4290-01

QA/QC-2

Percent Coarser than 75 µm (PHI = 3.737)	Percent Coarser than 50 µm (PHI = 4.322)
80.4 %	81.8 %

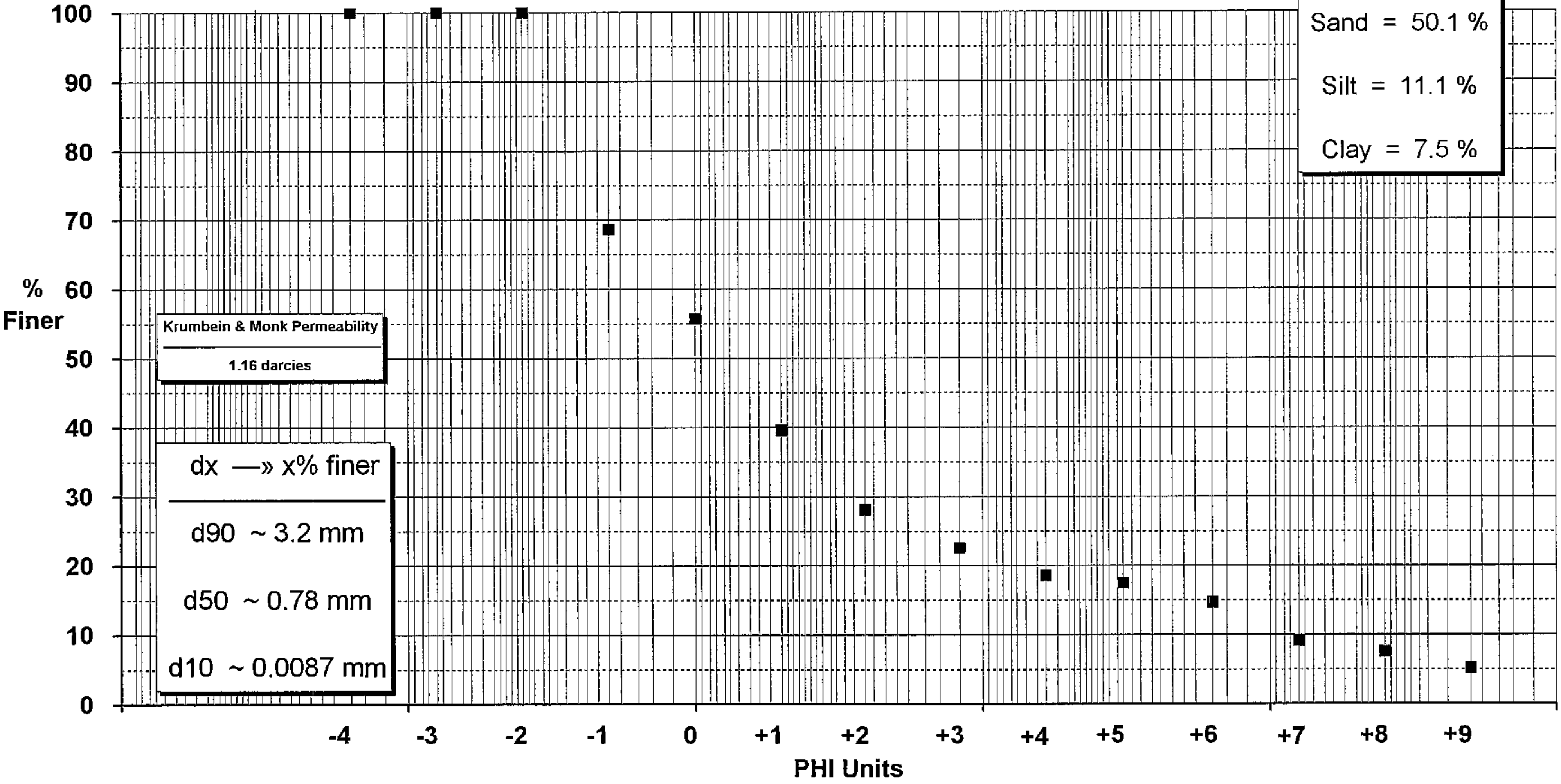
Wentworth

Gravel = 31.3 %

Sand = 50.1 %

Silt = 11.1 %

Clay = 7.5 %



Krumbein & Monk Permeability

1.16 darcies

dx —» x% finer

d90 ~ 3.2 mm

d50 ~ 0.78 mm

d10 ~ 0.0087 mm

Approved

Maxxam Analytics International Corporation

200 Bluewater Road, Suite 105, Bedford, Nova Scotia B4B 1G9 Tel: 902-420-0203 Fax: 902-420-8612 Toll Free: 1-800-565-7227
49 Elizabeth Ave., St John's, NL A1A 1W9 Tel: 709-754-0203 Fax: 709-754-8612 Toll Free: 1-888-492-7227
90 Esplanade Sydney, NS B1P 1A1 Tel: 902-567-1255 Fax: 902-539-6504 Toll Free: 1-888-535-7770
www.maxxamanalytics.com E-mail: Clientservicesbedford@maxxamanalytics.com

MAXXAM Chain of Custody Record

COC #: **B** 121711

Page 1 of 2

This column for lab use only:

Client Code:

Maxxam Job #:

Cooler ID	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp
			3	3	4	
			2	2	1	

Integrity [✓ YES] NO

Integrity / Checklist by: GK

Labelled by:

Location / Bin #:

INVOICE INFORMATION:

Company Name:
Contact Name:
Address:
Postal Code:
Email:
Ph:
Fax:

REPORT INFORMATION (if differs from invoice):

Company Name: Intrinsik ENL
Contact Name: Christine Moore
Address: 5721 Sackville st
Halifax, NS
Postal Code: B3J 1K1
Email:
Ph: (902) 429-0278
Fax:

PO #:
Project # / Phase #: 055453
Project Name / Site Location: Belledune, NB
Quote: B14952
Site #:
Task Order #:
Sampled by: M. Gaines / M. Graves

TURNAROUND TIME

Standard ☑
10 day ☐
If RUSH Specify Date:
Pre-schedule rush work

Charge for # Jars used but not submitted:

Guideline Requirements / Detection Limits / Special Instructions

*Specify Matrix: Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

								Metals Water			Metals Soil					Hydrocarbons											
Field Sample Identification	Matrix*	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose Total or Diss Metals	RCAP-MS Choose Total or Diss Metals	Total Digest (Default Method) for well water, surface water	Dissolved for ground water	Mercury	Metals & Mercury Default Available Digest Method	Metals Total Digest - for Ocean sediments (HNO3/HF/HCLO4)	Mercury Low level by Cold Vapour AA	Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Hot Water soluble Boron (required for CCME Agricultural)	RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	NB Potable Water BTEX, VPH, Low level T.E.H.	TPH Fractionation	PAH's	PAH's with Acridine, Quinoline	TOC (LECO)	pH	Particle Size	(Sieve & Pipette)		
1 HESED-1	Sediment	Sept. 12/11 11:31am	bag	N	N						✓											✓	✓	✓			
2 HESED-2	Sediment	Sept. 12/11 2:48pm	bag	N	N						✓											✓	✓	✓			
3 HESED-3	Sediment	Sept. 13/11 9:12am	bag	N	N						✓											✓	✓	✓			
4 HESED-4	Sediment	Sept. 13/11 10:51am	bag	N	N						✓											✓	✓	✓			
5 HESED-5	Sediment	Sept. 13/11 3:39pm	bag	N	N						✓											✓	✓	✓			
6 HESED-6	Sediment	Sept. 13/11 3:12pm	bag	N	N						✓											✓	✓	✓			
7 HESED-7	Sediment	Sept. 13/11 4:08pm	bag	N	N						✓											✓	✓	✓			
8 UNSED-1	Sediment	Sept. 13/11 12:58pm	bag	N	N						✓											✓	✓	✓			
9 UNSED-2	Sediment	Sept. 13/11 1:17pm	bag	N	N						✓											✓	✓	✓			
10 UNSED-3	Sediment	Sept. 13/11 2:03pm	bag	N	N						✓											✓	✓	✓			

RELINQUISHED BY: (Signature/Print)	Date	Time	RECEIVED BY: (Signature/Print)	Date	Time
Michael C. Gaines	Sept. 15/11	2:00pm			

White: Maxxam Yellow : Mail Pink: Client

Maxxam Analytics International Corporation

200 Bluewater Road, Suite 105, Bedford, Nova Scotia B4B 1G9 Tel: 902-420-0203 Fax: 902-420-8612 Toll Free: 1-800-565-7227
49 Elizabeth Ave., St John's, NL A1A 1W9 Tel: 709-754-0203 Fax: 709-754-8612 Toll Free: 1-888-492-7227
90 Esplanade Sydney, NS B1P 1A1 Tel: 902-567-1255 Fax: 902-539-6504 Toll Free: 1-888-535-7770
www.maxxamanalytics.com E-mail: Clientservicesbedford@maxxamanalytics.com

MAXXAM Chain of Custody Record

COC #: **B** 121712

Page 2 of 2

This column for lab use only:

Client Code

Maxxam Job #

Cooler ID	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp
			3	3	4	
			2	2	1	

Integrity [✓ YES] NO

Integrity / Checklist by: GR

Labelled by

Location / Bin #

INVOICE INFORMATION:

Company Name:
Contact Name:
Address:
Postal Code
Email:
Ph: **Fax:**

REPORT INFORMATION (if differs from invoice):

Company Name: Intrinsik Env
Contact Name: Christine Moore
Address: 5121 Sackville St
Halifax, NS **Postal Code** B3J 1K1
Email:
Ph: (902) 429-0278 **Fax:**

PO #
Project # / Phase # 055453
Project Name / Site Location Belledune, NB
Quote B14952
Site #
Task Order #
Sampled by M. Gainey / M. Graves

TURNAROUND TIME
Standard ☑
10 day ☐
If RUSH Specify Date:
Pre-schedule rush work
Charge for # Jars used but not submitted

Guideline Requirements / Detection Limits / Special Instructions

*Specify Matrix: Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

								Metals Water			**Metals Soil**					**Hydrocarbons**									
Field Sample Identification	**Matrix***	**Date/Time Sampled**	**# & type of bottles**	**Field Filtered & Preserved**	**Lab Filtration Required**	**RCAP-30** Choose Total or Diss Metals	**RCAP-MS** Choose Total or Diss Metals	**Total Digest (Default Method)** for well water, surface water	**Dissolved** for ground water	**Mercury**	**Metals & Mercury** Default Available Digest Method	**Metals Total Digest** - for Ocean sediments (HNO3/HF/HCLO4)	**Mercury** Low level by Cold Vapour AA	**Selenium** (low level) Req'd for CCME Residential, Parklands, Agricultural	**Hot Water soluble Boron** (required for CCME Agricultural)	**RBCA Hydrocarbons** (BTEX, C6-C32)	Hydrocarbons **Soil** (Potable), NS Fuel Oil Spill Policy **Low Level** BTEX, C6-C32	**NB Potable Water BTEX, VPH, Low level T.E.H.**	**TPH Fractionation**	**PAH's**	**PAH's with Acridine, Quinoline**	TOC (LECO)	pH	Particle Size (Sieve & pipette)	
1 Pond-1	Sediment	Sept.13/11 2:21pm	bag	N	N						✓											✓	✓	✓	
2 Pond-2	Sediment	Sept.13/11 2:43pm	bag	N	N						✓											✓	✓	✓	
3 ARMSED-1	Sediment	Sept.14/11 8:19am	bag	N	N						✓											✓	✓	✓	
4 ARMSED-2	Sediment	Sept.14/11 8:41am	bag	N	N						✓											✓	✓	✓	
5 ARMSED-3	Sediment	Sept.14/11 9:29am	bag	N	N						✓											✓	✓	✓	
6 ARMSED-4	Sediment	Sept.14/11 10:11am	bag	N	N						✓											✓	✓	✓	
7 ARMSED-5	Sediment	Sept.14/11 11:00am	bag	N	N						✓											✓	✓	✓	
8 QA/QC-1	Sediment	Sept.13/11 3:43pm	bag	N	N						✓											✓	✓	✓	
9 QA/QC-2	Sediment	Sept.14/11 10:15am	bag	N	N						✓											✓	✓	✓	
10																									

RELINQUISHED BY: (Signature/Print)	**Date**	**Time**	**RECEIVED BY: (Signature/Print)**	**Date**	**Time**
Michael C. Gainey	Sept.15/11	2:00pm			

2011 SEP 16 AM 8:28

White: Maxxam Yellow : Mail Pink: Client

Your Project #: 055453
Site Location: BELLEDUNE, NB
Your C.O.C. #: B 121711

Attention: Christine Moore
Intrinsik Environmental Sciences
5121 Sackville Street
Suite 506
Halifax, NS
CANADA B3J 1K1

Report Date: 2011/09/26

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B1E2550
Received: 2011/09/16, 8:27

Sample Matrix: Soil
Samples Received: 18

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Metals Solid Avail. Unified MS - Nper	7	2011/09/19	2011/09/19	ATL SOP 00024 R5	Based on EPA6020A
Metals Solid Avail. Unified MS - Nper	6	2011/09/19	2011/09/20	ATL SOP 00024 R5	Based on EPA6020A
Metals Solid Avail. Unified MS - Nper	5	2011/09/20	2011/09/21	ATL SOP 00024 R5	Based on EPA6020A
pH (5:1 DI Water Extract)	18	2011/09/21	2011/09/22	ATL SOP 00005 R7	Based on SM4500H+B
Particle size in solids (pipette&sieve)	18	N/A	2011/09/23	ATL SOP 00012 R3	based on MSAMS-1978
Total Organic Carbon in Soil	3	2011/09/21	2011/09/21	ATL SOP 00044 R4/00045 R4	LECO 203-601-224
Total Organic Carbon in Soil	15	2011/09/23	2011/09/23	ATL SOP 00044 R4/00045 R4	LECO 203-601-224

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
* Results relate only to the items tested.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

MICHELLE HILL, Project Manager
Email: MHill@maxxam.ca
Phone# (902) 420-0203

==
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Total cover pages: 1

Maxxam Job #: B1E2550
Report Date: 2011/09/26

Intrinsik Environmental Sciences
Client Project #: 055453
Site Location: BELLEDUNE, NB
Sampler Initials: MG

RESULTS OF ANALYSES OF SOIL

Maxxam ID		KX4271	KX4273	KX4274	KX4275	KX4276		KX4277		KX4278		KX4279		
Sampling Date		2011/09/12 11:31	2011/09/13 14:48	2011/09/13 09:12	2011/09/13 10:51	2011/09/13 15:39		2011/09/13 15:12		2011/09/13 16:08		2011/09/13 12:58		
	Units	**HESED-1**	**HESED-2**	**HESED-3**	**HESED-4**	**HESED-5**	**RDL**	**HESED-6**	**RDL**	**HESED-7**	**RDL**	**UNSED-1**	**RDL**	**QC Batch**
Inorganics														
Organic Carbon (TOC)	g/kg	3.2	5.5	15	24	4.4	0.2	110	0.7	6.3	0.2	58	2	2625083
Soluble (5:1) pH	pH	7.49	7.23	7.28	6.90	7.99	N/A	6.82	N/A	6.45	N/A	7.52	N/A	2622691
< -4 Phi (16 mm)	%	100	100	100	100	100	0.1	100	0.1	100	0.1	100	0.1	2624288
< -3 Phi (8 mm)	%	100	100	100	100	100	0.1	100	0.1	100	0.1	100	0.1	2624288
< -2 Phi (4 mm)	%	100	100	100	100	100	0.1	100	0.1	100	0.1	100	0.1	2624288
< -1 Phi (2 mm)	%	61	65	59	82	72	0.1	71	0.1	40	0.1	13	0.1	2624288
< 0 Phi (1 mm)	%	33	30	38	57	56	0.1	64	0.1	25	0.1	9.7	0.1	2624288
< +1 Phi (0.5 mm)	%	7.3	9.2	21	25	26	0.1	47	0.1	12	0.1	8.0	0.1	2624288
< +2 Phi (0.25 mm)	%	2.6	3.9	12	12	7.5	0.1	27	0.1	5.7	0.1	6.6	0.1	2624288
< +3 Phi (0.12 mm)	%	2.1	2.5	8.4	7.3	4.5	0.1	17	0.1	3.6	0.1	5.6	0.1	2624288
< +4 Phi (0.062 mm)	%	1.8	1.9	6.3	5.0	3.1	0.1	11	0.1	2.5	0.1	4.8	0.1	2624288
< +5 Phi (0.031 mm)	%	1.8	1.7	6.0	4.8	2.8	0.1	11	0.1	2.5	0.1	4.8	0.1	2624288
< +6 Phi (0.016 mm)	%	1.4	1.4	4.9	3.9	2.3	0.1	8.5	0.1	2.0	0.1	4.2	0.1	2624288
< +7 Phi (0.0078 mm)	%	1.0	1.0	2.8	2.4	1.6	0.1	4.9	0.1	1.3	0.1	3.3	0.1	2624288
< +8 Phi (0.0039 mm)	%	0.7	0.9	2.0	1.8	1.2	0.1	3.6	0.1	1.3	0.1	3.1	0.1	2624288
< +9 Phi (0.0020 mm)	%	0.6	0.9	1.6	1.2	0.9	0.1	2.4	0.1	1.0	0.1	1.7	0.1	2624288
Gravel	%	39	35	41	18	28	0.1	29	0.1	60	0.1	87	0.1	2624288
Sand	%	59	63	53	77	69	0.1	60	0.1	38	0.1	8.2	0.1	2624288
Silt	%	1.1	1.0	4.2	3.2	1.8	0.1	7.8	0.1	1.2	0.1	1.8	0.1	2624288
Clay	%	0.7	0.9	2.0	1.8	1.2	0.1	3.6	0.1	1.3	0.1	3.1	0.1	2624288

N/A = Not Applicable
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam Job #: B1E2550
Report Date: 2011/09/26

Intrinsik Environmental Sciences
Client Project #: 055453
Site Location: BELLEDUNE, NB
Sampler Initials: MG

RESULTS OF ANALYSES OF SOIL

Maxxam ID		KX4280			KX4281		KX4283	KX4283		KX4284	KX4285	KX4285		
Sampling Date		2011/09/13 13:17			2011/09/13 14:03		2011/09/13 14:21	2011/09/13 14:21		2011/09/14 08:19	2011/09/14 08:41	2011/09/14 08:41		
	Units	**UNSED-2**	**RDL**	**QC Batch**	**UNSED-3**	**RDL**	**POND-1**	**POND-1 Lab-Dup**	**RDL**	**ARMSED-1**	**ARMSED-2**	**ARMSED-2 Lab-Dup**	**RDL**	**QC Batch**
Inorganics														
Organic Carbon (TOC)	g/kg	16	0.6	2625083	4.1	0.2	26		0.5	1.1	6.4		0.2	2625083
Soluble (5:1) pH	pH	7.87	N/A	2622691	7.59	N/A	7.50		N/A	9.77	7.37		N/A	2622691
< -4 Phi (16 mm)	%	100	0.1	2624288	100	0.1	100	100	0.1	100	100	100	0.1	2624423
< -3 Phi (8 mm)	%	100	0.1	2624288	100	0.1	100	100	0.1	100	100	100	0.1	2624423
< -2 Phi (4 mm)	%	100	0.1	2624288	100	0.1	100	100	0.1	100	100	100	0.1	2624423
< -1 Phi (2 mm)	%	47	0.1	2624288	46	0.1	15	23(1)	0.1	86	76	63	0.1	2624423
< 0 Phi (1 mm)	%	30	0.1	2624288	37	0.1	7.3	13(2)	0.1	78	59	44	0.1	2624423
< +1 Phi (0.5 mm)	%	17	0.1	2624288	22	0.1	5.3	9.1(2)	0.1	48	43	31	0.1	2624423
< +2 Phi (0.25 mm)	%	10	0.1	2624288	9.5	0.1	4.3	6.9(2)	0.1	9.2	25	19	0.1	2624423
< +3 Phi (0.12 mm)	%	8.2	0.1	2624288	7.3	0.1	3.7	5.4	0.1	4.6	15	13	0.1	2624423
< +4 Phi (0.062 mm)	%	6.7	0.1	2624288	5.1	0.1	3.1	4.0	0.1	2.9	7.9	10	0.1	2624423
< +5 Phi (0.031 mm)	%	6.1	0.1	2624288	5.0	0.1	2.8	3.7	0.1	2.9	7.1	9.5	0.1	2624423
< +6 Phi (0.016 mm)	%	4.9	0.1	2624288	3.6	0.1	2.5	3.2	0.1	2.4	5.5	6.8	0.1	2624423
< +7 Phi (0.0078 mm)	%	2.9	0.1	2624288	2.2	0.1	1.8	2.5	0.1	1.7	3.0	4.4	0.1	2624423
< +8 Phi (0.0039 mm)	%	2.2	0.1	2624288	1.8	0.1	1.5	1.8	0.1	1.6	2.2	3.6(3)	0.1	2624423
< +9 Phi (0.0020 mm)	%	1.0	0.1	2624288	1.2	0.1	1.2	1.3	0.1	1.1	1.5	2.5(2)	0.1	2624423
Gravel	%	53	0.1	2624288	54	0.1	85	77	0.1	14	24	37(2)	0.1	2624423
Sand	%	41	0.1	2624288	41	0.1	12	19(2)	0.1	84	68	53	0.1	2624423
Silt	%	4.5	0.1	2624288	3.4	0.1	1.5	2.2(2)	0.1	1.3	5.7	6.6	0.1	2624423
Clay	%	2.2	0.1	2624288	1.8	0.1	1.5	1.8	0.1	1.6	2.2	3.6(2)	0.1	2624423

N/A = Not Applicable
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
(1) - PSA: %RPD flags not applicable for individual PHI fractions. %RPD acceptable. Duplicate values agree within 10% absolute on the sand and silt.
(2) - Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.
(3) - PSA: %RPD flags not applicable for individual PHI fractions.

Maxxam Job #: B1E2550
Report Date: 2011/09/26

Intrinsik Environmental Sciences
Client Project #: 055453
Site Location: BELLEDUNE, NB
Sampler Initials: MG

RESULTS OF ANALYSES OF SOIL

Maxxam ID		KX4286	KX4287	KX4287		KX4288	KX4289	KX4290		
Sampling Date		2011/09/14 09:29	2011/09/14 10:11	2011/09/14 10:11		2011/09/14 11:00	2011/09/13 15:43	2011/09/14 10:15		
	Units	**ARMSED-3**	**ARMSED-4**	**ARMSED-4 Lab-Dup**	**QC Batch**	**ARMSED-5**	**QA/QC-1**	**QA/QC-2**	**RDL**	**QC Batch**
Inorganics										
Organic Carbon (TOC)	g/kg	7.7	13		2625083	13	3.6	12	0.2	2621579
Soluble (5:1) pH	pH	7.11	7.20	7.18	2622691	7.33	8.15	7.20	N/A	2622691
< -4 Phi (16 mm)	%	100	100		2624423	100	100	100	0.1	2624423
< -3 Phi (8 mm)	%	100	100		2624423	100	100	100	0.1	2624423
< -2 Phi (4 mm)	%	100	100		2624423	100	100	100	0.1	2624423
< -1 Phi (2 mm)	%	93	94		2624423	78	64	69	0.1	2624423
< 0 Phi (1 mm)	%	89	76		2624423	49	48	56	0.1	2624423
< +1 Phi (0.5 mm)	%	80	50		2624423	23	25	40	0.1	2624423
< +2 Phi (0.25 mm)	%	46	30		2624423	14	8.5	28	0.1	2624423
< +3 Phi (0.12 mm)	%	25	22		2624423	11	3.8	23	0.1	2624423
< +4 Phi (0.062 mm)	%	16	18		2624423	9.6	1.9	19	0.1	2624423
< +5 Phi (0.031 mm)	%	14	17		2624423	8.9	1.7	17	0.1	2624423
< +6 Phi (0.016 mm)	%	10	13		2624423	7.0	1.4	15	0.1	2624423
< +7 Phi (0.0078 mm)	%	6.5	8.4		2624423	4.2	0.8	9.1	0.1	2624423
< +8 Phi (0.0039 mm)	%	4.9	6.7		2624423	3.4	1.2	7.5	0.1	2624423
< +9 Phi (0.0020 mm)	%	3.0	4.5		2624423	1.9	0.8	5.2	0.1	2624423
Gravel	%	6.9	5.6		2624423	22	36	31	0.1	2624423
Sand	%	77	77		2624423	68	62	50	0.1	2624423
Silt	%	11	11		2624423	6.2	0.7	11	0.1	2624423
Clay	%	4.9	6.7		2624423	3.4	1.2	7.5	0.1	2624423

N/A = Not Applicable
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		KX4271	KX4273		KX4274	KX4275		KX4276	KX4277	KX4278		
Sampling Date		2011/09/12 11:31	2011/09/13 14:48		2011/09/13 09:12	2011/09/13 10:51		2011/09/13 15:39	2011/09/13 15:12	2011/09/13 16:08		
	Units	**HESED-1**	**HESED-2**	**RDL**	**HESED-3**	**HESED-4**	**RDL**	**HESED-5**	**HESED-6**	**HESED-7**	**RDL**	**QC Batch**
Metals												
Available Aluminum (Al)	mg/kg	18000	24000	10	32000	30000	10	25000	15000	21000	10	2618555
Available Antimony (Sb)	mg/kg	ND	ND	2	ND	ND	2	ND	ND	ND	2	2618555
Available Arsenic (As)	mg/kg	35	30	2	31	27	2	12	20	14	2	2618555
Available Barium (Ba)	mg/kg	79	150	5	140	99	5	45	94	59	5	2618555
Available Beryllium (Be)	mg/kg	ND	ND	2	ND	ND	2	ND	ND	ND	2	2618555
Available Bismuth (Bi)	mg/kg	ND	ND	2	ND	ND	2	ND	ND	ND	2	2618555
Available Boron (B)	mg/kg	ND	ND	5	ND	ND	5	ND	ND	ND	5	2618555
Available Cadmium (Cd)	mg/kg	1.1	2.3	0.3	1.4	0.8	0.3	ND	1.0	0.4	0.3	2618555
Available Chromium (Cr)	mg/kg	32	35	2	53	52	2	68	31	50	2	2618555
Available Cobalt (Co)	mg/kg	14	19	1	21	20	1	20	13	17	1	2618555
Available Copper (Cu)	mg/kg	13	15	2	27	12	2	34	23	25	2	2618555
Available Iron (Fe)	mg/kg	30000	42000	50	52000	50000	500	41000	38000	41000	50	2618555
Available Lead (Pb)	mg/kg	49	50	0.5	54	49	0.5	18	81	41	0.5	2618555
Available Lithium (Li)	mg/kg	28	35	2	48	46	2	25	21	31	2	2618555
Available Manganese (Mn)	mg/kg	860	2900	2	2100	1400	2	960	810	530	2	2618555
Available Mercury (Hg)	mg/kg	ND	ND	0.1	0.1	ND	0.1	ND	ND	ND	0.1	2618555
Available Molybdenum (Mo)	mg/kg	ND	ND	2	ND	ND	2	ND	ND	ND	2	2618555
Available Nickel (Ni)	mg/kg	44	52	2	60	58	2	49	29	55	2	2618555
Available Rubidium (Rb)	mg/kg	8	11	2	15	12	2	5	7	6	2	2618555
Available Selenium (Se)	mg/kg	ND	ND	2	ND	ND	2	ND	ND	ND	2	2618555
Available Silver (Ag)	mg/kg	ND	ND	0.5	ND	ND	0.5	ND	ND	ND	0.5	2618555
Available Strontium (Sr)	mg/kg	8	9	5	12	8	5	12	16	8	5	2618555
Available Thallium (Tl)	mg/kg	0.3	0.4	0.1	0.4	0.3	0.1	0.1	0.2	0.2	0.1	2618555
Available Tin (Sn)	mg/kg	ND	ND	2	ND	ND	2	ND	ND	ND	2	2618555
Available Uranium (U)	mg/kg	0.5	0.5	0.1	0.8	0.5	0.1	0.4	0.7	0.4	0.1	2618555
Available Vanadium (V)	mg/kg	59	62	2	91	65	2	93	53	52	2	2618555
Available Zinc (Zn)	mg/kg	170	300	5	260	270	5	100	220	110	5	2618555

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		KX4279		KX4280	KX4280	KX4281	KX4283	KX4284	KX4285		KX4286		
Sampling Date		2011/09/13 12:58		2011/09/13 13:17	2011/09/13 13:17	2011/09/13 14:03	2011/09/13 14:21	2011/09/14 08:19	2011/09/14 08:41		2011/09/14 09:29		
	Units	**UNSED-1**	**RDL**	**UNSED-2**	**UNSED-2 Lab-Dup**	**UNSED-3**	**POND-1**	**ARMSED-1**	**ARMSED-2**	**QC Batch**	**ARMSED-3**	**RDL**	**QC Batch**
Metals													
Available Aluminum (Al)	mg/kg	12000	10	16000	14000	16000	22000	13000	17000	2619686	19000	10	2621359
Available Antimony (Sb)	mg/kg	5	2	2	2	2	11	ND	ND	2619686	ND	2	2621359
Available Arsenic (As)	mg/kg	54	2	13	13	22	38	11	9	2619686	10	2	2621359
Available Barium (Ba)	mg/kg	1800	5	190	180	190	97	48	100	2619686	88	5	2621359
Available Beryllium (Be)	mg/kg	ND	2	ND	ND	ND	ND	ND	ND	2619686	ND	2	2621359
Available Bismuth (Bi)	mg/kg	ND	2	ND	ND	ND	ND	ND	ND	2619686	ND	2	2621359
Available Boron (B)	mg/kg	ND	5	ND	ND	ND	ND	ND	ND	2619686	ND	5	2621359
Available Cadmium (Cd)	mg/kg	4.3	0.3	1.1	1.1	2.0	4.8	ND	0.3	2619686	ND	0.3	2621359
Available Chromium (Cr)	mg/kg	29	2	36	29	39	69	22	32	2619686	39	2	2621359
Available Cobalt (Co)	mg/kg	34	1	16	13	16	20	10	19	2619686	17	1	2621359
Available Copper (Cu)	mg/kg	39	2	16	15	21	67	10	17	2619686	22	2	2621359
Available Iron (Fe)	mg/kg	120000	500	31000	28000	33000	40000	21000	42000	2619686	35000	50	2621359
Available Lead (Pb)	mg/kg	150	0.5	61	61	140	460	23	21	2619686	25	0.5	2621359
Available Lithium (Li)	mg/kg	18	2	25	20	26	31	20	23	2619686	27	2	2621359
Available Manganese (Mn)	mg/kg	45000	20	4500	4100	3000	760	610	1300	2619686	1000	2	2621359
Available Mercury (Hg)	mg/kg	0.2	0.1	0.1	0.1	0.1	ND	ND	ND	2619686	ND	0.1	2621359
Available Molybdenum (Mo)	mg/kg	3	2	ND	ND	ND	3	ND	ND	2619686	ND	2	2621359
Available Nickel (Ni)	mg/kg	39	2	40	34	39	47	28	59	2619686	50	2	2621359
Available Rubidium (Rb)	mg/kg	6	2	9	8	7	9	10	8	2619686	8	2	2621359
Available Selenium (Se)	mg/kg	2	2	ND	ND	ND	ND	ND	ND	2619686	ND	2	2621359
Available Silver (Ag)	mg/kg	0.7	0.5	ND	ND	ND	0.5	ND	ND	2619686	ND	0.5	2621359
Available Strontium (Sr)	mg/kg	46	5	32	34	11	31	19	11	2619686	11	5	2621359
Available Thallium (Tl)	mg/kg	1.4	0.1	0.4	0.4	0.3	4.1	0.1	0.1	2619686	0.1	0.1	2621359
Available Tin (Sn)	mg/kg	8	2	2	2	3	41	ND	ND	2619686	ND	2	2621359
Available Uranium (U)	mg/kg	0.5	0.1	0.5	0.5	0.5	0.5	0.4	0.4	2619686	0.6	0.1	2621359
Available Vanadium (V)	mg/kg	52	2	52	44	63	81	32	40	2619686	53	2	2621359
Available Zinc (Zn)	mg/kg	680	5	190	180	400	1600	63	100	2619686	110	5	2621359

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam Job #: B1E2550
Report Date: 2011/09/26

Intrinsik Environmental Sciences
Client Project #: 055453
Site Location: BELLEDUNE, NB
Sampler Initials: MG

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		KX4286		KX4287		KX4288	KX4289		KX4290		
Sampling Date		2011/09/14 09:29		2011/09/14 10:11		2011/09/14 11:00	2011/09/13 15:43		2011/09/14 10:15		
	Units	**ARMSED-3 Lab-Dup**	**RDL**	**ARMSED-4**	**RDL**	**ARMSED-5**	**QA/QC-1**	**RDL**	**QA/QC-2**	**RDL**	**QC Batch**
Metals											
Available Aluminum (Al)	mg/kg	18000	10	15000	10	11000	25000	10	13000	10	2621359
Available Antimony (Sb)	mg/kg	ND	2	ND	2	ND	ND	2	ND	2	2621359
Available Arsenic (As)	mg/kg	10	2	12	2	10	10	2	12	2	2621359
Available Barium (Ba)	mg/kg	89	5	150	5	130	51	5	150	5	2621359
Available Beryllium (Be)	mg/kg	ND	2	ND	2	ND	ND	2	ND	2	2621359
Available Bismuth (Bi)	mg/kg	ND	2	ND	2	ND	ND	2	ND	2	2621359
Available Boron (B)	mg/kg	ND	5	ND	5	ND	ND	5	ND	5	2621359
Available Cadmium (Cd)	mg/kg	0.3	0.3	0.4	0.3	0.4	ND	0.3	0.3	0.3	2621359
Available Chromium (Cr)	mg/kg	34	2	39	2	23	82	2	33	2	2621359
Available Cobalt (Co)	mg/kg	17	1	23	1	15	21	1	20	1	2621359
Available Copper (Cu)	mg/kg	20	2	24	2	14	24	2	20	2	2621359
Available Iron (Fe)	mg/kg	35000	50	54000	500	38000	41000	50	47000	500	2621359
Available Lead (Pb)	mg/kg	25	0.5	25	0.5	21	23	0.5	23	0.5	2621359
Available Lithium (Li)	mg/kg	28	2	20	2	13	25	2	17	2	2621359
Available Manganese (Mn)	mg/kg	930	2	1900	2	2000	1000	2	1900	2	2621359
Available Mercury (Hg)	mg/kg	ND	0.1	ND	0.1	ND	ND	0.1	ND	0.1	2621359
Available Molybdenum (Mo)	mg/kg	ND	2	ND	2	ND	ND	2	ND	2	2621359
Available Nickel (Ni)	mg/kg	48	2	78	2	36	54	2	69	2	2621359
Available Rubidium (Rb)	mg/kg	8	2	11	2	8	6	2	9	2	2621359
Available Selenium (Se)	mg/kg	ND	2	ND	2	ND	ND	2	ND	2	2621359
Available Silver (Ag)	mg/kg	ND	0.5	ND	0.5	ND	ND	0.5	ND	0.5	2621359
Available Strontium (Sr)	mg/kg	11	5	14	5	14	13	5	12	5	2621359
Available Thallium (Tl)	mg/kg	0.1	0.1	0.2	0.1	0.2	0.2	0.1	0.1	0.1	2621359
Available Tin (Sn)	mg/kg	ND	2	ND	2	ND	ND	2	ND	2	2621359
Available Uranium (U)	mg/kg	0.6	0.1	0.5	0.1	0.4	0.6	0.1	0.4	0.1	2621359
Available Vanadium (V)	mg/kg	49	2	44	2	34	99	2	42	2	2621359
Available Zinc (Zn)	mg/kg	110	5	170	5	260	120	5	140	5	2621359

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Package 1	3.3°C
Package 2	1.7°C

Each temperature is the average of up to three cooler temperatures taken at receipt

GENERAL COMMENTS

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
2618555	Available Aluminum (Al)	2011/09/19			111	75 - 125	ND, RDL=10	mg/kg			105	75 - 125
2618555	Available Arsenic (As)	2011/09/19			108	75 - 125	ND, RDL=2	mg/kg			126(1, 2)	75 - 125
2618555	Available Barium (Ba)	2011/09/19			106	75 - 125	ND, RDL=5	mg/kg			120	75 - 125
2618555	Available Chromium (Cr)	2011/09/19			109	75 - 125	ND, RDL=2	mg/kg			112	75 - 125
2618555	Available Cobalt (Co)	2011/09/19			107	75 - 125	ND, RDL=1	mg/kg			106	75 - 125
2618555	Available Copper (Cu)	2011/09/19			107	75 - 125	ND, RDL=2	mg/kg			101	75 - 125
2618555	Available Iron (Fe)	2011/09/19			109	75 - 125	ND, RDL=50	mg/kg			105	75 - 125
2618555	Available Lead (Pb)	2011/09/19			108	75 - 125	ND, RDL=0.5	mg/kg			105	75 - 125
2618555	Available Manganese (Mn)	2011/09/19			110	75 - 125	ND, RDL=2	mg/kg			114	75 - 125
2618555	Available Nickel (Ni)	2011/09/19			107	75 - 125	ND, RDL=2	mg/kg			114	75 - 125
2618555	Available Strontium (Sr)	2011/09/19			108	75 - 125	ND, RDL=5	mg/kg			96	75 - 125
2618555	Available Vanadium (V)	2011/09/19			107	75 - 125	ND, RDL=2	mg/kg			132(1, 2)	75 - 125
2618555	Available Zinc (Zn)	2011/09/19			109	75 - 125	ND, RDL=5	mg/kg			115	75 - 125
2618555	Available Antimony (Sb)	2011/09/19			90	75 - 125	ND, RDL=2	mg/kg				
2618555	Available Beryllium (Be)	2011/09/19			109	75 - 125	ND, RDL=2	mg/kg				
2618555	Available Bismuth (Bi)	2011/09/19			98	75 - 125	ND, RDL=2	mg/kg				
2618555	Available Boron (B)	2011/09/19			118	75 - 125	ND, RDL=5	mg/kg				
2618555	Available Cadmium (Cd)	2011/09/19			107	75 - 125	ND, RDL=0.3	mg/kg				
2618555	Available Lithium (Li)	2011/09/19			106	75 - 125	ND, RDL=2	mg/kg				
2618555	Available Mercury (Hg)	2011/09/19			112	75 - 125	ND, RDL=0.1	mg/kg				
2618555	Available Molybdenum (Mo)	2011/09/19			106	75 - 125	ND, RDL=2	mg/kg				
2618555	Available Rubidium (Rb)	2011/09/19			109	75 - 125	ND, RDL=2	mg/kg				
2618555	Available Selenium (Se)	2011/09/19			86	75 - 125	ND, RDL=2	mg/kg				
2618555	Available Silver (Ag)	2011/09/19			109	75 - 125	ND, RDL=0.5	mg/kg				
2618555	Available Thallium (Tl)	2011/09/19			103	75 - 125	ND, RDL=0.1	mg/kg				
2618555	Available Tin (Sn)	2011/09/19			110	75 - 125	ND, RDL=2	mg/kg				
2618555	Available Uranium (U)	2011/09/19			96	75 - 125	ND, RDL=0.1	mg/kg				
2619686	Available Aluminum (Al)	2011/09/20	NC	75 - 125	103	75 - 125	ND, RDL=10	mg/kg	17.1	35	101	75 - 125
2619686	Available Antimony (Sb)	2011/09/20	76	75 - 125	89	75 - 125	ND, RDL=2	mg/kg	NC	35		
2619686	Available Arsenic (As)	2011/09/20	NC	75 - 125	96	75 - 125	ND, RDL=2	mg/kg	2.0	35	121	75 - 125
2619686	Available Barium (Ba)	2011/09/20	NC	75 - 125	100	75 - 125	ND, RDL=5	mg/kg	7.0	35	122	75 - 125
2619686	Available Beryllium (Be)	2011/09/20	94	75 - 125	93	75 - 125	ND, RDL=2	mg/kg	NC	35		
2619686	Available Bismuth (Bi)	2011/09/20	88	75 - 125	93	75 - 125	ND, RDL=2	mg/kg	NC	35		
2619686	Available Boron (B)	2011/09/20	81	75 - 125	95	75 - 125	ND, RDL=5	mg/kg	NC	35		
2619686	Available Cadmium (Cd)	2011/09/20	101	75 - 125	99	75 - 125	ND, RDL=0.3	mg/kg	NC	35		
2619686	Available Chromium (Cr)	2011/09/20	NC	75 - 125	107	75 - 125	ND, RDL=2	mg/kg	20.3	35	107	75 - 125
2619686	Available Cobalt (Co)	2011/09/20	NC	75 - 125	104	75 - 125	ND, RDL=1	mg/kg	16.7	35	105	75 - 125
2619686	Available Copper (Cu)	2011/09/20	NC	75 - 125	105	75 - 125	ND, RDL=2	mg/kg	9.6	35	96	75 - 125
2619686	Available Iron (Fe)	2011/09/20	NC	75 - 125	97	75 - 125	ND, RDL=50	mg/kg	9.9	35	99	75 - 125
2619686	Available Lead (Pb)	2011/09/20	NC	75 - 125	103	75 - 125	ND, RDL=0.5	mg/kg	1.0	35	105	75 - 125

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
2619686	Available Lithium (Li)	2011/09/20	NC	75 - 125	103	75 - 125	ND, RDL=2	mg/kg	22.7	35		
2619686	Available Manganese (Mn)	2011/09/20	NC	75 - 125	101	75 - 125	ND, RDL=2	mg/kg	10.5	35	113	75 - 125
2619686	Available Mercury (Hg)	2011/09/20	126(1, 3)	75 - 125	122	75 - 125	ND, RDL=0.1	mg/kg	NC	35		
2619686	Available Molybdenum (Mo)	2011/09/20	105	75 - 125	101	75 - 125	ND, RDL=2	mg/kg	NC	35		
2619686	Available Nickel (Ni)	2011/09/20	NC	75 - 125	106	75 - 125	ND, RDL=2	mg/kg	15.6	35	106	75 - 125
2619686	Available Rubidium (Rb)	2011/09/20	90	75 - 125	104	75 - 125	ND, RDL=2	mg/kg	NC	35		
2619686	Available Selenium (Se)	2011/09/20	97	75 - 125	103	75 - 125	ND, RDL=2	mg/kg	NC	35		
2619686	Available Silver (Ag)	2011/09/20	101	75 - 125	104	75 - 125	ND, RDL=0.5	mg/kg	NC	35		
2619686	Available Strontium (Sr)	2011/09/20	NC	75 - 125	105	75 - 125	ND, RDL=5	mg/kg	7.3	35	98	75 - 125
2619686	Available Thallium (Tl)	2011/09/20	94	75 - 125	100	75 - 125	ND, RDL=0.1	mg/kg	NC	35		
2619686	Available Tin (Sn)	2011/09/20	110	75 - 125	104	75 - 125	ND, RDL=2	mg/kg	NC	35		
2619686	Available Uranium (U)	2011/09/20	94	75 - 125	99	75 - 125	ND, RDL=0.1	mg/kg	NC	35		
2619686	Available Vanadium (V)	2011/09/20	NC	75 - 125	110	75 - 125	ND, RDL=2	mg/kg	16.7	35	130(1, 2)	75 - 125
2619686	Available Zinc (Zn)	2011/09/20	92	75 - 125	98	75 - 125	ND, RDL=5	mg/kg	4.2	35	108	75 - 125
2621359	Available Aluminum (Al)	2011/09/21	NC	75 - 125	106	75 - 125	ND, RDL=10	mg/kg	1.2	35	112	75 - 125
2621359	Available Antimony (Sb)	2011/09/21	75	75 - 125	87	75 - 125	ND, RDL=2	mg/kg	NC	35		
2621359	Available Arsenic (As)	2011/09/21	NC	75 - 125	92	75 - 125	ND, RDL=2	mg/kg	NC	35	115	75 - 125
2621359	Available Barium (Ba)	2011/09/21	NC	75 - 125	102	75 - 125	ND, RDL=5	mg/kg	0.8	35	128(1, 4)	75 - 125
2621359	Available Beryllium (Be)	2011/09/21	106	75 - 125	97	75 - 125	ND, RDL=2	mg/kg	NC	35		
2621359	Available Bismuth (Bi)	2011/09/21	92	75 - 125	87	75 - 125	ND, RDL=2	mg/kg	NC	35		
2621359	Available Boron (B)	2011/09/21	87	75 - 125	89	75 - 125	ND, RDL=5	mg/kg	NC	35		
2621359	Available Cadmium (Cd)	2011/09/21	104	75 - 125	99	75 - 125	ND, RDL=0.3	mg/kg	NC	35		
2621359	Available Chromium (Cr)	2011/09/21	NC	75 - 125	98	75 - 125	ND, RDL=2	mg/kg	15.5	35	129(1, 5)	75 - 125
2621359	Available Cobalt (Co)	2011/09/21	NC	75 - 125	98	75 - 125	ND, RDL=1	mg/kg	0.9	35	114	75 - 125
2621359	Available Copper (Cu)	2011/09/21	NC	75 - 125	96	75 - 125	ND, RDL=2	mg/kg	11.5	35	110	75 - 125
2621359	Available Iron (Fe)	2011/09/21	NC	75 - 125	92	75 - 125	ND, RDL=50	mg/kg	0.2	35	105	75 - 125
2621359	Available Lead (Pb)	2011/09/21	NC	75 - 125	99	75 - 125	ND, RDL=0.5	mg/kg	3.4	35	115	75 - 125
2621359	Available Lithium (Li)	2011/09/21	NC	75 - 125	101	75 - 125	ND, RDL=2	mg/kg	3.6	35		
2621359	Available Manganese (Mn)	2011/09/21	NC	75 - 125	106	75 - 125	ND, RDL=2	mg/kg	7.4	35	115	75 - 125
2621359	Available Mercury (Hg)	2011/09/21	115	75 - 125	108	75 - 125	ND, RDL=0.1	mg/kg	NC	35		
2621359	Available Molybdenum (Mo)	2011/09/21	105	75 - 125	100	75 - 125	ND, RDL=2	mg/kg	NC	35		
2621359	Available Nickel (Ni)	2011/09/21	NC	75 - 125	98	75 - 125	ND, RDL=2	mg/kg	4.1	35	122	75 - 125
2621359	Available Rubidium (Rb)	2011/09/21	95	75 - 125	102	75 - 125	ND, RDL=2	mg/kg	NC	35		
2621359	Available Selenium (Se)	2011/09/21	87	75 - 125	100	75 - 125	ND, RDL=2	mg/kg	NC	35		
2621359	Available Silver (Ag)	2011/09/21	113	75 - 125	107	75 - 125	ND, RDL=0.5	mg/kg	NC	35		
2621359	Available Strontium (Sr)	2011/09/21	NC	75 - 125	102	75 - 125	ND, RDL=5	mg/kg	NC	35	99	75 - 125
2621359	Available Thallium (Tl)	2011/09/21	99	75 - 125	102	75 - 125	ND, RDL=0.1	mg/kg	NC	35		
2621359	Available Tin (Sn)	2011/09/21	109	75 - 125	102	75 - 125	ND, RDL=2	mg/kg	NC	35		
2621359	Available Uranium (U)	2011/09/21	103	75 - 125	97	75 - 125	ND, RDL=0.1	mg/kg	8.2	35		
2621359	Available Vanadium (V)	2011/09/21	NC	75 - 125	100	75 - 125	ND, RDL=2	mg/kg	7.1	35	152(1, 2)	75 - 125

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
2621359	Available Zinc (Zn)	2011/09/21	102	75 - 125	102	75 - 125	ND, RDL=5	mg/kg	5.7	35	118	75 - 125
2621579	Organic Carbon (TOC)	2011/09/21					ND, RDL=0.2	g/kg	1	35	94	75 - 125
2622691	Soluble (5:1) pH	2011/09/22							0.3	N/A		
2624288	Gravel	2011/09/23							NC	25		
2624288	Sand	2011/09/23							6.6	25		
2624288	Silt	2011/09/23							44.4(1, 6)	25		
2624288	Clay	2011/09/23							6.3	25		
2624423	Gravel	2011/09/23							40.6(1)	25		
2624423	Sand	2011/09/23							24.1(1)	25		
2624423	Silt	2011/09/23							14.7(1)	25		
2624423	Clay	2011/09/23							46.3(1)	25		
2625083	Organic Carbon (TOC)	2011/09/23					ND, RDL=0.2	g/kg	NC	35	97	75 - 125

Maxxam Job #: B1E2550
Report Date: 2011/09/26

Intrinsik Environmental Sciences
Client Project #: 055453
Site Location: BELLEDUNE, NB
Sampler Initials: MG

QUALITY ASSURANCE REPORT

			Reagent Blank	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**
2622691	Soluble (5:1) pH	2011/09/22	5.85	N/A

N/A = Not Applicable
RDL = Reportable Detection Limit
RPD = Relative Percent Difference
Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.
Reagent Blank: A blank matrix containing all reagents used in the analytical procedure. Used to determine any analytical contamination.
Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.
QC Standard: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.
NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.
NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.
(1) - Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.
(2) - Secondary RM is acceptable.
(3) - Elevated reporting limit due to sample matrix.
(4) - Data point within 2 SD. Secondary RM is acceptable.
(5) - Data point within 3 SD. Secondary RM is acceptable.
(6) - PSA: %RPD acceptable. Duplicate values agree within 10% absolute.

Validation Signature Page

Maxxam Job #: B1E2550

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

CAcker

COLLEEN ACKER,

Mike Mac Gillivray

MIKE MACGILLIVRAY, Scientific Specialist (Inorganics)

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Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Your Project #: 055453
Site Location: BELLEDUNE, NB
Your C.O.C. #: B 121453, B 121708, B 121709, B 121710

Attention: Christine Moore
Intrinsik Environmental Sciences
5121 Sackville Street
Suite 506
Halifax, NS
CANADA B3J 1K1

Report Date: 2011/09/23

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B1E2798
Received: 2011/09/16, 8:28

Sample Matrix: Water
Samples Received: 19

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Carbonate, Bicarbonate and Hydroxide	19	N/A	2011/09/20	CAM SOP-00102	APHA 4500-CO2 D
Alkalinity	19	N/A	2011/09/23	ATL SOP 00013 R4	Based on EPA310.2
Chloride	19	N/A	2011/09/23	ATL SOP 00014 R6	Based on SM4500-Cl-
Colour	19	N/A	2011/09/23	ATL SOP 00020 R3.	Based on SM2120C
Conductance - water	19	N/A	2011/09/19	ATL SOP 00004 R5/00006 R4	Based on SM2510B
Hardness (calculated as CaCO3)	19	N/A	2011/09/20	ATL SOP 00048	Based on SM2340B
Mercury - Total (CVAA,LL)	8	2011/09/16	2011/09/19	ATL SOP 00026 R6	Based on EPA245.1
Mercury - Total (CVAA,LL)	11	2011/09/20	2011/09/21	ATL SOP 00026 R6	Based on EPA245.1
Metals Water Diss. MS	19	N/A	2011/09/19	ATL SOP 00059 R1	Based on EPA6020A
Metals Water Total MS	3	2011/09/19	2011/09/20	ATL SOP 00059 R1	Based on EPA6020A
Metals Water Total MS	1	2011/09/20	2011/09/20	ATL SOP 00059 R1	Based on EPA6020A
Metals Water Total MS	15	2011/09/22	2011/09/22	ATL SOP 00059 R1	Based on EPA6020A
Ion Balance (% Difference)	19	N/A	2011/09/23		
Anion and Cation Sum	11	N/A	2011/09/22		
Anion and Cation Sum	8	N/A	2011/09/23		
Nitrogen Ammonia - water	16	N/A	2011/09/22	ATL SOP 00015 R5	Based on USEPA 350.1
Nitrogen Ammonia - water	3	N/A	2011/09/23	ATL SOP 00015 R5	Based on USEPA 350.1
Nitrogen - Nitrate + Nitrite	19	N/A	2011/09/23	ATL SOP 00016 R4	Based on USGS - Enz.
Nitrogen - Nitrite	19	N/A	2011/09/22	ATL SOP 00017 R4	Based on SM4500-NO2B
Nitrogen - Nitrate (as N)	19	N/A	2011/09/23	ATL SOP 00018 R3	Based on ASTMD3867
pH	19	N/A	2011/09/19	ATL SOP 00003 R5/00005 R7	Based on SM4500H+B
Phosphorus - ortho	19	N/A	2011/09/23	ATL SOP 00021 R3	Based on USEPA 365.1
Sat. pH and Langelier Index (@ 20C)	19	N/A	2011/09/23		
Sat. pH and Langelier Index (@ 4C)	19	N/A	2011/09/23		
Reactive Silica	18	N/A	2011/09/22	ATL SOP 00022 R3	Based on EPA 366.0
Reactive Silica	1	N/A	2011/09/23	ATL SOP 00022 R3	Based on EPA 366.0
Sulphate	19	N/A	2011/09/23	ATL SOP 00023 R3	Based on EPA 375.4
Total Dissolved Solids (TDS calc)	19	N/A	2011/09/23		
Organic carbon - Total (TOC)	19	N/A	2011/09/23	ATL SOP 00037 R4	Based on SM5310C
Turbidity	19	N/A	2011/09/21	ATL SOP 00011 R5	based on EPA 180.1

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
* Results relate only to the items tested.

../2

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

MICHELLE HILL, Project Manager
Email: MHill@maxxam.ca
Phone# (902) 420-0203

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Total cover pages: 2

RESULTS OF ANALYSES OF WATER

Maxxam ID		KX3777	KX3803		KX3804	KX3805	KX3806	KX3806		KX3807		
Sampling Date		2011/09/12 11:31	2011/09/12 14:48		2011/09/13 09:12	2011/09/13 10:51	2011/09/13 15:39	2011/09/13 15:39		2011/09/13 15:12		
	Units	**HESED-1**	**HESED-2**	**QC Batch**	**HESED-3**	**HESED-4**	**HESED-5**	**HESED-5 Lab-Dup**	**QC Batch**	**HESED-6**	**RDL**	**QC Batch**
Calculated Parameters												
Anion Sum	me/L	1.60	1.57	2618260	1.49	1.54	1.14		2618260	2.53	N/A	2618260
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	63	62	2618257	57	59	45		2618257	84	1	2618257
Calculated TDS	mg/L	88	86	2618263	83	84	64		2618263	139	1	2618263
Carb. Alkalinity (calc. as CaCO3)	mg/L	ND	ND	2618257	ND	ND	ND		2618257	ND	1	2618257
Cation Sum	me/L	1.62	1.53	2618260	1.47	1.47	1.16		2618260	2.38	N/A	2618260
Hardness (CaCO3)	mg/L	59	56	2618258	53	52	39		2618258	81	1	2618258
Ion Balance (% Difference)	%	0.620	1.29	2618259	0.680	2.33	0.870		2618259	3.05	N/A	2618259
Langelier Index (@ 20C)	N/A	-0.225	-0.325	2618261	-0.427	-0.387	-0.701		2618261	-0.0880		2618261
Langelier Index (@ 4C)	N/A	-0.476	-0.576	2618262	-0.678	-0.639	-0.953		2618262	-0.338		2618262
Nitrate (N)	mg/L	0.05	0.05	2616939	0.07	0.06	0.05		2616939	0.17	0.05	2619103
Saturation pH (@ 20C)	N/A	8.22	8.25	2618261	8.32	8.31	8.54		2618261	8.00		2618261
Saturation pH (@ 4C)	N/A	8.47	8.50	2618262	8.57	8.56	8.79		2618262	8.25		2618262
Inorganics												
Total Alkalinity (Total as CaCO3)	mg/L	64	63	2621977	57	59	45	47	2621977	85	5	2621993
Dissolved Chloride (Cl)	mg/L	7	7	2621978	8	8	7	7	2621978	14	1	2621999
Colour	TCU	34	36	2621982	39	36	39	37	2621982	22	5	2622007
Nitrate + Nitrite	mg/L	0.05	0.05	2621985	0.07	0.06	0.05	ND	2621985	0.17	0.05	2622011
Nitrite (N)	mg/L	ND	ND	2621987	ND	ND	ND	ND	2621987	ND	0.01	2622015
Nitrogen (Ammonia Nitrogen)	mg/L	1.2	0.66	2621418	0.20	0.09	0.41		2621418	ND	0.05	2621418
Total Organic Carbon (C)	mg/L	6.3	7.1	2624820	6.5	6.9	7.2		2624820	5.6	0.5	2624820
Orthophosphate (P)	mg/L	ND	ND	2621983	ND	ND	ND	ND	2621983	ND	0.01	2622010
pH	pH	7.99	7.92	2618228	7.89	7.92	7.84		2618559	7.91	N/A	2618559
Reactive Silica (SiO2)	mg/L	4.7	4.7	2621981	4.7	4.8	4.8	4.8	2621981	4.8	0.5	2622005
Dissolved Sulphate (SO4)	mg/L	5	5	2621979	6	6	2	ND	2621979	20	2	2622002
Turbidity	NTU	0.6	0.4	2621385	0.5	0.8	3.0		2621385	0.8	0.1	2621385
Conductivity	uS/cm	150	140	2618229	140	140	110		2618560	230	1	2618560

N/A = Not Applicable
ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

RESULTS OF ANALYSES OF WATER

Maxxam ID		KX3807		KX3808			KX3809	KX3809		KX3810		
Sampling Date		2011/09/13 15:12		2011/09/13 16:08			2011/09/13 12:58	2011/09/13 12:58		2011/09/13 13:17		
	Units	**HESED-6 Lab-Dup**	**RDL**	**HESED-7**	**RDL**	**QC Batch**	**UNSED-1**	**UNSED-1 Lab-Dup**	**QC Batch**	**UNSED-2**	**RDL**	**QC Batch**
Calculated Parameters												
Anion Sum	me/L		N/A	1.40	N/A	2618260	7.82		2618260	4.67	N/A	2618260
Bicarb. Alkalinity (calc. as CaCO3)	mg/L		1	51	1	2618257	354		2618257	210	1	2618257
Calculated TDS	mg/L		1	78	1	2618263	407		2618263	245	1	2618263
Carb. Alkalinity (calc. as CaCO3)	mg/L		1	ND	1	2618257	3		2618257	2	1	2618257
Cation Sum	me/L		N/A	1.38	N/A	2618260	7.60		2618260	4.51	N/A	2618260
Hardness (CaCO3)	mg/L		1	35	1	2618258	360		2618258	200	1	2618258
Ion Balance (% Difference)	%		N/A	0.720	N/A	2618259	1.43		2618259	1.74	N/A	2618259
Langelier Index (@ 20C)	N/A			-0.906		2618261	1.10		2618261	0.786		2618261
Langelier Index (@ 4C)	N/A			-1.16		2618262	0.855		2618262	0.536		2618262
Nitrate (N)	mg/L		0.05	ND	0.05	2619103	2.2		2619103	0.10	0.05	2619103
Saturation pH (@ 20C)	N/A			8.54		2618261	6.78		2618261	7.20		2618261
Saturation pH (@ 4C)	N/A			8.79		2618262	7.03		2618262	7.45		2618262
Inorganics												
Total Alkalinity (Total as CaCO3)	mg/L		5	51	5	2621993	360		2621993	210	30	2621993
Dissolved Chloride (Cl)	mg/L		1	13	1	2621999	7		2621999	8	1	2621999
Colour	TCU		5	63	30	2622007	16		2622007	21	5	2622007
Nitrate + Nitrite	mg/L		0.05	ND	0.05	2622011	2.2		2622011	0.10	0.05	2622011
Nitrite (N)	mg/L		0.01	ND	0.01	2622015	ND		2622015	ND	0.01	2622015
Nitrogen (Ammonia Nitrogen)	mg/L	ND	0.05	0.13	0.05	2621418	0.71		2621418	0.35	0.05	2621418
Total Organic Carbon (C)	mg/L		0.5	7.8	0.5	2624820	12	12	2624862	7.4	0.5	2624820
Orthophosphate (P)	mg/L		0.01	ND	0.01	2622010	ND		2622010	ND	0.01	2622010
pH	pH		N/A	7.63	N/A	2618559	7.88		2618559	7.99	N/A	2618559
Reactive Silica (SiO2)	mg/L		0.5	5.0	0.5	2622005	7.9		2622005	5.7	0.5	2622005
Dissolved Sulphate (SO4)	mg/L		2	ND	2	2622002	16		2622002	9	2	2622002
Turbidity	NTU		0.1	0.6	0.1	2621385	4.0		2621385	2.1	0.1	2621385
Conductivity	uS/cm		1	130	1	2618560	680		2618560	420	1	2618560

N/A = Not Applicable
ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

RESULTS OF ANALYSES OF WATER

Maxxam ID		KX3811		KX3812		KX3813		KX3814	KX3814		KX3815		
Sampling Date		2011/09/13 14:03		2011/09/13 14:21		2011/09/13 14:43		2011/09/14 08:19	2011/09/14 08:19		2011/09/14 08:41		
	Units	**UNSED-3**	**RDL**	**POND-1**	**QC Batch**	**POND-2**	**RDL**	**ARMSED-1**	**ARMSED-1 Lab-Dup**	**QC Batch**	**ARMSED-2**	**RDL**	**QC Batch**
Calculated Parameters													
Anion Sum	me/L	3.61	N/A	6.50	2618260	6.48	N/A	1.90		2618260	1.77	N/A	2618260
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	151	1	91	2618257	92	1	78		2618257	77	1	2618257
Calculated TDS	mg/L	191	1	400	2618263	400	1	101		2618263	92	1	2618263
Carb. Alkalinity (calc. as CaCO3)	mg/L	2	1	ND	2618257	ND	1	ND		2618257	ND	1	2618257
Cation Sum	me/L	3.56	N/A	6.02	2618260	6.08	N/A	1.81		2618260	1.67	N/A	2618260
Hardness (CaCO3)	mg/L	150	1	240	2618258	240	1	73		2618258	72	1	2618258
Ion Balance (% Difference)	%	0.700	N/A	3.83	2618259	3.18	N/A	2.43		2618259	2.91	N/A	2618259
Langelier Index (@ 20C)	N/A	0.786		0.512	2618261	0.516		-0.0270		2618261	-0.0370		2618261
Langelier Index (@ 4C)	N/A	0.536		0.263	2618262	0.268		-0.278		2618262	-0.288		2618262
Nitrate (N)	mg/L	0.13	0.05	ND	2619103	ND	0.05	0.18		2619103	0.05	0.05	2619103
Saturation pH (@ 20C)	N/A	7.44		7.54	2618261	7.53		8.09		2618261	8.10		2618261
Saturation pH (@ 4C)	N/A	7.69		7.79	2618262	7.78		8.34		2618262	8.35		2618262
Inorganics													
Total Alkalinity (Total as CaCO3)	mg/L	150	30	92	2621993	93	5	79		2621993	78	5	2621993
Dissolved Chloride (Cl)	mg/L	10	1	19	2621999	19	1	9		2621999	5	1	2621999
Colour	TCU	15	5	7	2622007	10	5	31		2622007	31	5	2622007
Nitrate + Nitrite	mg/L	0.13	0.05	ND	2622011	ND	0.05	0.18		2622011	0.05	0.05	2622011
Nitrite (N)	mg/L	ND	0.01	ND	2622015	ND	0.01	ND		2622015	ND	0.01	2622015
Nitrogen (Ammonia Nitrogen)	mg/L	0.16	0.05	ND	2621418	ND	0.05	ND	ND	2622933	ND	0.05	2622946
Total Organic Carbon (C)	mg/L	4.0	0.5	2.7	2624862	2.7	0.5	4.0		2624862	3.9	0.5	2624862
Orthophosphate (P)	mg/L	ND	0.01	ND	2622010	ND	0.01	ND		2622010	ND	0.01	2622010
pH	pH	8.23	N/A	8.05	2618559	8.05	N/A	8.06		2618559	8.06	N/A	2618559
Reactive Silica (SiO2)	mg/L	5.3	0.5	4.1	2622005	4.0	0.5	5.6		2622005	5.2	0.5	2622005
Dissolved Sulphate (SO4)	mg/L	12	2	200	2622002	200	10	3		2622002	3	2	2622002
Turbidity	NTU	0.2	0.1	0.7	2621385	1.1	0.1	1.6		2621385	1.7	0.1	2621385
Conductivity	uS/cm	330	1	600	2618560	600	1	180		2618560	160	1	2618560

N/A = Not Applicable
ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

RESULTS OF ANALYSES OF WATER

Maxxam ID		KX3816	KX3816		KX3817		KX3818		KX3819	KX3820	KX3820		
Sampling Date		2011/09/14 09:29	2011/09/14 09:29		2011/09/14 10:11		2011/09/14 11:00		2011/09/13 15:43	2011/09/14 10:15	2011/09/14 10:15		
	Units	**ARMSED-3**	**ARMSED-3 Lab-Dup**	**QC Batch**	**ARMSED-4**	**RDL**	**ARMSED-5**	**RDL**	**QA/QC-1**	**QA/QC-2**	**QA/QC-2 Lab-Dup**	**RDL**	**QC Batch**
Calculated Parameters													
Anion Sum	me/L	1.71		2618260	2.19	N/A	2.15	N/A	1.16	2.19		N/A	2618260
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	74		2618257	96	1	97	1	46	97		1	2618257
Calculated TDS	mg/L	90		2618263	114	1	113	1	64	114		1	2618263
Carb. Alkalinity (calc. as CaCO3)	mg/L	ND		2618257	1	1	1	1	ND	1		1	2618257
Cation Sum	me/L	1.65		2618260	2.13	N/A	2.18	N/A	1.13	2.13		N/A	2618260
Hardness (CaCO3)	mg/L	71		2618258	93	1	99	1	39	93		1	2618258
Ion Balance (% Difference)	%	1.79		2618259	1.39	N/A	0.690	N/A	1.31	1.39		N/A	2618259
Langelier Index (@ 20C)	N/A	-0.0500		2618261	0.251		0.245		-0.680	0.224			2618261
Langelier Index (@ 4C)	N/A	-0.301		2618262	0.000		-0.00600		-0.931	-0.0270			2618262
Nitrate (N)	mg/L	0.05		2619103	ND	0.05	ND	0.05	ND	ND		0.05	2619103
Saturation pH (@ 20C)	N/A	8.12		2618261	7.92		7.89		8.53	7.92			2618261
Saturation pH (@ 4C)	N/A	8.37		2618262	8.17		8.14		8.78	8.17			2618262
Inorganics													
Total Alkalinity (Total as CaCO3)	mg/L	75		2621993	98	5	99	10	46	98		5	2621993
Dissolved Chloride (Cl)	mg/L	5		2621999	6	1	4	1	7	6		1	2621999
Colour	TCU	30		2622007	30	5	27	5	42	31		5	2622007
Nitrate + Nitrite	mg/L	0.05		2622011	ND	0.05	ND	0.05	ND	ND		0.05	2622011
Nitrite (N)	mg/L	ND		2622015	ND	0.01	0.02	0.01	ND	ND		0.01	2622015
Nitrogen (Ammonia Nitrogen)	mg/L	ND		2622946	ND	0.05	ND	0.05	ND	ND		0.05	2622946
Total Organic Carbon (C)	mg/L	4.2		2624862	2.6	0.5	2.5	0.5	7.0	2.6		0.5	2624862
Orthophosphate (P)	mg/L	ND		2622010	ND	0.01	ND	0.01	ND	ND		0.01	2622010
pH	pH	8.07		2618559	8.17	N/A	8.13	N/A	7.85	8.14	8.19	N/A	2618559
Reactive Silica (SiO2)	mg/L	5.3		2622005	5.7	0.5	5.6	0.5	4.8	5.8		0.5	2622005
Dissolved Sulphate (SO4)	mg/L	3		2622002	4	2	4	2	2	4		2	2622002
Turbidity	NTU	1.8	2.1	2621385	2.9	0.1	4.2	0.1	2.7	2.9		0.1	2621392
Conductivity	uS/cm	160		2618560	200	1	200	1	110	200	200	1	2618560

N/A = Not Applicable
ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

MERCURY BY COLD VAPOUR AA (WATER)

Maxxam ID		KX3777	KX3803	KX3804	KX3805	KX3806	KX3807	KX3808	KX3809		
Sampling Date		2011/09/12 11:31	2011/09/12 14:48	2011/09/13 09:12	2011/09/13 10:51	2011/09/13 15:39	2011/09/13 15:12	2011/09/13 16:08	2011/09/13 12:58		
	Units	**HESED-1**	**HESED-2**	**HESED-3**	**HESED-4**	**HESED-5**	**HESED-6**	**HESED-7**	**UNSED-1**	**RDL**	**QC Batch**
Metals											
Total Mercury (Hg)	ug/L	ND	ND	ND	ND	0.013	ND	ND	ND	0.013	2618463

Maxxam ID		KX3810	KX3810	KX3811	KX3812	KX3813	KX3814		
Sampling Date		2011/09/13 13:17	2011/09/13 13:17	2011/09/13 14:03	2011/09/13 14:21	2011/09/13 14:43	2011/09/14 08:19		
	Units	**UNSED-2**	**UNSED-2 Lab-Dup**	**UNSED-3**	**POND-1**	**POND-2**	**ARMSED-1**	**RDL**	**QC Batch**
Metals									
Total Mercury (Hg)	ug/L	ND	ND	ND	ND	ND	ND	0.013	2621399

Maxxam ID		KX3815	KX3816	KX3817	KX3818	KX3819	KX3820		
Sampling Date		2011/09/14 08:41	2011/09/14 09:29	2011/09/14 10:11	2011/09/14 11:00	2011/09/13 15:43	2011/09/14 10:15		
	Units	**ARMSED-2**	**ARMSED-3**	**ARMSED-4**	**ARMSED-5**	**QA/QC-1**	**QA/QC-2**	**RDL**	**QC Batch**
Metals									
Total Mercury (Hg)	ug/L	ND	ND	ND	ND	ND	ND	0.013	2621399

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam Job #: B1E2798
Report Date: 2011/09/23

Intrinsik Environmental Sciences
Client Project #: 055453
Site Location: BELLEDUNE, NB

ELEMENTS BY ICP/MS (WATER)

Maxxam ID		KX3777	KX3803	KX3804	KX3805	KX3806	KX3807	KX3808	KX3809	KX3810		
Sampling Date		2011/09/12 11:31	2011/09/12 14:48	2011/09/13 09:12	2011/09/13 10:51	2011/09/13 15:39	2011/09/13 15:12	2011/09/13 16:08	2011/09/13 12:58	2011/09/13 13:17		
	Units	**HESED-1**	**HESED-2**	**HESED-3**	**HESED-4**	**HESED-5**	**HESED-6**	**HESED-7**	**UNSED-1**	**UNSED-2**	**RDL**	**QC Batch**
Metals												
Dissolved Aluminum (Al)	ug/L	42.7	43.0	38.4	39.7	69.1	8.2	33.0	7.4	7.8	5.0	2618540
Total Aluminum (Al)	ug/L	71.1	64.0	64.1	75.8	354	24.8	51.6	18.0	83.6	5.0	2622839
Dissolved Antimony (Sb)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0	2618540
Total Antimony (Sb)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0	2622839
Dissolved Arsenic (As)	ug/L	ND	ND	ND	ND	1.0	ND	ND	ND	ND	1.0	2618540
Total Arsenic (As)	ug/L	ND	ND	ND	ND	1.2	ND	ND	1.1	1.4	1.0	2622839
Dissolved Barium (Ba)	ug/L	31.4	29.0	23.8	23.1	19.0	27.4	17.1	154	151	1.0	2618540
Total Barium (Ba)	ug/L	33.2	30.0	25.2	24.2	22.0	29.2	18.0	158	174	1.0	2622839
Dissolved Beryllium (Be)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0	2618540
Total Beryllium (Be)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0	2622839
Dissolved Bismuth (Bi)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.0	2618540
Total Bismuth (Bi)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.0	2622839
Dissolved Boron (B)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	50	2618540
Total Boron (B)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	50	2622839
Dissolved Cadmium (Cd)	ug/L	0.027	0.026	ND	ND	0.018	ND	0.021	0.032	0.036	0.017	2618540
Total Cadmium (Cd)	ug/L	0.028	0.025	ND	0.018	0.022	ND	0.018	0.032	0.061	0.017	2622839
Dissolved Calcium (Ca)	ug/L	20800	19700	18300	18100	13400	27400	12100	132000	75100	100	2618540
Total Calcium (Ca)	ug/L	21300	19500	18300	18200	13800	27500	11600	133000	76400	100	2622839
Dissolved Chromium (Cr)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0	2618540
Total Chromium (Cr)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0	2622839
Dissolved Cobalt (Co)	ug/L	ND	ND	ND	ND	ND	ND	ND	0.54	0.41	0.40	2618540
Total Cobalt (Co)	ug/L	ND	ND	ND	ND	ND	ND	ND	0.53	0.52	0.40	2622839
Dissolved Copper (Cu)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.0	2618540
Total Copper (Cu)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.0	2622839
Dissolved Iron (Fe)	ug/L	70	76	71	78	105	86	147	540	325	50	2618540
Total Iron (Fe)	ug/L	91	91	91	108	291	139	193	892	1450	50	2622839
Dissolved Lead (Pb)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.50	2618540
Total Lead (Pb)	ug/L	ND	ND	ND	ND	0.62	ND	ND	ND	1.54	0.50	2622839
Dissolved Magnesium (Mg)	ug/L	1630	1610	1700	1750	1320	3030	1200	6680	3950	100	2618540
Total Magnesium (Mg)	ug/L	1660	1600	1730	1740	1400	3050	1170	6400	3900	100	2622839
Dissolved Manganese (Mn)	ug/L	3.3	7.7	4.7	9.5	26.1	65.3	19.3	1760	4920	2.0	2618540
Total Manganese (Mn)	ug/L	5.5	9.9	7.4	14.6	33.3	78.3	22.1	1700	5370	2.0	2622839
Dissolved Molybdenum (Mo)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.0	2618540

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

ELEMENTS BY ICP/MS (WATER)

Maxxam ID		KX3777	KX3803	KX3804	KX3805	KX3806	KX3807	KX3808	KX3809	KX3810		
Sampling Date		2011/09/12 11:31	2011/09/12 14:48	2011/09/13 09:12	2011/09/13 10:51	2011/09/13 15:39	2011/09/13 15:12	2011/09/13 16:08	2011/09/13 12:58	2011/09/13 13:17		
	Units	**HESED-1**	**HESED-2**	**HESED-3**	**HESED-4**	**HESED-5**	**HESED-6**	**HESED-7**	**UNSED-1**	**UNSED-2**	**RDL**	**QC Batch**
Total Molybdenum (Mo)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.0	2622839
Dissolved Nickel (Ni)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.0	2618540
Total Nickel (Ni)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.0	2622839
Total Phosphorus (P)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	100	2622839
Dissolved Potassium (K)	ug/L	460	469	485	472	442	895	125	2450	1490	100	2618540
Total Potassium (K)	ug/L	488	472	514	504	384	974	143	2480	1520	100	2622839
Dissolved Selenium (Se)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0	2618540
Total Selenium (Se)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0	2622839
Dissolved Silver (Ag)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.10	2618540
Total Silver (Ag)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.10	2622839
Dissolved Sodium (Na)	ug/L	8020	8040	8990	9170	7770	17000	15100	6970	8480	100	2618540
Total Sodium (Na)	ug/L	7740	7660	8580	8820	7380	16200	13700	6560	8110	100	2622839
Dissolved Strontium (Sr)	ug/L	43.3	42.8	40.7	41.7	26.5	80.9	28.1	276	159	2.0	2618540
Total Strontium (Sr)	ug/L	46.2	43.6	41.8	42.1	28.7	84.5	27.9	285	163	2.0	2622839
Dissolved Thallium (Tl)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.10	2618540
Total Thallium (Tl)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.10	2622839
Dissolved Tin (Sn)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.0	2618540
Total Tin (Sn)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.0	2622839
Dissolved Titanium (Ti)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.0	2618540
Total Titanium (Ti)	ug/L	ND	ND	ND	ND	6.3	ND	ND	ND	5.8	2.0	2622839
Dissolved Uranium (U)	ug/L	ND	ND	ND	ND	ND	ND	ND	0.17	0.11	0.10	2618540
Total Uranium (U)	ug/L	ND	ND	ND	ND	ND	ND	ND	0.16	0.14	0.10	2622839
Dissolved Vanadium (V)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.0	2618540
Total Vanadium (V)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.0	2622839
Dissolved Zinc (Zn)	ug/L	ND	5.2	ND	ND	6.1	5.9	ND	6.0	9.2	5.0	2618540
Total Zinc (Zn)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	7.8	5.0	2622839

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

ELEMENTS BY ICP/MS (WATER)

Maxxam ID		KX3811		KX3812	KX3813	KX3814	KX3815		
Sampling Date		2011/09/13 14:03		2011/09/13 14:21	2011/09/13 14:43	2011/09/14 08:19	2011/09/14 08:41		
	Units	**UNSED-3**	**QC Batch**	**POND-1**	**POND-2**	**ARMSED-1**	**ARMSED-2**	**RDL**	**QC Batch**
Metals									
Dissolved Aluminum (Al)	ug/L	9.8	2618540	11.1	17.9	20.6	18.3	5.0	2618545
Total Aluminum (Al)	ug/L	22.8	2622839	25.7	18.7	73.5	52.1	5.0	2622839
Dissolved Antimony (Sb)	ug/L	ND	2618540	13.2	13.6	ND	ND	1.0	2618545
Total Antimony (Sb)	ug/L	ND	2622839	13.4	13.6	ND	ND	1.0	2622839
Dissolved Arsenic (As)	ug/L	ND	2618540	10.5	10.7	ND	ND	1.0	2618545
Total Arsenic (As)	ug/L	ND	2622839	12.5	11.9	ND	ND	1.0	2622839
Dissolved Barium (Ba)	ug/L	133	2618540	133	133	29.1	24.6	1.0	2618545
Total Barium (Ba)	ug/L	135	2622839	136	135	30.7	25.7	1.0	2622839
Dissolved Beryllium (Be)	ug/L	ND	2618540	ND	ND	ND	ND	1.0	2618545
Total Beryllium (Be)	ug/L	ND	2622839	ND	ND	ND	ND	1.0	2622839
Dissolved Bismuth (Bi)	ug/L	ND	2618540	ND	ND	ND	ND	2.0	2618545
Total Bismuth (Bi)	ug/L	ND	2622839	ND	ND	ND	ND	2.0	2622839
Dissolved Boron (B)	ug/L	ND	2618540	143	144	ND	ND	50	2618545
Total Boron (B)	ug/L	ND	2622839	146	147	ND	ND	50	2622839
Dissolved Cadmium (Cd)	ug/L	0.057	2618540	1.12	1.12	ND	ND	0.017	2618545
Total Cadmium (Cd)	ug/L	0.030	2622839	1.60	1.48	ND	ND	0.017	2622839
Dissolved Calcium (Ca)	ug/L	57700	2618540	88500	89100	23100	22400	100	2618545
Total Calcium (Ca)	ug/L	57500	2622839	86900	88200	23100	22100	100	2622839
Dissolved Chromium (Cr)	ug/L	ND	2618540	ND	ND	ND	ND	1.0	2618545
Total Chromium (Cr)	ug/L	ND	2622839	ND	ND	ND	ND	1.0	2622839
Dissolved Cobalt (Co)	ug/L	ND	2618540	ND	ND	ND	ND	0.40	2618545
Total Cobalt (Co)	ug/L	ND	2622839	ND	ND	ND	ND	0.40	2622839
Dissolved Copper (Cu)	ug/L	2.3	2618540	ND	ND	ND	ND	2.0	2618545
Total Copper (Cu)	ug/L	ND	2622839	ND	ND	ND	ND	2.0	2622839
Dissolved Iron (Fe)	ug/L	63	2618540	60	64	164	177	50	2618545
Total Iron (Fe)	ug/L	ND	2622839	188	120	226	230	50	2622839
Dissolved Lead (Pb)	ug/L	ND	2618540	1.34	1.32	ND	ND	0.50	2618545
Total Lead (Pb)	ug/L	ND	2622839	9.24	3.19	ND	ND	0.50	2622839
Dissolved Magnesium (Mg)	ug/L	2450	2618540	4900	5040	3810	3780	100	2618545
Total Magnesium (Mg)	ug/L	2410	2622839	4630	4610	3900	3790	100	2622839
Dissolved Manganese (Mn)	ug/L	12.7	2618540	5.8	6.6	29.8	16.9	2.0	2618545
Total Manganese (Mn)	ug/L	13.3	2622839	29.0	24.5	34.7	25.3	2.0	2622839
Dissolved Molybdenum (Mo)	ug/L	ND	2618540	8.1	7.9	ND	ND	2.0	2618545

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

ELEMENTS BY ICP/MS (WATER)

Maxxam ID		KX3811		KX3812	KX3813	KX3814	KX3815		
Sampling Date		2011/09/13 14:03		2011/09/13 14:21	2011/09/13 14:43	2011/09/14 08:19	2011/09/14 08:41		
	Units	**UNSED-3**	**QC Batch**	**POND-1**	**POND-2**	**ARMSED-1**	**ARMSED-2**	**RDL**	**QC Batch**
Total Molybdenum (Mo)	ug/L	ND	2622839	8.1	8.0	ND	ND	2.0	2622839
Dissolved Nickel (Ni)	ug/L	2.9	2618540	ND	ND	ND	ND	2.0	2618545
Total Nickel (Ni)	ug/L	ND	2622839	ND	ND	ND	ND	2.0	2622839
Total Phosphorus (P)	ug/L	ND	2622839	ND	ND	ND	ND	100	2622839
Dissolved Potassium (K)	ug/L	1020	2618540	6460	6530	575	448	100	2618545
Total Potassium (K)	ug/L	896	2622839	6310	6470	633	471	100	2622839
Dissolved Selenium (Se)	ug/L	ND	2618540	2.5	2.4	ND	ND	1.0	2618545
Total Selenium (Se)	ug/L	ND	2622839	2.2	2.5	ND	ND	1.0	2622839
Dissolved Silver (Ag)	ug/L	ND	2618540	ND	ND	ND	ND	0.10	2618545
Total Silver (Ag)	ug/L	ND	2622839	ND	ND	ND	ND	0.10	2622839
Dissolved Sodium (Na)	ug/L	10200	2618540	23700	24100	7520	5100	100	2618545
Total Sodium (Na)	ug/L	9240	2622839	22300	22100	7210	4790	100	2622839
Dissolved Strontium (Sr)	ug/L	118	2618540	686	695	50.9	47.6	2.0	2618545
Total Strontium (Sr)	ug/L	122	2622839	682	674	53.5	48.7	2.0	2622839
Dissolved Thallium (Tl)	ug/L	ND	2618540	2.50	2.53	ND	ND	0.10	2618545
Total Thallium (Tl)	ug/L	ND	2622839	2.53	2.44	ND	ND	0.10	2622839
Dissolved Tin (Sn)	ug/L	ND	2618540	ND	ND	ND	ND	2.0	2618545
Total Tin (Sn)	ug/L	ND	2622839	ND	ND	ND	ND	2.0	2622839
Dissolved Titanium (Ti)	ug/L	ND	2618540	ND	ND	ND	ND	2.0	2618545
Total Titanium (Ti)	ug/L	ND	2622839	ND	ND	3.3	ND	2.0	2622839
Dissolved Uranium (U)	ug/L	0.17	2618540	0.11	0.11	ND	ND	0.10	2618545
Total Uranium (U)	ug/L	0.17	2622839	0.11	0.10	ND	ND	0.10	2622839
Dissolved Vanadium (V)	ug/L	ND	2618540	ND	ND	ND	ND	2.0	2618545
Total Vanadium (V)	ug/L	ND	2622839	ND	ND	ND	ND	2.0	2622839
Dissolved Zinc (Zn)	ug/L	18.8	2618540	26.1	27.6	ND	ND	5.0	2618545
Total Zinc (Zn)	ug/L	7.4	2622839	44.3	30.8	ND	ND	5.0	2622839

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

ELEMENTS BY ICP/MS (WATER)

Maxxam ID		KX3816		KX3817	KX3818	KX3819		KX3820		
Sampling Date		2011/09/14 09:29		2011/09/14 10:11	2011/09/14 11:00	2011/09/13 15:43		2011/09/14 10:15		
	Units	**ARMSED-3**	**QC Batch**	**ARMSED-4**	**ARMSED-5**	**QA/QC-1**	**QC Batch**	**QA/QC-2**	**RDL**	**QC Batch**
Metals										
Dissolved Aluminum (Al)	ug/L	19.3	2618545	15.9	14.3	72.3	2618545	17.2	5.0	2618545
Total Aluminum (Al)	ug/L	63.2	2622839	46.9	195	295	2619948	45.7	5.0	2620201
Dissolved Antimony (Sb)	ug/L	ND	2618545	ND	ND	ND	2618545	ND	1.0	2618545
Total Antimony (Sb)	ug/L	ND	2622839	ND	ND	ND	2619948	ND	1.0	2620201
Dissolved Arsenic (As)	ug/L	ND	2618545	ND	ND	1.1	2618545	ND	1.0	2618545
Total Arsenic (As)	ug/L	ND	2622839	ND	ND	1.2	2619948	ND	1.0	2620201
Dissolved Barium (Ba)	ug/L	24.8	2618545	28.9	35.0	19.2	2618545	29.0	1.0	2618545
Total Barium (Ba)	ug/L	25.7	2622839	30.7	36.7	21.3	2619948	30.2	1.0	2620201
Dissolved Beryllium (Be)	ug/L	ND	2618545	ND	ND	ND	2618545	ND	1.0	2618545
Total Beryllium (Be)	ug/L	ND	2622839	ND	ND	ND	2619948	ND	1.0	2620201
Dissolved Bismuth (Bi)	ug/L	ND	2618545	ND	ND	ND	2618545	ND	2.0	2618545
Total Bismuth (Bi)	ug/L	ND	2622839	ND	ND	ND	2619948	ND	2.0	2620201
Dissolved Boron (B)	ug/L	ND	2618545	ND	ND	ND	2618545	ND	50	2618545
Total Boron (B)	ug/L	ND	2622839	ND	ND	ND	2619948	ND	50	2620201
Dissolved Cadmium (Cd)	ug/L	ND	2618545	ND	ND	ND	2618545	ND	0.017	2618545
Total Cadmium (Cd)	ug/L	ND	2622839	ND	ND	0.023	2619948	ND	0.017	2620201
Dissolved Calcium (Ca)	ug/L	22100	2618545	27900	29900	13400	2618545	28100	100	2618545
Total Calcium (Ca)	ug/L	21900	2622839	28000	28400	13400	2619948	27700	100	2620201
Dissolved Chromium (Cr)	ug/L	ND	2618545	ND	1.6	ND	2618545	ND	1.0	2618545
Total Chromium (Cr)	ug/L	ND	2622839	ND	1.0	ND	2619948	ND	1.0	2620201
Dissolved Cobalt (Co)	ug/L	ND	2618545	ND	ND	ND	2618545	ND	0.40	2618545
Total Cobalt (Co)	ug/L	ND	2622839	ND	ND	ND	2619948	ND	0.40	2620201
Dissolved Copper (Cu)	ug/L	ND	2618545	ND	ND	ND	2618545	ND	2.0	2618545
Total Copper (Cu)	ug/L	ND	2622839	ND	ND	ND	2619948	ND	2.0	2620201
Dissolved Iron (Fe)	ug/L	176	2618545	352	214	106	2618545	374	50	2618545
Total Iron (Fe)	ug/L	233	2622839	443	543	270	2619948	444	50	2620201
Dissolved Lead (Pb)	ug/L	ND	2618545	ND	ND	ND	2618545	ND	0.50	2618545
Total Lead (Pb)	ug/L	ND	2622839	ND	ND	0.60	2619948	ND	0.50	2620201
Dissolved Magnesium (Mg)	ug/L	3740	2618545	5660	5880	1340	2618545	5560	100	2618545
Total Magnesium (Mg)	ug/L	3670	2622839	5350	5500	1380	2619948	5600	100	2620201
Dissolved Manganese (Mn)	ug/L	19.4	2618545	34.4	59.5	26.1	2618545	34.4	2.0	2618545
Total Manganese (Mn)	ug/L	27.8	2622839	45.5	87.0	31.2	2619948	45.7	2.0	2620201
Dissolved Molybdenum (Mo)	ug/L	ND	2618545	ND	ND	ND	2618545	ND	2.0	2618545

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

ELEMENTS BY ICP/MS (WATER)

Maxxam ID		KX3816		KX3817	KX3818	KX3819		KX3820		
Sampling Date		2011/09/14 09:29		2011/09/14 10:11	2011/09/14 11:00	2011/09/13 15:43		2011/09/14 10:15		
	Units	**ARMSED-3**	**QC Batch**	**ARMSED-4**	**ARMSED-5**	**QA/QC-1**	**QC Batch**	**QA/QC-2**	**RDL**	**QC Batch**
Total Molybdenum (Mo)	ug/L	ND	2622839	ND	ND	ND	2619948	ND	2.0	2620201
Dissolved Nickel (Ni)	ug/L	ND	2618545	ND	ND	ND	2618545	ND	2.0	2618545
Total Nickel (Ni)	ug/L	ND	2622839	ND	ND	ND	2619948	ND	2.0	2620201
Total Phosphorus (P)	ug/L	ND	2622839	ND	ND	ND	2619948	ND	100	2620201
Dissolved Potassium (K)	ug/L	553	2618545	493	472	322	2618545	513	100	2618545
Total Potassium (K)	ug/L	449	2622839	529	513	354	2619948	531	100	2620201
Dissolved Selenium (Se)	ug/L	ND	2618545	ND	ND	ND	2618545	ND	1.0	2618545
Total Selenium (Se)	ug/L	ND	2622839	ND	ND	ND	2619948	ND	1.0	2620201
Dissolved Silver (Ag)	ug/L	ND	2618545	ND	ND	ND	2618545	ND	0.10	2618545
Total Silver (Ag)	ug/L	ND	2622839	ND	ND	ND	2619948	ND	0.10	2620201
Dissolved Sodium (Na)	ug/L	5110	2618545	5600	4210	7840	2618545	5570	100	2618545
Total Sodium (Na)	ug/L	4630	2622839	5230	3830	7270	2619948	5430	100	2620201
Dissolved Strontium (Sr)	ug/L	46.0	2618545	47.7	50.2	27.2	2618545	48.2	2.0	2618545
Total Strontium (Sr)	ug/L	46.9	2622839	49.5	49.4	26.9	2619948	49.2	2.0	2620201
Dissolved Thallium (Tl)	ug/L	ND	2618545	ND	ND	ND	2618545	ND	0.10	2618545
Total Thallium (Tl)	ug/L	ND	2622839	ND	ND	ND	2619948	ND	0.10	2620201
Dissolved Tin (Sn)	ug/L	ND	2618545	ND	ND	ND	2618545	ND	2.0	2618545
Total Tin (Sn)	ug/L	ND	2622839	ND	ND	ND	2619948	ND	2.0	2620201
Dissolved Titanium (Ti)	ug/L	ND	2618545	ND	ND	ND	2618545	ND	2.0	2618545
Total Titanium (Ti)	ug/L	ND	2622839	ND	ND	4.7	2619948	ND	2.0	2620201
Dissolved Uranium (U)	ug/L	ND	2618545	ND	ND	ND	2618545	ND	0.10	2618545
Total Uranium (U)	ug/L	ND	2622839	ND	ND	ND	2619948	ND	0.10	2620201
Dissolved Vanadium (V)	ug/L	ND	2618545	ND	ND	ND	2618545	ND	2.0	2618545
Total Vanadium (V)	ug/L	ND	2622839	ND	ND	ND	2619948	ND	2.0	2620201
Dissolved Zinc (Zn)	ug/L	6.9	2618545	ND	ND	ND	2618545	ND	5.0	2618545
Total Zinc (Zn)	ug/L	ND	2622839	ND	ND	ND	2619948	ND	5.0	2620201

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Package 1	3.3°C
Package 2	1.7°C

Each temperature is the average of up to three cooler temperatures taken at receipt

GENERAL COMMENTS

Sample KX3803-01: RCAp Ion Balance acceptable. Anion/cation agreement within 0.2 meq/L.

Sample KX3805-01: RCAp Ion Balance acceptable. Anion/cation agreement within 0.2 meq/L.

Sample KX3819-01: RCAp Ion Balance acceptable. Anion/cation agreement within 0.2 meq/L.

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**	**% Recovery**	**QC Limits**
2618228	pH	2011/09/19							0.1	25	101	80 - 120
2618229	Conductivity	2011/09/19			101	80 - 120	ND, RDL=1	uS/cm	0	25		
2618463	Total Mercury (Hg)	2011/09/19	106	80 - 120	87	80 - 120	ND, RDL=0.013	ug/L	NC	25	93	80 - 120
2618540	Dissolved Aluminum (Al)	2011/09/19	94	80 - 120	102	80 - 120	ND, RDL=5.0	ug/L				
2618540	Dissolved Antimony (Sb)	2011/09/19	96	80 - 120	95	80 - 120	ND, RDL=1.0	ug/L				
2618540	Dissolved Arsenic (As)	2011/09/19	97	80 - 120	96	80 - 120	ND, RDL=1.0	ug/L				
2618540	Dissolved Barium (Ba)	2011/09/19	90	80 - 120	92	80 - 120	ND, RDL=1.0	ug/L				
2618540	Dissolved Beryllium (Be)	2011/09/19	97	80 - 120	99	80 - 120	ND, RDL=1.0	ug/L				
2618540	Dissolved Bismuth (Bi)	2011/09/19	90	80 - 120	93	80 - 120	ND, RDL=2.0	ug/L				
2618540	Dissolved Boron (B)	2011/09/19	93	80 - 120	96	80 - 120	ND, RDL=50	ug/L				
2618540	Dissolved Cadmium (Cd)	2011/09/19	96	80 - 120	94	80 - 120	ND, RDL=0.017	ug/L	NC	25		
2618540	Dissolved Calcium (Ca)	2011/09/19	NC	80 - 120	100	80 - 120	ND, RDL=100	ug/L	0.5	25		
2618540	Dissolved Chromium (Cr)	2011/09/19	93	80 - 120	93	80 - 120	ND, RDL=1.0	ug/L				
2618540	Dissolved Cobalt (Co)	2011/09/19	91	80 - 120	92	80 - 120	ND, RDL=0.40	ug/L				
2618540	Dissolved Copper (Cu)	2011/09/19	91	80 - 120	92	80 - 120	ND, RDL=2.0	ug/L	NC	25		
2618540	Dissolved Iron (Fe)	2011/09/19	102	80 - 120	101	80 - 120	ND, RDL=50	ug/L	NC	25		
2618540	Dissolved Lead (Pb)	2011/09/19	88	80 - 120	90	80 - 120	ND, RDL=0.50	ug/L	NC	25		
2618540	Dissolved Magnesium (Mg)	2011/09/19	97	80 - 120	102	80 - 120	ND, RDL=100	ug/L	0.6	25		
2618540	Dissolved Manganese (Mn)	2011/09/19	NC	80 - 120	96	80 - 120	ND, RDL=2.0	ug/L	1.4	25		
2618540	Dissolved Molybdenum (Mo)	2011/09/19	93	80 - 120	96	80 - 120	ND, RDL=2.0	ug/L				
2618540	Dissolved Nickel (Ni)	2011/09/19	96	80 - 120	96	80 - 120	ND, RDL=2.0	ug/L				
2618540	Dissolved Potassium (K)	2011/09/19	99	80 - 120	100	80 - 120	ND, RDL=100	ug/L	0.8	25		
2618540	Dissolved Selenium (Se)	2011/09/19	99	80 - 120	99	80 - 120	ND, RDL=1.0	ug/L				
2618540	Dissolved Silver (Ag)	2011/09/19	101	80 - 120	100	80 - 120	ND, RDL=0.10	ug/L				
2618540	Dissolved Sodium (Na)	2011/09/19	96	80 - 120	96	80 - 120	ND, RDL=100	ug/L	0.1	25		
2618540	Dissolved Strontium (Sr)	2011/09/19	89	80 - 120	92	80 - 120	ND, RDL=2.0	ug/L				
2618540	Dissolved Thallium (Tl)	2011/09/19	87	80 - 120	95	80 - 120	ND, RDL=0.10	ug/L				
2618540	Dissolved Tin (Sn)	2011/09/19	95	80 - 120	95	80 - 120	ND, RDL=2.0	ug/L				
2618540	Dissolved Titanium (Ti)	2011/09/19	102	80 - 120	100	80 - 120	ND, RDL=2.0	ug/L				
2618540	Dissolved Uranium (U)	2011/09/19	102	80 - 120	103	80 - 120	ND, RDL=0.10	ug/L				
2618540	Dissolved Vanadium (V)	2011/09/19	93	80 - 120	94	80 - 120	ND, RDL=2.0	ug/L				
2618540	Dissolved Zinc (Zn)	2011/09/19	100	80 - 120	98	80 - 120	ND, RDL=5.0	ug/L	NC	25		
2618545	Dissolved Aluminum (Al)	2011/09/19	98	80 - 120	106	80 - 120	ND, RDL=5.0	ug/L				
2618545	Dissolved Antimony (Sb)	2011/09/19	98	80 - 120	94	80 - 120	ND, RDL=1.0	ug/L				
2618545	Dissolved Arsenic (As)	2011/09/19	97	80 - 120	97	80 - 120	ND, RDL=1.0	ug/L				
2618545	Dissolved Barium (Ba)	2011/09/19	90	80 - 120	91	80 - 120	ND, RDL=1.0	ug/L				
2618545	Dissolved Beryllium (Be)	2011/09/19	96	80 - 120	95	80 - 120	ND, RDL=1.0	ug/L				
2618545	Dissolved Bismuth (Bi)	2011/09/19	94	80 - 120	94	80 - 120	ND, RDL=2.0	ug/L				
2618545	Dissolved Boron (B)	2011/09/19	93	80 - 120	94	80 - 120	ND, RDL=50	ug/L				
2618545	Dissolved Cadmium (Cd)	2011/09/19	95	80 - 120	94	80 - 120	ND, RDL=0.017	ug/L				

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**	**% Recovery**	**QC Limits**
2618545	Dissolved Calcium (Ca)	2011/09/19	NC	80 - 120	101	80 - 120	ND, RDL=100	ug/L				
2618545	Dissolved Chromium (Cr)	2011/09/19	92	80 - 120	94	80 - 120	ND, RDL=1.0	ug/L				
2618545	Dissolved Cobalt (Co)	2011/09/19	91	80 - 120	92	80 - 120	ND, RDL=0.40	ug/L				
2618545	Dissolved Copper (Cu)	2011/09/19	91	80 - 120	92	80 - 120	ND, RDL=2.0	ug/L				
2618545	Dissolved Iron (Fe)	2011/09/19	101	80 - 120	103	80 - 120	ND, RDL=50	ug/L				
2618545	Dissolved Lead (Pb)	2011/09/19	90	80 - 120	90	80 - 120	ND, RDL=0.50	ug/L				
2618545	Dissolved Magnesium (Mg)	2011/09/19	101	80 - 120	106	80 - 120	ND, RDL=100	ug/L				
2618545	Dissolved Manganese (Mn)	2011/09/19	96	80 - 120	95	80 - 120	ND, RDL=2.0	ug/L	NC	25		
2618545	Dissolved Molybdenum (Mo)	2011/09/19	96	80 - 120	97	80 - 120	ND, RDL=2.0	ug/L				
2618545	Dissolved Nickel (Ni)	2011/09/19	95	80 - 120	97	80 - 120	ND, RDL=2.0	ug/L				
2618545	Dissolved Potassium (K)	2011/09/19	98	80 - 120	100	80 - 120	ND, RDL=100	ug/L				
2618545	Dissolved Selenium (Se)	2011/09/19	99	80 - 120	99	80 - 120	ND, RDL=1.0	ug/L				
2618545	Dissolved Silver (Ag)	2011/09/19	93	80 - 120	100	80 - 120	ND, RDL=0.10	ug/L				
2618545	Dissolved Sodium (Na)	2011/09/19	NC	80 - 120	100	80 - 120	ND, RDL=100	ug/L				
2618545	Dissolved Strontium (Sr)	2011/09/19	NC	80 - 120	91	80 - 120	ND, RDL=2.0	ug/L				
2618545	Dissolved Thallium (Tl)	2011/09/19	95	80 - 120	94	80 - 120	ND, RDL=0.10	ug/L				
2618545	Dissolved Tin (Sn)	2011/09/19	96	80 - 120	93	80 - 120	ND, RDL=2.0	ug/L				
2618545	Dissolved Titanium (Ti)	2011/09/19	98	80 - 120	97	80 - 120	ND, RDL=2.0	ug/L				
2618545	Dissolved Uranium (U)	2011/09/19	104	80 - 120	103	80 - 120	ND, RDL=0.10	ug/L				
2618545	Dissolved Vanadium (V)	2011/09/19	94	80 - 120	95	80 - 120	ND, RDL=2.0	ug/L				
2618545	Dissolved Zinc (Zn)	2011/09/19	99	80 - 120	101	80 - 120	ND, RDL=5.0	ug/L				
2618559	pH	2011/09/19							0.6	25	102	80 - 120
2618560	Conductivity	2011/09/19			101	80 - 120	1, RDL=1	uS/cm	1.0	25		
2619948	Total Aluminum (Al)	2011/09/20	102	80 - 120	101	80 - 120	6.7, RDL=5.0(1)	ug/L				
2619948	Total Antimony (Sb)	2011/09/20	101	80 - 120	103	80 - 120	ND, RDL=1.0	ug/L				
2619948	Total Arsenic (As)	2011/09/20	98	80 - 120	99	80 - 120	ND, RDL=1.0	ug/L				
2619948	Total Barium (Ba)	2011/09/20	97	80 - 120	99	80 - 120	ND, RDL=1.0	ug/L				
2619948	Total Beryllium (Be)	2011/09/20	98	80 - 120	99	80 - 120	ND, RDL=1.0	ug/L				
2619948	Total Bismuth (Bi)	2011/09/20	95	80 - 120	98	80 - 120	ND, RDL=2.0	ug/L				
2619948	Total Boron (B)	2011/09/20	100	80 - 120	100	80 - 120	ND, RDL=50	ug/L				
2619948	Total Cadmium (Cd)	2011/09/20	99	80 - 120	98	80 - 120	ND, RDL=0.017	ug/L				
2619948	Total Calcium (Ca)	2011/09/20	NC	80 - 120	101	80 - 120	ND, RDL=100	ug/L				
2619948	Total Chromium (Cr)	2011/09/20	97	80 - 120	99	80 - 120	ND, RDL=1.0	ug/L				
2619948	Total Cobalt (Co)	2011/09/20	98	80 - 120	98	80 - 120	ND, RDL=0.40	ug/L				
2619948	Total Copper (Cu)	2011/09/20	NC	80 - 120	97	80 - 120	ND, RDL=2.0	ug/L				
2619948	Total Iron (Fe)	2011/09/20	102	80 - 120	103	80 - 120	ND, RDL=50	ug/L	NC	25		
2619948	Total Lead (Pb)	2011/09/20	94	80 - 120	96	80 - 120	ND, RDL=0.50	ug/L	0.2	25		
2619948	Total Magnesium (Mg)	2011/09/20	NC	80 - 120	103	80 - 120	ND, RDL=100	ug/L				
2619948	Total Manganese (Mn)	2011/09/20	94	80 - 120	94	80 - 120	ND, RDL=2.0	ug/L				
2619948	Total Molybdenum (Mo)	2011/09/20	104	80 - 120	105	80 - 120	ND, RDL=2.0	ug/L				

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**	**% Recovery**	**QC Limits**
2619948	Total Nickel (Ni)	2011/09/20	NC	80 - 120	97	80 - 120	ND, RDL=2.0	ug/L				
2619948	Total Phosphorus (P)	2011/09/20	101	80 - 120	102	80 - 120	ND, RDL=100	ug/L				
2619948	Total Potassium (K)	2011/09/20	97	80 - 120	100	80 - 120	ND, RDL=100	ug/L				
2619948	Total Selenium (Se)	2011/09/20	99	80 - 120	100	80 - 120	ND, RDL=1.0	ug/L				
2619948	Total Silver (Ag)	2011/09/20	97	80 - 120	101	80 - 120	ND, RDL=0.10	ug/L				
2619948	Total Sodium (Na)	2011/09/20	NC	80 - 120	94	80 - 120	ND, RDL=100	ug/L				
2619948	Total Strontium (Sr)	2011/09/20	NC	80 - 120	96	80 - 120	ND, RDL=2.0	ug/L				
2619948	Total Thallium (Tl)	2011/09/20	97	80 - 120	99	80 - 120	ND, RDL=0.10	ug/L				
2619948	Total Tin (Sn)	2011/09/20	103	80 - 120	102	80 - 120	ND, RDL=2.0	ug/L				
2619948	Total Titanium (Ti)	2011/09/20	98	80 - 120	103	80 - 120	ND, RDL=2.0	ug/L				
2619948	Total Uranium (U)	2011/09/20	106	80 - 120	108	80 - 120	ND, RDL=0.10	ug/L				
2619948	Total Vanadium (V)	2011/09/20	99	80 - 120	100	80 - 120	ND, RDL=2.0	ug/L				
2619948	Total Zinc (Zn)	2011/09/20	NC	80 - 120	97	80 - 120	ND, RDL=5.0	ug/L				
2620201	Total Aluminum (Al)	2011/09/20	105	80 - 120	110	80 - 120	5.9, RDL=5.0(1)	ug/L	NC	25		
2620201	Total Antimony (Sb)	2011/09/20	102	80 - 120	104	80 - 120	ND, RDL=1.0	ug/L	NC	25		
2620201	Total Arsenic (As)	2011/09/20	98	80 - 120	103	80 - 120	ND, RDL=1.0	ug/L	NC	25		
2620201	Total Barium (Ba)	2011/09/20	NC	80 - 120	98	80 - 120	ND, RDL=1.0	ug/L	NC	25		
2620201	Total Beryllium (Be)	2011/09/20	99	80 - 120	97	80 - 120	ND, RDL=1.0	ug/L	NC	25		
2620201	Total Bismuth (Bi)	2011/09/20	99	80 - 120	103	80 - 120	ND, RDL=2.0	ug/L	NC	25		
2620201	Total Boron (B)	2011/09/20	NC	80 - 120	97	80 - 120	ND, RDL=50	ug/L	NC	25		
2620201	Total Cadmium (Cd)	2011/09/20	97	80 - 120	101	80 - 120	ND, RDL=0.017	ug/L	NC	25		
2620201	Total Calcium (Ca)	2011/09/20	NC	80 - 120	104	80 - 120	ND, RDL=100	ug/L	1.8	25		
2620201	Total Chromium (Cr)	2011/09/20	96	80 - 120	101	80 - 120	ND, RDL=1.0	ug/L	NC	25		
2620201	Total Cobalt (Co)	2011/09/20	94	80 - 120	101	80 - 120	ND, RDL=0.40	ug/L	NC	25		
2620201	Total Copper (Cu)	2011/09/20	93	80 - 120	100	80 - 120	ND, RDL=2.0	ug/L	0.7	25		
2620201	Total Iron (Fe)	2011/09/20	112	80 - 120	106	80 - 120	ND, RDL=50	ug/L	NC	25		
2620201	Total Lead (Pb)	2011/09/20	94	80 - 120	99	80 - 120	ND, RDL=0.50	ug/L	NC	25		
2620201	Total Magnesium (Mg)	2011/09/20	99	80 - 120	109	80 - 120	ND, RDL=100	ug/L	1.7	25		
2620201	Total Manganese (Mn)	2011/09/20	96	80 - 120	100	80 - 120	ND, RDL=2.0	ug/L	NC	25		
2620201	Total Molybdenum (Mo)	2011/09/20	104	80 - 120	108	80 - 120	ND, RDL=2.0	ug/L	NC	25		
2620201	Total Nickel (Ni)	2011/09/20	95	80 - 120	101	80 - 120	ND, RDL=2.0	ug/L	NC	25		
2620201	Total Phosphorus (P)	2011/09/20	106	80 - 120	108	80 - 120	ND, RDL=100	ug/L	NC	25		
2620201	Total Potassium (K)	2011/09/20	99	80 - 120	104	80 - 120	ND, RDL=100	ug/L	0.9	25		
2620201	Total Selenium (Se)	2011/09/20	95	80 - 120	102	80 - 120	ND, RDL=1.0	ug/L	NC	25		
2620201	Total Silver (Ag)	2011/09/20	97	80 - 120	102	80 - 120	ND, RDL=0.10	ug/L	NC	25		
2620201	Total Sodium (Na)	2011/09/20	NC	80 - 120	101	80 - 120	ND, RDL=100	ug/L	1.7	25		
2620201	Total Strontium (Sr)	2011/09/20	NC	80 - 120	99	80 - 120	ND, RDL=2.0	ug/L	2.6	25		
2620201	Total Thallium (Tl)	2011/09/20	99	80 - 120	104	80 - 120	ND, RDL=0.10	ug/L	NC	25		
2620201	Total Tin (Sn)	2011/09/20	116	80 - 120	105	80 - 120	ND, RDL=2.0	ug/L	NC	25		
2620201	Total Titanium (Ti)	2011/09/20	102	80 - 120	107	80 - 120	ND, RDL=2.0	ug/L	NC	25		

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**	**% Recovery**	**QC Limits**
2620201	Total Uranium (U)	2011/09/20	109	80 - 120	112	80 - 120	ND, RDL=0.10	ug/L	NC	25		
2620201	Total Vanadium (V)	2011/09/20	98	80 - 120	103	80 - 120	ND, RDL=2.0	ug/L	NC	25		
2620201	Total Zinc (Zn)	2011/09/20	97	80 - 120	101	80 - 120	ND, RDL=5.0	ug/L	NC	25		
2621385	Turbidity	2011/09/21					ND, RDL=0.1	NTU	13.5	25	101	80 - 120
2621392	Turbidity	2011/09/21					ND, RDL=0.1	NTU	NC	25	100	80 - 120
2621399	Total Mercury (Hg)	2011/09/21	100	80 - 120	89	80 - 120	ND, RDL=0.013	ug/L	NC	25	86	80 - 120
2621418	Nitrogen (Ammonia Nitrogen)	2011/09/22	97	80 - 120	96	80 - 120	ND, RDL=0.05	mg/L	NC	25	102	80 - 120
2621977	Total Alkalinity (Total as CaCO3)	2011/09/23	NC	80 - 120	106	80 - 120	ND, RDL=5	mg/L	5.5	25	104	80 - 120
2621978	Dissolved Chloride (Cl)	2011/09/23	100	80 - 120	100	80 - 120	ND, RDL=1	mg/L	1.5	25	103	80 - 120
2621979	Dissolved Sulphate (SO4)	2011/09/23	113	80 - 120	105	80 - 120	ND, RDL=2	mg/L	NC	25	107	80 - 120
2621981	Reactive Silica (SiO2)	2011/09/22	99	80 - 120	100	80 - 120	ND, RDL=0.5	mg/L	0.7	25	101	75 - 125
2621982	Colour	2011/09/23					ND, RDL=5	TCU	3.6	25	110	80 - 120
2621983	Orthophosphate (P)	2011/09/23	91	80 - 120	101	80 - 120	ND, RDL=0.01	mg/L	NC	25	100	80 - 120
2621985	Nitrate + Nitrite	2011/09/23	104	80 - 120	104	80 - 120	ND, RDL=0.05	mg/L	NC	25	108	80 - 120
2621987	Nitrite (N)	2011/09/22	91	80 - 120	96	80 - 120	ND, RDL=0.01	mg/L	NC	25	105	80 - 120
2621993	Total Alkalinity (Total as CaCO3)	2011/09/23	111	80 - 120	107	80 - 120	ND, RDL=5	mg/L	NC	25	105	80 - 120
2621999	Dissolved Chloride (Cl)	2011/09/23	102	80 - 120	101	80 - 120	ND, RDL=1	mg/L	NC	25	103	80 - 120
2622002	Dissolved Sulphate (SO4)	2011/09/23	102	80 - 120	104	80 - 120	ND, RDL=2	mg/L	NC	25	106	80 - 120
2622005	Reactive Silica (SiO2)	2011/09/22	98	80 - 120	99	80 - 120	ND, RDL=0.5	mg/L	NC	25	100	75 - 125
2622007	Colour	2011/09/23					ND, RDL=5	TCU	NC	25	108	80 - 120
2622010	Orthophosphate (P)	2011/09/23	97	80 - 120	92	80 - 120	ND, RDL=0.01	mg/L	NC	25	100	80 - 120
2622011	Nitrate + Nitrite	2011/09/23	105	80 - 120	97	80 - 120	ND, RDL=0.05	mg/L	NC	25	108	80 - 120
2622015	Nitrite (N)	2011/09/22	93	80 - 120	91	80 - 120	ND, RDL=0.01	mg/L	NC	25	100	80 - 120
2622839	Total Aluminum (Al)	2011/09/22	101	80 - 120	105	80 - 120	9.1, RDL=5.0(1)	ug/L				
2622839	Total Antimony (Sb)	2011/09/22	106	80 - 120	107	80 - 120	ND, RDL=1.0	ug/L				
2622839	Total Arsenic (As)	2011/09/22	98	80 - 120	100	80 - 120	ND, RDL=1.0	ug/L	NC	25		
2622839	Total Barium (Ba)	2011/09/22	97	80 - 120	99	80 - 120	ND, RDL=1.0	ug/L				
2622839	Total Beryllium (Be)	2011/09/22	99	80 - 120	104	80 - 120	ND, RDL=1.0	ug/L				
2622839	Total Bismuth (Bi)	2011/09/22	100	80 - 120	102	80 - 120	ND, RDL=2.0	ug/L				
2622839	Total Boron (B)	2011/09/22	103	80 - 120	107	80 - 120	ND, RDL=50	ug/L				
2622839	Total Cadmium (Cd)	2011/09/22	100	80 - 120	99	80 - 120	ND, RDL=0.017	ug/L				
2622839	Total Calcium (Ca)	2011/09/22	103	80 - 120	104	80 - 120	ND, RDL=100	ug/L				
2622839	Total Chromium (Cr)	2011/09/22	96	80 - 120	98	80 - 120	ND, RDL=1.0	ug/L				
2622839	Total Cobalt (Co)	2011/09/22	95	80 - 120	98	80 - 120	ND, RDL=0.40	ug/L				
2622839	Total Copper (Cu)	2011/09/22	92	80 - 120	95	80 - 120	ND, RDL=2.0	ug/L				
2622839	Total Iron (Fe)	2011/09/22	100	80 - 120	102	80 - 120	ND, RDL=50	ug/L				
2622839	Total Lead (Pb)	2011/09/22	95	80 - 120	97	80 - 120	ND, RDL=0.50	ug/L				
2622839	Total Magnesium (Mg)	2011/09/22	102	80 - 120	105	80 - 120	ND, RDL=100	ug/L				
2622839	Total Manganese (Mn)	2011/09/22	98	80 - 120	100	80 - 120	ND, RDL=2.0	ug/L				
2622839	Total Molybdenum (Mo)	2011/09/22	107	80 - 120	105	80 - 120	ND, RDL=2.0	ug/L				

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**	**% Recovery**	**QC Limits**
2622839	Total Nickel (Ni)	2011/09/22	95	80 - 120	98	80 - 120	ND, RDL=2.0	ug/L				
2622839	Total Phosphorus (P)	2011/09/22	101	80 - 120	104	80 - 120	ND, RDL=100	ug/L				
2622839	Total Potassium (K)	2011/09/22	99	80 - 120	101	80 - 120	ND, RDL=100	ug/L				
2622839	Total Selenium (Se)	2011/09/22	99	80 - 120	100	80 - 120	ND, RDL=1.0	ug/L				
2622839	Total Silver (Ag)	2011/09/22	101	80 - 120	102	80 - 120	ND, RDL=0.10	ug/L				
2622839	Total Sodium (Na)	2011/09/22	NC	80 - 120	96	80 - 120	ND, RDL=100	ug/L				
2622839	Total Strontium (Sr)	2011/09/22	97	80 - 120	98	80 - 120	ND, RDL=2.0	ug/L				
2622839	Total Thallium (Tl)	2011/09/22	101	80 - 120	102	80 - 120	ND, RDL=0.10	ug/L				
2622839	Total Tin (Sn)	2011/09/22	105	80 - 120	107	80 - 120	ND, RDL=2.0	ug/L				
2622839	Total Titanium (Ti)	2011/09/22	99	80 - 120	102	80 - 120	ND, RDL=2.0	ug/L				
2622839	Total Uranium (U)	2011/09/22	108	80 - 120	109	80 - 120	ND, RDL=0.10	ug/L				
2622839	Total Vanadium (V)	2011/09/22	98	80 - 120	100	80 - 120	ND, RDL=2.0	ug/L				
2622839	Total Zinc (Zn)	2011/09/22	97	80 - 120	100	80 - 120	ND, RDL=5.0	ug/L				
2622933	Nitrogen (Ammonia Nitrogen)	2011/09/22	107	80 - 120	105	80 - 120	ND, RDL=0.05	mg/L	NC	25	109	80 - 120
2622946	Nitrogen (Ammonia Nitrogen)	2011/09/23	105	80 - 120	108	80 - 120	ND, RDL=0.05	mg/L	NC	25	111	80 - 120
2624820	Total Organic Carbon (C)	2011/09/23	102	80 - 120	99	80 - 120	ND, RDL=0.5	mg/L	NC	25	104	80 - 120
2624862	Total Organic Carbon (C)	2011/09/23	NC	80 - 120	98	80 - 120	ND, RDL=0.5	mg/L	2.2	25	93	80 - 120

N/A = Not Applicable
RDL = Reportable Detection Limit
RPD = Relative Percent Difference
Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.
Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.
QC Standard: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.
NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.
NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.
(1) - Low level lab contamination. Minimal impact on data quality.

Validation Signature Page

Maxxam Job #: B1E2798

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Kevin A. MacDonald

KEVIN MACDONALD, Inorganics Supervisor

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Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Analytics International Corporation

200 Bluewater Road, Suite 105, Bedford, Nova Scotia B4B 1G9 Tel: 902-420-0203 Fax: 902-420-8612 Toll Free: 1-800-565-7227
49 Elizabeth Ave., St John's, NL A1A 1W9 Tel: 709-754-0203 Fax: 709-754-8612 Toll Free: 1-888-492-7227
90 Esplanade Sydney, NS B1P 1A1 Tel: 902-567-1255 Fax: 902-539-6504 Toll Free: 1-888-535-7770
www.maxxamanalytics.com E-mail: Clientservicesbedford@maxxamanalytics.com

MAXXAM Chain of Custody Record

COC #: B 121453 Page 1 of 4

This column for lab use only:
Client Code 22319
Maxxam Job # B1E2798

Cooler ID	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp
			3	3	4	
			2	2	1	

Integrity YES [✓ NO]
Integrity / Checklist by MKh
Labelled by
Location / Bin # E1AA

INVOICE INFORMATION:
Company Name:
Contact Name:
Address:
Postal Code
Email:
Ph: Fax:

REPORT INFORMATION (if differs from invoice):
Company Name: Intrinsik ENL
Contact Name: Christine Moore
Address: 5121 Sackville st
Halifax, NS Postal Code B3J 1K1
Email:
Ph: (902) 429-0278 Fax:

PO #
Project # / Phase # 055453
Project Name / Site Location Belledune, NB
Quote B14952
Site #
Task Order #
Sampled by M.Gaines / M.Graves

TURNAROUND TIME
Standard ☑
10 day ☐
If RUSH Specify Date:
Pre-schedule rush work
Charge for # Jars used but not submitted

Guideline Requirements / Detection Limits / Special Instructions

*Specify Matrix: Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

	Field Sample Identification	Matrix*	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose Total or Diss Metals	RCAP-MS Choose Total or Diss Metals	Metals Water: Total Digest (Default Method) for well water, surface water	Metals Water: Dissolved for ground water	Metals Water: Mercury (Total)	Metals Soil: Metals & Mercury Default Available Digest Method	Metals Soil: Metals Total Digest - for Ocean sediments (HNO3/HF/HCLO4)	Metals Soil: Mercury Low level by Cold Vapour AA	Metals Soil: Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Metals Soil: Hot Water soluble Boron (required for CCME Agricultural)	Hydrocarbons: RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons: Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	Hydrocarbons: NB Potable Water BTEX, VPH, Low level T.E.H.	Hydrocarbons: TPH Fractionation	Hydrocarbons: PAH's	Hydrocarbons: PAH's with Acridine, Quinoline
1	HESED-1	water	Sept. 12/11 11:31am	1X250ml 1X100ml 1X50ml	N	N		✓			✓											
2	HESED-1 (filtered)	water	Sept. 12/11 11:31am	1X50ml	✓	N				✓												
3	HESED-2	water	Sept. 12/11 2:48pm	1X250ml 1X100ml 1X50ml	N	N		✓			✓											
4	HESED-2 (filtered)	water	Sept. 12/11 2:48pm	1X50ml	✓	N				✓												
5	HESED-3	water	Sept. 13/11 9:12am	1X250ml 1X100ml 1X50ml	N	N		✓			✓											
6	HESED-3 (filtered)	water	Sept. 13/11 9:12am	1X50ml	✓	N				✓												
7	HESED-4	water	Sept. 13/11 10:51am	1X250ml 1X100ml 1X50ml	N	N		✓			✓											
8	HESED-4 (filtered)	water	Sept. 13/11 10:51am	1X50ml	✓	N				✓												
9	HESED-5	water	Sept. 13/11 3:39pm	1X250ml 1X100ml 1X50ml	N	N		✓			✓											
10	HESED-5 (filtered)	water	Sept. 13/11 3:39pm	1X50ml	✓	N				✓												

RELINQUISHED BY: (Signature/Print)	Date	Time	RECEIVED BY: (Signature/Print)	Date	Time
Michael C. Gaines	Sept. 15/11	2:00pm	Ryan Pet	2011 SEP 16	8:28

White: Maxxam Yellow : Mail Pink: Client

Maxxam Analytics International Corporation

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49 Elizabeth Ave., St John's, NL A1A 1W9 Tel: 709-754-0203 Fax: 709-754-8612 Toll Free: 1-888-492-7227
90 Esplanade Sydney, NS B1P 1A1 Tel: 902-567-1255 Fax: 902-539-6504 Toll Free: 1-888-535-7770
www.maxxamanalytics.com E-mail: Clientservicesbedford@maxxamanalytics.com

MAXXAM Chain of Custody Record

COC #: **B** 121708

Page 2 of 4

This column for lab use only:

Client Code 22319

Maxxam Job # BIE2798

Cooler ID	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp
			[illegible]	3	4	
			2	2	1	

Integrity YES NO

Integrity / Checklist by

Labelled by

Location / Bin #

INVOICE INFORMATION:

Company Name:
Contact Name:
Address:
Postal Code
Email:
Ph: Fax:

REPORT INFORMATION (if differs from invoice):

Company Name: Intrinsik ENV
Contact Name: Christine Moore
Address: 5121 Sackville st
Halifax, NS Postal Code B3J 1K1
Email:
Ph: (902) 429-0278 Fax:

PO #
Project # / Phase # 055953
Project Name / Site Location Belledune, NB
Quote B14952
Site #
Task Order #
Sampled by M. Gaines / M. Graves

TURNAROUND TIME
Standard ☑
10 day ☐
If RUSH Specify Date
Pre-schedule rush work
Charge for # Jars used but not submitted

Guideline Requirements / Detection Limits / Special Instructions

*Specify Matrix: Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

	Field Sample Identification	Matrix*	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose Total or Diss Metals	RCAP-MS Choose [✓ Total] or Diss Metals	Metals Water: Total Digest (Default Method) for well water, surface water	Metals Water: Dissolved for ground water	Metals Water: Mercury (total)	Metals Soil: Metals & Mercury Default Available Digest Method	Metals Soil: Metals Total Digest - for Ocean sediments (HNO3/HF/HCLO4)	Metals Soil: Mercury Low level by Cold Vapour AA	Metals Soil: Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Metals Soil: Hot Water soluble Boron (required for CCME Agricultural)	Hydrocarbons: RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons: Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	Hydrocarbons: NB Potable Water BTEX, VPH, Low level T.E.H.	Hydrocarbons: TPH Fractionation	Hydrocarbons: PAH's	Hydrocarbons: PAH's with Acridine, Quinoline				
1	HESED-6	water	Sept-13/11 3:12pm	1X250ml 1X100ml 1X50ml	N	N		✓			✓															
2	HESED-6 (filtered)	water	Sept-13/11 3:12pm	1X50ml	✓	N				✓																
3	HESED-7	water	Sept-13/11 4:08pm	1X250ml 1X100ml 1X50ml	N	N		✓			✓															
4	HESED-7 (filtered)	water	Sept-13/11 4:08pm	1X50ml	✓	N				✓																
5	UNSED-1	water	Sept-13/11 12:58pm	1X250ml 1X100ml 1X50ml	N	N		✓			✓															
6	UNSED-1 (filtered)	water	Sept-13/11 12:58pm	1X50ml	✓	N				✓																
7	UNSED-2	water	Sept-13/11 1:17pm	1X250ml 1X100ml 1X50ml	N	N		✓			✓															
8	UNSED-2 (filtered)	water	Sept-13/11 1:17pm	1X50ml	✓	N				✓																
9	UNSED-3	water	Sept-13/11 2:03pm	1X250ml 1X100ml 1X50ml	N	N		✓			✓															
10	UNSED-3 (filtered)	water	Sept-13/11 2:03pm	1X50ml	✓	N				✓																

RELINQUISHED BY: (Signature/Print)	Date	Time	RECEIVED BY: (Signature/Print)	Date	Time
Michael C. Gaines	Sept. 15/11	2:10pm			

White: Maxxam Yellow : Mail Pink: Client

Maxxam Analytics International Corporation

200 Bluewater Road, Suite 105, Bedford, Nova Scotia B4B 1G9 Tel: 902-420-0203 Fax: 902-420-8612 Toll Free: 1-800-565-7227
49 Elizabeth Ave., St John's, NL A1A 1W9 Tel: 709-754-0203 Fax: 709-754-8612 Toll Free: 1-888-492-7227
90 Esplanade Sydney, NS B1P 1A1 Tel: 902-567-1255 Fax: 902-539-6504 Toll Free: 1-888-535-7770
www.maxxamanalytics.com E-mail: Clientservicesbedford@maxxamanalytics.com

MAXXAM Chain of Custody Record

COC #: **B** 121709 Page 3 of 4

This column for lab use only:

Client Code 22319

Maxxam Job # B1E2798

Cooler ID	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp
			3	3	4	
			2	2	1	

Integrity YES NO

Integrity / Checklist by

Labelled by

Location / Bin #

INVOICE INFORMATION:

Company Name:

Contact Name:

Address:

Postal Code

Email:

Ph: Fax:

REPORT INFORMATION (if differs from invoice):

Company Name: Intrinsik EVL

Contact Name: Christine Moore

Address: 5121 Sackville st

Halifax, NS Postal Code B3J 1K1

Email:

Ph: (902) 429-0278 Fax:

PO #

Project # / Phase # 055453

Project Name / Site Location Belledune, NB

Quote B14952

Site #

Task Order #

Sampled by M.Gaines / M.Graves

TURNAROUND TIME

Standard ☑

10 day ☐

If RUSH Specify Date:

Pre-schedule rush work

Charge for # Jars used but not submitted

Guideline Requirements / Detection Limits / Special Instructions

*Specify Matrix: Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

									Metals Water			Metals Soil					Hydrocarbons									
	Field Sample Identification	Matrix*	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose Total or Diss Metals	RCAP-MS Choose [✓ Total] or Diss Metals	Total Digest (Default Method) for well water, surface water	Dissolved for ground water	Mercury	Metals & Mercury Default Available Digest Method	Metals Total Digest - for Ocean sediments (HNO3/HF/HCLO4)	Mercury Low level by Cold Vapour AA	Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Hot Water soluble Boron (required for CCME Agricultural)	RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	NB Potable Water BTEX, VPH, Low level T.E.H.	TPH Fractionation	PAH's	PAH's with Acridine, Quinoline				
1	Pond-1	water	Sept.13/11 2:21pm	1x250ml 1x100ml 1x50ml	N	N		✓			✓															
2	Pond-1 (filtered)	water	Sept.13/11 2:21pm	1x50ml	✓	N				✓																
3	Pond-2	water	Sept.13/11 2:43pm	1x250ml 1x100ml 1x50ml	N	N		✓			✓															
4	Pond-2 (filtered)	water	Sept.13/11 2:43pm	~~[illegible]~~ ~~[illegible]~~ 1x50ml	✓	N				✓																
5	ARMSED-1	water	Sept.14/11 8:19am	1x250ml 1x100ml 1x50ml	N	N		✓			✓															
6	ARMSED-1 (filtered)	water	Sept.14/11 8:19am	1x50ml	✓	N				✓																
7	ARMSED-2	water	Sept.14/11 8:41am	1x250ml 1x100ml 1x50ml	N	N		✓			✓															
8	ARMSED-2 (filtered)	water	Sept.14/11 8:41am	1x50ml	✓	N				✓																
9	ARMSED-3	water	Sept.14/11 9:29am	1x250ml 1x100ml 1x50ml	N	N		✓			✓															
10	ARMSED-3 (filtered)	water	Sept.14/11 9:29am	1x50ml	✓	N				✓																

RELINQUISHED BY: (Signature/Print)	Date	Time	RECEIVED BY: (Signature/Print)	Date	Time
Michael C. Gaines	Sept.15/11	2:00pm	D Ryan Pet		
				2011 SEP 16 AM 8:28	

White: Maxxam Yellow : Mail Pink: Client

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Maxxam Analytics International Corporation

200 Bluewater Road, Suite 105, Bedford, Nova Scotia B4B 1G9 Tel: 902-420-0203 Fax: 902-420-8612 Toll Free: 1-800-565-7227
49 Elizabeth Ave., St John's, NL A1A 1W9 Tel: 709-754-0203 Fax: 709-754-8612 Toll Free: 1-888-492-7227
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www.maxxamanalytics.com E-mail: Clientservicesbedford@maxxamanalytics.com

MAXXAM Chain of Custody Record

COC #: **B** 121710

Page 4 of 4

This column for lab use only:

Client Code 22319

Maxxam Job # B1E2798

Cooler ID	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp
			3	3	4	
			2	2	1	

Integrity YES NO

Integrity / Checklist by

Labelled by

Location / Bin #

INVOICE INFORMATION:

Company Name:

Contact Name:

Address:

Postal Code

Email:

Ph: Fax:

REPORT INFORMATION (if differs from invoice):

Company Name: Intrinsik Env

Contact Name: Christine Moore

Address: 5121 Sackville st

Halifax, NS Postal Code B3J 1K1

Email:

Ph: (902) 429-0278 Fax:

PO #

Project # / Phase # 055453

Project Name / Site Location Belledune, NB

Quote B14952

Site #

Task Order #

Sampled by M. Gaines / M. Graves

TURNAROUND TIME

Standard ☑

10 day ☐

If RUSH Specify Date:

Pre-schedule rush work

Charge for # Jars used but not submitted

Guideline Requirements / Detection Limits / Special Instructions

*Specify Matrix: Surface/Salt/Ground/Tapwater/Sewage/Effluent/Potable/NonPotable/Tissue/Soil/Sludge/Metal/Seawater

	Field Sample Identification	Matrix*	Date/Time Sampled	# & type of bottles	Field Filtered & Preserved	Lab Filtration Required	RCAP-30 Choose Total or Diss Metals	RCAP-MS Choose [✓ Total] or Diss Metals	Metals Water: Total Digest (Default Method) for well water, surface water	Metals Water: Dissolved for ground water	Metals Water: Mercury (total)	Metals Soil: Metals & Mercury Default Available Digest Method	Metals Soil: Metals Total Digest - for Ocean sediments (HNO3/HF/HCLO4)	Metals Soil: Mercury Low level by Cold Vapour AA	Metals Soil: Selenium (low level) Req'd for CCME Residential, Parklands, Agricultural	Metals Soil: Hot Water soluble Boron (required for CCME Agricultural)	Hydrocarbons: RBCA Hydrocarbons (BTEX, C6-C32)	Hydrocarbons: Hydrocarbons Soil (Potable), NS Fuel Oil Spill Policy Low Level BTEX, C6-C32	Hydrocarbons: NB Potable Water BTEX, VPH, Low level T.E.H.	Hydrocarbons: TPH Fractionation	Hydrocarbons: PAH's	Hydrocarbons: PAH's with Acridine, Quinoline
1	ARMSED-4	water	Sept. 14/11 10:11am	1x250ml 1x100ml 1x50ml	N	N		✓			✓											
2	ARMSED-4 (filtered)	water	Sept. 14/11 10:11am	1x50ml	✓	N				✓												
3	ARMSED-5	water	Sept. 14/11 11:00am	1x250ml 1x100ml 1x50ml	N	N		✓			✓											
4	ARMSED-5 (filtered)	water	Sept. 14/11 11:00am	1x50ml	✓	N				✓												
5	QA/QC-1	water	Sept. 13/11 3:43pm	1x250ml 1x100ml 1x50ml	N	N		✓			✓											
6	QA/QC-1 (filtered)	water	Sept. 13/11 3:43pm	1x50ml	✓	N				✓												
7	QA/QC-2	water	Sept. 14/11 10:15am	1x250ml 1x100ml 1x50ml	N	N		✓			✓											
8	QA/QC-2 (filtered)	water	Sept. 14/11 10:15am	1x50ml	✓	N				✓												
9																						
10																						

RELINQUISHED BY: (Signature/Print)	Date	Time	RECEIVED BY: (Signature/Print)	Date	Time
Michael C. Gaines	Sept. 15/11	2:00pm			

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ATL FCD 00149 / Revision 10

APPENDIX E

SOIL DATA QUALITY ASSURANCE EVALUATION

APPENDIX E SOIL DATA QUALITY ASSURANCE EVALUATION

Table of Contents

Attachments

Attachment E-1	RPD/ABD Calculations
Attachment E-2	Certified Reference Material Certificates of Analysis and Results of Analysis of “ERA Lot# D064 and D067” CRMS

APPENDIX E SOIL DATA QUALITY ASSURANCE EVALUATION

E-1.0 INTRODUCTION

Soil chemistry data were collected from various stations in the Belledune area in July and August of 2009, with supplementary soil chemistry data collected in August of 2010, and October of 2011. Details of the soil sampling and analytical programs are provided within the main ERA report (Section 2.0) and in Appendix A. All soil samples were analyzed by Maxxam Analytics in Bedford, Nova Scotia. To ensure that soil chemistry data used within the ERA are of acceptable quality, a soil data quality assurance evaluation was conducted on the soil chemistry data. This evaluation comprises part of a soil data quality assurance and quality control (QA/QC) program that was conducted concurrently with the soil sampling and analytical programs. The soil data QA/QC program consisted of the following activities:

- Internal laboratory QA/QC procedures and measures (including: QC standards, spiked blanks, method blanks, matrix spikes, certified reference materials (CRMs)).
- Approximately 10% of soil samples were analyzed by the primary lab (*i.e.*, Maxxam Analytics) as laboratory duplicates.
- Approximately 10% of soil samples were submitted to the primary lab (*i.e.*, Maxxam Analytics) as blind field duplicates, and analyzed by the lab as discrete soil samples.
- Approximately 10% of soil samples from the July-August 2009 sampling event were submitted to a secondary laboratory (*i.e.*, RPC Laboratories in Fredericton, NB) for analysis as inter-laboratory duplicates (N=14).
- Of the 14 samples submitted to RPC for inter-laboratory duplicate analysis, three internal laboratory duplicates were analyzed by RPC.

Both the primary and secondary laboratories used in the soil data QA/QC program have internal QA/QC requirements that must be met in order to maintain their accreditations for the analyses performed. Both Maxxam and RPC currently maintain accreditation to ISO/IEC 17025 through the Standards Council of Canada (SCC).

This soil data quality assurance evaluation is organized as follows. Section E-2.0 provides a summary of the primary laboratory's (*i.e.*, Maxxam) internal QA/QC outcomes (which includes QC standards, spiked blanks, method blanks, matrix spikes, and CRMs), as well as primary laboratory performance with respect to RDLs, and laboratory and field duplicates. Section E-3.0 provides a summary of the secondary laboratory's (*i.e.*, RPC) internal QA/QC outcomes (which includes blanks and CRMs), as well as secondary laboratory performance with respect to RDLs and laboratory duplicates). Section E-4.0 describes and discusses inter-laboratory duplicate performance. Section E-5.0 provides a summary of the soil data QA evaluation outcomes, and provides conclusions and recommendations, where/if necessary. Section E-6.0 provides a list of references cited.

E-2.0 PRIMARY LABORATORY (MAXXAM) SOIL DATA QA/QC OUTCOMES

E-2.1 Internal Laboratory Quality Assurance/Quality Control Procedures and Outcomes (Maxxam)

Internal laboratory quality assurance/quality control measures consist of QC standards, spiked blanks, method blanks, matrix spikes, and certified reference material (CRM) analysis (laboratory duplicates are also part of the internal laboratory QA/QC measures, but these are described separately in Section E-2.4). For the quality assurance review of all internal laboratory QA/QC procedures and outcomes, the acceptance criteria (or QC limits) used by the laboratory (*i.e.*, Maxxam Analytics) were the benchmarks of comparison. Maxxam defines these measures as follows:

- QC Standard: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
- Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
- Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.
- Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.
- While not specifically defined by Maxxam, Certified Reference Materials (CRM) are "reference material" that is characterized by a metrologically valid procedure for one or more specified properties, accompanied by a certificate that provides the value of the specified property, its associated uncertainty, and a statement of metrological traceability. A "reference material" is defined as material that is sufficiently homogeneous and stable with respect to one or more specified properties, and which has been established to be fit for its intended use in a measurement process (NIST, 2010). CRM can be used to evaluate analyte recovery, laboratory contamination and overall performance of the laboratory methods in achieving accurate and precise chemical parameter measurements.

Further details on laboratory QA/QC with respect to each of these internal measures is provided in the laboratory certificates of analysis (Appendix D).

E-2.1.1 QC Standards

The criteria (QC limits) used by Maxxam for QC standards are 75%-125% (per cent recovery) for all soil parameters. In one QC standard sample, there was an available Lead (Pb) per cent recovery of 48%. The laboratory notes indicated this was a typical recovery for the reference material matrix, and that the secondary RM was acceptable. All other parameters analyzed in QC standard samples are within the QC limits used by Maxxam. Thus, there are no apparent issues with respect to analyte recovery.

E-2.1.2 Spiked Blanks

The criteria (QC limits) used by Maxxam for spiked blanks are 75%-125% (per cent recovery) for all soil parameters. All of the parameters analyzed in soil spiked blank samples are within the QC limits used by Maxxam. As such, there are no apparent issues with respect to analyte recovery.

E-2.1.3 Method Blanks

For method blanks, the acceptance criteria for any analytical laboratory is a <RDL result. All parameters analyzed for in method blank soil samples were below their respective RDLs. Therefore, there are no apparent issues with respect to laboratory contamination.

E-2.1.4 Matrix Spikes

The criteria (QC limits) used by Maxxam for matrix spikes are 75%-125% (per cent recovery) for all soil parameters. The majority of parameters analyzed in matrix spike soil samples are within the QC limits used by Maxxam. Exceptions were as follows (see below bullets). For these instances, excursions outside the QC limits were marginal, which may indicate a slight potential for high or low bias, but the potential for significant bias in either direction was considered to be low. There were also a number of instances where per cent recovery was not calculable for various parameters in matrix spike soil samples. It is not uncommon for recovery of a parameter in a matrix spike sample to be non-calculable, due to elevated concentrations of that parameter in the parent sample, which can make the relative difference between the spiked and unspiked (parent sample) concentrations insufficiently significant to permit a reliable recovery calculation. The laboratory certificates of analysis indicated that this was the reason for the non-calculable recoveries for a number of parameters in matrix spike soil samples. Per cent recovery in matrix spike samples can also be non-calculable if the spiked concentration is less than 2 x that which is native to the parent sample.

The soil matrix spike analytical results are suggestive of a relatively high incidence of matrix interference in the soil samples that were analyzed. This is not unexpected though for a heterogeneous matrix such as soil. In some soil samples, matrix interference led to elevated RDLs for some soil parameters (See Section E-2.2). While it is important to identify the degree of matrix interference that may affect analytical results, it is difficult to control for. Thus, given that most parameters analyzed in matrix spike soil samples are within QC limits, there are no major data quality issues apparent in relation to matrix spikes and the degree of sample matrix interference.

- Maxxam Job No. A9B7567:
    - Available Antimony (Sb) per cent recovery of 73%; Available Boron (B) per cent recovery of 71% in one matrix spike soil sample. Laboratory notes indicated poor recovery due to sample matrix.
    - Available Antimony (Sb) per cent recovery of 62% in one matrix spike soil sample. Laboratory notes indicated poor recovery due to sample matrix.
    - There were a number of instances where per cent recovery was not calculable for various parameters in soil matrix spike samples. The affected parameters (with number of instances in brackets) are as follows: Aluminum (2); Arsenic (2); Barium (2); Chromium (2); Cobalt (2); Copper (2); Iron (2); Lead (2); Lithium (2); Manganese (2); Nickel (2); Rubidium (1); Strontium (1); Vanadium (2).
- Maxxam Job No. A9B7652:
    - Available Boron (B) per cent recovery of 61%; Available Selenium (Se) per cent recovery of 69% in one soil matrix spike sample. Laboratory notes indicated low recoveries due to sample matrix.
    - Available Rubidium per cent recovery of 71% in one soil matrix spike sample. Laboratory notes indicated low recovery due to sample matrix.
    - There were a number of instances where per cent recovery was not calculable for various parameters in soil matrix spike samples. The affected parameters (with number of instances in brackets) are as follows: Aluminum (2); Barium (2); Chromium (2); Cobalt (2); Copper (1); Iron (2); Lead (2); Lithium (2); Manganese (2); Nickel (2); Vanadium (2).
- Maxxam Job No. A9B7632:
    - Available Antimony (Sb) per cent recovery of 65%; Available Arsenic (As) per cent recovery of 62%; Available Rubidium (Rb) per cent recovery of 72%; Available Selenium (Se) per cent recovery of 52% in one matrix spike soil sample. Laboratory notes indicated low recoveries due to sample matrix.
    - Available Boron (B) per cent recovery of 61%; Available Selenium (Se) per cent recovery of 69% in one matrix spike soil sample. Laboratory notes indicated low recoveries due to sample matrix.
    - There were a number of instances where per cent recovery was not calculable for various parameters in soil matrix spike samples. The affected parameters (with number of instances in brackets) are as follows: Aluminum (2); Barium (2); Chromium (2); Cobalt (2); Copper (1); Iron (2); Lead (2); Lithium (2); Manganese (2); Nickel (2); Vanadium (2).
- Maxxam Job No. A9B8179:
    - Available Rubidium (Rb) per cent recovery of 71% in one matrix spike soil sample. Laboratory notes indicated low recovery due to sample matrix.
    - Available Antimony (Sb) per cent recovery of 70%; and Available Boron (B) per cent recovery of 65% in one matrix spike soil sample. Laboratory notes indicated low recoveries due to sample matrix.
    - There were a number of instances where per cent recovery was not calculable for various parameters in soil matrix spike samples. The affected parameters (with number of instances in brackets) are as follows: Aluminum (2); Barium (2);

    Chromium (2); Cobalt (2); Copper (2); Iron (2); Lead (2); Lithium (2); Manganese (2); Nickel (2); Vanadium (2).

- Maxxam Job No. A9B7570:
    - Available Antimony (Sb) per cent recovery of 62% in one matrix spike soil sample. Laboratory notes indicated low recovery due to sample matrix.
    - Available Boron (B) per cent recovery of 73% in one matrix spike soil sample. Laboratory notes indicated low recovery due to sample matrix.
    - There were a number of instances where per cent recovery was not calculable for various parameters in soil matrix spike samples. The affected parameters (with number of instances in brackets) are as follows: Aluminum (2); Arsenic (1); Barium (2); Chromium (2); Cobalt (2); Copper (2); Iron (2); Lead (2); Lithium (2); Manganese (2); Nickel (2); Strontium (1); Vanadium (2).
- Maxxam Job No. A9B7575:
    - Available Boron (B) per cent recovery of 73% in one matrix spike soil sample. Laboratory notes indicated low recovery due to sample matrix.
    - Available Antimony (Sb) per cent recovery of 60%; Available Boron (B) per cent recovery of 64%; and Available Molybdenum (Mo) per cent recovery of 64% in one matrix spike soil sample. Laboratory notes indicated low recoveries due to sample matrix.
    - There were a number of instances where per cent recovery was not calculable for various parameters in soil matrix spike samples. The affected parameters (with number of instances in brackets) are as follows: Aluminum (2); Arsenic (1); Barium (2); Chromium (2); Cobalt (2); Copper (2); Iron (2); Lead (2); Lithium (2); Manganese (2); Nickel (2); Vanadium (2).
- Maxxam Job No. A9B7578:
    - Available Antimony (Sb) per cent recovery of 60%; Available Boron (B) per cent recovery of 64%; Available Molybdenum per cent recovery of 64% in one matrix spike soil sample. Laboratory notes indicated low recoveries due to sample matrix.
    - Available Antimony per cent recovery of 69%; Available Selenium (Se) per cent recovery of 71% in one matrix spike soil sample. Laboratory notes indicated low recoveries due to sample matrix.
    - Available Antimony (Sb) per cent recovery of 65%; Available Arsenic (As) per cent recovery of 62%; Available Rubidium (Rb) per cent recovery of 72%; and Available Selenium (Se) per cent recovery of 52% in one matrix spike soil sample. Laboratory notes indicated low recoveries due to sample matrix.
    - There were a number of instances where per cent recovery was not calculable for various parameters in soil matrix spike samples. The affected parameters (with number of instances in brackets) are as follows: Aluminum (3); Arsenic (2); Barium (3); Chromium (3); Cobalt (3); Copper (2); Iron (3); Lead (3); Lithium (3); Manganese (3); Nickel (3); Vanadium (3).
- Maxxam Job No. DB0B4390:
    - There were several instances where per cent recovery was not calculable for various parameters in the single soil matrix spike sample that was analyzed. The affected parameters are as follows (1 instance each): Aluminum; Arsenic; Barium; Chromium; Copper; Iron; Lead; Manganese; Vanadium.

- Maxxam Job No. DB1G7201:
    - Available Chromium (Cr) per cent recovery of 131%. Laboratory notes indicated elevated recovery due to sample matrix.
    - Available Nickel (Ni) per cent recovery of 52%. Laboratory notes indicated low recovery due to sample matrix.
    - Available Boron (B) per cent recovery of 67%. Laboratory notes indicated low recovery due to sample matrix.
    - There were several instances where per cent recovery was not calculable for various parameters in the soil matrix spike samples that were analyzed. The affected parameters are as follows: Aluminum (1); Arsenic (1); Barium (1); Cadmium (1); Copper (1); Iron (1); Lead (1); Manganese (1); Selenium (1); Strontium (1); Thallium (1); Vanadium (1); Zinc (2).

E-2.1.5 Certified Reference Materials (CRM)

For CRM, the typical acceptance criteria for an analytical laboratory is a result within either the 95% confidence interval, or range, for the specific certified reference material (as provided in the certificate of analysis for a given CRM). For some CRM, certain parameters may not have certified values available. However, in such cases, the certificates for that CRM typically provide values that were obtained from available laboratory performance tests, which can be used as indicators of quality control. For some CRM, these non-certified values are called 'reference values'. They are generally used in the same manner as certified values, in that they are considered the best estimate of the true value, but have more associated uncertainties, and may be based on results from a single analytical method (certified values are usually based on the results from two or more analytical methods).

In the July-August 2009 soil sampling and analytical program, NIST 2711 was the primary CRM utilized by Maxxam. The certificate of analysis for this CRM is provided in Attachment E-2.

Table E-1 provides the results of Maxxam's analysis of the NIST 2711 CRM samples in comparison with the certified and/or reference values for this CRM, as reported in its certificate of analysis.

Table E-1 Maxxam Certified Reference Material Analytical Results and Comparisons; mg/kg

	CRM: NIST 2711[a]		Maxxam Sample IDs and Analyses of NIST 2711 Samples							
			DQ5416	DQ5387	DQ5395	DQ5427	DQ5441	DQ5442	DQ7283	DQ5433
Elements	Min	Max	Batch #4 - NIST 2711	Batch #3 - NIST 2711	Batch #2 - NIST 2711	Batch #5 - NIST 2711	Batch #7 - NIST 2711 #1	Batch #7 - NIST 2711 #2	Batch #1 - NIST 2711	Batch #6 - NIST 2711
Aluminum (Al)	12000	23000	12000	11000	13000	12000	12000	12000	12000	13000
Antimony (Sb)	<10[b]	<10[b]	15	17	17	17	15	19	18	18
Arsenic (As)	88	110	87	88	95	89	96	100	100	97
Barium (Ba)	170	260	180	170	180	160	190	190	180	180
Beryllium (Be)	NV	NV	<2	<2	<2	<2	<2	<2	<2	<2
Bismuth (Bi)	NV	NV	2	2	2	2	2	2	3	2
Boron (B)	NV	NV	6	<5	6	<5	7	5	6	5
Cadmium (Cd)	32	46	37	38	40	36	39	42	41	42
Chromium (Cr)	15	25	17	17	17	16	16	18	19	17
Cobalt (Co)	7	12	8	7	8	7	8	8	9	8
Copper (Cu)	91	110	100	94	98	94	98	100	110	99
Iron (Fe)	17000	26000	18000	16000	18000	17000	18000	18000	18000	18000
Lead (Pb)	930	1500	1200	1100	1100	1100	1100	1100	1200	1100
Lithium (Li)	NV	NV	11	10	12	10	11	11	12	12
Manganese (Mn)	400	620	510	450	500	480	500	470	520	510
Molybdenum (Mo)	<2[b]	<2[b]	<2	<2	<2	<2	<2	<2	<2	<2
Nickel (Ni)	14	20	15	14	14	14	14	16	17	15
Rubidium (Rb)	NV	NV	20	22	23	20	23	24	24	23
Selenium (Se)	NV[c]	NV[c]	<2	<2	<2	<2	<2	<2	<2	<2
Silver (Ag)	2.5	5.5	4.5	4.0	4.7	4.1	4.6	4.8	5.0	4.7
Strontium (Sr)	48	55	36	36	37	36	39	39	38	38
Thallium (Tl)	NV	NV	1.5	1.4	1.3	1.5	1.3	1.3	1.6	1.3
Tin (Sn)	NV	NV	<2	2	2	2	2	2	2	2

Table E-1 Maxxam Certified Reference Material Analytical Results and Comparisons; mg/kg

Uranium (U)	NV	NV	0.8	0.9	0.9	0.9	0.8	0.9	1.1	0.8
Vanadium (V)	34	50	38	38	37	36	38	42	44	39
Zinc (Zn)	290	340	300	270	300	280	300	320	320	310

Notes:

'NV' indicates no CRM value is available for this parameter; '<' indicates concentration is less than the laboratory RDL.

Shading indicates a concentration outside of the CRM range or confidence interval.

a Ranges are from Table 3 of Addendum to Certificate of Analysis for Standard Reference Material 2711.

b Range not available. Values from Table 3 are reported as medians.

c While selenium is listed in Table 3 from NIST, it is coded as "nr" – no range reported by the laboratory.

Based on the comparisons presented in Table E-1, it is evident that there were several instances where the Maxxam-obtained parameter concentrations in the NIST 2711 CRM samples fell outside the concentration ranges that are stipulated for this CRM in its certificate of analysis. In all eight samples analyzed by Maxxam, antimony exceeded its stipulated value (the median in this case), while strontium was below its stipulated concentration range. For arsenic, barium, and iron, there was one sample each (all different samples though) where the Maxxam-obtained concentrations were slightly below the stipulated concentration range for these parameters. For zinc, there were two samples where the Maxxam-obtained concentrations were slightly below the stipulated concentration range for this parameter. For all other parameters with stipulated CRM values available (*i.e.*, aluminum, cadmium, chromium, cobalt, copper, lead, manganese, molybdenum, nickel, silver, and vanadium), the Maxxam-obtained concentrations in all eight NIST 2711 samples were within the stipulated CRM concentration ranges. Nine parameters lack ranges or other values for the NIST 2711 CRM (*i.e.*, beryllium, bismuth, boron, lithium, rubidium, selenium, thallium, tin, and uranium), and therefore, it is not possible to comment on laboratory performance for these parameters. Given the data presented in Table E-1, and given that the excursions outside of the stipulated CRM values were generally marginal, there are no apparent data quality issues indicated by Maxxam's performance with the NIST 2711 CRM. In general, there was reasonably good agreement between Maxxam's CRM results and the values stipulated in the CRM certificate of analysis, which suggests no apparent issues with respect to analyte recovery, laboratory contamination and overall performance of the laboratory methods in achieving accurate and precise chemical parameter measurements. As such, soil data quality was considered acceptable for ERA purposes, with respect to CRM recovery by Maxxam.

In addition to the NIST 2711 CRM (which was requested for the July-August 2009 soil samples), Maxxam routinely runs another CRM with all batches of soil samples (*i.e.*, ERA Lot # D064 HCl). While analytical results for this CRM are not usually reported, they were requested in this case. For this CRM, 26 element parameters have target or certified values available. Maxxam reports the outcomes of the analysis of this CRM as per cent recovery, and uses QC limits of 75% to 125%. Out of the eight samples of ERA Lot # D064 HCl that were analyzed in the same batches as the July-August 2009 soil samples, there were few instances where an element's measured concentration was outside the per cent recovery QC limits, as follows. All other parameter concentrations fell within QC limits in the analyses of this CRM. Attachment E-2 provides the analytical results and per cent recoveries for all 8 analyses of the ERA Lot # D064 HCl CRM.

- In 2 of the 8 CRM samples, aluminum recovery was slightly below QC limits.
- In 4 of the 8 CRM samples, titanium recovery was slightly below QC limits.
- In all 8 CRM samples, antimony recovery was considerably above QC limits (per cent recovery ranged from 260% to 318%). Discussions with Maxxam personnel about these antimony recoveries revealed that the high per cent recovery of this parameter is not due to analytical interference, but is a result of Maxxam's digestion efficiency being greater than the digestion efficiency in the method used to certify this particular reference material. The form of antimony in this CRM (which is an artificial solid matrix) is generally not readily extractable using digestions that extract available metals. But, Maxxam's digestion procedure is able to liberate more of the "total" antimony than the

methods used to generate the certified values for this material. Thus, the high antimony recoveries in the 8 samples of this CRM are considered acceptable and typical.

In the August 2010 soil samples, Maxxam ran a similar CRM with the submitted soil samples (*i.e.*, ERA Lot #D067). For this CRM, 28 element parameters have target or certified values available. Two samples of this CRM were analyzed. The certificate of analysis for this CRM was provided to Intrinsik by Maxxam (See Attachment E-2). Expressing the outcome of the analysis of this CRM as per cent recovery, and using the same QC limits of 75% to 125%, only antimony had a measured concentration that was outside the per cent recovery QC limits (188% and 197%, respectively). As for the ERA Lot # D064 CRM, the high per cent recovery of antimony is not believed to be due to analytical interference, but rather, is attributed to Maxxam's digestion efficiency being greater than the digestion efficiency in the method used to certify the ERA Lot #D067 CRM. Attachment E-2 provides the analytical results and per cent recoveries for the two analyses of the ERA Lot # D067 CRM, as well as the certificate of analysis for this CRM.

Maxxam's analytical results for the ERA Lot # D064 HCl and ERA Lot #D067 CRM samples support the conclusion made regarding Maxxam's performance for the NIST 2711 CRM. That is, there are no apparent issues with respect to analyte recovery, laboratory contamination and overall performance of the laboratory methods in achieving accurate and precise chemical parameter measurements. As such, soil data quality was considered acceptable for risk assessment purposes, with respect to CRM recovery.

E-2.2 Reportable Detection Limits (RDLs)

Review of the RDLs that were achieved in the soil analyses indicates that typical and acceptable RDLs were achieved for the majority of parameters in all soil samples. Elevated RDLs were only noted for aluminum (typical RDL was elevated 10-fold in four samples), iron (typical RDL was elevated 10-fold in 15 samples), and strontium (typical RDL was elevated 10-fold in 14 samples). In all of the samples affected by elevated RDLs, there were no issues associated with the achieved RDL for a specific sample being higher than soil quality guidelines. Strontium has no soil quality guidelines, and every soil sample where the RDL was elevated for aluminum and iron contained measurable concentrations that were substantially higher than the elevated RDL. In the laboratory certificates of analysis, elevated RDLs are consistently attributed to matrix interference or the sample matrix.

In the analyses of metals and metalloids in soil samples, it is not uncommon for some parameters in some samples to have elevated RDLs due to matrix effects. Overall, none of the recorded instances of elevated RDLs are considered to adversely impact soil data quality.

E-2.3 Other Data Quality Items or Issues

There were a few miscellaneous items noted within the laboratory certificates of analysis that relate to soil analytical results. These are summarized below, with further details provided within the certificates of analysis. None are considered to significantly impact data quality.

There were a few instances where sample inhomogeneity was noted to have resulted in a poor RPD between laboratory duplicate and original sample analytical results for some parameters. However, in all cases, the reported RPD in Maxxam's QA sheets were within the laboratory's internal QC limits.

In one soil sample, a 1:10 aqueous leachate was conducted due to sample matrix.

E-2.4 Duplicates – Maxxam

Duplicate samples provide a measure of the reproducibility (or precision) of the analyses performed on a sample. U.S. EPA (2004) defines a duplicate as a second aliquot of a sample that is treated the same as the original sample in order to determine the precision of the analytical method.

Two types of duplicate samples were evaluated in this project – laboratory duplicates and field duplicates. A laboratory duplicate is the same sample material (can be the same aliquot of a sample with non-destructive analyses, but is a different aliquot of the sample if the analytical method is destructive) being analyzed using the same analytical method and equipment. A field duplicate differs from a laboratory duplicate in that it is generated in the field (not the laboratory), and is not necessarily the same sample material as the original sample. Typically, field duplicates are collected adjacent to original samples in the field (*i.e.*, at the same general location) but can comprise the same sample material if the field duplicates are generated from composite samples that are mixed in the field. Because field duplicates can represent different sample material than the original samples and/or can often be subject to incomplete mixing of composite samples, it is not uncommon for there to be lower reproducibility (or precision) between a field duplicate and its original sample, relative to the precision obtained between a laboratory duplicate and its original sample.

E-2.4.1 Data Quality Objectives for Duplicates

The data quality objectives described in this section were established prior to the initiation of the soil sampling and analytical programs.

Data quality objectives (DQOs) are important in determining whether or not the collected analytical data are of suitable quality for assessment purposes. In order to have a means of determining whether or not the analytical data for this project are of adequate quality in terms of duplicate samples, the DQOs described in U.S. EPA (2006) were used, with consideration also given to the DQOs typically used by the primary laboratory (Maxxam Analytics). These DQOs were applied equally to both laboratory and field duplicates.

The two main measures (or calculations) with respect to duplicate data quality assurance are relative per cent difference (RPD) and absolute difference (ABD). The general equation for the RPD calculation is as follows (from U.S. EPA, 2004):

$$RPD = \{|S-D| \div (S+D)/2)\} \times 100$$

Where,

RPD = Relative Per cent Difference
S = Sample Result (original)
D = Duplicate Result

The general equation for ABD is simply $|S-D|$.

RPD and ABD calculations are not performed when both corresponding sample values (in the original and the duplicate sample) are <RDLs. While U.S. EPA (2006) suggests that ABD be calculated when one sample value is measured and the other is <RDL, this is not considered reasonable as a <RDL result is an unknown value, and it is not appropriate to compare a known quantified value to an unknown, unquantified value. In situations where both the original sample and the duplicate sample have measured values >RDLs, the following decision rules are used to determine if RPD or ABD should be calculated (U.S. EPA, 2006; 2004). If analytical results in both of the samples are <5 times the reported detection limit (RDL), then only ABD is calculated. If analytical results in both of the samples are ≥5 times the RDL, then only RPD is calculated. Both the RPD and ABD are calculated if one sample is <5 times the RDL and the other sample is ≥5 times the RDL. It should be noted that U.S. EPA decision rules are based on contract-required quantitation limits (CRQLs), which are values set by the U.S. EPA for contract labs. It is not uncommon though for CRQLs to differ from achievable RDLs at a given laboratory. As there is no identified Canadian guidance that is similar to U.S. EPA (2006), the U.S. EPA decision rules are applied on the basis of the RDLs that were achieved by Maxxam, rather than CRQLs. This is consistent with U.S. EPA policy on data quality assurance which suggests replacing the CRQL with the MDL (generally analogous to the RDL) when the MDL is the higher value (U.S. EPA, 2006).

For laboratory and field duplicate soil samples, U.S. EPA (2006) Standard Operating Procedures (SOP) permit a DQO for RPD of up to 35% as the primary acceptance limit. Maxxam utilizes the same DQO for RPD between original and duplicate soil samples[1]. The U.S. EPA considers RPDs between ≥35% and <120% to be acceptable for assessment purposes, but stipulates that if either of the original sample or duplicate sample results that produced an RPD in this range are to be used for assessment purposes, that they be flagged as estimated values. U.S. EPA (2006) recommends the rejection of soil samples when RPDs are ≥120%.

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[1] The only soil parameter for which Maxxam Analytics does not use a RPD DQO of 35% is sieve size results, where 25% is the acceptance limit. However, for consistency with all other soil parameters, the primary acceptance limit DQO for RPD was set at 35%.

For ABD between an original soil sample and its laboratory or field duplicate sample, the, U.S. EPA (2006) permits a DQO up to 2 x RDL as the primary acceptance limit. The U.S. EPA (2006) considers an ABD between 2 x RDL and 4 x RDL to be acceptable for assessment purposes, but stipulates that if either of the original sample or duplicate sample results that produced an ABD in this range are to be used for assessment purposes, that they be flagged as estimated values. U.S. EPA (2006) recommends the rejection of soil samples when the ABD is ≥4 x RDL.

Outcomes of the data quality assurance evaluation pertaining to laboratory duplicates and field duplicates are described in the following sections. Detailed RPD and ABD results are presented in Attachment E-1.

E-2.4.2 Laboratory Duplicate Results

For all possible parameter comparisons between original soil samples and their corresponding laboratory duplicates (*i.e.,* 159 parameter comparisons across all soil data could be made), the RPD and ABD DQOs (primary acceptance limits) were met.

It is therefore considered that soil data quality is acceptable with respect to laboratory duplicates.

E-2.4.3 Field Duplicate Results

For all possible parameter comparisons between original soil samples and their corresponding field duplicates (*i.e.,* 287 parameter comparisons across all data could be made), the RPD and ABD DQOs (primary acceptance limits) were largely met.

Table E-2 summarizes the number of instances (by parameter) wherein the RPD or ABD DQOs were not met. Shaded cells in Table E-2 indicate whether or not a given parameter comparison failed to meet rejection limits for RPD or ABD.

Table E-2 Number of Instances (By Parameter) in Comparisons between Original Soil Samples and Soil Field Duplicate Samples where the DQO Was Not Met (RPD of ≥35% or ABD ≥2 times the RDL)

Parameter – Sample(s)	# of instances RPD DQO not met	#of instances ABD DQO not met
Available Barium (Ba) – S46A and Dup; S27A and Dup	2	0
Available Cadmium (Cd) – S46A and Dup	1	0
Available Copper (Cu) – S46A and Dup	1	0
Available Lead (Pb) – S46A and Dup; S3A and Dup	2	0
Available Zinc (Zn) – S46A and Dup; S27A and Dup	2	0
Available Arsenic (As) – S3A and Dup; S27A and Dup	2	0
Available Chromium (Cr) – S3A and Dup	1	0
Available Vanadium (V) – S3A and Dup; S27A and Dup; S24A and Dup	3	1
Available Iron (Fe) – S27A and Dup; S24A and Dup	2	0
Available Manganese (Mn) – S27A and Dup; S24A and Dup	2	0
Available Nickel (Ni) – S27A and Dup	1	0
Available Lead (Pb) – BS-T4-1 and Dup	1	0
Available Lithium (Li) – BS-T4-1 and Dup	1	0

Notes:
RPD=relative per cent difference; ABD=absolute difference; DQO=data quality objective.
Shaded cell indicates that rejection criteria were exceeded (either ≥120% RPD or ≥4*RDL for ABD).
Parameters that met the RPD or ABD DQOs in all comparisons between original samples and field duplicate samples are not included in this table.

Of the 287 possible parameter comparisons, Table E-2 shows that there were very few instances where the RPD and/or ABD DQOs were not met (22/287 or 7.7% total RPD and ABD DQO failures). For all parameters where these DQOs were not met, concentrations should be flagged as estimates if they are to be used for assessment purposes, unless rejection limits were exceeded, in which case the parameter concentrations in the affected samples should be considered for rejection. As shown in Table E-2, rejection limits were not exceeded for any of the possible comparisons.

Overall, it is considered that soil data quality is acceptable with respect to field duplicates. It is important to recognize that element concentrations and other parameters in a heterogeneous matrix such as soil can often be variable, and hence, some differences between original samples and field duplicates are expected, typically more so than between original samples and laboratory duplicates.

E-3.0 SECONDARY LABORATORY (RPC) INTERNAL QA/QC RESULTS

As previously mentioned, approximately 10% of soil samples analyzed by the primary laboratory (Maxxam) were submitted to a secondary laboratory (*i.e.*, RPC Laboratories in Fredericton, NB) for analysis as inter-laboratory duplicates (N=14). These 14 interlab samples underwent RPC internal QA/QC as well, which included three laboratory duplicate samples, QA/QC blanks (which are analogous to method blanks), and analysis of certified reference materials (CRM).

E-3.1 QA/QC Blanks

As mentioned previously, the acceptance criteria for any analytical laboratory with respect to blanks is a <RDL result. Three QA/QC blank samples were analyzed by RPC. With the exceptions of tin (all three blank samples), and aluminum (one blank sample), all parameters were below their respective RDLs in the blanks. For tin and aluminum, the measured concentrations in the blanks were only marginally above the RDL for these parameters. Thus, the measured concentration of these two metals in blank samples are considered to have a negligible impact on data quality and likely reflects low level laboratory contamination.

E-3.2 Certified Reference Materials (CRMs)

As previously stated with respect to the CRMs analyzed by Maxxam, the typical acceptance criteria for an analytical laboratory is a result within either the 95% confidence interval, or range, for the specific certified reference material (as provided in the certificate of analysis for a given CRM). For some CRM, certain parameters may not have certified values available, but in such cases, the CRM certificates typically provide values that were obtained from available laboratory performance tests, which can be used as indicators of quality control. For some CRM, these non-certified values are called ‘reference values’. They are generally used in the same manner as certified values, in that they are considered the best estimate of the true value, but have more associated uncertainties, and may be based on results from a single analytical method (certified values are usually based on the results from two or more analytical methods).

In the July-August 2009 soil sampling and analytical program, NIST 2709a and SS-2 were the CRMs analyzed by RPC. The certificates of analysis for these CRMs are provided in Attachment E-2.

Tables E-3 and E-4 provide the results of RPC’s analysis of the CRM samples in comparison with the certified and/or reference values for these CRM, as reported in their respective certificates of analysis.

Table E-3 RPC Certified Reference Material Analytical Results and Comparisons; mg/kg

	Certified Reference Material Values				RPC Sample IDs and Analyses of SS-2 and NIST 2709a Samples					
Elements	**SS-2[a]**		**NIST 2709a[b]**		**SS-2A**	**SS-2B**	**SS-2C**	**NIST 2709aA**	**NIST 2709aB**	**NIST 2709aC**
Aluminum	12114	14416	13000	17000	15300	15300	15600	24800	23800	25700
Antimony	0.8[c]		1.2	1.5	0.3	0.4	0.4	< 0.1	< 0.1	< 0.1
Arsenic	65	85	6.4	10	84	86	86	8	8	9
Barium	202	228	350	400	274	266	275	448	424	447
Beryllium	0.70[c]		0.50	0.72	0.8	0.8	0.9	0.7	0.7	0.8
Bismuth	NV		NV		< 1	< 1	< 1	< 1	< 1	< 1
Boron	12[c]		NV		14	14	14	38	36	39
Cadmium	2[c]		0.33	0.66	1.94	1.92	1.90	0.35	0.37	0.36
Chromium	30	38	46	67	43	44	44	74	70	74
Cobalt	11	13	8.2	13.0	12.7	12.6	12.7	11.4	11.0	11.4
Copper	182	200	24	28	196	192	192	29	28	29
Iron	19597	22495	22000	26000	24800	24700	24700	28300	27400	28600
Lead	116	136	8.1	11	138	142	138	11.4	10.8	11.3
Lithium	12	16	NV		16.6	16.3	16.6	35.9	34.7	36.2
Manganese	433	481	380	450	542	539	538	465	451	467
Molybdenum	4[c]		NV		3.0	2.7	2.9	0.6	0.6	0.6
Nickel	50	58	59	71	58	59	58	73	70	73
Rubidium	NV		NV		29.8	29.8	30.4	34.0	32.5	34.7
Selenium	0.8[c]		0.69	1.90	< 1	< 1	< 1	< 1	< 1	1
Silver	1.30[c]		0.14	4.10	0.4	0.4	0.4	< 0.1	< 0.1	< 0.1
Strontium	202	226	NV		245	248	258	111	106	112
Thallium	0.3[c]		0.74	1.60	0.4	0.4	0.4	0.2	0.2	0.2
Tin	NV		NV		< 1	< 1	< 1	< 1	< 1	< 1

Table E-3 RPC Certified Reference Material Analytical Results and Comparisons; mg/kg

Uranium	1.3[c]		NV		1.2	1.2	1.2	1.7	1.7	1.8
Vanadium	31	37	43	71	45	44	44	69	66	71
Zinc	444	490	69	87	510	493	495	90	86	89

Notes:

'NV' indicates no CRM value is available for this parameter; '<' indicates concentration is less than the laboratory RDL.

Shading indicates a concentration outside of the CRM range or confidence interval.

a Numbers in cells are the lower to upper 95% confidence intervals of the EPA 3050A Digestion Values unless otherwise noted. SS-2 documentation notes that confidence intervals should be used for routine quality control.

b Range (Min-Max). Baseline Trace Element Concentrations. Leachable Concentrations Determined Using EPA Methods 200.7 and 3050B. Table A1.

c Consensus information value for SS-2, but not a certified value.

Based on the comparisons presented in Table E-3, it is evident that there were numerous instances where the RPC-obtained parameter concentrations in the SS-2 and NIST 2709a CRM samples fell outside the 95% confidence interval or concentration ranges that are stipulated for these CRMs in their certificates of analysis.

With respect to SS-2, there were relatively few parameters where the RPC-obtained concentrations fell within the 95% confidence intervals for this CRM (*i.e.*, lithium and arsenic were within their respective confidence intervals in 1/3 samples; nickel was within its confidence interval in 2/3 CRM samples, cadmium, cobalt and copper were within their respective confidence intervals in all 3 samples). Three parameters lack confidence intervals or other values for the SS-2 CRM (*i.e.*, bismuth, rubidium, and tin). Thus, it is not possible to comment on laboratory performance for these parameters. For the SS-2 CRM, there are nine parameters that have only a single consensus value rather than a confidence interval (and these consensus values are not "certified", but are provided in the SS-2 certificate of analysis for information purposes). These parameters are: antimony, beryllium, boron, cadmium, molybdenum, selenium, silver, thallium, and uranium. For these parameters, none of the RPC-obtained analytical results for SS-2 equaled these values, however, this is not unexpected, as all soil samples (even CRMs) have some degree of variability in element concentrations such that falling within a specified range or confidence interval is a far more practical measure of laboratory performance, rather than achieving a single consensus value. Further perspective on these nine parameters in the SS-2 CRM are provided in Table E-4. In this table, per cent recovery was calculated for each element that only has a single consensus value, by dividing the RPC-obtained analytical result by the consensus value. A per cent recovery QC limit of 75% to 125% was considered reasonable, as this is the range routinely used by Maxxam for QC standards, spiked blanks and matrix spikes.

With respect to NIST 2709a, laboratory performance was slightly better than it was for the SS-2 CRM, but there were also relatively few parameters where the RPC-obtained concentrations fell within the stipulated range for this CRM (*i.e.*, arsenic, cadmium, cobalt and vanadium were within their respective ranges in 3/3 CRM samples; beryllium was within its range in 2/3 samples; copper, lead, nickel and zinc were within their respective ranges in 1/3 samples). Selenium appeared to fall within its range in 2/3 samples (it was within its range in one CRM sample), but this cannot be determined with certainty as the RDL in the RPC analyses was 1.0 mg/kg, and the range for selenium in NIST 2709a is 0.69 to 1.9 mg/kg. Eight parameters lack ranges or other values for the NIST 2709a CRM (*i.e.*, bismuth, boron, lithium, molybdenum, rubidium, strontium, tin, and uranium). Thus, it is not possible to comment on laboratory performance for these parameters.

Table E- 4 Comparisons of SS-2 CRM Consensus Values to RPC-Obtained Results on SS-2 Samples (Expressed as Per Cent Recovery)

Metals	SS-2 Consensus Value[a]	RPC SS-2A	Per cent Recovery	RPC SS-2B	Per cent Recovery	RPC SS-2C	Per cent Recovery
Antimony	0.8	0.3	37.5%	0.4	50%	0.4	50%
Beryllium	0.7	0.8	114%	0.8	114%	0.9	129%
Boron	12	14	117%	14	117%	14	117%
Cadmium	2	1.94	97%	1.92	96%	1.90	95%
Molybdenum	4	3.0	75%	2.7	67.5%	2.9	72.5%
Selenium	0.8	<1	nc	<1	nc	<1	nc
Silver	1.3	0.4	30.8%	0.4	30.8%	0.4	30.8%
Thallium	0.3	0.4	133%	0.4	133%	0.4	133%
Uranium	1.3	1.2	92.3%	1.2	92.3%	1.2	92.3%

Notes:

nc= not calculated as RPC-measured concentration was <RDL.

Shading indicates per cent recovery is outside of the QC limit (75%-125%).

[a] Consensus values are not “certified”, but are provided in the SS-2 certificate of analysis for information purposes.

As shown in Table E-4, per cent recoveries for antimony, silver, and thallium were outside the QC limits in all three SS-2 samples analyzed by RPC. Molybdenum was outside the QC limits in 2 samples, while beryllium was outside the QC limits in 1 sample. Per cent recoveries were within QC limits for beryllium (2 samples), molybdenum (1 sample), and boron, cadmium and uranium (all three samples).

While a large number of parameters in the SS-2 and NIST 2709a CRM samples that were analyzed by RPC did not fall within the stipulated confidence intervals or ranges for these CRMs, most excursions outside these intervals or ranges were marginal. Although, there were some parameters in both the SS-2 and NIST 2709a CRM samples analyzed by RPC for which the obtained concentrations were outside their stipulated confidence intervals or ranges by a considerable degree (*e.g.*, manganese, silver, vanadium in SS-2 samples; aluminum, antimony, silver and thallium in NIST 2709a samples). For the parameters in SS-2 and NIST 2709a that were outside the stipulated confidence intervals or ranges for these CRMs, the RPC-obtained results were mostly (but not always) higher than the upper confidence interval or upper bound of the range (Table E-3, and E-4).

While marginal excursions outside of stipulated confidence intervals or ranges for a CRM are not generally a cause for concern with respect to data quality, the fact that some excursions were not marginal, and the large number of parameters in these CRMs that did not fall within their stipulated intervals or ranges in the RPC-analyzed samples is notable. Thus, RPC’s performance with the SS-2 and NIST 2709a CRMs is suggestive of possible data quality issues related to analyte recovery, potential laboratory contamination and overall ability to achieve accurate and precise chemical parameter measurements. However, with respect to NIST 2709a, there are some indications that the published values for leachable metals may not be entirely accurate for some parameters (R. Kean, RPC, Personal communication). It was also noted by RPC that for NIST 2709a and other CRMs, relatively low recoveries for antimony and silver are typical, as these elements are not generally well recovered using the EPA 3050B digest and are somewhat susceptible to interference from chloride ion concentrations.

RPC's performance on these CRMs, relative to Maxxam's performance on CRM results (which involved different CRMs) is considered further in Section E-4.0, which addresses inter-laboratory duplicates.

E-3.3 Reportable Detection Limits (RDLs)

Review of the RDLs that were achieved in the soil samples analyzed by RPC (N=14) indicates that typical and acceptable RDLs were achieved for all elements.

Comparison of the RPC to the Maxxam typical RDLs reveals some substantial differences across the parameters measured in soil. Table E-5 presents the typical RDLs that Maxxam and RPC achieve for elements in soil. However, it is not uncommon for different labs to vary with respect to the RDLs they can typically achieve. Although RPC is able to achieve lower RDLs than Maxxam for all elements, there were no major data quality issues identified with Maxxam's RDL performance (See Section E-2.2). As such, the fact that these two labs have different sets of typical RDLs does not have any major impact on soil data quality.

Table E-5 Typical RDLs for Soil Analyses - Maxxam Versus RPC

Parameter	Maxxam RDLs	RPC RDLs
Aluminum	10[a]	1
Antimony	2	0.1
Arsenic	2	1
Barium	5	1
Beryllium	2	0.1
Bismuth	2	1
Boron	5	1
Cadmium	0.3	0.01
Chromium	2	1
Cobalt	1	0.1
Copper	2	1
Iron	50[a]	20
Lead	0.5	0.1
Lithium	2	0.1
Manganese	2	1
Molybdenum	2	0.1
Nickel	2	1
Rubidium	2	0.1
Selenium	2	1
Silver	0.5	0.1
Strontium	5[a]	1
Thallium	0.1	0.1
Tin	2	1
Uranium	0.1	0.1
Vanadium	2	1
Zinc	5	1

Notes:

a. Aluminum, Iron, and Strontium had elevated RDLs for some samples (see Section E-2.2); only typical RDLs are presented in this table.

E-3.4 Other Data Quality Items or Issues

No data quality items or issues additional to those addressed elsewhere in this Appendix were identified.

E-3.5 RPC Duplicates

As RPC's role in the soil data quality evaluation was to provide inter-laboratory duplicate analytical results, no field duplicate samples were submitted. Only laboratory duplicate samples were analyzed by RPC, as part of their internal QA/QC program.

E-3.5.1 Laboratory Duplicate Results

The same DQOs and calculations for laboratory duplicates that are described in Section E-2.4.1 were applied to the RPC laboratory duplicate results. For all possible parameter comparisons between original soil samples and their corresponding laboratory duplicates (*i.e.,* 78 parameter comparisons across all data could be made), the RPD and ABD DQOs (primary acceptance limits) were met. Thus, it is considered that soil data quality is acceptable with respect to internal laboratory duplicates. Detailed RPD and ABD results are presented in Attachment E-1.

E-4.0 INTER-LABORATORY DUPLICATES

As part of the soil data quality evaluation, a random subset of samples (N=14) from the July-August 2009 sampling event were split, and the aliquots were sent to RPC (the secondary laboratory) to permit evaluation of inter-laboratory duplicate analytical results. Prior to sample shipment to RPC, all samples were dried and sieved at Maxxam, to remove these sample preparation steps as potential variables. Thus, RPC only performed acid digestions and ICP-MS analyses on these 14 samples.

The U.S. EPA does not provide specific guidance on inter-laboratory duplicate DQOs for inorganics in soil (nor does any identified regulatory agency in Canada). This lack of guidance may reflect the common finding that inter-laboratory duplicate results can be much more variable than intra-laboratory duplicate results due to potential differences in drying, sieving, acid digestion, overall sample handling, and slight calibration differences in analytical instrumentation. Nonetheless, inter-laboratory duplicates provide a means of evaluating variability and precision between laboratories that use either the same or very similar sample preparation and analytical methods. For consistency, the same DQOs used for laboratory and field duplicates were applied to the inter-laboratory duplicate results (See Section E-2.4.1). It is recognized however, that these DQOs are probably overly stringent for inter-laboratory duplicate analytical results.

Table E-6 summarizes the number of instances (by parameter) wherein RPD or ABD DQOs were not met for the inter-laboratory duplicate samples. Shaded cells in Table E-6 indicate whether or not a given parameter comparison failed to meet rejection limits for RPD or ABD. Detailed RPD and ABD results are presented in Attachment E-1.

Table E-6 Number of Instances (By Parameter) in Comparisons between Original Soil Samples and Inter-laboratory Duplicate Samples where the DQO Was Not Met (RPD of ≥35% or ABD ≥2 times the RDL)

Parameter – Sample(s)	**# of instances RPD DQO not met**	**#of instances ABD DQO not met**
Available Aluminum (Al) – R3A and Dup; S19A and Dup; S20A and Dup; S33A and Dup; S48A and Dup	5	0
Available Cadmium (Cd) – R3A and Dup; S18A and Dup; S20A and Dup	0	3
Available Lithium (Li) – R3A and Dup; R4A and Dup; S2A and Dup; S18A and Dup; S19A and Dup; S20A and Dup; S30A and Dup; S33A and Dup; S38A and Dup; S48A and Dup; S51A and Dup; S61A and Dup	12	3
Available Manganese (Mn) – R3A and Dup; S2A and Dup; S20A and Dup	3	0
Available Rubidium (Rb) – R3A and Dup; R4A and Dup; R19A and Dup; S2A and Dup; S18A and Dup; S19A and Dup; S30A and Dup; S32A and Dup; S33A and Dup; S38A and Dup; S48A and Dup; S51A and Dup; S61A and Dup	13	10
Available Strontium (Sr) – R3A and Dup; S18A and Dup; S38A and Dup; S48A and Dup	1	4[a]
Available Nickel (Ni) – S2A and Dup; S19A and Dup; S20A and Dup; S30A and Dup; S33A and Dup	5	0
Available Uranium (U) – S2A and Dup; S19A and Dup	2	0
Available Thallium (Tl) – S18A and Dup; S38A and Dup; S48A and Dup	3	1
Available Antimony (Sb) – S19A and Dup; S30A and Dup; S32A and Dup; S32A and Dup; S33A and Dup; S61A and Dup	4[b]	5
Available Silver (Ag) – S19A and Dup; S30A and Dup; S32A and Dup; S48A and Dup; S51A and Dup; S61A and Dup	2	6[c]
Available Arsenic (As) – S20A and Dup	1	1
Available Barium (Ba) – S20A and Dup	0	1
Available Chromium (Cr) – S20A and Dup; S30A and Dup; S48A and Dup	3	0
Available Cobalt (Co) – S20A and Dup	0	2[d]
Available Copper (Cu) – S20A and Dup	1	1
Available Iron (Fe) – S20A and Dup	1	0
Available Vanadium (V) – S20A and Dup	1	0
Available Molybdenum (Mo) – S32A and Dup; S51A and Dup	1	2[e]
Available Tin (Sn) – S32A and Dup	1	0

Notes:
RPD=relative per cent difference; ABD=absolute difference; DQO=data quality objective.
Shaded cell indicates that rejection criteria were exceeded (either ≥120% RPD or ≥4*RDL for ABD).
Parameters that met the RPD or ABD DQOs in all comparisons between original samples and field duplicate samples are not included in this table.
a Strontium exceeded the ABD rejection limit for R3A and S48A only.
b Antimony exceeded the RPD rejection limit for S19A, S32A, S48A only.
c Silver exceeded the ABD rejection limit for S19A, S32A, S61A only.
d Cobalt exceeded the ABD rejection limit for S20A only.
e Molybdenum exceeded the ABD rejection limit for S32A only.

Of the 265 possible parameter comparisons, Table E-6 shows that there were a number of instances where the RPD and/or ABD DQOs were not met (*i.e.*, 98/265 or 37% total RPD and ABD DQO failures). For all parameters where these DQOs were not met, concentrations should be flagged as estimates if they are to be used for assessment purposes, unless rejection limits were exceeded, in which case the parameter concentrations in the affected samples should be considered for rejection. Inter-laboratory duplicate performance was particularly poor for lithium and rubidium. As shown in Table E-6, rejection limits were exceeded in 33 parameter comparisons (12%). Of these rejection limit failures, 29 affected ABD comparisons, while only 4 affected RPD comparisons. It is possible that the higher number of ABD rejection limit failures is related to lower RDLs being achieved by RPC than by Maxxam (See Section E-3.3).

If the DQOs used to evaluate inter-laboratory duplicates are strictly followed, then a number of samples would be flagged for rejection. While the results of the inter-laboratory duplicate comparisons are suggestive of potential data quality issues, it is important to recognize that the DQOs used are probably overly stringent, as they are the same DQOs used to evaluate intra-laboratory performance with respect to both laboratory and field duplicates. Less variability is expected within a single laboratory (intra-lab) than between two or more laboratories (inter-lab). Furthermore, the majority of parameter comparisons between the original Maxxam-analyzed samples and their inter-laboratory duplicates did meet their DQOs (*i.e.*, 63% of comparisons met the RPD or ABD DQO). Considering these points, and given the performance of both Maxxam and RPC on the other QA/QC measures (such as the CRM testing), there is believed to be no valid reason to reject any of the July-August 2009 soil sample analytical results for any measured parameter.

A key question when considering inter-laboratory duplicate results is whether or not there is an apparent need to adjust primary laboratory data. Among the key considerations when addressing this question are:

- Whether or not the results from the primary laboratory are consistently higher (or lower) than the results from the secondary laboratory.
- Performance of both the primary and secondary laboratory on CRM analyses.
- Whether or not the parameters with the greatest differences in the inter-laboratory duplicates are COPCs, or parameters of lesser interest.

For the majority of parameters where RPD and/or ABD could be calculated, the analytical results from RPC were higher than the results from Maxxam for aliquots of the same sample (the only samples where the Maxxam results had a slightly greater number of maxima than the RPC results were S30A and S32A). This suggests that RPC's analytical results may be biased high. This is supported by the results of RPC's CRM analyses. As mentioned in Section E-3.2, for the parameters in the SS-2 and NIST 2709a CRMs that were outside the stipulated confidence intervals or ranges, the RPC-obtained results were mostly (but not always) higher than the upper confidence interval or upper bound of the range (See Table E-3 and E-4).

The discussions of Maxxam and RPC performance on CRMs (Sections E-2.1.5 and E-3.2, respectively) demonstrate that Maxxam had substantially fewer issues with respect to achieving the stipulated values for the CRMs that were tested.

The COPCs for the ecological risk assessment (See Appendix G, and Section 5.3 of the main report) are antimony, arsenic, cadmium, lead, thallium and zinc. There were no DQO failures among the inter-laboratory duplicate samples with respect to lead or zinc, but there were a few instances of DQO failures for the other COPCs (Table E-6).

Overall, it is not unexpected to find a higher degree of DQO failures for inter-laboratory duplicates relative to intra-laboratory duplicates (which includes field and laboratory duplicates). This reflects the fact that there are more potential sources of variability when results are compared between two different laboratories. Although sieving and drying was conducted by Maxxam prior to shipping sample aliquots to RPC, some sources of variability remain (such as slight differences in acid digestion procedures, different laboratory technicians, different analytical instruments and potential calibration differences).

As indicated in the preceding sections, both the primary (Maxxam) and secondary (RPC) laboratories performed adequately with respect to internal QA/QC measures. However, Maxxam’s performance with CRMs was superior to that of RPC. As such, there is no valid reason to consider adjusting the Maxxam soil chemistry data based on the outcomes of the inter-laboratory duplicate evaluation. Thus, all Maxxam soil analytical results were considered acceptable for use in the ERA without adjustment.

E-5.0 CONCLUSIONS

The outcomes of the soil data QA review are summarized as follows, along with suggested actions (if necessary) for situations where the review identified data quality issues that could affect the use of some data for assessment purposes.

- Maxxam internal laboratory QA/QC procedures for soil samples (QC standards, spiked blanks, method blanks and matrix spikes) produced acceptable outcomes, and none of the instances where QC limits were not met are expected to significantly impact data quality.
- RPC internal laboratory QA/QC procedures (QA/QC blanks) produced acceptable outcomes in that parameter concentrations were less than RDLs with the exceptions of tin (three blank samples), and aluminum (one blank sample). For tin and aluminum, the measured concentrations in the blanks were only marginally above the RDL for these parameters. Thus, the measured concentrations of these two metals in blank samples are considered to have a negligible impact on data quality, and likely reflects low level laboratory contamination.
- There was reasonably good agreement between Maxxam's CRM results and the values stipulated in the CRM certificates of analysis, which suggests no apparent issues with respect to analyte recovery, laboratory contamination and overall performance of the laboratory methods in achieving accurate and precise chemical parameter measurements. As such, soil data quality was considered acceptable for ERA purposes, with respect to CRM recovery by Maxxam.
- RPC's performance with CRMs showed a greater frequency of excursions outside the values stipulated in the CRM certificates of analysis, relative to Maxxam's CRM performance.
- Review of the RDLs that were achieved by Maxxam in the soil analyses indicates that typical and acceptable RDLs were achieved for the majority of parameters in all soil samples. For the samples and parameters affected by elevated RDLs, there were no issues associated with the achieved RDL for a specific parameter in a given sample being higher than soil quality guidelines. In the laboratory certificates of analysis from Maxxam, elevated RDLs are consistently attributed to matrix interference or sample matrix.
- Review of the RDLs that were achieved in the soil samples analyzed by RPC (N=14) indicates that typical and acceptable RDLs were achieved for all elements.
- Comparison of the RPC to the Maxxam typical RDLs reveals some substantial differences across the parameters measured in soil (See Table E-5). However, it is not uncommon for different labs to vary with respect to the RDLs they can typically achieve. Although RPC is able to achieve lower RDLs than Maxxam for all elements, there were no major data quality issues identified with Maxxam's RDL performance. As such, the fact that these two labs have different sets of typical RDLs does not have any major impact on soil data quality.
- For all possible parameter comparisons between original soil samples and their corresponding laboratory duplicates that were analyzed by Maxxam, the RPD and ABD DQOs (primary acceptance limits) were met. Thus, it is considered that soil data quality is acceptable with respect to laboratory duplicates.
- For all possible parameter comparisons between original soil samples and their corresponding laboratory duplicates that were analyzed by RPC, the RPD and ABD

DQOs (primary acceptance limits) were met. Thus, it is considered that soil data quality is acceptable with respect to internal laboratory duplicates.

- For all possible parameter comparisons between original soil samples and their corresponding field duplicates, as analyzed by Maxxam, the RPD and ABD DQOs (primary acceptance limits) were largely met. There were very few instances where the RPD and/or ABD DQOs were not met. For all parameters where these DQOs were not met, concentrations should be flagged as estimates if they are to be used for assessment purposes, unless rejection limits were exceeded, in which case the parameter concentrations in the affected samples should be considered for rejection. Rejection limits were not exceeded for any of the possible comparisons. Overall, it is considered that soil data quality is acceptable with respect to field duplicates.
- The outcome of the evaluation of inter-laboratory duplicates was that all Maxxam (primary laboratory) soil analytical results were considered acceptable for use in the ERA without adjustment.

In general, none of the instances where DQOs for field or inter-laboratory duplicates were not met are surprising. Variability arising from the sub-sampling of non-homogenous matrices such as soil is a common occurrence, and most instances where RPD and/or APD DQOs were not met can be attributed to sample inhomogeneity, and slight variations in sample preparation and analysis in the case of inter-laboratory duplicates.

E-6.0 REFERENCES

NIST. 2010. NIST Standard Reference Materials – Definitions. http://www.nist.gov/srm/definitions.cfm

U.S. EPA. 2006. Validation of Metals for the Contract Laboratory Program (CLP) based on SOW ILMO5.3 (SOP Revision 13). Data Assessment and Contract Compliance Review. Standard Operating Procedure. U.S. EPA Region 2. SOP; HW – 2. Revision 13 Appendix A.1. September, 2006.

U.S. EPA. 2004. USEPA Contract Laboratory Program. National Functional Guidelines for Inorganic Data Review. Final. Office of Superfund Remediation and Technology Innovation (OSRTI), U.S. Environmental Protection Agency. Washington, DC. OSWER 9240.1-45. EPA 540-R-04-004. October, 2004.

ATTACHMENT E-1

RPD / ABD CALCULATIONS

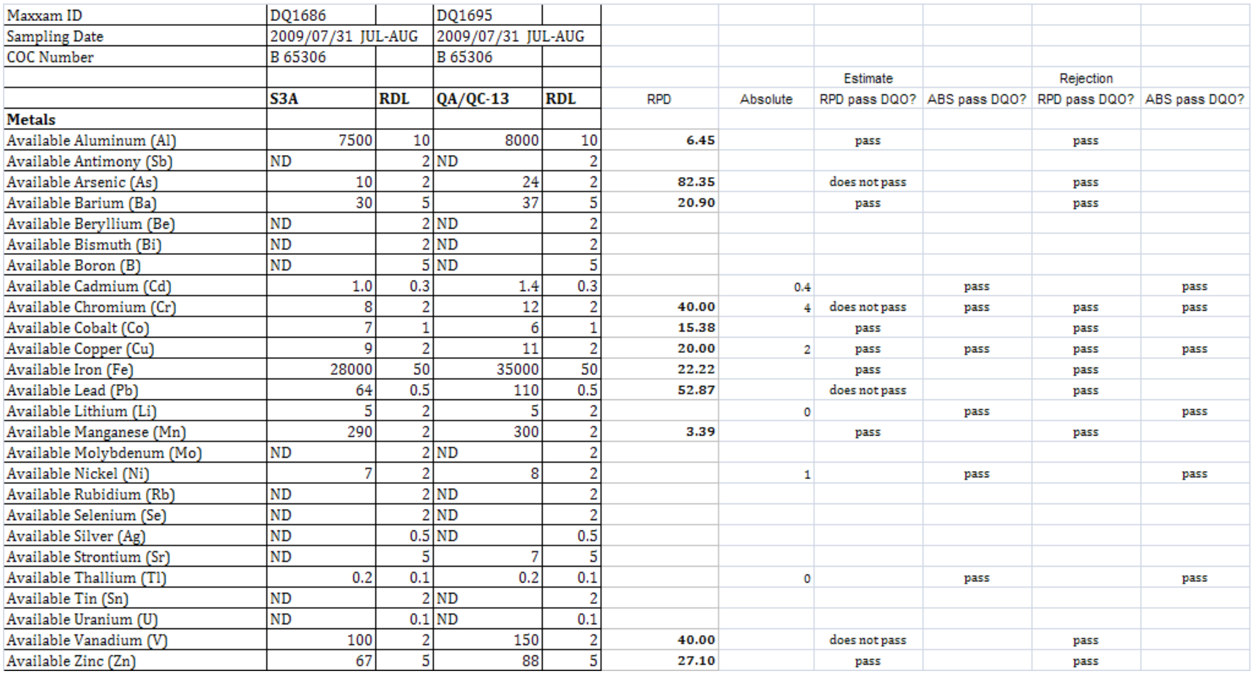
E-1-1.0 PRIME LABORATORY (MAXXAM) RPD / ABD CALCULATIONS

Maxxam ID	DQ2116		DQ2121							
Sampling Date										
COC Number	B 65319		B 65319							
							Estimate		Rejection	
	S53A	**RDL**	**QA/QC-3**	**RDL**	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD pass DQO?	ABS pass DQO?
Metals										
Available Aluminum (Al)	25000	10	28000	10	**11.32**		pass		pass	
Available Antimony (Sb)	2	2	3	2		1		pass		pass
Available Arsenic (As)	41	2	45	2	**9.30**		pass		pass	
Available Barium (Ba)	260	5	300	5	**14.29**		pass		pass	
Available Beryllium (Be)	ND	2	ND	2						
Available Bismuth (Bi)	ND	2	ND	2						
Available Boron (B)	ND	5	ND	5						
Available Cadmium (Cd)	3.6	0.3	3.9	0.3	**8.00**		pass		pass	
Available Chromium (Cr)	35	2	39	2	**10.81**		pass		pass	
Available Cobalt (Co)	13	1	14	1	**7.41**		pass		pass	
Available Copper (Cu)	31	2	33	2	**6.25**		pass		pass	
Available Iron (Fe)	28000	50	31000	50	**10.17**		pass		pass	
Available Lead (Pb)	230	0.5	240	0.5	**4.26**		pass		pass	
Available Lithium (Li)	27	2	30	2	**10.53**		pass		pass	
Available Manganese (Mn)	1900	2	2100	2	**10.00**		pass		pass	
Available Molybdenum (Mo)	ND	2	ND	2						
Available Nickel (Ni)	41	2	43	2	**4.76**		pass		pass	
Available Rubidium (Rb)	14	2	15	2	**6.90**		pass		pass	
Available Selenium (Se)	ND	2	ND	2						
Available Silver (Ag)	0.8	0.5	1.0	0.5		0.2		pass		pass
Available Strontium (Sr)	ND (1)	50	ND (1)	50						
Available Thallium (Tl)	0.8	0.1	0.9	0.1	**11.76**		pass		pass	
Available Tin (Sn)	3	2	5	2		2		pass		pass
Available Uranium (U)	1.5	0.1	1.8	0.1	**18.18**		pass		pass	
Available Vanadium (V)	49	2	53	2	**7.84**		pass		pass	
Available Zinc (Zn)	320	5	340	5	**6.06**		pass		pass	

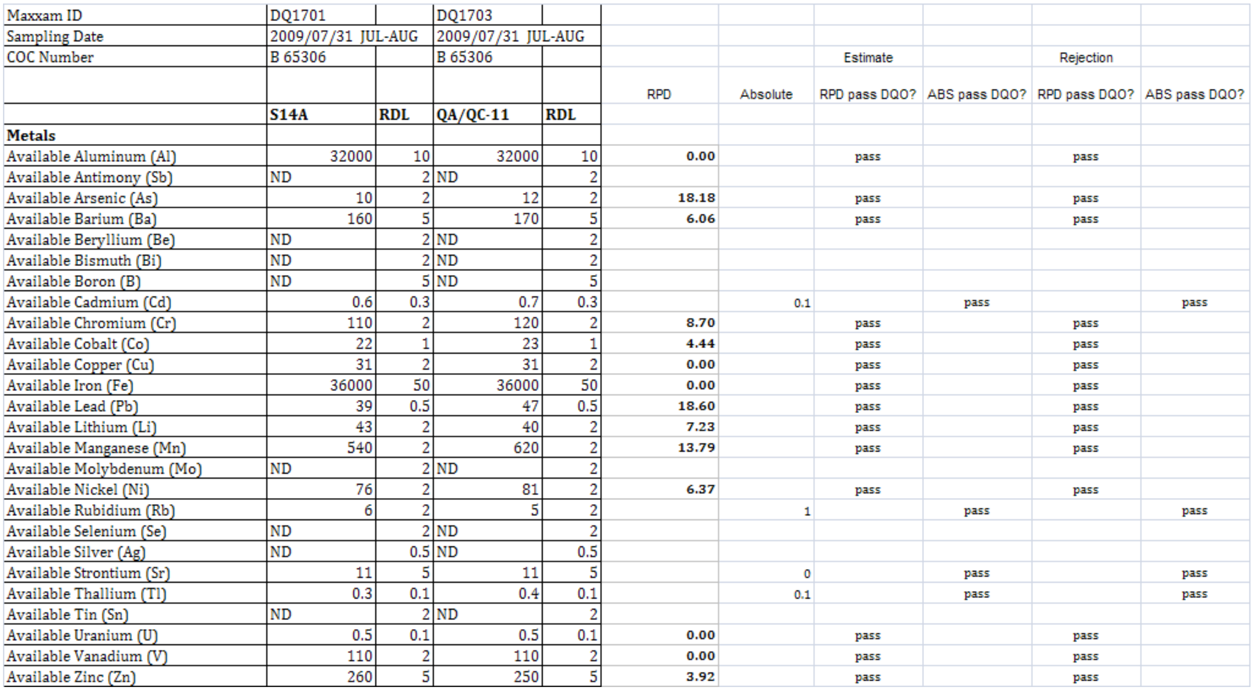
Maxxam ID	DQ2131		DQ2144							
Sampling Date										
COC Number	B 65319		B 65319							
							Estimate		Rejection	
	R1A	**RDL**	**QA/QC-22**	**RDL**	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD pass DQO?	ABS pass DQO?
Metals										
Available Aluminum (Al)	21000	10	20000	10	**4.88**		pass		pass	
Available Antimony (Sb)	ND	2	ND	2						
Available Arsenic (As)	3	2	3	2		0		pass		pass
Available Barium (Ba)	64	5	67	5	**4.58**		pass		pass	
Available Beryllium (Be)	ND	2	ND	2						
Available Bismuth (Bi)	ND	2	ND	2						
Available Boron (B)	ND	5	ND	5						
Available Cadmium (Cd)	ND	0.3	ND	0.3						
Available Chromium (Cr)	23	2	20	2	**13.95**		pass		pass	
Available Cobalt (Co)	11	1	10	1	**9.52**		pass		pass	
Available Copper (Cu)	7	2	7	2		0		pass		pass
Available Iron (Fe)	39000	50	38000	50	**2.60**		pass		pass	
Available Lead (Pb)	15	0.5	14	0.5	**6.90**		pass		pass	
Available Lithium (Li)	13	2	12	2	**8.00**		pass		pass	
Available Manganese (Mn)	500	2	400	2	**22.22**		pass		pass	
Available Molybdenum (Mo)	ND	2	ND	2						
Available Nickel (Ni)	19	2	15	2	**23.53**		pass		pass	
Available Rubidium (Rb)	6	2	6	2		0		pass		pass
Available Selenium (Se)	ND	2	ND	2						
Available Silver (Ag)	ND	0.5	ND	0.5						
Available Strontium (Sr)	9	5	10	5		1		pass		pass
Available Thallium (Tl)	ND	0.1	ND	0.1						
Available Tin (Sn)	ND	2	ND	2						
Available Uranium (U)	0.4	0.1	0.4	0.1		0		pass		pass
Available Vanadium (V)	68	2	70	2	**2.90**		pass		pass	
Available Zinc (Zn)	59	5	57	5	**3.45**		pass		pass	

Maxxam ID	DQ2034		DQ2038							
Sampling Date										
COC Number	B 65315		B 65315							
							Estimate		Rejection	
	S43A	**RDL**	**QA/QC-10**	**RDL**	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD pass DQO?	ABS pass DQO?
Metals										
Available Aluminum (Al)	17000	10	19000	10	**11.11**		pass		pass	
Available Antimony (Sb)	ND	2	ND	2						
Available Arsenic (As)	9	2	10	2	**10.53**	1	pass	pass	pass	pass
Available Barium (Ba)	150	5	120	5	**22.22**		pass		pass	
Available Beryllium (Be)	ND	2	ND	2						
Available Bismuth (Bi)	ND	2	ND	2						
Available Boron (B)	ND	5	ND	5						
Available Cadmium (Cd)	0.4	0.3	0.7	0.3		0.3		pass		pass
Available Chromium (Cr)	29	2	30	2	**3.39**		pass		pass	
Available Cobalt (Co)	13	1	13	1	**0.00**		pass		pass	
Available Copper (Cu)	11	2	15	2	**30.77**		pass		pass	
Available Iron (Fe)	28000	50	30000	50	**6.90**		pass		pass	
Available Lead (Pb)	32	0.5	37	0.5	**14.49**		pass		pass	
Available Lithium (Li)	14	2	15	2	**6.90**		pass		pass	
Available Manganese (Mn)	3500	2	4100	2	**15.79**		pass		pass	
Available Molybdenum (Mo)	ND	2	ND	2						
Available Nickel (Ni)	24	2	28	2	**15.38**		pass		pass	
Available Rubidium (Rb)	12	2	11	2	**8.70**		pass		pass	
Available Selenium (Se)	ND	2	ND	2						
Available Silver (Ag)	ND	0.5	ND	0.5						
Available Strontium (Sr)	8	5	7	5		1		pass		pass
Available Thallium (Tl)	0.2	0.1	0.3	0.1		0.1		pass		pass
Available Tin (Sn)	ND	2	ND	2						
Available Uranium (U)	0.3	0.1	0.4	0.1		0.1		pass		pass
Available Vanadium (V)	47	2	50	2	**6.19**		pass		pass	
Available Zinc (Zn)	82	5	81	5	**1.23**		pass		pass	

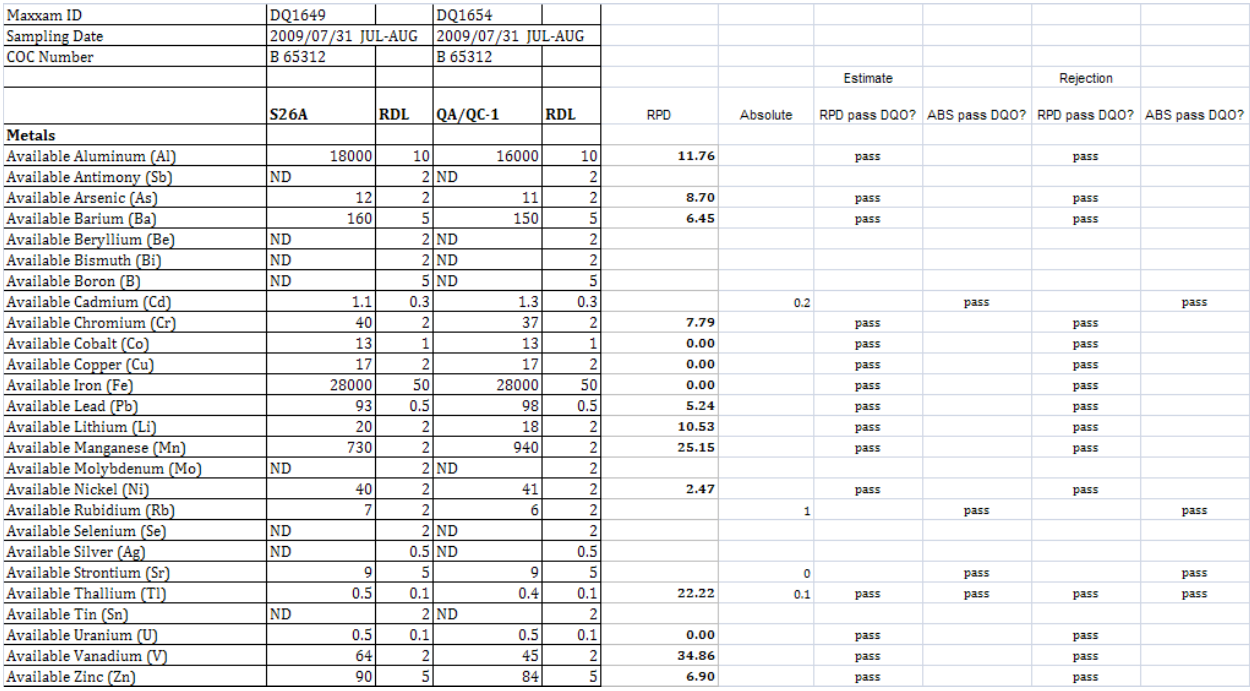
Maxxam ID	DQ2037		DQ2046							
Sampling Date										
COC Number	B 65315		B 65315							
							Estimate		Rejection	
	S46A	**RDL**	**QA/QC-4**	**RDL**	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD pass DQO?	ABS pass DQO?
Metals										
Available Aluminum (Al)	9700	10	10000	10	**3.05**		pass		pass	
Available Antimony (Sb)	ND	2	2	2						
Available Arsenic (As)	8	2	11	2	**31.58**	3	pass	pass	pass	pass
Available Barium (Ba)	67	5	100	5	**39.52**		does not pass		pass	
Available Beryllium (Be)	ND	2	ND	2						
Available Bismuth (Bi)	ND	2	ND	2						
Available Boron (B)	ND	5	ND	5						
Available Cadmium (Cd)	1.5	0.3	2.3	0.3	**42.11**		does not pass		pass	
Available Chromium (Cr)	15	2	15	2	**0.00**		pass		pass	
Available Cobalt (Co)	5	1	5	1	**0.00**		pass		pass	
Available Copper (Cu)	14	2	20	2	**35.29**		does not pass		pass	
Available Iron (Fe)	18000	50	18000	50	**0.00**		pass		pass	
Available Lead (Pb)	150	0.5	220	0.5	**37.84**		does not pass		pass	
Available Lithium (Li)	9	2	10	2	**10.53**	1	pass	pass	pass	pass
Available Manganese (Mn)	270	2	270	2	**0.00**		pass		pass	
Available Molybdenum (Mo)	ND	2	ND	2						
Available Nickel (Ni)	10	2	12	2	**18.18**		pass		pass	
Available Rubidium (Rb)	5	2	8	2		3		pass		pass
Available Selenium (Se)	ND	2	ND	2						
Available Silver (Ag)	ND	0.5	0.8	0.5						
Available Strontium (Sr)	10	5	9	5		1		pass		pass
Available Thallium (Tl)	0.3	0.1	0.4	0.1		0.1		pass		pass
Available Tin (Sn)	ND	2	ND	2						
Available Uranium (U)	0.3	0.1	0.3	0.1		0		pass		pass
Available Vanadium (V)	45	2	49	2	**8.51**		pass		pass	
Available Zinc (Zn)	110	5	170	5	**42.86**		does not pass		pass	



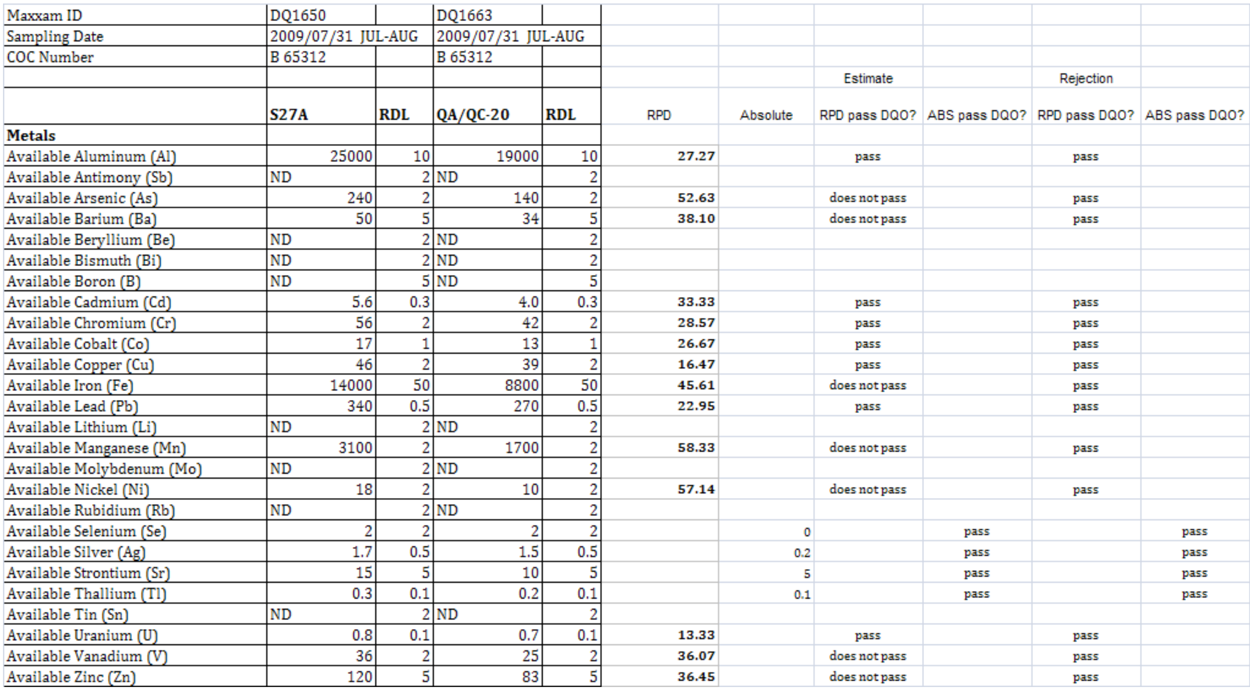
Maxxam ID	DQ1686		DQ1695							
Sampling Date	2009/07/31 JUL-AUG		2009/07/31 JUL-AUG							
COC Number	B 65306		B 65306							
							Estimate		Rejection	
	S3A	**RDL**	**QA/QC-13**	**RDL**	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD pass DQO?	ABS pass DQO?
Metals										
Available Aluminum (Al)	7500	10	8000	10	6.45		pass		pass	
Available Antimony (Sb)	ND	2	ND	2						
Available Arsenic (As)	10	2	24	2	82.35		does not pass		pass	
Available Barium (Ba)	30	5	37	5	20.90		pass		pass	
Available Beryllium (Be)	ND	2	ND	2						
Available Bismuth (Bi)	ND	2	ND	2						
Available Boron (B)	ND	5	ND	5						
Available Cadmium (Cd)	1.0	0.3	1.4	0.3		0.4		pass		pass
Available Chromium (Cr)	8	2	12	2	40.00	4	does not pass	pass	pass	pass
Available Cobalt (Co)	7	1	6	1	15.38		pass		pass	
Available Copper (Cu)	9	2	11	2	20.00	2	pass	pass	pass	pass
Available Iron (Fe)	28000	50	35000	50	22.22		pass		pass	
Available Lead (Pb)	64	0.5	110	0.5	52.87		does not pass		pass	
Available Lithium (Li)	5	2	5	2		0		pass		pass
Available Manganese (Mn)	290	2	300	2	3.39		pass		pass	
Available Molybdenum (Mo)	ND	2	ND	2						
Available Nickel (Ni)	7	2	8	2		1		pass		pass
Available Rubidium (Rb)	ND	2	ND	2						
Available Selenium (Se)	ND	2	ND	2						
Available Silver (Ag)	ND	0.5	ND	0.5						
Available Strontium (Sr)	ND	5	7	5						
Available Thallium (Tl)	0.2	0.1	0.2	0.1		0		pass		pass
Available Tin (Sn)	ND	2	ND	2						
Available Uranium (U)	ND	0.1	ND	0.1						
Available Vanadium (V)	100	2	150	2	40.00		does not pass		pass	
Available Zinc (Zn)	67	5	88	5	27.10		pass		pass	



Maxxam ID	DQ1701		DQ1703							
Sampling Date	2009/07/31 JUL-AUG		2009/07/31 JUL-AUG							
COC Number	B 65306		B 65306				Estimate		Rejection	
					RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD pass DQO?	ABS pass DQO?
	S14A	**RDL**	**QA/QC-11**	**RDL**						
Metals										
Available Aluminum (Al)	32000	10	32000	10	0.00		pass		pass	
Available Antimony (Sb)	ND	2	ND	2						
Available Arsenic (As)	10	2	12	2	18.18		pass		pass	
Available Barium (Ba)	160	5	170	5	6.06		pass		pass	
Available Beryllium (Be)	ND	2	ND	2						
Available Bismuth (Bi)	ND	2	ND	2						
Available Boron (B)	ND	5	ND	5						
Available Cadmium (Cd)	0.6	0.3	0.7	0.3		0.1		pass		pass
Available Chromium (Cr)	110	2	120	2	8.70		pass		pass	
Available Cobalt (Co)	22	1	23	1	4.44		pass		pass	
Available Copper (Cu)	31	2	31	2	0.00		pass		pass	
Available Iron (Fe)	36000	50	36000	50	0.00		pass		pass	
Available Lead (Pb)	39	0.5	47	0.5	18.60		pass		pass	
Available Lithium (Li)	43	2	40	2	7.23		pass		pass	
Available Manganese (Mn)	540	2	620	2	13.79		pass		pass	
Available Molybdenum (Mo)	ND	2	ND	2						
Available Nickel (Ni)	76	2	81	2	6.37		pass		pass	
Available Rubidium (Rb)	6	2	5	2		1		pass		pass
Available Selenium (Se)	ND	2	ND	2						
Available Silver (Ag)	ND	0.5	ND	0.5						
Available Strontium (Sr)	11	5	11	5		0		pass		pass
Available Thallium (Tl)	0.3	0.1	0.4	0.1		0.1		pass		pass
Available Tin (Sn)	ND	2	ND	2						
Available Uranium (U)	0.5	0.1	0.5	0.1	0.00		pass		pass	
Available Vanadium (V)	110	2	110	2	0.00		pass		pass	
Available Zinc (Zn)	260	5	250	5	3.92		pass		pass	



Maxxam ID	DQ1649		DQ1654							
Sampling Date	2009/07/31 JUL-AUG		2009/07/31 JUL-AUG							
COC Number	B 65312		B 65312							
							Estimate		Rejection	
	S26A	**RDL**	**QA/QC-1**	**RDL**	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD pass DQO?	ABS pass DQO?
Metals										
Available Aluminum (Al)	18000	10	16000	10	**11.76**		pass		pass	
Available Antimony (Sb)	ND	2	ND	2						
Available Arsenic (As)	12	2	11	2	**8.70**		pass		pass	
Available Barium (Ba)	160	5	150	5	**6.45**		pass		pass	
Available Beryllium (Be)	ND	2	ND	2						
Available Bismuth (Bi)	ND	2	ND	2						
Available Boron (B)	ND	5	ND	5						
Available Cadmium (Cd)	1.1	0.3	1.3	0.3		0.2		pass		pass
Available Chromium (Cr)	40	2	37	2	**7.79**		pass		pass	
Available Cobalt (Co)	13	1	13	1	**0.00**		pass		pass	
Available Copper (Cu)	17	2	17	2	**0.00**		pass		pass	
Available Iron (Fe)	28000	50	28000	50	**0.00**		pass		pass	
Available Lead (Pb)	93	0.5	98	0.5	**5.24**		pass		pass	
Available Lithium (Li)	20	2	18	2	**10.53**		pass		pass	
Available Manganese (Mn)	730	2	940	2	**25.15**		pass		pass	
Available Molybdenum (Mo)	ND	2	ND	2						
Available Nickel (Ni)	40	2	41	2	**2.47**		pass		pass	
Available Rubidium (Rb)	7	2	6	2		1		pass		pass
Available Selenium (Se)	ND	2	ND	2						
Available Silver (Ag)	ND	0.5	ND	0.5						
Available Strontium (Sr)	9	5	9	5		0		pass		pass
Available Thallium (Tl)	0.5	0.1	0.4	0.1	**22.22**	0.1	pass	pass	pass	pass
Available Tin (Sn)	ND	2	ND	2						
Available Uranium (U)	0.5	0.1	0.5	0.1	**0.00**		pass		pass	
Available Vanadium (V)	64	2	45	2	**34.86**		pass		pass	
Available Zinc (Zn)	90	5	84	5	**6.90**		pass		pass	



Maxxam ID	DQ1650		DQ1663							
Sampling Date	2009/07/31 JUL-AUG		2009/07/31 JUL-AUG							
COC Number	B 65312		B 65312							
							Estimate		Rejection	
	S27A	**RDL**	**QA/QC-20**	**RDL**	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD pass DQO?	ABS pass DQO?
Metals										
Available Aluminum (Al)	25000	10	19000	10	**27.27**		pass		pass	
Available Antimony (Sb)	ND	2	ND	2						
Available Arsenic (As)	240	2	140	2	**52.63**		does not pass		pass	
Available Barium (Ba)	50	5	34	5	**38.10**		does not pass		pass	
Available Beryllium (Be)	ND	2	ND	2						
Available Bismuth (Bi)	ND	2	ND	2						
Available Boron (B)	ND	5	ND	5						
Available Cadmium (Cd)	5.6	0.3	4.0	0.3	**33.33**		pass		pass	
Available Chromium (Cr)	56	2	42	2	**28.57**		pass		pass	
Available Cobalt (Co)	17	1	13	1	**26.67**		pass		pass	
Available Copper (Cu)	46	2	39	2	**16.47**		pass		pass	
Available Iron (Fe)	14000	50	8800	50	**45.61**		does not pass		pass	
Available Lead (Pb)	340	0.5	270	0.5	**22.95**		pass		pass	
Available Lithium (Li)	ND	2	ND	2						
Available Manganese (Mn)	3100	2	1700	2	**58.33**		does not pass		pass	
Available Molybdenum (Mo)	ND	2	ND	2						
Available Nickel (Ni)	18	2	10	2	**57.14**		does not pass		pass	
Available Rubidium (Rb)	ND	2	ND	2						
Available Selenium (Se)	2	2	2	2		0		pass		pass
Available Silver (Ag)	1.7	0.5	1.5	0.5		0.2		pass		pass
Available Strontium (Sr)	15	5	10	5		5		pass		pass
Available Thallium (Tl)	0.3	0.1	0.2	0.1		0.1		pass		pass
Available Tin (Sn)	ND	2	ND	2						
Available Uranium (U)	0.8	0.1	0.7	0.1	**13.33**		pass		pass	
Available Vanadium (V)	36	2	25	2	**36.07**		does not pass		pass	
Available Zinc (Zn)	120	5	83	5	**36.45**		does not pass		pass	

Maxxam ID	DQ1570		DQ1584							
Sampling Date	2009/07/31 JUL-AUG		2009/07/31 JUL-AUG							
COC Number	B 65309		B 65309							
							Estimate		Rejection	
	S16A	**RDL**	**QA/QC-30**	**RDL**	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD pass DQO?	ABS pass DQO?
Metals										
Available Aluminum (Al)	18000	10	18000	10	**0.00**		pass		pass	
Available Antimony (Sb)	ND	2	ND	2						
Available Arsenic (As)	7	2	8	2		1		pass		pass
Available Barium (Ba)	12	5	13	5		1		pass		pass
Available Beryllium (Be)	ND	2	ND	2						
Available Bismuth (Bi)	ND	2	ND	2						
Available Boron (B)	ND	5	ND	5						
Available Cadmium (Cd)	ND	0.3	ND	0.3						
Available Chromium (Cr)	28	2	29	2	**3.51**		pass		pass	
Available Cobalt (Co)	8	1	7	1	**13.33**		pass		pass	
Available Copper (Cu)	12	2	10	2	**18.18**		pass		pass	
Available Iron (Fe)	38000	50	38000	50	**0.00**		pass		pass	
Available Lead (Pb)	18	0.5	23	0.5	**24.39**		pass		pass	
Available Lithium (Li)	13	2	16	2	**20.69**		pass		pass	
Available Manganese (Mn)	180	2	200	2	**10.53**		pass		pass	
Available Molybdenum (Mo)	ND	2	ND	2						
Available Nickel (Ni)	13	2	14	2	**7.41**		pass		pass	
Available Rubidium (Rb)	ND	2	ND	2						
Available Selenium (Se)	ND	2	ND	2						
Available Silver (Ag)	ND	0.5	ND	0.5						
Available Strontium (Sr)	ND	5	ND	5						
Available Thallium (Tl)	0.1	0.1	ND	0.1						
Available Tin (Sn)	ND	2	ND	2						
Available Uranium (U)	0.2	0.1	0.2	0.1		0		pass		pass
Available Vanadium (V)	140	2	140	2	**0.00**		pass		pass	
Available Zinc (Zn)	43	5	41	5	**4.76**		pass		pass	

Maxxam ID	DQ1591		DQ1595							
Sampling Date	2009/07/31 JUL-AUG		2009/07/31 JUL-AUG							
COC Number	B 65309		B 65309							
							Estimate		Rejection	
	S24A	**RDL**	**QA/QC-12**	**RDL**	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD pass DQO?	ABS pass DQO?
Metals										
Available Aluminum (Al)	14000	10	15000	10	**6.90**		pass		pass	
Available Antimony (Sb)	ND	2	ND	2						
Available Arsenic (As)	3	2	3	2		0		pass		pass
Available Barium (Ba)	110	5	150	5	**30.77**		pass		pass	
Available Beryllium (Be)	ND	2	ND	2						
Available Bismuth (Bi)	ND	2	ND	2						
Available Boron (B)	ND	5	ND	5						
Available Cadmium (Cd)	0.5	0.3	0.4	0.3		0.1		pass		pass
Available Chromium (Cr)	21	2	25	2	**17.39**		pass		pass	
Available Cobalt (Co)	2	1	3	1		1		pass		pass
Available Copper (Cu)	17	2	22	2	**25.64**		pass		pass	
Available Iron (Fe)	3500	50	5200	50	**39.08**		does not pass		pass	
Available Lead (Pb)	37	0.5	33	0.5	**11.43**		pass		pass	
Available Lithium (Li)	4	2	8	2		4		pass		pass
Available Manganese (Mn)	23	2	53	2	**78.95**		does not pass		pass	
Available Molybdenum (Mo)	ND	2	ND	2						
Available Nickel (Ni)	13	2	18	2	**32.26**		pass		pass	
Available Rubidium (Rb)	ND	2	3	2						
Available Selenium (Se)	ND	2	ND	2						
Available Silver (Ag)	0.9	0.5	ND	0.5						
Available Strontium (Sr)	13	5	9	5		4		pass		pass
Available Thallium (Tl)	0.1	0.1	0.1	0.1		0		pass		pass
Available Tin (Sn)	ND	2	ND	2						
Available Uranium (U)	2.4	0.1	1.7	0.1	**34.15**		pass		pass	
Available Vanadium (V)	9	2	14	2	**43.48**	5	does not pass	does not pass	pass	pass
Available Zinc (Zn)	14	5	22	5		8		pass		pass

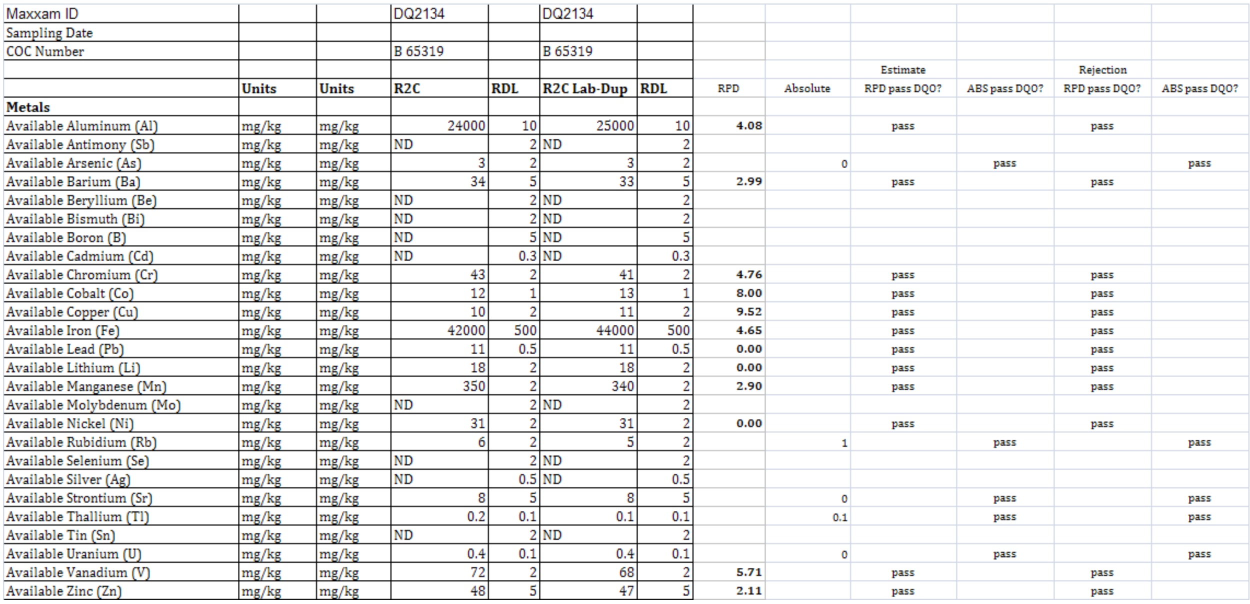
Maxxam ID	DQ1610		DQ1621							
Sampling Date										
COC Number	B 65323		B 65323							
							Estimate		Rejection	
	R5A	**RDL**	**QA/QC-21**	**RDL**	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD pass DQO?	ABS pass DQO?
Metals										
Available Aluminum (Al)	70000	100	66000	100	5.88		pass		pass	
Available Antimony (Sb)	ND	2	ND	2						
Available Arsenic (As)	6	2	8	2		2		pass		pass
Available Barium (Ba)	360	5	450	5	22.22		pass		pass	
Available Beryllium (Be)	7	2	7	2		0		pass		pass
Available Bismuth (Bi)	ND	2	ND	2						
Available Boron (B)	ND	5	ND	5						
Available Cadmium (Cd)	3.3	0.3	4.2	0.3	24.00		pass		pass	
Available Chromium (Cr)	28	2	28	2	0.00		pass		pass	
Available Cobalt (Co)	10	1	11	1	9.52		pass		pass	
Available Copper (Cu)	9	2	10	2	10.53	1	pass	pass	pass	pass
Available Iron (Fe)	24000	50	27000	50	11.76		pass		pass	
Available Lead (Pb)	21	0.5	19	0.5	10.00		pass		pass	
Available Lithium (Li)	15	2	15	2	0.00		pass		pass	
Available Manganese (Mn)	13000	2	17000	2	26.67		pass		pass	
Available Molybdenum (Mo)	5	2	7	2		2		pass		pass
Available Nickel (Ni)	45	2	45	2	0.00		pass		pass	
Available Rubidium (Rb)	6	2	8	2		2		pass		pass
Available Selenium (Se)	3	2	2	2		1		pass		pass
Available Silver (Ag)	1.2	0.5	1.2	0.5		0		pass		pass
Available Strontium (Sr)	ND (1)	50	ND (2)	50						
Available Thallium (Tl)	0.9	0.1	0.9	0.1	0.00		pass		pass	
Available Tin (Sn)	ND	2	ND	2						
Available Uranium (U)	3.4	0.1	2.9	0.1	15.87		pass		pass	
Available Vanadium (V)	19	2	24	2	23.26		pass		pass	
Available Zinc (Zn)	53	5	69	5	26.23		pass		pass	

Maxxam ID	DQ1623		DQ1632							
Sampling Date										
COC Number	B 65323		B 65323							
							Estimate		Rejection	
	R9A	**RDL**	**QA/QC-31**	**RDL**	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD pass DQO?	ABS pass DQO?
Metals										
Available Aluminum (Al)	12000	10	11000	10	8.70		pass		pass	
Available Antimony (Sb)	ND	2	ND	2						
Available Arsenic (As)	5	2	5	2		0		pass		pass
Available Barium (Ba)	450	5	460	5	2.20		pass		pass	
Available Beryllium (Be)	ND	2	ND	2						
Available Bismuth (Bi)	ND	2	ND	2						
Available Boron (B)	ND	5	ND	5						
Available Cadmium (Cd)	1.0	0.3	1.0	0.3		0		pass		pass
Available Chromium (Cr)	28	2	25	2	11.32		pass		pass	
Available Cobalt (Co)	8	1	7	1	13.33		pass		pass	
Available Copper (Cu)	12	2	11	2	8.70		pass		pass	
Available Iron (Fe)	15000	50	15000	50	0.00		pass		pass	
Available Lead (Pb)	40	0.5	39	0.5	2.53		pass		pass	
Available Lithium (Li)	9	2	7	2		2		pass		pass
Available Manganese (Mn)	4400	2	4300	2	2.30		pass		pass	
Available Molybdenum (Mo)	ND	2	ND	2						
Available Nickel (Ni)	21	2	19	2	10.00		pass		pass	
Available Rubidium (Rb)	8	2	7	2		1		pass		pass
Available Selenium (Se)	ND	2	ND	2						
Available Silver (Ag)	ND	0.5	ND	0.5						
Available Strontium (Sr)	ND (1)	50	ND (1)	50						
Available Thallium (Tl)	0.2	0.1	0.2	0.1		0		pass		pass
Available Tin (Sn)	ND	2	ND	2						
Available Uranium (U)	1.3	0.1	1.2	0.1	8.00		pass		pass	
Available Vanadium (V)	26	2	22	2	16.67		pass		pass	
Available Zinc (Zn)	58	5	59	5	1.71		pass		pass	

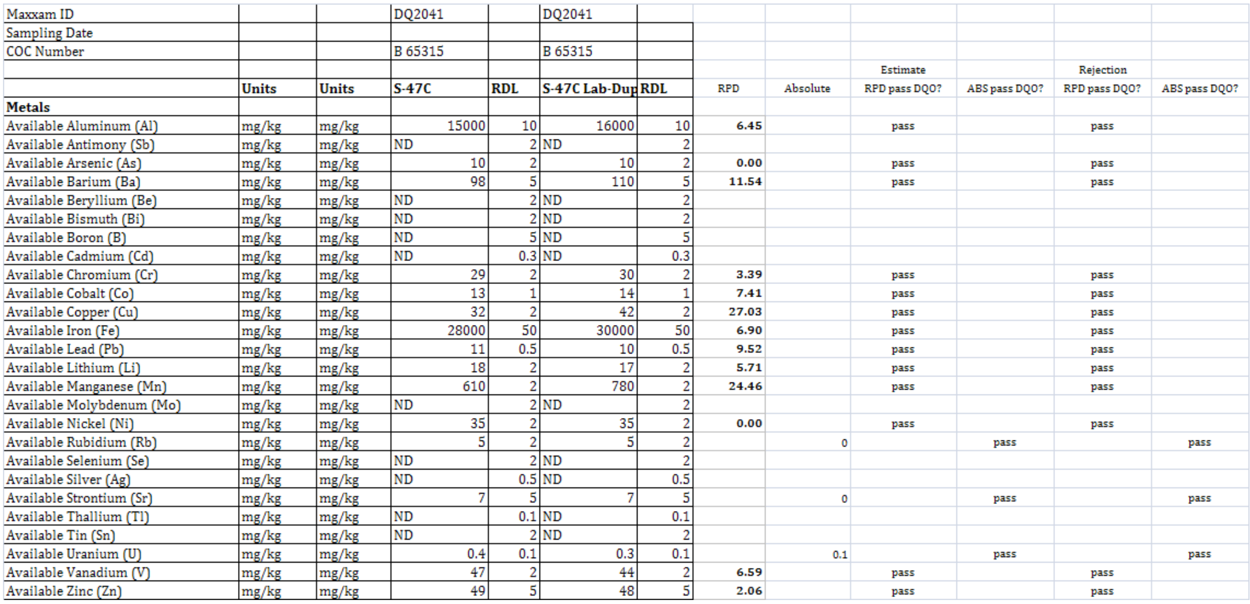
Maxxam ID	DQ1643		DQ1642							
Sampling Date										
COC Number	B 65323		B 65323							
							Estimate		Rejection	
	R21A	**RDL**	**QA/QC-23**	**RDL**	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD pass DQO?	ABS pass DQO?
Metals										
Available Aluminum (Al)	20000	10	17000	10	**16.22**		pass		pass	
Available Antimony (Sb)	ND	2	ND	2						
Available Arsenic (As)	3	2	2	2		1		pass		pass
Available Barium (Ba)	41	5	36	5	**12.99**		pass		pass	
Available Beryllium (Be)	ND	2	ND	2						
Available Bismuth (Bi)	ND	2	ND	2						
Available Boron (B)	ND	5	ND	5						
Available Cadmium (Cd)	ND	0.3	ND	0.3						
Available Chromium (Cr)	22	2	19	2	**14.63**		pass		pass	
Available Cobalt (Co)	10	1	9	1	**10.53**		pass		pass	
Available Copper (Cu)	15	2	11	2	**30.77**		pass		pass	
Available Iron (Fe)	36000	50	31000	50	**14.93**		pass		pass	
Available Lead (Pb)	12	0.5	10	0.5	**18.18**		pass		pass	
Available Lithium (Li)	15	2	11	2	**30.77**		pass		pass	
Available Manganese (Mn)	290	2	260	2	**10.91**		pass		pass	
Available Molybdenum (Mo)	ND	2	ND	2						
Available Nickel (Ni)	19	2	16	2	**17.14**		pass		pass	
Available Rubidium (Rb)	8	2	6	2		2		pass		pass
Available Selenium (Se)	ND	2	ND	2						
Available Silver (Ag)	ND	0.5	ND	0.5						
Available Strontium (Sr)	6	5	ND	5						
Available Thallium (Tl)	ND	0.1	ND	0.1						
Available Tin (Sn)	ND	2	ND	2						
Available Uranium (U)	0.5	0.1	0.4	0.1	**22.22**	0.1	pass	pass	pass	pass
Available Vanadium (V)	57	2	51	2	**11.11**		pass		pass	
Available Zinc (Zn)	70	5	59	5	**17.05**		pass		pass	

Maxxam ID	DQ4356		DQ4366							
Sampling Date	7/1/2009		7/1/2009							
COC Number	B 65302		B 65302							
							Estimate		Rejection	
	S40A	**RDL**	**QA/QC-2**	**RDL**	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD pass DQO?	ABS pass DQO?
Metals										
Available Aluminum (Al)	11000	10	13000	10	**16.67**		pass		pass	
Available Antimony (Sb)	5	2	6	2		1		pass		pass
Available Arsenic (As)	27	2	29	2	**7.14**		pass		pass	
Available Barium (Ba)	92	5	110	5	**17.82**		pass		pass	
Available Beryllium (Be)	ND	2	ND	2						
Available Bismuth (Bi)	ND	2	ND	2						
Available Boron (B)	ND	5	ND	5						
Available Cadmium (Cd)	6.3	0.3	6.7	0.3	**6.15**		pass		pass	
Available Chromium (Cr)	24	2	28	2	**15.38**		pass		pass	
Available Cobalt (Co)	8	1	9	1	**11.76**		pass		pass	
Available Copper (Cu)	32	2	37	2	**14.49**		pass		pass	
Available Iron (Fe)	24000	50	26000	50	**8.00**		pass		pass	
Available Lead (Pb)	430	0.5	450	0.5	**4.55**		pass		pass	
Available Lithium (Li)	14	2	14	2	**0.00**		pass		pass	
Available Manganese (Mn)	410	2	420	2	**2.41**		pass		pass	
Available Molybdenum (Mo)	ND	2	ND	2						
Available Nickel (Ni)	22	2	24	2	**8.70**		pass		pass	
Available Rubidium (Rb)	7	2	8	2		1		pass		pass
Available Selenium (Se)	ND	2	ND	2						
Available Silver (Ag)	0.8	0.5	1.0	0.5		0.2		pass		pass
Available Strontium (Sr)	13	5	15	5		2		pass		pass
Available Thallium (Tl)	1.4	0.1	1.5	0.1	**6.90**		pass		pass	
Available Tin (Sn)	8	2	8	2		0		pass		pass
Available Uranium (U)	0.6	0.1	0.6	0.1	**0.00**		pass		pass	
Available Vanadium (V)	52	2	61	2	**15.93**		pass		pass	
Available Zinc (Zn)	360	5	400	5	**10.53**		pass		pass	

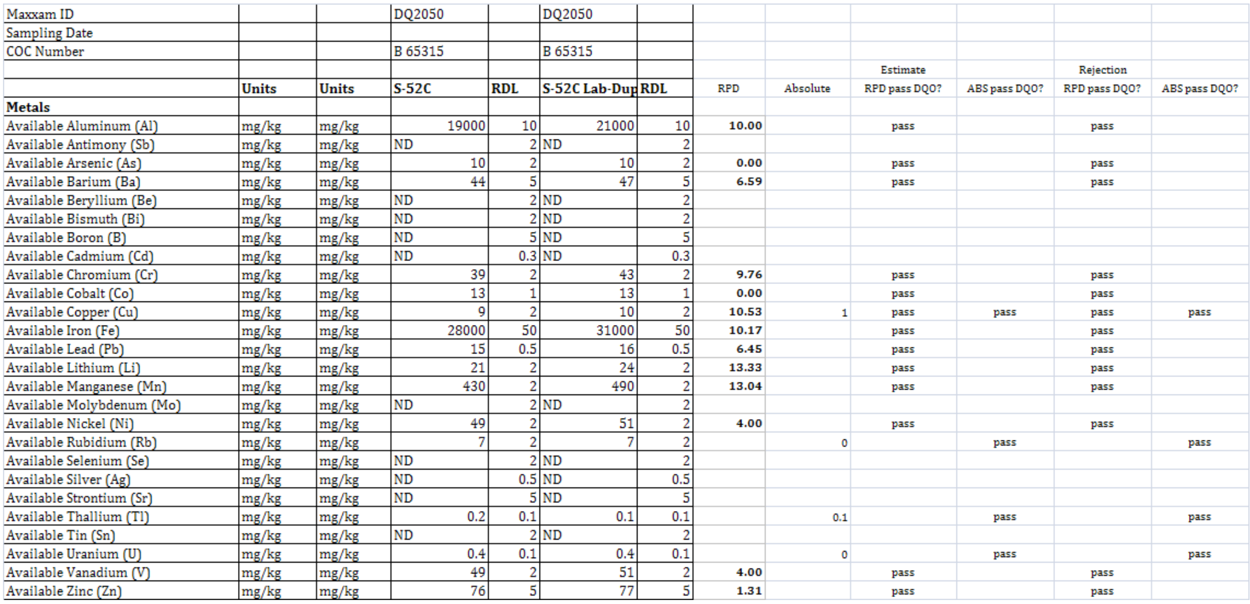
Maxxam ID	DQ4356		DQ4366							
Sampling Date	7/1/2009		7/1/2009							
COC Number	B 65302		B 65302							
							Estimate		Rejection	
	S40A	**RDL**	**QA/QC-2**	**RDL**	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD pass DQO?	ABS pass DQO?
Charge/Prep Analysis										
Dry Mass to Volume Ratio	0.045138889	N/A	0.045138889	N/A	**0.95**		pass			
Inorganics										
Organic Carbon (TOC)	53	0.5	54	0.6	**1.87**		pass		pass	
Soluble (5:1) pH	5.75	N/A	5.50	N/A	**4.77**		pass			



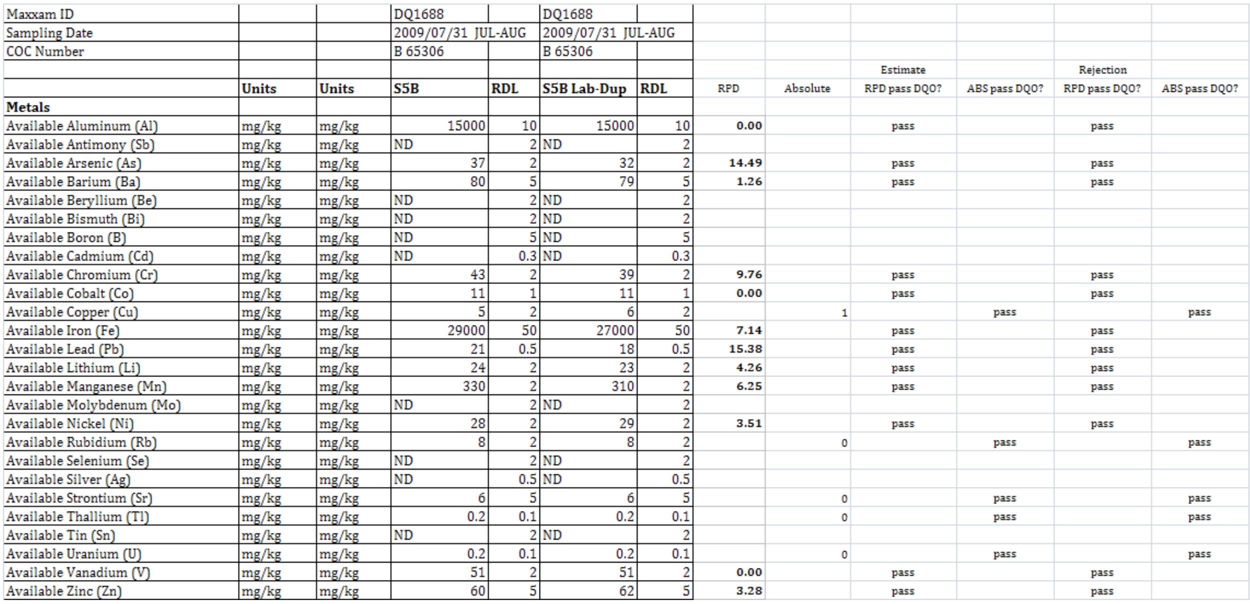
Maxxam ID			DQ2134		DQ2134							
Sampling Date												
COC Number			B 65319		B 65319							
									Estimate		Rejection	
	Units	**Units**	**R2C**	**RDL**	**R2C Lab-Dup**	**RDL**	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD pass DQO?	ABS pass DQO?
Metals												
Available Aluminum (Al)	mg/kg	mg/kg	24000	10	25000	10	**4.08**		pass		pass	
Available Antimony (Sb)	mg/kg	mg/kg	ND	2	ND	2						
Available Arsenic (As)	mg/kg	mg/kg	3	2	3	2		0		pass		pass
Available Barium (Ba)	mg/kg	mg/kg	34	5	33	5	**2.99**		pass		pass	
Available Beryllium (Be)	mg/kg	mg/kg	ND	2	ND	2						
Available Bismuth (Bi)	mg/kg	mg/kg	ND	2	ND	2						
Available Boron (B)	mg/kg	mg/kg	ND	5	ND	5						
Available Cadmium (Cd)	mg/kg	mg/kg	ND	0.3	ND	0.3						
Available Chromium (Cr)	mg/kg	mg/kg	43	2	41	2	**4.76**		pass		pass	
Available Cobalt (Co)	mg/kg	mg/kg	12	1	13	1	**8.00**		pass		pass	
Available Copper (Cu)	mg/kg	mg/kg	10	2	11	2	**9.52**		pass		pass	
Available Iron (Fe)	mg/kg	mg/kg	42000	500	44000	500	**4.65**		pass		pass	
Available Lead (Pb)	mg/kg	mg/kg	11	0.5	11	0.5	**0.00**		pass		pass	
Available Lithium (Li)	mg/kg	mg/kg	18	2	18	2	**0.00**		pass		pass	
Available Manganese (Mn)	mg/kg	mg/kg	350	2	340	2	**2.90**		pass		pass	
Available Molybdenum (Mo)	mg/kg	mg/kg	ND	2	ND	2						
Available Nickel (Ni)	mg/kg	mg/kg	31	2	31	2	**0.00**		pass		pass	
Available Rubidium (Rb)	mg/kg	mg/kg	6	2	5	2		1		pass		pass
Available Selenium (Se)	mg/kg	mg/kg	ND	2	ND	2						
Available Silver (Ag)	mg/kg	mg/kg	ND	0.5	ND	0.5						
Available Strontium (Sr)	mg/kg	mg/kg	8	5	8	5		0		pass		pass
Available Thallium (Tl)	mg/kg	mg/kg	0.2	0.1	0.1	0.1		0.1		pass		pass
Available Tin (Sn)	mg/kg	mg/kg	ND	2	ND	2						
Available Uranium (U)	mg/kg	mg/kg	0.4	0.1	0.4	0.1		0		pass		pass
Available Vanadium (V)	mg/kg	mg/kg	72	2	68	2	**5.71**		pass		pass	
Available Zinc (Zn)	mg/kg	mg/kg	48	5	47	5	**2.11**		pass		pass	



Maxxam ID			DQ2041		DQ2041							
Sampling Date												
COC Number			B 65315		B 65315							
									Estimate		Rejection	
	Units	**Units**	**S-47C**	**RDL**	**S-47C Lab-Dup**	**RDL**	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD pass DQO?	ABS pass DQO?
Metals												
Available Aluminum (Al)	mg/kg	mg/kg	15000	10	16000	10	**6.45**		pass		pass	
Available Antimony (Sb)	mg/kg	mg/kg	ND	2	ND	2						
Available Arsenic (As)	mg/kg	mg/kg	10	2	10	2	**0.00**		pass		pass	
Available Barium (Ba)	mg/kg	mg/kg	98	5	110	5	**11.54**		pass		pass	
Available Beryllium (Be)	mg/kg	mg/kg	ND	2	ND	2						
Available Bismuth (Bi)	mg/kg	mg/kg	ND	2	ND	2						
Available Boron (B)	mg/kg	mg/kg	ND	5	ND	5						
Available Cadmium (Cd)	mg/kg	mg/kg	ND	0.3	ND	0.3						
Available Chromium (Cr)	mg/kg	mg/kg	29	2	30	2	**3.39**		pass		pass	
Available Cobalt (Co)	mg/kg	mg/kg	13	1	14	1	**7.41**		pass		pass	
Available Copper (Cu)	mg/kg	mg/kg	32	2	42	2	**27.03**		pass		pass	
Available Iron (Fe)	mg/kg	mg/kg	28000	50	30000	50	**6.90**		pass		pass	
Available Lead (Pb)	mg/kg	mg/kg	11	0.5	10	0.5	**9.52**		pass		pass	
Available Lithium (Li)	mg/kg	mg/kg	18	2	17	2	**5.71**		pass		pass	
Available Manganese (Mn)	mg/kg	mg/kg	610	2	780	2	**24.46**		pass		pass	
Available Molybdenum (Mo)	mg/kg	mg/kg	ND	2	ND	2						
Available Nickel (Ni)	mg/kg	mg/kg	35	2	35	2	**0.00**		pass		pass	
Available Rubidium (Rb)	mg/kg	mg/kg	5	2	5	2		0		pass		pass
Available Selenium (Se)	mg/kg	mg/kg	ND	2	ND	2						
Available Silver (Ag)	mg/kg	mg/kg	ND	0.5	ND	0.5						
Available Strontium (Sr)	mg/kg	mg/kg	7	5	7	5		0		pass		pass
Available Thallium (Tl)	mg/kg	mg/kg	ND	0.1	ND	0.1						
Available Tin (Sn)	mg/kg	mg/kg	ND	2	ND	2						
Available Uranium (U)	mg/kg	mg/kg	0.4	0.1	0.3	0.1		0.1		pass		pass
Available Vanadium (V)	mg/kg	mg/kg	47	2	44	2	**6.59**		pass		pass	
Available Zinc (Zn)	mg/kg	mg/kg	49	5	48	5	**2.06**		pass		pass	



Maxxam ID			DQ2050		DQ2050							
Sampling Date												
COC Number			B 65315		B 65315							
									Estimate		Rejection	
	Units	**Units**	**S-52C**	**RDL**	**S-52C Lab-Dup**	**RDL**	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD pass DQO?	ABS pass DQO?
Metals												
Available Aluminum (Al)	mg/kg	mg/kg	19000	10	21000	10	**10.00**		pass		pass	
Available Antimony (Sb)	mg/kg	mg/kg	ND	2	ND	2						
Available Arsenic (As)	mg/kg	mg/kg	10	2	10	2	**0.00**		pass		pass	
Available Barium (Ba)	mg/kg	mg/kg	44	5	47	5	**6.59**		pass		pass	
Available Beryllium (Be)	mg/kg	mg/kg	ND	2	ND	2						
Available Bismuth (Bi)	mg/kg	mg/kg	ND	2	ND	2						
Available Boron (B)	mg/kg	mg/kg	ND	5	ND	5						
Available Cadmium (Cd)	mg/kg	mg/kg	ND	0.3	ND	0.3						
Available Chromium (Cr)	mg/kg	mg/kg	39	2	43	2	**9.76**		pass		pass	
Available Cobalt (Co)	mg/kg	mg/kg	13	1	13	1	**0.00**		pass		pass	
Available Copper (Cu)	mg/kg	mg/kg	9	2	10	2	**10.53**	1	pass	pass	pass	pass
Available Iron (Fe)	mg/kg	mg/kg	28000	50	31000	50	**10.17**		pass		pass	
Available Lead (Pb)	mg/kg	mg/kg	15	0.5	16	0.5	**6.45**		pass		pass	
Available Lithium (Li)	mg/kg	mg/kg	21	2	24	2	**13.33**		pass		pass	
Available Manganese (Mn)	mg/kg	mg/kg	430	2	490	2	**13.04**		pass		pass	
Available Molybdenum (Mo)	mg/kg	mg/kg	ND	2	ND	2						
Available Nickel (Ni)	mg/kg	mg/kg	49	2	51	2	**4.00**		pass		pass	
Available Rubidium (Rb)	mg/kg	mg/kg	7	2	7	2		0		pass		pass
Available Selenium (Se)	mg/kg	mg/kg	ND	2	ND	2						
Available Silver (Ag)	mg/kg	mg/kg	ND	0.5	ND	0.5						
Available Strontium (Sr)	mg/kg	mg/kg	ND	5	ND	5						
Available Thallium (Tl)	mg/kg	mg/kg	0.2	0.1	0.1	0.1		0.1		pass		pass
Available Tin (Sn)	mg/kg	mg/kg	ND	2	ND	2						
Available Uranium (U)	mg/kg	mg/kg	0.4	0.1	0.4	0.1		0		pass		pass
Available Vanadium (V)	mg/kg	mg/kg	49	2	51	2	**4.00**		pass		pass	
Available Zinc (Zn)	mg/kg	mg/kg	76	5	77	5	**1.31**		pass		pass	



Maxxam ID			DQ1688		DQ1688							
Sampling Date			2009/07/31 JUL-AUG		2009/07/31 JUL-AUG							
COC Number			B 65306		B 65306							
									Estimate		Rejection	
	Units	**Units**	**S5B**	**RDL**	**S5B Lab-Dup**	**RDL**	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD pass DQO?	ABS pass DQO?
Metals												
Available Aluminum (Al)	mg/kg	mg/kg	15000	10	15000	10	**0.00**		pass		pass	
Available Antimony (Sb)	mg/kg	mg/kg	ND	2	ND	2						
Available Arsenic (As)	mg/kg	mg/kg	37	2	32	2	**14.49**		pass		pass	
Available Barium (Ba)	mg/kg	mg/kg	80	5	79	5	**1.26**		pass		pass	
Available Beryllium (Be)	mg/kg	mg/kg	ND	2	ND	2						
Available Bismuth (Bi)	mg/kg	mg/kg	ND	2	ND	2						
Available Boron (B)	mg/kg	mg/kg	ND	5	ND	5						
Available Cadmium (Cd)	mg/kg	mg/kg	ND	0.3	ND	0.3						
Available Chromium (Cr)	mg/kg	mg/kg	43	2	39	2	**9.76**		pass		pass	
Available Cobalt (Co)	mg/kg	mg/kg	11	1	11	1	**0.00**		pass		pass	
Available Copper (Cu)	mg/kg	mg/kg	5	2	6	2		1		pass		pass
Available Iron (Fe)	mg/kg	mg/kg	29000	50	27000	50	**7.14**		pass		pass	
Available Lead (Pb)	mg/kg	mg/kg	21	0.5	18	0.5	**15.38**		pass		pass	
Available Lithium (Li)	mg/kg	mg/kg	24	2	23	2	**4.26**		pass		pass	
Available Manganese (Mn)	mg/kg	mg/kg	330	2	310	2	**6.25**		pass		pass	
Available Molybdenum (Mo)	mg/kg	mg/kg	ND	2	ND	2						
Available Nickel (Ni)	mg/kg	mg/kg	28	2	29	2	**3.51**		pass		pass	
Available Rubidium (Rb)	mg/kg	mg/kg	8	2	8	2		0		pass		pass
Available Selenium (Se)	mg/kg	mg/kg	ND	2	ND	2						
Available Silver (Ag)	mg/kg	mg/kg	ND	0.5	ND	0.5						
Available Strontium (Sr)	mg/kg	mg/kg	6	5	6	5		0		pass		pass
Available Thallium (Tl)	mg/kg	mg/kg	0.2	0.1	0.2	0.1		0		pass		pass
Available Tin (Sn)	mg/kg	mg/kg	ND	2	ND	2						
Available Uranium (U)	mg/kg	mg/kg	0.2	0.1	0.2	0.1		0		pass		pass
Available Vanadium (V)	mg/kg	mg/kg	51	2	51	2	**0.00**		pass		pass	
Available Zinc (Zn)	mg/kg	mg/kg	60	5	62	5	**3.28**		pass		pass	

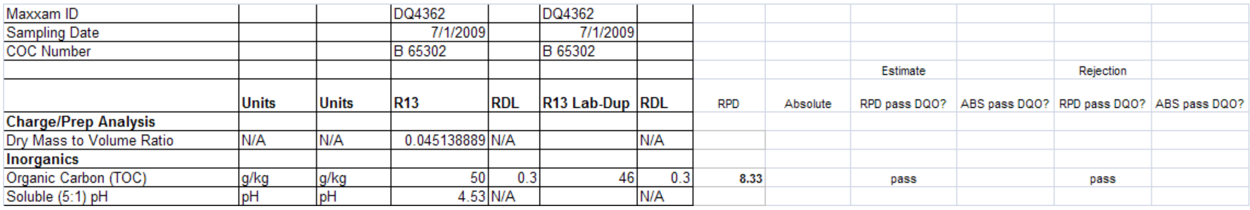
Maxxam ID			DQ1666		DQ1666							
Sampling Date			2009/07/31 JUL-AUG		2009/07/31 JUL-AUG							
COC Number			B 65312		B 65312							
									Estimate		Rejection	
	Units	**Units**	**S35C**	**RDL**	**S35C Lab-Dup**	**RDL**	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD pass DQO?	ABS pass DQO?
Metals												
Available Aluminum (Al)	mg/kg	mg/kg	25000	10	27000	10	**7.69**		pass		pass	
Available Antimony (Sb)	mg/kg	mg/kg	ND	2	ND	2						
Available Arsenic (As)	mg/kg	mg/kg	53	2	69	2	**26.23**		pass		pass	
Available Barium (Ba)	mg/kg	mg/kg	46	5	55	5	**17.82**		pass		pass	
Available Beryllium (Be)	mg/kg	mg/kg	ND	2	ND	2						
Available Bismuth (Bi)	mg/kg	mg/kg	ND	2	ND	2						
Available Boron (B)	mg/kg	mg/kg	ND	5	ND	5						
Available Cadmium (Cd)	mg/kg	mg/kg	0.4	0.3	0.5	0.3		0.1		pass		pass
Available Chromium (Cr)	mg/kg	mg/kg	73	2	74	2	**1.36**		pass		pass	
Available Cobalt (Co)	mg/kg	mg/kg	14	1	15	1	**6.90**		pass		pass	
Available Copper (Cu)	mg/kg	mg/kg	19	2	21	2	**10.00**		pass		pass	
Available Iron (Fe)	mg/kg	mg/kg	49000	500	48000	500	**2.06**		pass		pass	
Available Lead (Pb)	mg/kg	mg/kg	27	0.5	29	0.5	**7.14**		pass		pass	
Available Lithium (Li)	mg/kg	mg/kg	24	2	26	2	**8.00**		pass		pass	
Available Manganese (Mn)	mg/kg	mg/kg	360	2	430	2	**17.72**		pass		pass	
Available Molybdenum (Mo)	mg/kg	mg/kg	7	2	ND	2						
Available Nickel (Ni)	mg/kg	mg/kg	35	2	39	2	**10.81**		pass		pass	
Available Rubidium (Rb)	mg/kg	mg/kg	8	2	9	2		1		pass		pass
Available Selenium (Se)	mg/kg	mg/kg	ND	2	ND	2						
Available Silver (Ag)	mg/kg	mg/kg	ND	0.5	0.5	0.5						
Available Strontium (Sr)	mg/kg	mg/kg	ND	5	ND	5						
Available Thallium (Tl)	mg/kg	mg/kg	0.1	0.1	0.2	0.1		0.1		pass		pass
Available Tin (Sn)	mg/kg	mg/kg	ND	2	ND	2						
Available Uranium (U)	mg/kg	mg/kg	0.3	0.1	0.3	0.1		0		pass		pass
Available Vanadium (V)	mg/kg	mg/kg	110	2	100	2	**9.52**		pass		pass	
Available Zinc (Zn)	mg/kg	mg/kg	100	5	120	5	**18.18**		pass		pass	

Maxxam ID			DQ1578		DQ1578							
Sampling Date			2009/07/31 JUL-AUG		2009/07/31 JUL-AUG							
COC Number			B 65309		B 65309							
									Estimate		Rejection	
	Units	**Units**	**S18B**	**RDL**	**S18B Lab-Dup**	**RDL**	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD pass DQO?	ABS pass DQO?
Metals												
Available Aluminum (Al)	mg/kg	mg/kg	27000	10	27000	10	**0.00**		pass		pass	
Available Antimony (Sb)	mg/kg	mg/kg	ND	2	ND	2						
Available Arsenic (As)	mg/kg	mg/kg	27	2	32	2	**16.95**		pass		pass	
Available Barium (Ba)	mg/kg	mg/kg	51	5	56	5	**9.35**		pass		pass	
Available Beryllium (Be)	mg/kg	mg/kg	ND	2	ND	2						
Available Bismuth (Bi)	mg/kg	mg/kg	ND	2	ND	2						
Available Boron (B)	mg/kg	mg/kg	ND	5	ND	5						
Available Cadmium (Cd)	mg/kg	mg/kg	0.4	0.3	0.4	0.3		0		pass		pass
Available Chromium (Cr)	mg/kg	mg/kg	43	2	43	2	**0.00**		pass		pass	
Available Cobalt (Co)	mg/kg	mg/kg	13	1	15	1	**14.29**		pass		pass	
Available Copper (Cu)	mg/kg	mg/kg	19	2	19	2	**0.00**		pass		pass	
Available Iron (Fe)	mg/kg	mg/kg	55000	500	54000	500	**1.83**		pass		pass	
Available Lead (Pb)	mg/kg	mg/kg	27	0.5	30	0.5	**10.53**		pass		pass	
Available Lithium (Li)	mg/kg	mg/kg	34	2	34	2	**0.00**		pass		pass	
Available Manganese (Mn)	mg/kg	mg/kg	600	2	710	2	**16.79**		pass		pass	
Available Molybdenum (Mo)	mg/kg	mg/kg	ND	2	ND	2						
Available Nickel (Ni)	mg/kg	mg/kg	29	2	29	2	**0.00**		pass		pass	
Available Rubidium (Rb)	mg/kg	mg/kg	13	2	14	2	**7.41**		pass		pass	
Available Selenium (Se)	mg/kg	mg/kg	ND	2	ND	2						
Available Silver (Ag)	mg/kg	mg/kg	ND	0.5	ND	0.5						
Available Strontium (Sr)	mg/kg	mg/kg	ND	5	ND	5						
Available Thallium (Tl)	mg/kg	mg/kg	0.2	0.1	0.2	0.1		0		pass		pass
Available Tin (Sn)	mg/kg	mg/kg	ND	2	ND	2						
Available Uranium (U)	mg/kg	mg/kg	0.8	0.1	0.8	0.1	**0.00**		pass		pass	
Available Vanadium (V)	mg/kg	mg/kg	67	2	68	2	**1.48**		pass		pass	
Available Zinc (Zn)	mg/kg	mg/kg	130	5	130	5	**0.00**		pass		pass	

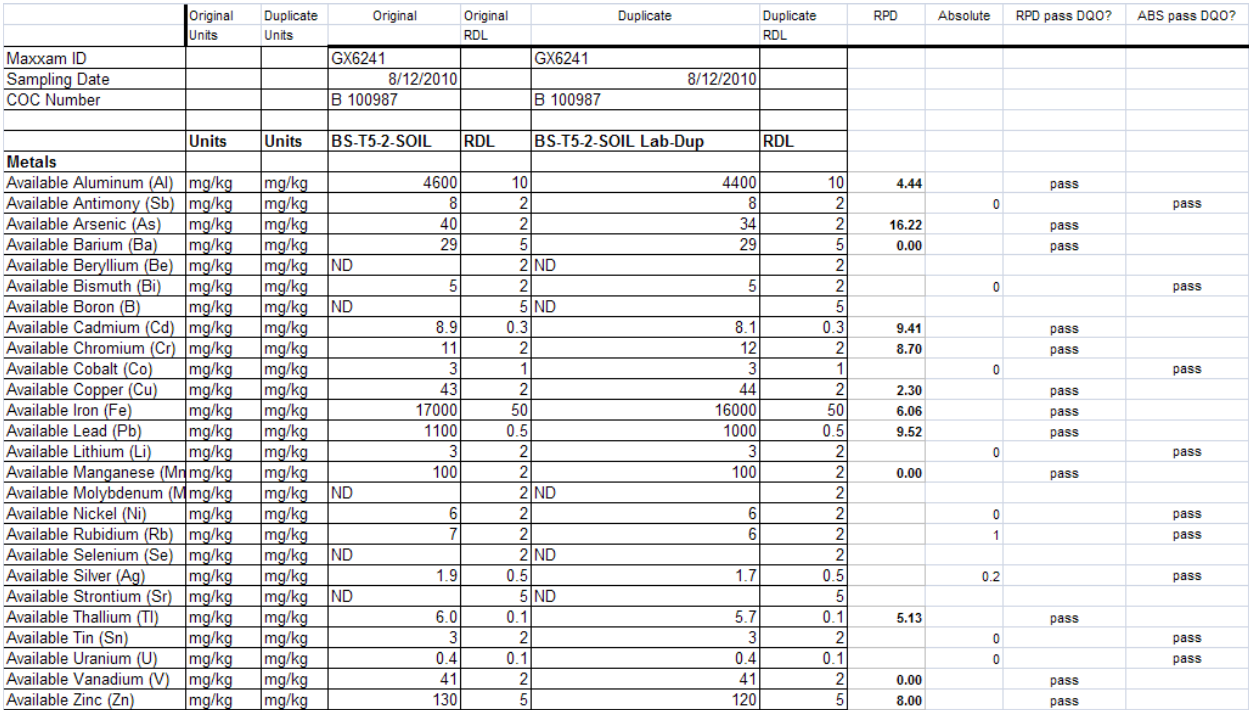
Maxxam ID			DQ1596		DQ1596							
Sampling Date			2009/07/31 JUL-AUG		2009/07/31 JUL-AUG							
COC Number			B 65309		B 65309							
									Estimate		Rejection	
	Units	**Units**	**S28A**	**RDL**	**S28A Lab-Dup**	**RDL**	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD pass DQO?	ABS pass DQO?
Metals												
Available Aluminum (Al)	mg/kg	mg/kg	28000	10	28000	10	**0.00**		pass		pass	
Available Antimony (Sb)	mg/kg	mg/kg	ND	2	ND	2						
Available Arsenic (As)	mg/kg	mg/kg	310	2	370	2	**17.65**		pass		pass	
Available Barium (Ba)	mg/kg	mg/kg	83	5	96	5	**14.53**		pass		pass	
Available Beryllium (Be)	mg/kg	mg/kg	ND	2	ND	2						
Available Bismuth (Bi)	mg/kg	mg/kg	ND	2	ND	2						
Available Boron (B)	mg/kg	mg/kg	ND	5	ND	5						
Available Cadmium (Cd)	mg/kg	mg/kg	1.0	0.3	1.0	0.3		0		pass		pass
Available Chromium (Cr)	mg/kg	mg/kg	76	2	76	2	**0.00**		pass		pass	
Available Cobalt (Co)	mg/kg	mg/kg	32	1	37	1	**14.49**		pass		pass	
Available Copper (Cu)	mg/kg	mg/kg	12	2	11	2	**8.70**		pass		pass	
Available Iron (Fe)	mg/kg	mg/kg	83000	500	89000	500	**6.98**		pass		pass	
Available Lead (Pb)	mg/kg	mg/kg	59	0.5	54	0.5	**8.85**		pass		pass	
Available Lithium (Li)	mg/kg	mg/kg	25	2	26	2	**3.92**		pass		pass	
Available Manganese (Mn)	mg/kg	mg/kg	3300	2	4300	2	**26.32**		pass		pass	
Available Molybdenum (Mo)	mg/kg	mg/kg	8	2	9	2		1		pass		pass
Available Nickel (Ni)	mg/kg	mg/kg	23	2	23	2	**0.00**		pass		pass	
Available Rubidium (Rb)	mg/kg	mg/kg	8	2	8	2		0		pass		pass
Available Selenium (Se)	mg/kg	mg/kg	ND	2	ND	2						
Available Silver (Ag)	mg/kg	mg/kg	0.6	0.5	0.5	0.5		0.1		pass		pass
Available Strontium (Sr)	mg/kg	mg/kg	10	5	10	5		0		pass		pass
Available Thallium (Tl)	mg/kg	mg/kg	0.4	0.1	0.4	0.1		0		pass		pass
Available Tin (Sn)	mg/kg	mg/kg	ND	2	ND	2						
Available Uranium (U)	mg/kg	mg/kg	0.7	0.1	0.7	0.1	**0.00**		pass		pass	
Available Vanadium (V)	mg/kg	mg/kg	180	2	190	2	**5.41**		pass		pass	
Available Zinc (Zn)	mg/kg	mg/kg	140	5	150	5	**6.90**		pass		pass	

Maxxam ID			DQ1640		DQ1640							
Sampling Date												
COC Number			B 65323		B 65323							
									Estimate		Rejection	
	Units	**Units**	**R18C**	**RDL**	**R18C Lab-Dup**	**RDL**	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD pass DQO?	ABS pass DQO?
Metals												
Available Aluminum (Al)	mg/kg	mg/kg	29000	10	28000	10	**3.51**		pass		pass	
Available Antimony (Sb)	mg/kg	mg/kg	ND	2	ND	2						
Available Arsenic (As)	mg/kg	mg/kg	4	2	4	2		0		pass		pass
Available Barium (Ba)	mg/kg	mg/kg	65	5	64	5	**1.55**		pass		pass	
Available Beryllium (Be)	mg/kg	mg/kg	ND	2	ND	2						
Available Bismuth (Bi)	mg/kg	mg/kg	ND	2	ND	2						
Available Boron (B)	mg/kg	mg/kg	ND	5	ND	5						
Available Cadmium (Cd)	mg/kg	mg/kg	ND	0.3	ND	0.3						
Available Chromium (Cr)	mg/kg	mg/kg	33	2	36	2	**8.70**		pass		pass	
Available Cobalt (Co)	mg/kg	mg/kg	16	1	15	1	**6.45**		pass		pass	
Available Copper (Cu)	mg/kg	mg/kg	17	2	18	2	**5.71**		pass		pass	
Available Iron (Fe)	mg/kg	mg/kg	35000	50	35000	50	**0.00**		pass		pass	
Available Lead (Pb)	mg/kg	mg/kg	13	0.5	13	0.5	**0.00**		pass		pass	
Available Lithium (Li)	mg/kg	mg/kg	16	2	16	2	**0.00**		pass		pass	
Available Manganese (Mn)	mg/kg	mg/kg	340	2	330	2	**2.99**		pass		pass	
Available Molybdenum (Mo)	mg/kg	mg/kg	ND	2	ND	2						
Available Nickel (Ni)	mg/kg	mg/kg	31	2	31	2	**0.00**		pass		pass	
Available Rubidium (Rb)	mg/kg	mg/kg	9	2	9	2		0		pass		pass
Available Selenium (Se)	mg/kg	mg/kg	ND	2	ND	2						
Available Silver (Ag)	mg/kg	mg/kg	ND	0.5	ND	0.5						
Available Strontium (Sr)	mg/kg	mg/kg	6	5	6	5		0		pass		pass
Available Thallium (Tl)	mg/kg	mg/kg	ND	0.1	ND	0.1						
Available Tin (Sn)	mg/kg	mg/kg	ND	2	ND	2						
Available Uranium (U)	mg/kg	mg/kg	0.7	0.1	0.7	0.1	**0.00**		pass		pass	
Available Vanadium (V)	mg/kg	mg/kg	59	2	60	2	**1.68**		pass		pass	
Available Zinc (Zn)	mg/kg	mg/kg	61	5	60	5	**1.65**		pass		pass	

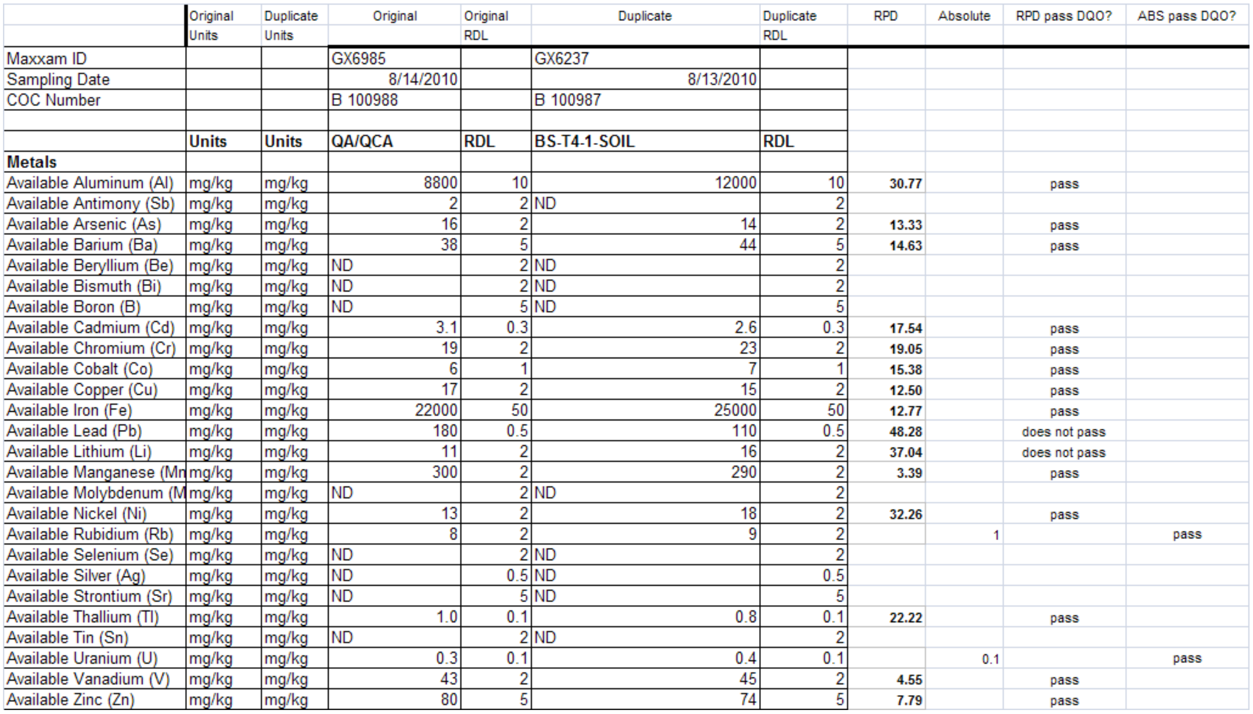
Maxxam ID			DQ4359		DQ4359							
Sampling Date			7/1/2009		7/1/2009							
COC Number			B 65302		B 65302							
									Estimate		Rejection	
	Units	**Units**	**R8A**	**RDL**	**R8A Lab-Dup**	**RDL**	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD pass DQO?	ABS pass DQO?
Charge/Prep Analysis												
Dry Mass to Volume Ratio	N/A	N/A	0.048611111	N/A		N/A						
Inorganics												
Organic Carbon (TOC)	g/kg	g/kg	230	2	250	2	**8.33**		pass		pass	
Soluble (5:1) pH	pH	pH	6.17	N/A		N/A						



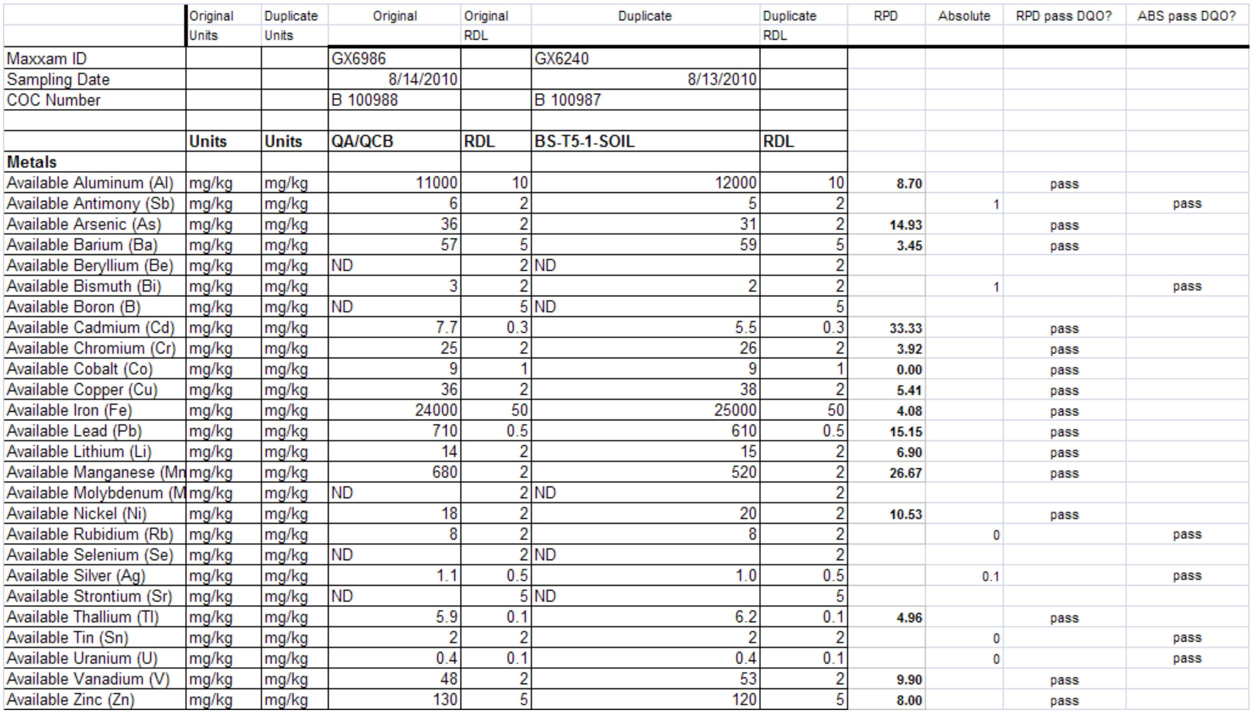
Maxxam ID			DQ4362		DQ4362							
Sampling Date			7/1/2009		7/1/2009							
COC Number			B 65302		B 65302							
									Estimate		Rejection	
	Units	**Units**	**R13**	**RDL**	**R13 Lab-Dup**	**RDL**	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD pass DQO?	ABS pass DQO?
Charge/Prep Analysis												
Dry Mass to Volume Ratio	N/A	N/A	0.045138889	N/A		N/A						
Inorganics												
Organic Carbon (TOC)	g/kg	g/kg	50	0.3	46	0.3	**8.33**		pass		pass	
Soluble (5:1) pH	pH	pH	4.53	N/A		N/A						



	Original Units	Duplicate Units	Original	Original RDL	Duplicate	Duplicate RDL	RPD	Absolute	RPD pass DQO?	ABS pass DQO?
Maxxam ID			GX6241		GX6241					
Sampling Date			8/12/2010		8/12/2010					
COC Number			B 100987		B 100987					
	Units	**Units**	**BS-T5-2-SOIL**	**RDL**	**BS-T5-2-SOIL Lab-Dup**	**RDL**				
Metals										
Available Aluminum (Al)	mg/kg	mg/kg	4600	10	4400	10	**4.44**		pass	
Available Antimony (Sb)	mg/kg	mg/kg	8	2	8	2		0		pass
Available Arsenic (As)	mg/kg	mg/kg	40	2	34	2	**16.22**		pass	
Available Barium (Ba)	mg/kg	mg/kg	29	5	29	5	**0.00**		pass	
Available Beryllium (Be)	mg/kg	mg/kg	ND	2	ND	2				
Available Bismuth (Bi)	mg/kg	mg/kg	5	2	5	2		0		pass
Available Boron (B)	mg/kg	mg/kg	ND	5	ND	5				
Available Cadmium (Cd)	mg/kg	mg/kg	8.9	0.3	8.1	0.3	**9.41**		pass	
Available Chromium (Cr)	mg/kg	mg/kg	11	2	12	2	**8.70**		pass	
Available Cobalt (Co)	mg/kg	mg/kg	3	1	3	1		0		pass
Available Copper (Cu)	mg/kg	mg/kg	43	2	44	2	**2.30**		pass	
Available Iron (Fe)	mg/kg	mg/kg	17000	50	16000	50	**6.06**		pass	
Available Lead (Pb)	mg/kg	mg/kg	1100	0.5	1000	0.5	**9.52**		pass	
Available Lithium (Li)	mg/kg	mg/kg	3	2	3	2		0		pass
Available Manganese (Mn	mg/kg	mg/kg	100	2	100	2	**0.00**		pass	
Available Molybdenum (M	mg/kg	mg/kg	ND	2	ND	2				
Available Nickel (Ni)	mg/kg	mg/kg	6	2	6	2		0		pass
Available Rubidium (Rb)	mg/kg	mg/kg	7	2	6	2		1		pass
Available Selenium (Se)	mg/kg	mg/kg	ND	2	ND	2				
Available Silver (Ag)	mg/kg	mg/kg	1.9	0.5	1.7	0.5		0.2		pass
Available Strontium (Sr)	mg/kg	mg/kg	ND	5	ND	5				
Available Thallium (Tl)	mg/kg	mg/kg	6.0	0.1	5.7	0.1	**5.13**		pass	
Available Tin (Sn)	mg/kg	mg/kg	3	2	3	2		0		pass
Available Uranium (U)	mg/kg	mg/kg	0.4	0.1	0.4	0.1		0		pass
Available Vanadium (V)	mg/kg	mg/kg	41	2	41	2	**0.00**		pass	
Available Zinc (Zn)	mg/kg	mg/kg	130	5	120	5	**8.00**		pass	



	Original Units	Duplicate Units	Original	Original RDL	Duplicate	Duplicate RDL	RPD	Absolute	RPD pass DQO?	ABS pass DQO?
Maxxam ID			GX6985		GX6237					
Sampling Date			8/14/2010		8/13/2010					
COC Number			B 100988		B 100987					
	Units	**Units**	**QA/QCA**	**RDL**	**BS-T4-1-SOIL**	**RDL**				
Metals										
Available Aluminum (Al)	mg/kg	mg/kg	8800	10	12000	10	30.77		pass	
Available Antimony (Sb)	mg/kg	mg/kg	2	2	ND	2				
Available Arsenic (As)	mg/kg	mg/kg	16	2	14	2	13.33		pass	
Available Barium (Ba)	mg/kg	mg/kg	38	5	44	5	14.63		pass	
Available Beryllium (Be)	mg/kg	mg/kg	ND	2	ND	2				
Available Bismuth (Bi)	mg/kg	mg/kg	ND	2	ND	2				
Available Boron (B)	mg/kg	mg/kg	ND	5	ND	5				
Available Cadmium (Cd)	mg/kg	mg/kg	3.1	0.3	2.6	0.3	17.54		pass	
Available Chromium (Cr)	mg/kg	mg/kg	19	2	23	2	19.05		pass	
Available Cobalt (Co)	mg/kg	mg/kg	6	1	7	1	15.38		pass	
Available Copper (Cu)	mg/kg	mg/kg	17	2	15	2	12.50		pass	
Available Iron (Fe)	mg/kg	mg/kg	22000	50	25000	50	12.77		pass	
Available Lead (Pb)	mg/kg	mg/kg	180	0.5	110	0.5	48.28		does not pass	
Available Lithium (Li)	mg/kg	mg/kg	11	2	16	2	37.04		does not pass	
Available Manganese (Mn	mg/kg	mg/kg	300	2	290	2	3.39		pass	
Available Molybdenum (M	mg/kg	mg/kg	ND	2	ND	2				
Available Nickel (Ni)	mg/kg	mg/kg	13	2	18	2	32.26		pass	
Available Rubidium (Rb)	mg/kg	mg/kg	8	2	9	2		1		pass
Available Selenium (Se)	mg/kg	mg/kg	ND	2	ND	2				
Available Silver (Ag)	mg/kg	mg/kg	ND	0.5	ND	0.5				
Available Strontium (Sr)	mg/kg	mg/kg	ND	5	ND	5				
Available Thallium (Tl)	mg/kg	mg/kg	1.0	0.1	0.8	0.1	22.22		pass	
Available Tin (Sn)	mg/kg	mg/kg	ND	2	ND	2				
Available Uranium (U)	mg/kg	mg/kg	0.3	0.1	0.4	0.1		0.1		pass
Available Vanadium (V)	mg/kg	mg/kg	43	2	45	2	4.55		pass	
Available Zinc (Zn)	mg/kg	mg/kg	80	5	74	5	7.79		pass	

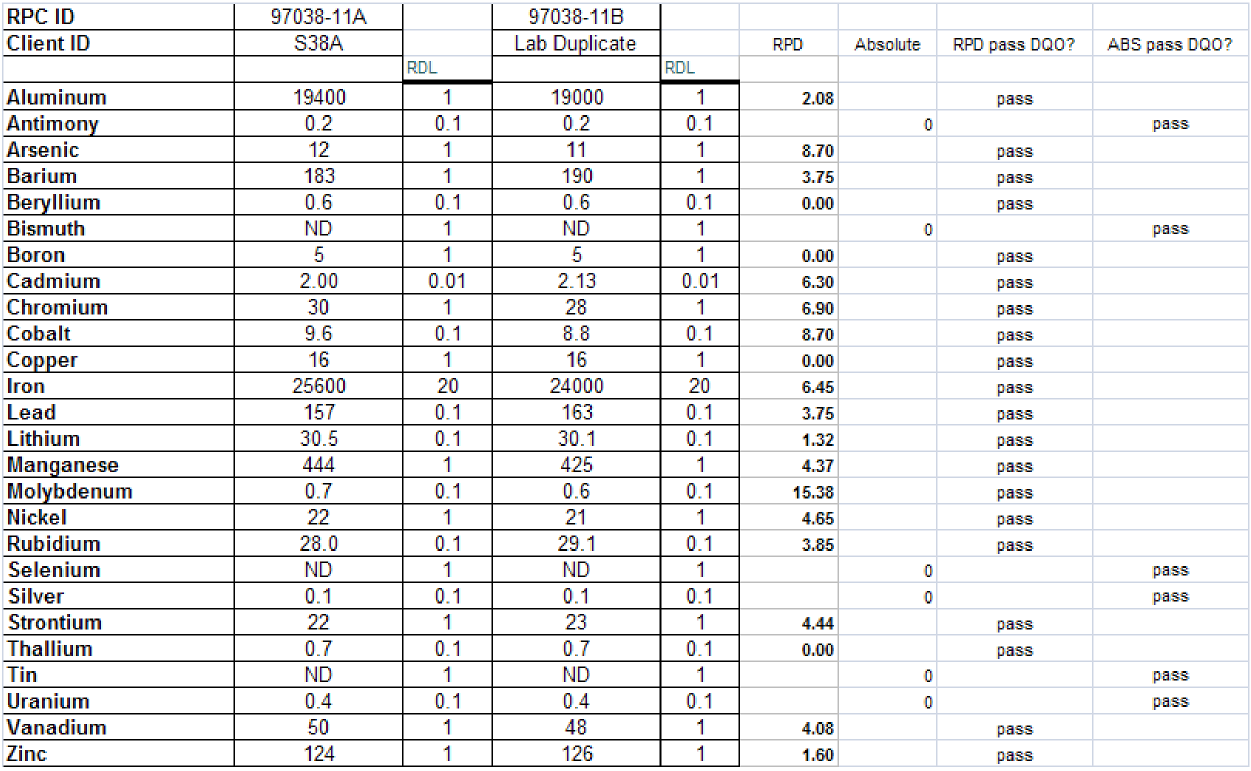


	Original Units	Duplicate Units	Original	Original RDL	Duplicate	Duplicate RDL	RPD	Absolute	RPD pass DQO?	ABS pass DQO?
Maxxam ID			GX6986		GX6240					
Sampling Date			8/14/2010		8/13/2010					
COC Number			B 100988		B 100987					
	Units	**Units**	**QA/QCB**	**RDL**	**BS-T5-1-SOIL**	**RDL**				
Metals										
Available Aluminum (Al)	mg/kg	mg/kg	11000	10	12000	10	8.70		pass	
Available Antimony (Sb)	mg/kg	mg/kg	6	2	5	2		1		pass
Available Arsenic (As)	mg/kg	mg/kg	36	2	31	2	14.93		pass	
Available Barium (Ba)	mg/kg	mg/kg	57	5	59	5	3.45		pass	
Available Beryllium (Be)	mg/kg	mg/kg	ND	2	ND	2				
Available Bismuth (Bi)	mg/kg	mg/kg	3	2	2	2		1		pass
Available Boron (B)	mg/kg	mg/kg	ND	5	ND	5				
Available Cadmium (Cd)	mg/kg	mg/kg	7.7	0.3	5.5	0.3	33.33		pass	
Available Chromium (Cr)	mg/kg	mg/kg	25	2	26	2	3.92		pass	
Available Cobalt (Co)	mg/kg	mg/kg	9	1	9	1	0.00		pass	
Available Copper (Cu)	mg/kg	mg/kg	36	2	38	2	5.41		pass	
Available Iron (Fe)	mg/kg	mg/kg	24000	50	25000	50	4.08		pass	
Available Lead (Pb)	mg/kg	mg/kg	710	0.5	610	0.5	15.15		pass	
Available Lithium (Li)	mg/kg	mg/kg	14	2	15	2	6.90		pass	
Available Manganese (Mn	mg/kg	mg/kg	680	2	520	2	26.67		pass	
Available Molybdenum (M	mg/kg	mg/kg	ND	2	ND	2				
Available Nickel (Ni)	mg/kg	mg/kg	18	2	20	2	10.53		pass	
Available Rubidium (Rb)	mg/kg	mg/kg	8	2	8	2		0		pass
Available Selenium (Se)	mg/kg	mg/kg	ND	2	ND	2				
Available Silver (Ag)	mg/kg	mg/kg	1.1	0.5	1.0	0.5		0.1		pass
Available Strontium (Sr)	mg/kg	mg/kg	ND	5	ND	5				
Available Thallium (Tl)	mg/kg	mg/kg	5.9	0.1	6.2	0.1	4.96		pass	
Available Tin (Sn)	mg/kg	mg/kg	2	2	2	2		0		pass
Available Uranium (U)	mg/kg	mg/kg	0.4	0.1	0.4	0.1		0		pass
Available Vanadium (V)	mg/kg	mg/kg	48	2	53	2	9.90		pass	
Available Zinc (Zn)	mg/kg	mg/kg	130	5	120	5	8.00		pass	

E-1-2.0 SECONDARY LABORATORY (RPC) RPD / ABD CALCULATIONS

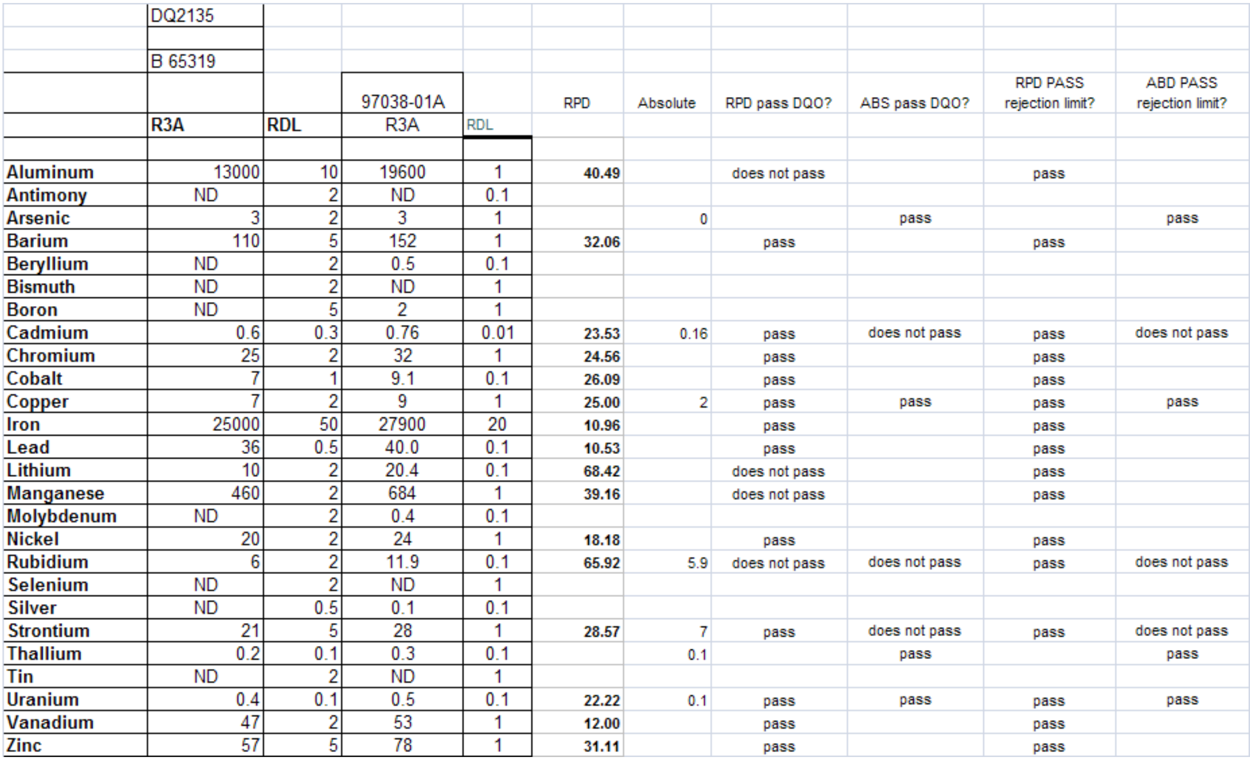
RPC ID	97038-01A		97038-01B					
Client ID	R3A	RDL	Lab Duplicate	RDL	RPD	Absolute	RPD pass DQO?	ABS pass DQO?
Aluminum	19600	1	18200	1	7.41		pass	
Antimony	ND	0.1	ND	0.1		0		pass
Arsenic	3	1	3	1		0		pass
Barium	152	1	146	1	4.03		pass	
Beryllium	0.5	0.1	0.5	0.1	0.00		pass	
Bismuth	ND	1	ND	1		0		pass
Boron	2	1	3	1		1		pass
Cadmium	0.76	0.01	0.76	0.01	0.00		pass	
Chromium	32	1	29	1	9.84		pass	
Cobalt	9.1	0.1	8.0	0.1	12.87		pass	
Copper	9	1	9	1	0.00		pass	
Iron	27900	20	24500	20	12.98		pass	
Lead	40.0	0.1	39.9	0.1	0.25		pass	
Lithium	20.4	0.1	18.5	0.1	9.77		pass	
Manganese	684	1	592	1	14.42		pass	
Molybdenum	0.4	0.1	0.4	0.1		0		pass
Nickel	24	1	24	1	0.00		pass	
Rubidium	11.9	0.1	11.5	0.1	3.42		pass	
Selenium	ND	1	ND	1		0		pass
Silver	0.1	0.1	ND	0.1		0		pass
Strontium	28	1	29	1	3.51		pass	
Thallium	0.3	0.1	0.3	0.1		0		pass
Tin	ND	1	ND	1		0		pass
Uranium	0.5	0.1	0.5	0.1	0.00		pass	
Vanadium	53	1	48	1	9.90		pass	
Zinc	78	1	74	1	5.26		pass	

RPC ID	97038-06A		97038-06B					
Client ID	S19A	RDL	Lab Duplicate	RDL	RPD	Absolute	RPD pass DQO?	ABS pass DQO?
Aluminum	19400	1	19800	1	2.04		pass	
Antimony	0.5	0.1	0.5	0.1	0.00		pass	
Arsenic	23	1	24	1	4.26		pass	
Barium	93	1	94	1	1.07		pass	
Beryllium	0.7	0.1	0.7	0.1	0.00		pass	
Bismuth	ND	1	ND	1		0		pass
Boron	3	1	3	1		0		pass
Cadmium	2.75	0.01	3.16	0.01	13.87		pass	
Chromium	31	1	31	1	0.00		pass	
Cobalt	14.4	0.1	12.7	0.1	12.55		pass	
Copper	38	1	38	1	0.00		pass	
Iron	33100	20	32300	20	2.45		pass	
Lead	394	0.1	422	0.1	6.86		pass	
Lithium	26.2	0.1	25.3	0.1	3.50		pass	
Manganese	831	1	687	1	18.97		pass	
Molybdenum	0.4	0.1	0.5	0.1	22.22	0.1	pass	pass
Nickel	36	1	33	1	8.70		pass	
Rubidium	18.9	0.1	20.4	0.1	7.63		pass	
Selenium	ND	1	ND	1		0		pass
Silver	0.7	0.1	0.7	0.1	0.00		pass	
Strontium	9	1	9	1	0.00		pass	
Thallium	1.0	0.1	1.1	0.1	9.52		pass	
Tin	ND	1	ND	1		0		pass
Uranium	0.6	0.1	0.6	0.1	0.00		pass	
Vanadium	53	1	53	1	0.00		pass	
Zinc	427	1	500	1	15.75		pass	

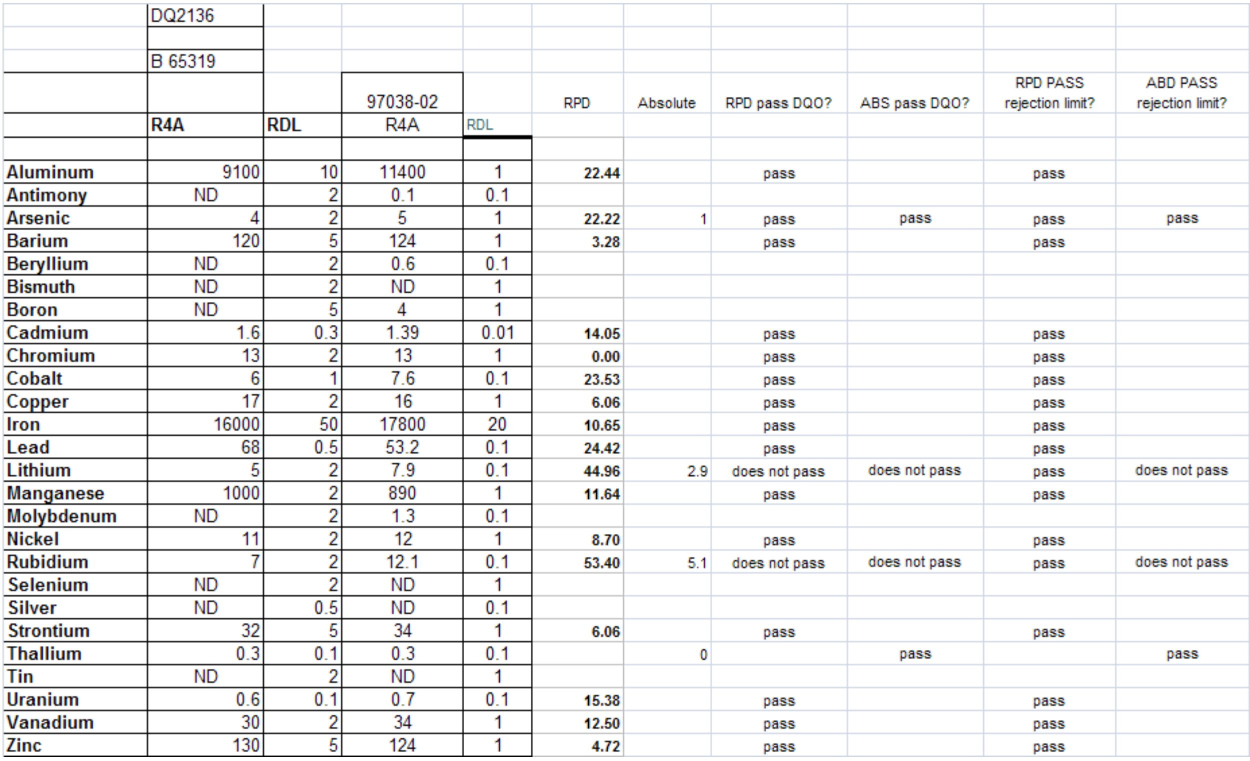


RPC ID	97038-11A		97038-11B					
Client ID	S38A		Lab Duplicate		RPD	Absolute	RPD pass DQO?	ABS pass DQO?
		RDL		RDL				
Aluminum	19400	1	19000	1	2.08		pass	
Antimony	0.2	0.1	0.2	0.1		0		pass
Arsenic	12	1	11	1	8.70		pass	
Barium	183	1	190	1	3.75		pass	
Beryllium	0.6	0.1	0.6	0.1	0.00		pass	
Bismuth	ND	1	ND	1		0		pass
Boron	5	1	5	1	0.00		pass	
Cadmium	2.00	0.01	2.13	0.01	6.30		pass	
Chromium	30	1	28	1	6.90		pass	
Cobalt	9.6	0.1	8.8	0.1	8.70		pass	
Copper	16	1	16	1	0.00		pass	
Iron	25600	20	24000	20	6.45		pass	
Lead	157	0.1	163	0.1	3.75		pass	
Lithium	30.5	0.1	30.1	0.1	1.32		pass	
Manganese	444	1	425	1	4.37		pass	
Molybdenum	0.7	0.1	0.6	0.1	15.38		pass	
Nickel	22	1	21	1	4.65		pass	
Rubidium	28.0	0.1	29.1	0.1	3.85		pass	
Selenium	ND	1	ND	1		0		pass
Silver	0.1	0.1	0.1	0.1		0		pass
Strontium	22	1	23	1	4.44		pass	
Thallium	0.7	0.1	0.7	0.1	0.00		pass	
Tin	ND	1	ND	1		0		pass
Uranium	0.4	0.1	0.4	0.1		0		pass
Vanadium	50	1	48	1	4.08		pass	
Zinc	124	1	126	1	1.60		pass	

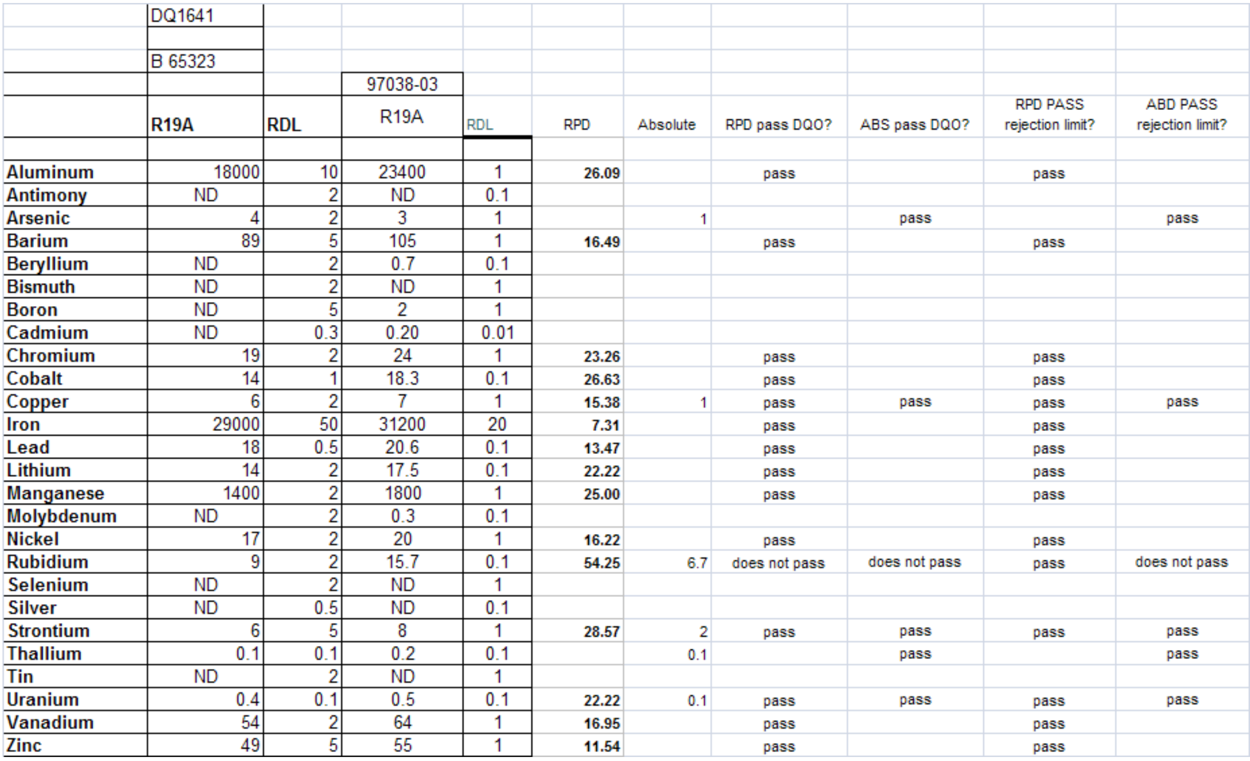
E-1-3.0 INTER-LABORATORY DUPLICATE CALCULATIONS



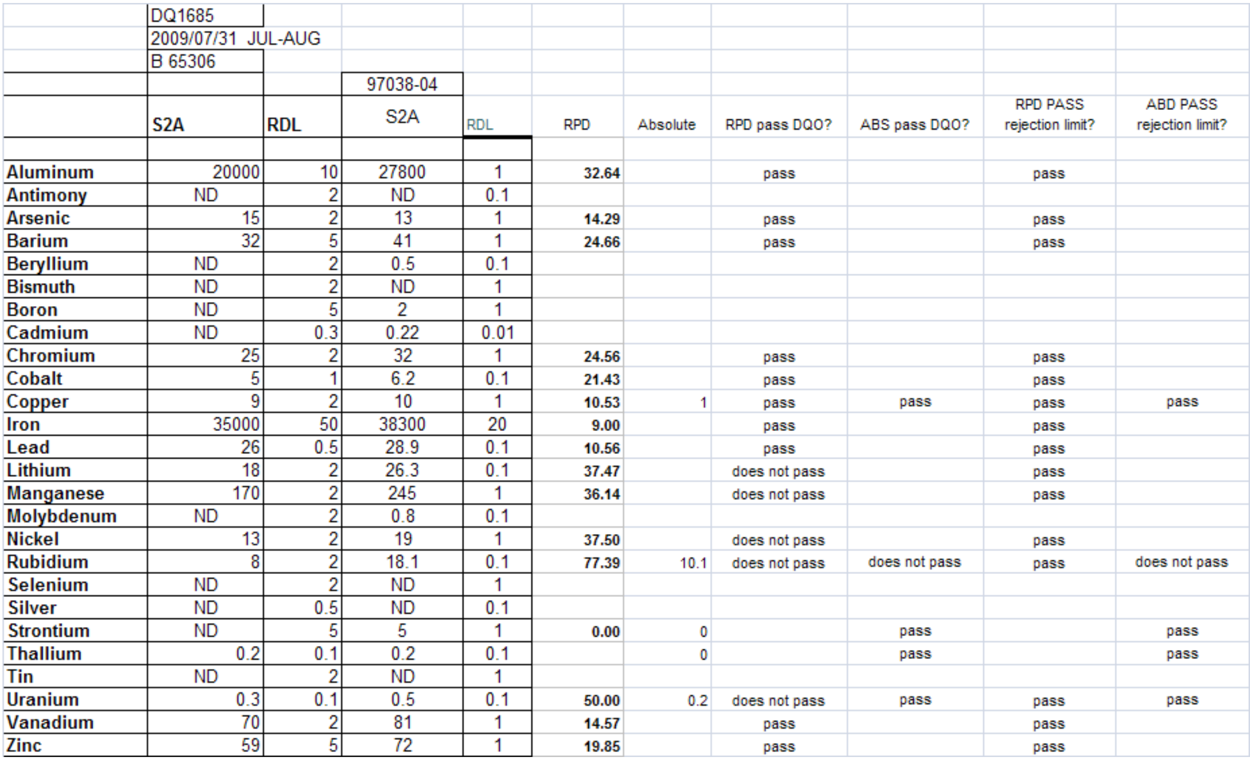
	DQ2135									
	B 65319									
			97038-01A		RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD PASS rejection limit?	ABD PASS rejection limit?
	R3A	**RDL**	R3A	RDL						
Aluminum	13000	10	19600	1	**40.49**		does not pass		pass	
Antimony	ND	2	ND	0.1						
Arsenic	3	2	3	1		0		pass		pass
Barium	110	5	152	1	**32.06**		pass		pass	
Beryllium	ND	2	0.5	0.1						
Bismuth	ND	2	ND	1						
Boron	ND	5	2	1						
Cadmium	0.6	0.3	0.76	0.01	**23.53**	0.16	pass	does not pass	pass	does not pass
Chromium	25	2	32	1	**24.56**		pass		pass	
Cobalt	7	1	9.1	0.1	**26.09**		pass		pass	
Copper	7	2	9	1	**25.00**	2	pass	pass	pass	pass
Iron	25000	50	27900	20	**10.96**		pass		pass	
Lead	36	0.5	40.0	0.1	**10.53**		pass		pass	
Lithium	10	2	20.4	0.1	**68.42**		does not pass		pass	
Manganese	460	2	684	1	**39.16**		does not pass		pass	
Molybdenum	ND	2	0.4	0.1						
Nickel	20	2	24	1	**18.18**		pass		pass	
Rubidium	6	2	11.9	0.1	**65.92**	5.9	does not pass	does not pass	pass	does not pass
Selenium	ND	2	ND	1						
Silver	ND	0.5	0.1	0.1						
Strontium	21	5	28	1	**28.57**	7	pass	does not pass	pass	does not pass
Thallium	0.2	0.1	0.3	0.1		0.1		pass		pass
Tin	ND	2	ND	1						
Uranium	0.4	0.1	0.5	0.1	**22.22**	0.1	pass	pass	pass	pass
Vanadium	47	2	53	1	**12.00**		pass		pass	
Zinc	57	5	78	1	**31.11**		pass		pass	



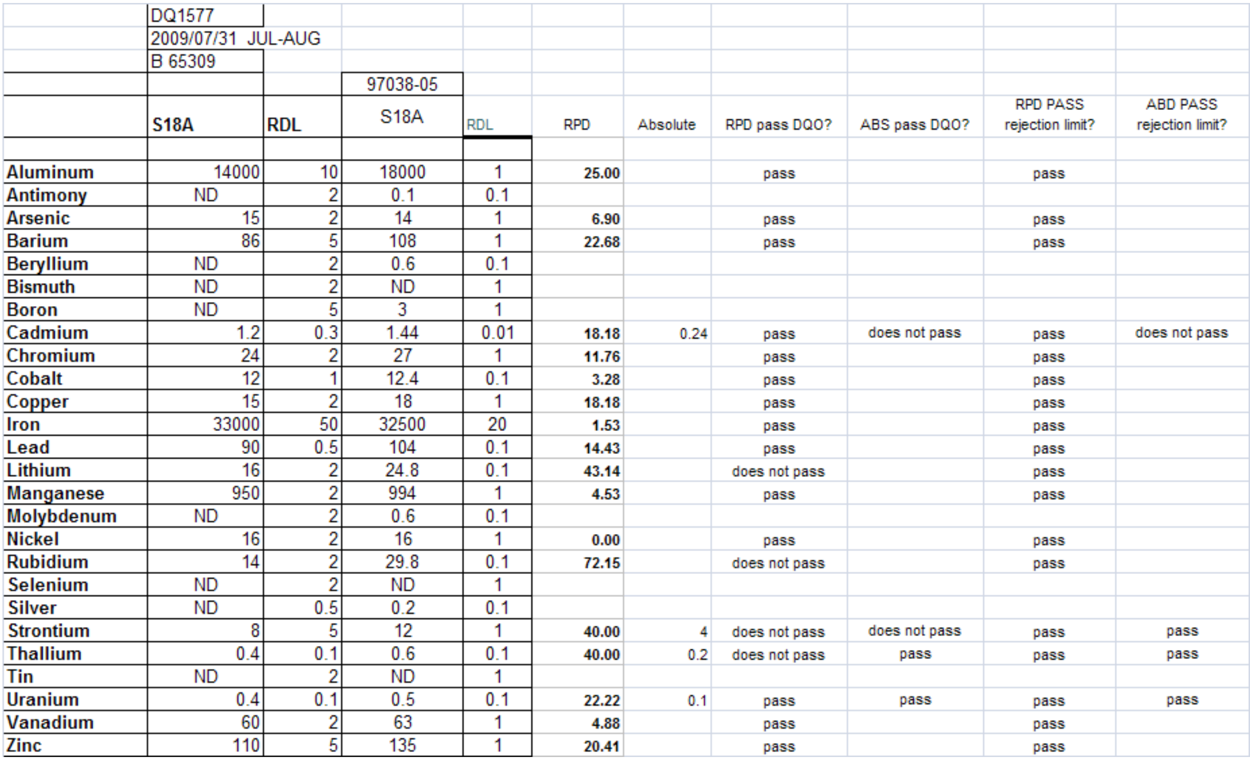
	DQ2136									
	B 65319									
			97038-02		RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD PASS rejection limit?	ABD PASS rejection limit?
	R4A	**RDL**	R4A	RDL						
Aluminum	9100	10	11400	1	**22.44**		pass		pass	
Antimony	ND	2	0.1	0.1						
Arsenic	4	2	5	1	**22.22**	1	pass	pass	pass	pass
Barium	120	5	124	1	**3.28**		pass		pass	
Beryllium	ND	2	0.6	0.1						
Bismuth	ND	2	ND	1						
Boron	ND	5	4	1						
Cadmium	1.6	0.3	1.39	0.01	**14.05**		pass		pass	
Chromium	13	2	13	1	**0.00**		pass		pass	
Cobalt	6	1	7.6	0.1	**23.53**		pass		pass	
Copper	17	2	16	1	**6.06**		pass		pass	
Iron	16000	50	17800	20	**10.65**		pass		pass	
Lead	68	0.5	53.2	0.1	**24.42**		pass		pass	
Lithium	5	2	7.9	0.1	**44.96**	2.9	does not pass	does not pass	pass	does not pass
Manganese	1000	2	890	1	**11.64**		pass		pass	
Molybdenum	ND	2	1.3	0.1						
Nickel	11	2	12	1	**8.70**		pass		pass	
Rubidium	7	2	12.1	0.1	**53.40**	5.1	does not pass	does not pass	pass	does not pass
Selenium	ND	2	ND	1						
Silver	ND	0.5	ND	0.1						
Strontium	32	5	34	1	**6.06**		pass		pass	
Thallium	0.3	0.1	0.3	0.1		0		pass		pass
Tin	ND	2	ND	1						
Uranium	0.6	0.1	0.7	0.1	**15.38**		pass		pass	
Vanadium	30	2	34	1	**12.50**		pass		pass	
Zinc	130	5	124	1	**4.72**		pass		pass	



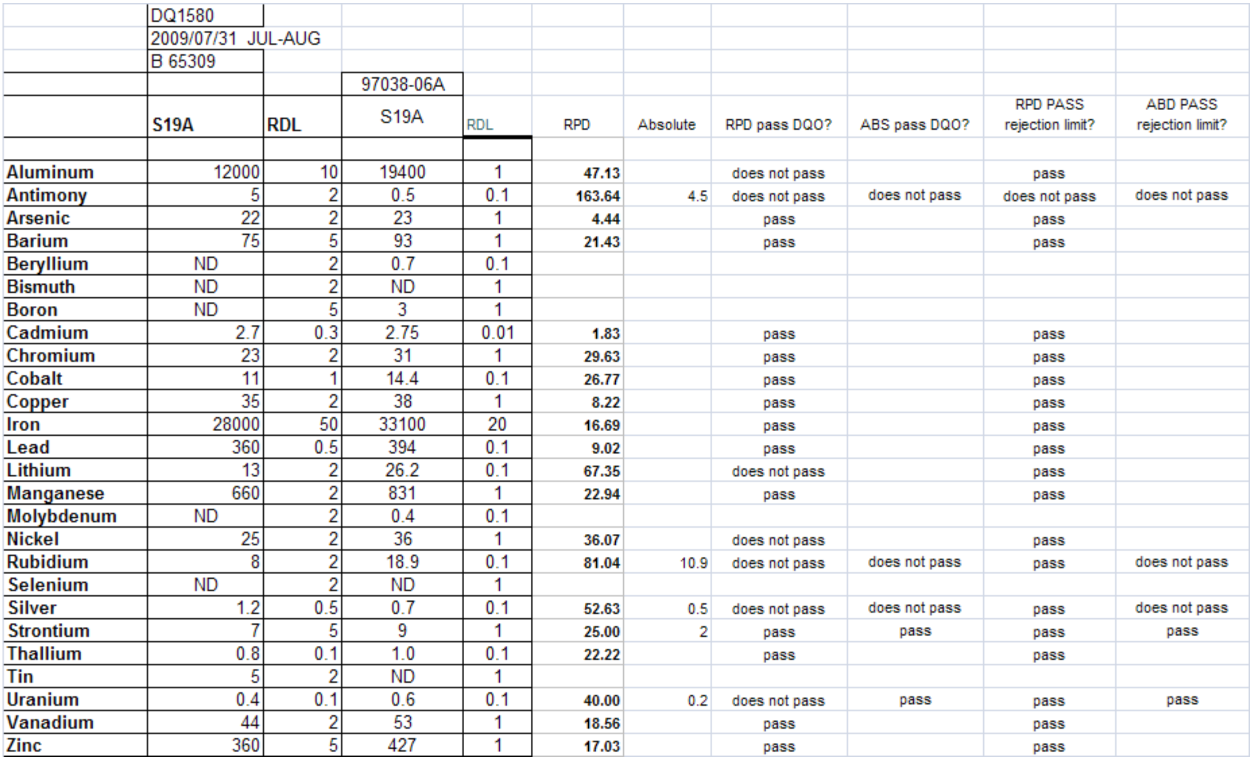
	DQ1641									
	B 65323									
			97038-03							
	R19A	RDL	R19A	RDL	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD PASS rejection limit?	ABD PASS rejection limit?
Aluminum	18000	10	23400	1	26.09		pass		pass	
Antimony	ND	2	ND	0.1						
Arsenic	4	2	3	1		1		pass		pass
Barium	89	5	105	1	16.49		pass		pass	
Beryllium	ND	2	0.7	0.1						
Bismuth	ND	2	ND	1						
Boron	ND	5	2	1						
Cadmium	ND	0.3	0.20	0.01						
Chromium	19	2	24	1	23.26		pass		pass	
Cobalt	14	1	18.3	0.1	26.63		pass		pass	
Copper	6	2	7	1	15.38	1	pass	pass	pass	pass
Iron	29000	50	31200	20	7.31		pass		pass	
Lead	18	0.5	20.6	0.1	13.47		pass		pass	
Lithium	14	2	17.5	0.1	22.22		pass		pass	
Manganese	1400	2	1800	1	25.00		pass		pass	
Molybdenum	ND	2	0.3	0.1						
Nickel	17	2	20	1	16.22		pass		pass	
Rubidium	9	2	15.7	0.1	54.25	6.7	does not pass	does not pass	pass	does not pass
Selenium	ND	2	ND	1						
Silver	ND	0.5	ND	0.1						
Strontium	6	5	8	1	28.57	2	pass	pass	pass	pass
Thallium	0.1	0.1	0.2	0.1		0.1		pass		pass
Tin	ND	2	ND	1						
Uranium	0.4	0.1	0.5	0.1	22.22	0.1	pass	pass	pass	pass
Vanadium	54	2	64	1	16.95		pass		pass	
Zinc	49	5	55	1	11.54		pass		pass	



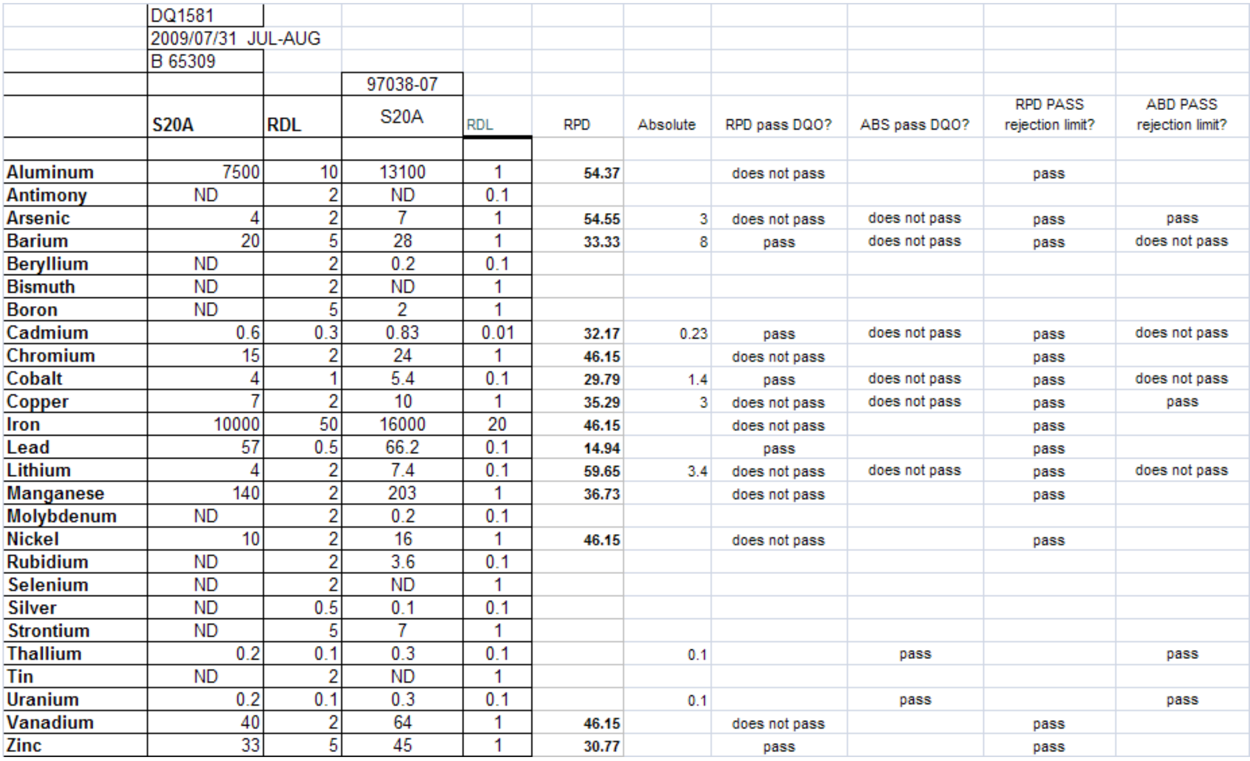
	DQ1685									
	2009/07/31 JUL-AUG									
	B 65306									
			97038-04							
	S2A	RDL	S2A	RDL	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD PASS rejection limit?	ABD PASS rejection limit?
Aluminum	20000	10	27800	1	32.64		pass		pass	
Antimony	ND	2	ND	0.1						
Arsenic	15	2	13	1	14.29		pass		pass	
Barium	32	5	41	1	24.66		pass		pass	
Beryllium	ND	2	0.5	0.1						
Bismuth	ND	2	ND	1						
Boron	ND	5	2	1						
Cadmium	ND	0.3	0.22	0.01						
Chromium	25	2	32	1	24.56		pass		pass	
Cobalt	5	1	6.2	0.1	21.43		pass		pass	
Copper	9	2	10	1	10.53	1	pass	pass	pass	pass
Iron	35000	50	38300	20	9.00		pass		pass	
Lead	26	0.5	28.9	0.1	10.56		pass		pass	
Lithium	18	2	26.3	0.1	37.47		does not pass		pass	
Manganese	170	2	245	1	36.14		does not pass		pass	
Molybdenum	ND	2	0.8	0.1						
Nickel	13	2	19	1	37.50		does not pass		pass	
Rubidium	8	2	18.1	0.1	77.39	10.1	does not pass	does not pass	pass	does not pass
Selenium	ND	2	ND	1						
Silver	ND	0.5	ND	0.1						
Strontium	ND	5	5	1	0.00	0		pass		pass
Thallium	0.2	0.1	0.2	0.1		0		pass		pass
Tin	ND	2	ND	1						
Uranium	0.3	0.1	0.5	0.1	50.00	0.2	does not pass	pass	pass	pass
Vanadium	70	2	81	1	14.57		pass		pass	
Zinc	59	5	72	1	19.85		pass		pass	



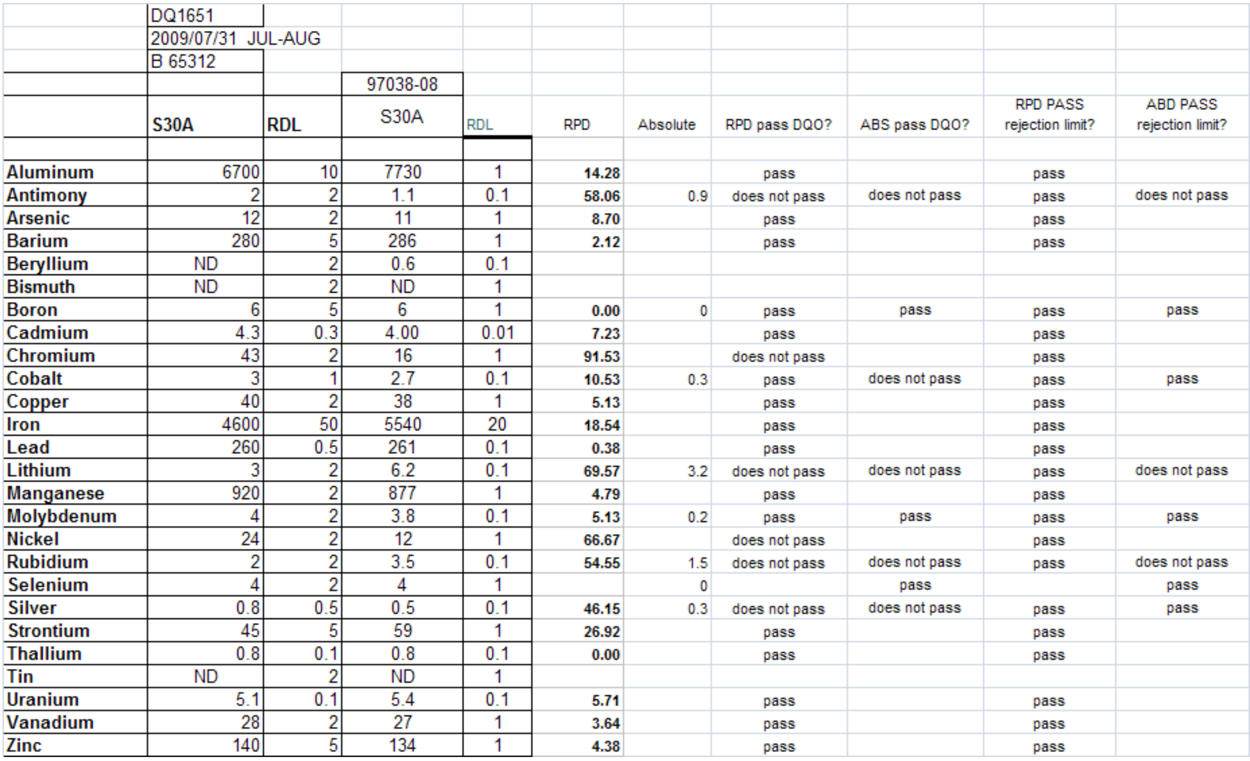
	DQ1577									
	2009/07/31 JUL-AUG									
	B 65309									
			97038-05							
	S18A	**RDL**	S18A	RDL	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD PASS rejection limit?	ABD PASS rejection limit?
Aluminum	14000	10	18000	1	**25.00**		pass		pass	
Antimony	ND	2	0.1	0.1						
Arsenic	15	2	14	1	**6.90**		pass		pass	
Barium	86	5	108	1	**22.68**		pass		pass	
Beryllium	ND	2	0.6	0.1						
Bismuth	ND	2	ND	1						
Boron	ND	5	3	1						
Cadmium	1.2	0.3	1.44	0.01	**18.18**	0.24	pass	does not pass	pass	does not pass
Chromium	24	2	27	1	**11.76**		pass		pass	
Cobalt	12	1	12.4	0.1	**3.28**		pass		pass	
Copper	15	2	18	1	**18.18**		pass		pass	
Iron	33000	50	32500	20	**1.53**		pass		pass	
Lead	90	0.5	104	0.1	**14.43**		pass		pass	
Lithium	16	2	24.8	0.1	**43.14**		does not pass		pass	
Manganese	950	2	994	1	**4.53**		pass		pass	
Molybdenum	ND	2	0.6	0.1						
Nickel	16	2	16	1	**0.00**		pass		pass	
Rubidium	14	2	29.8	0.1	**72.15**		does not pass		pass	
Selenium	ND	2	ND	1						
Silver	ND	0.5	0.2	0.1						
Strontium	8	5	12	1	**40.00**	4	does not pass	does not pass	pass	pass
Thallium	0.4	0.1	0.6	0.1	**40.00**	0.2	does not pass	pass	pass	pass
Tin	ND	2	ND	1						
Uranium	0.4	0.1	0.5	0.1	**22.22**	0.1	pass	pass	pass	pass
Vanadium	60	2	63	1	**4.88**		pass		pass	
Zinc	110	5	135	1	**20.41**		pass		pass	



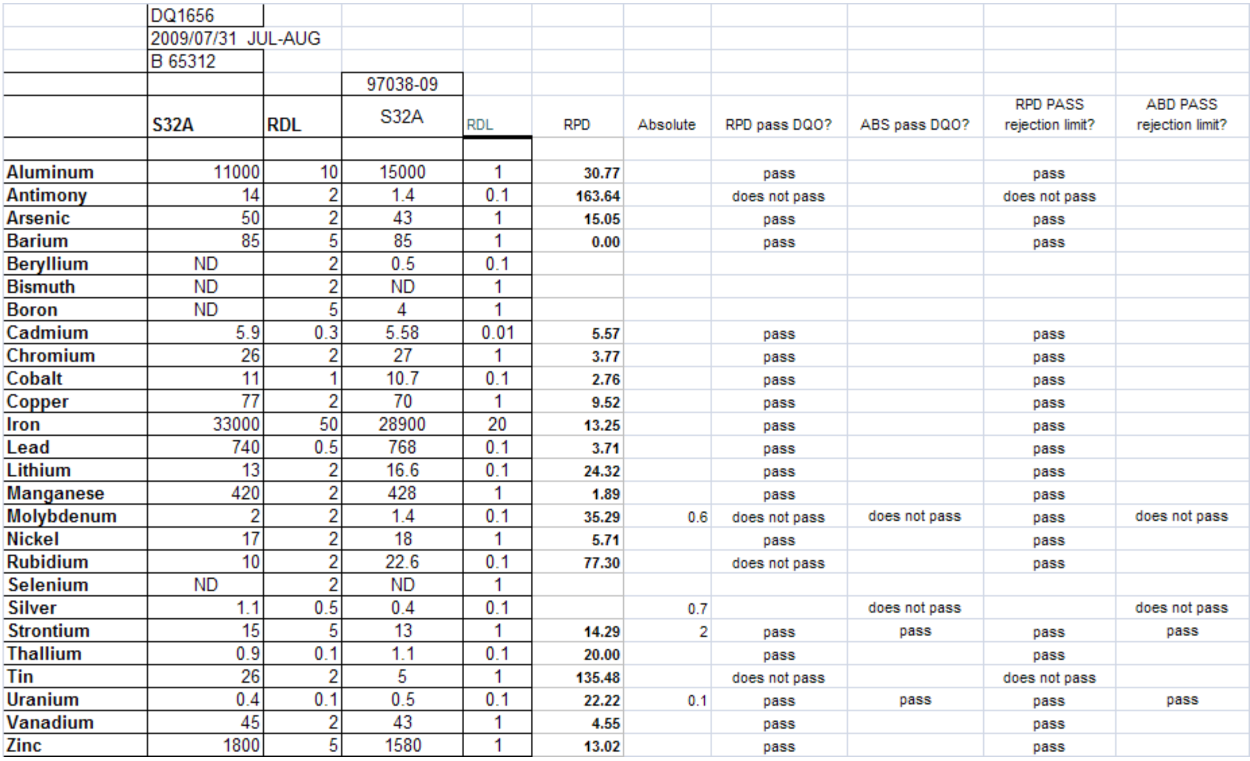
	DQ1580									
	2009/07/31 JUL-AUG									
	B 65309									
			97038-06A							
	S19A	**RDL**	S19A	RDL	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD PASS rejection limit?	ABD PASS rejection limit?
Aluminum	12000	10	19400	1	**47.13**		does not pass		pass	
Antimony	5	2	0.5	0.1	**163.64**	4.5	does not pass	does not pass	does not pass	does not pass
Arsenic	22	2	23	1	**4.44**		pass		pass	
Barium	75	5	93	1	**21.43**		pass		pass	
Beryllium	ND	2	0.7	0.1						
Bismuth	ND	2	ND	1						
Boron	ND	5	3	1						
Cadmium	2.7	0.3	2.75	0.01	**1.83**		pass		pass	
Chromium	23	2	31	1	**29.63**		pass		pass	
Cobalt	11	1	14.4	0.1	**26.77**		pass		pass	
Copper	35	2	38	1	**8.22**		pass		pass	
Iron	28000	50	33100	20	**16.69**		pass		pass	
Lead	360	0.5	394	0.1	**9.02**		pass		pass	
Lithium	13	2	26.2	0.1	**67.35**		does not pass		pass	
Manganese	660	2	831	1	**22.94**		pass		pass	
Molybdenum	ND	2	0.4	0.1						
Nickel	25	2	36	1	**36.07**		does not pass		pass	
Rubidium	8	2	18.9	0.1	**81.04**	10.9	does not pass	does not pass	pass	does not pass
Selenium	ND	2	ND	1						
Silver	1.2	0.5	0.7	0.1	**52.63**	0.5	does not pass	does not pass	pass	does not pass
Strontium	7	5	9	1	**25.00**	2	pass	pass	pass	pass
Thallium	0.8	0.1	1.0	0.1	**22.22**		pass		pass	
Tin	5	2	ND	1						
Uranium	0.4	0.1	0.6	0.1	**40.00**	0.2	does not pass	pass	pass	pass
Vanadium	44	2	53	1	**18.56**		pass		pass	
Zinc	360	5	427	1	**17.03**		pass		pass	



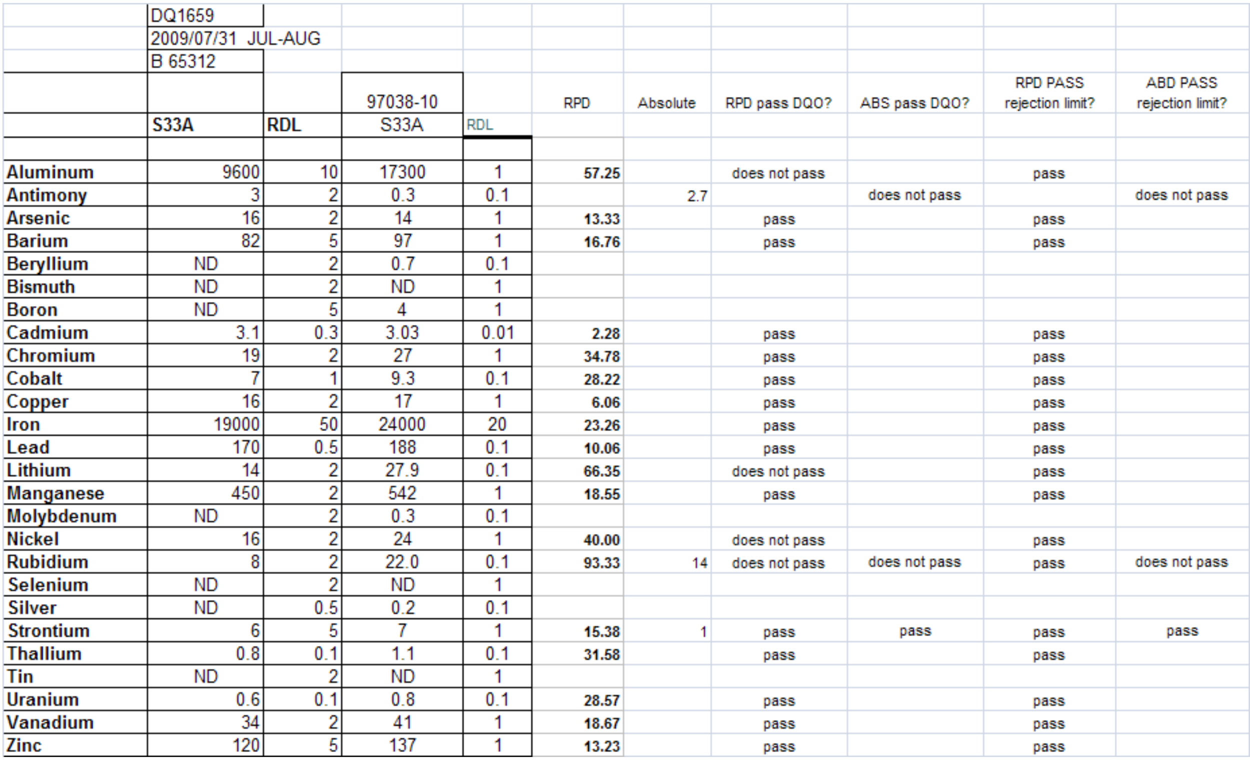
	DQ1581									
	2009/07/31 JUL-AUG									
	B 65309									
			97038-07							
	S20A	**RDL**	S20A	RDL	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD PASS rejection limit?	ABD PASS rejection limit?
Aluminum	7500	10	13100	1	**54.37**		does not pass		pass	
Antimony	ND	2	ND	0.1						
Arsenic	4	2	7	1	**54.55**	3	does not pass	does not pass	pass	pass
Barium	20	5	28	1	**33.33**	8	pass	does not pass	pass	does not pass
Beryllium	ND	2	0.2	0.1						
Bismuth	ND	2	ND	1						
Boron	ND	5	2	1						
Cadmium	0.6	0.3	0.83	0.01	**32.17**	0.23	pass	does not pass	pass	does not pass
Chromium	15	2	24	1	**46.15**		does not pass		pass	
Cobalt	4	1	5.4	0.1	**29.79**	1.4	pass	does not pass	pass	does not pass
Copper	7	2	10	1	**35.29**	3	does not pass	does not pass	pass	pass
Iron	10000	50	16000	20	**46.15**		does not pass		pass	
Lead	57	0.5	66.2	0.1	**14.94**		pass		pass	
Lithium	4	2	7.4	0.1	**59.65**	3.4	does not pass	does not pass	pass	does not pass
Manganese	140	2	203	1	**36.73**		does not pass		pass	
Molybdenum	ND	2	0.2	0.1						
Nickel	10	2	16	1	**46.15**		does not pass		pass	
Rubidium	ND	2	3.6	0.1						
Selenium	ND	2	ND	1						
Silver	ND	0.5	0.1	0.1						
Strontium	ND	5	7	1						
Thallium	0.2	0.1	0.3	0.1		0.1		pass		pass
Tin	ND	2	ND	1						
Uranium	0.2	0.1	0.3	0.1		0.1		pass		pass
Vanadium	40	2	64	1	**46.15**		does not pass		pass	
Zinc	33	5	45	1	**30.77**		pass		pass	



	DQ1651									
	2009/07/31 JUL-AUG									
	B 65312									
			97038-08							
	S30A	**RDL**	S30A	RDL	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD PASS rejection limit?	ABD PASS rejection limit?
Aluminum	6700	10	7730	1	**14.28**		pass		pass	
Antimony	2	2	1.1	0.1	**58.06**	0.9	does not pass	does not pass	pass	does not pass
Arsenic	12	2	11	1	**8.70**		pass		pass	
Barium	280	5	286	1	**2.12**		pass		pass	
Beryllium	ND	2	0.6	0.1						
Bismuth	ND	2	ND	1						
Boron	6	5	6	1	**0.00**	0	pass	pass	pass	pass
Cadmium	4.3	0.3	4.00	0.01	**7.23**		pass		pass	
Chromium	43	2	16	1	**91.53**		does not pass		pass	
Cobalt	3	1	2.7	0.1	**10.53**	0.3	pass	does not pass	pass	pass
Copper	40	2	38	1	**5.13**		pass		pass	
Iron	4600	50	5540	20	**18.54**		pass		pass	
Lead	260	0.5	261	0.1	**0.38**		pass		pass	
Lithium	3	2	6.2	0.1	**69.57**	3.2	does not pass	does not pass	pass	does not pass
Manganese	920	2	877	1	**4.79**		pass		pass	
Molybdenum	4	2	3.8	0.1	**5.13**	0.2	pass	pass	pass	pass
Nickel	24	2	12	1	**66.67**		does not pass		pass	
Rubidium	2	2	3.5	0.1	**54.55**	1.5	does not pass	does not pass	pass	does not pass
Selenium	4	2	4	1		0		pass		pass
Silver	0.8	0.5	0.5	0.1	**46.15**	0.3	does not pass	does not pass	pass	pass
Strontium	45	5	59	1	**26.92**		pass		pass	
Thallium	0.8	0.1	0.8	0.1	**0.00**		pass		pass	
Tin	ND	2	ND	1						
Uranium	5.1	0.1	5.4	0.1	**5.71**		pass		pass	
Vanadium	28	2	27	1	**3.64**		pass		pass	
Zinc	140	5	134	1	**4.38**		pass		pass	



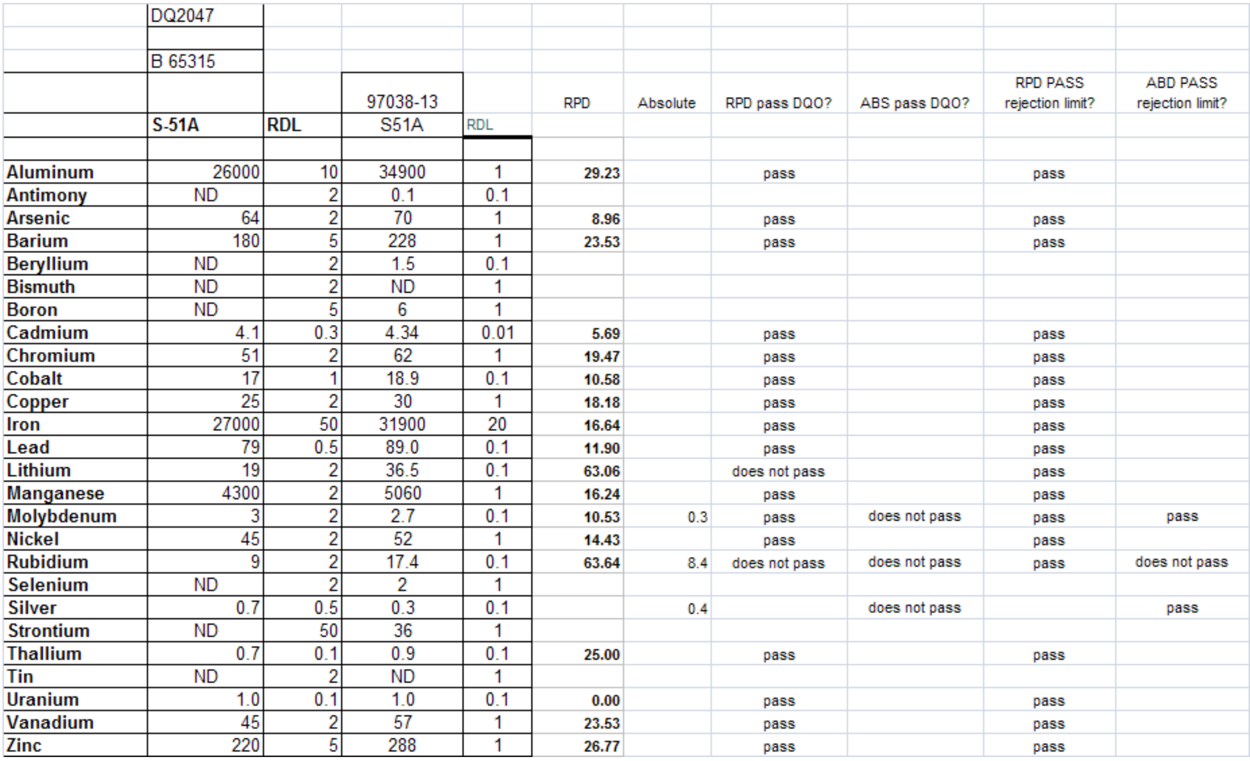
	DQ1656 2009/07/31 JUL-AUG B 65312 S32A	RDL	97038-09 S32A	RDL	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD PASS rejection limit?	ABD PASS rejection limit?
Aluminum	11000	10	15000	1	30.77		pass		pass	
Antimony	14	2	1.4	0.1	163.64		does not pass		does not pass	
Arsenic	50	2	43	1	15.05		pass		pass	
Barium	85	5	85	1	0.00		pass		pass	
Beryllium	ND	2	0.5	0.1						
Bismuth	ND	2	ND	1						
Boron	ND	5	4	1						
Cadmium	5.9	0.3	5.58	0.01	5.57		pass		pass	
Chromium	26	2	27	1	3.77		pass		pass	
Cobalt	11	1	10.7	0.1	2.76		pass		pass	
Copper	77	2	70	1	9.52		pass		pass	
Iron	33000	50	28900	20	13.25		pass		pass	
Lead	740	0.5	768	0.1	3.71		pass		pass	
Lithium	13	2	16.6	0.1	24.32		pass		pass	
Manganese	420	2	428	1	1.89		pass		pass	
Molybdenum	2	2	1.4	0.1	35.29	0.6	does not pass	does not pass	pass	does not pass
Nickel	17	2	18	1	5.71		pass		pass	
Rubidium	10	2	22.6	0.1	77.30		does not pass		pass	
Selenium	ND	2	ND	1						
Silver	1.1	0.5	0.4	0.1		0.7		does not pass		does not pass
Strontium	15	5	13	1	14.29	2	pass	pass	pass	pass
Thallium	0.9	0.1	1.1	0.1	20.00		pass		pass	
Tin	26	2	5	1	135.48		does not pass		does not pass	
Uranium	0.4	0.1	0.5	0.1	22.22	0.1	pass	pass	pass	pass
Vanadium	45	2	43	1	4.55		pass		pass	
Zinc	1800	5	1580	1	13.02		pass		pass	



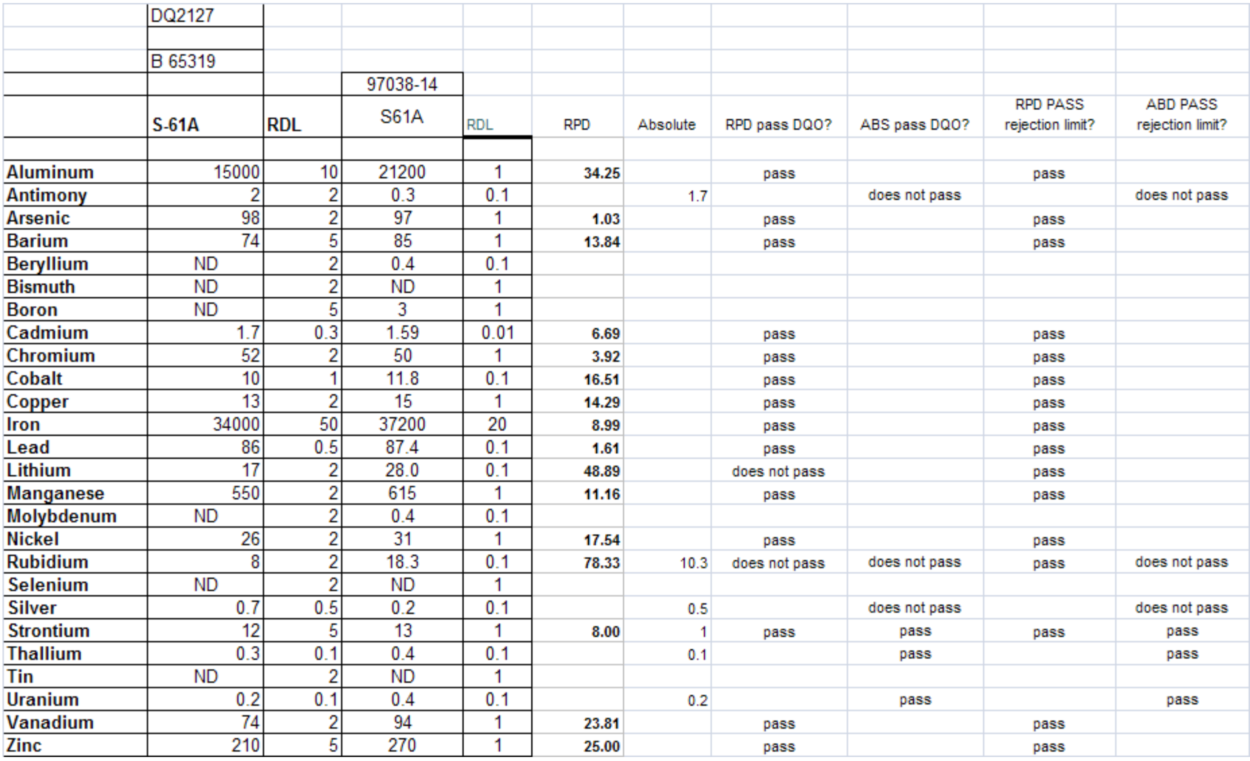
	DQ1659 2009/07/31 JUL-AUG B 65312 S33A	RDL	97038-10 S33A	RDL	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD PASS rejection limit?	ABD PASS rejection limit?
Aluminum	9600	10	17300	1	57.25		does not pass		pass	
Antimony	3	2	0.3	0.1		2.7		does not pass		does not pass
Arsenic	16	2	14	1	13.33		pass		pass	
Barium	82	5	97	1	16.76		pass		pass	
Beryllium	ND	2	0.7	0.1						
Bismuth	ND	2	ND	1						
Boron	ND	5	4	1						
Cadmium	3.1	0.3	3.03	0.01	2.28		pass		pass	
Chromium	19	2	27	1	34.78		pass		pass	
Cobalt	7	1	9.3	0.1	28.22		pass		pass	
Copper	16	2	17	1	6.06		pass		pass	
Iron	19000	50	24000	20	23.26		pass		pass	
Lead	170	0.5	188	0.1	10.06		pass		pass	
Lithium	14	2	27.9	0.1	66.35		does not pass		pass	
Manganese	450	2	542	1	18.55		pass		pass	
Molybdenum	ND	2	0.3	0.1						
Nickel	16	2	24	1	40.00		does not pass		pass	
Rubidium	8	2	22.0	0.1	93.33	14	does not pass	does not pass	pass	does not pass
Selenium	ND	2	ND	1						
Silver	ND	0.5	0.2	0.1						
Strontium	6	5	7	1	15.38	1	pass	pass	pass	pass
Thallium	0.8	0.1	1.1	0.1	31.58		pass		pass	
Tin	ND	2	ND	1						
Uranium	0.6	0.1	0.8	0.1	28.57		pass		pass	
Vanadium	34	2	41	1	18.67		pass		pass	
Zinc	120	5	137	1	13.23		pass		pass	

	DQ1668									
	2009/07/31 JUL-AUG									
	B 65312				RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD PASS rejection limit?	ABD PASS rejection limit?
			97038-11A							
	S-38A	**RDL**	S38A	RDL						
Aluminum	14000	10	19400	1	**32.34**		pass		pass	
Antimony	ND	2	0.2	0.1						
Arsenic	11	2	12	1	**8.70**		pass		pass	
Barium	160	5	183	1	**13.41**		pass		pass	
Beryllium	ND	2	0.6	0.1						
Bismuth	ND	2	ND	1						
Boron	ND	5	5	1						
Cadmium	1.9	0.3	2.00	0.01	**5.13**		pass		pass	
Chromium	24	2	30	1	**22.22**		pass		pass	
Cobalt	9	1	9.6	0.1	**6.45**		pass		pass	
Copper	15	2	16	1	**6.45**		pass		pass	
Iron	25000	50	25600	20	**2.37**		pass		pass	
Lead	130	0.5	157	0.1	**18.82**		pass		pass	
Lithium	21	2	30.5	0.1	**36.89**		does not pass		pass	
Manganese	410	2	444	1	**7.96**		pass		pass	
Molybdenum	ND	2	0.7	0.1						
Nickel	20	2	22	1	**9.52**		pass		pass	
Rubidium	11	2	28.0	0.1	**87.18**		does not pass		pass	
Selenium	ND	2	ND	1						
Silver	ND	0.5	0.1	0.1						
Strontium	18	5	22	1	**20.00**	4	pass	does not pass	pass	pass
Thallium	0.4	0.1	0.7	0.1	**54.55**	0.3	does not pass	does not pass	pass	pass
Tin	ND	2	ND	1						
Uranium	0.3	0.1	0.4	0.1		0.1		pass		pass
Vanadium	41	2	50	1	**19.78**		pass		pass	
Zinc	110	5	124	1	**11.97**		pass		pass	

	DQ2042									
	B 65315									
			97038-12	RDL	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD PASS rejection limit?	ABD PASS rejection limit?
	S-48A	**RDL**	S48A							
Aluminum	10000	10	17700	1	**55.60**		does not pass		pass	
Antimony	4	2	0.6	0.1	**147.83**	3.4	does not pass	does not pass	does not pass	does not pass
Arsenic	42	2	41	1	**2.41**		pass		pass	
Barium	220	5	279	1	**23.65**		pass		pass	
Beryllium	ND	2	0.7	0.1						
Bismuth	ND	2	1	1						
Boron	ND	5	4	1						
Cadmium	3.1	0.3	3.55	0.01	**13.53**		pass		pass	
Chromium	22	2	33	1	**40.00**		does not pass		pass	
Cobalt	9	1	9.8	0.1	**8.51**		pass		pass	
Copper	23	2	22	1	**4.44**		pass		pass	
Iron	15000	50	17900	20	**17.63**		pass		pass	
Lead	290	0.5	292	0.1	**0.69**		pass		pass	
Lithium	13	2	22.6	0.1	**53.93**		does not pass		pass	
Manganese	1000	2	852	1	**15.98**		pass		pass	
Molybdenum	ND	2	0.9	0.1						
Nickel	19	2	25	1	**27.27**		pass		pass	
Rubidium	7	2	21.0	0.1	**100.00**	14	does not pass	does not pass	pass	does not pass
Selenium	ND	2	ND	1						
Silver	0.6	0.5	0.2	0.1		0.4		does not pass		pass
Strontium	15	5	21	1	**33.33**	6	pass	does not pass	pass	does not pass
Thallium	0.7	0.1	1.0	0.1	**35.29**		does not pass		pass	
Tin	7	2	ND	1						
Uranium	2.7	0.1	3.3	0.1	**20.00**		pass		pass	
Vanadium	35	2	42	1	**18.18**		pass		pass	
Zinc	310	5	352	1	**12.69**		pass		pass	



	DQ2047									
	B 65315									
			97038-13		RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD PASS rejection limit?	ABD PASS rejection limit?
	S-51A	**RDL**	S51A	RDL						
Aluminum	26000	10	34900	1	**29.23**		pass		pass	
Antimony	ND	2	0.1	0.1						
Arsenic	64	2	70	1	**8.96**		pass		pass	
Barium	180	5	228	1	**23.53**		pass		pass	
Beryllium	ND	2	1.5	0.1						
Bismuth	ND	2	ND	1						
Boron	ND	5	6	1						
Cadmium	4.1	0.3	4.34	0.01	**5.69**		pass		pass	
Chromium	51	2	62	1	**19.47**		pass		pass	
Cobalt	17	1	18.9	0.1	**10.58**		pass		pass	
Copper	25	2	30	1	**18.18**		pass		pass	
Iron	27000	50	31900	20	**16.64**		pass		pass	
Lead	79	0.5	89.0	0.1	**11.90**		pass		pass	
Lithium	19	2	36.5	0.1	**63.06**		does not pass		pass	
Manganese	4300	2	5060	1	**16.24**		pass		pass	
Molybdenum	3	2	2.7	0.1	**10.53**	0.3	pass	does not pass	pass	pass
Nickel	45	2	52	1	**14.43**		pass		pass	
Rubidium	9	2	17.4	0.1	**63.64**	8.4	does not pass	does not pass	pass	does not pass
Selenium	ND	2	2	1						
Silver	0.7	0.5	0.3	0.1		0.4		does not pass		pass
Strontium	ND	50	36	1						
Thallium	0.7	0.1	0.9	0.1	**25.00**		pass		pass	
Tin	ND	2	ND	1						
Uranium	1.0	0.1	1.0	0.1	**0.00**		pass		pass	
Vanadium	45	2	57	1	**23.53**		pass		pass	
Zinc	220	5	288	1	**26.77**		pass		pass	



	DQ2127									
	B 65319									
			97038-14							
	S-61A	**RDL**	S61A	RDL	RPD	Absolute	RPD pass DQO?	ABS pass DQO?	RPD PASS rejection limit?	ABD PASS rejection limit?
Aluminum	15000	10	21200	1	**34.25**		pass		pass	
Antimony	2	2	0.3	0.1		1.7		does not pass		does not pass
Arsenic	98	2	97	1	**1.03**		pass		pass	
Barium	74	5	85	1	**13.84**		pass		pass	
Beryllium	ND	2	0.4	0.1						
Bismuth	ND	2	ND	1						
Boron	ND	5	3	1						
Cadmium	1.7	0.3	1.59	0.01	**6.69**		pass		pass	
Chromium	52	2	50	1	**3.92**		pass		pass	
Cobalt	10	1	11.8	0.1	**16.51**		pass		pass	
Copper	13	2	15	1	**14.29**		pass		pass	
Iron	34000	50	37200	20	**8.99**		pass		pass	
Lead	86	0.5	87.4	0.1	**1.61**		pass		pass	
Lithium	17	2	28.0	0.1	**48.89**		does not pass		pass	
Manganese	550	2	615	1	**11.16**		pass		pass	
Molybdenum	ND	2	0.4	0.1						
Nickel	26	2	31	1	**17.54**		pass		pass	
Rubidium	8	2	18.3	0.1	**78.33**	10.3	does not pass	does not pass	pass	does not pass
Selenium	ND	2	ND	1						
Silver	0.7	0.5	0.2	0.1		0.5		does not pass		does not pass
Strontium	12	5	13	1	**8.00**	1	pass	pass	pass	pass
Thallium	0.3	0.1	0.4	0.1		0.1		pass		pass
Tin	ND	2	ND	1						
Uranium	0.2	0.1	0.4	0.1		0.2		pass		pass
Vanadium	74	2	94	1	**23.81**		pass		pass	
Zinc	210	5	270	1	**25.00**		pass		pass	

ATTACHMENT E-2

CERTIFIED REFERENCE MATERIAL CERTIFICATES OF ANALYSIS AND RESULTS OF ANALYSIS OF “ERA LOT# D064 AND D067” CRMs

National Institute of Standards & Technology

Certificate of Analysis

Standard Reference Material® 2711

Montana Soil

Moderately Elevated Trace Element Concentrations

This Standard Reference Material (SRM) is intended primarily for use in the analysis of soils, sediments, or other materials of a similar matrix. SRM 2711 is a moderately contaminated soil that was oven-dried, sieved, and blended to achieve a high degree of homogeneity. A unit of SRM 2711 consists of 50 g of the dried material.

The certified elements for SRM 2711 are given in Table 1. The values are based on measurements using one definitive method or two or more independent and reliable analytical methods. Noncertified values for a number of elements are given in Table 2 as additional information on the composition. The noncertified values should **NOT** be used for calibration or quality control. Analytical methods used for the characterization of this SRM are given in Table 3 along with analysts and cooperating laboratories. All values (except for carbon) are based on measurements using a sample weight of at least 250 mg. Carbon measurements are based on 100 mg samples.

NOTICE AND WARNINGS TO USERS

Expiration of Certification: This certification of SRM 2711 is valid, within the measurement uncertainties specified, until **31 December 2011**, provided the SRM is handled in accordance with instructions given in this certificate (see Instructions for Use). This certification is nullified if the SRM is damaged, contaminated, or otherwise modified.

Maintenance of SRM Certification: NIST will monitor this SRM over the period of its certification. If substantive technical changes occur that affect the certification before the expiration of this certificate, NIST will notify the purchaser. Return of the attached registration card will facilitate notification.

Statistical consultation was provided by S.B. Schiller of the NIST Statistical Engineering Division.

The overall direction and coordination of the analyses were under the chairmanship of M.S. Epstein and R.L. Watters, Jr., of the NIST Inorganic Analytical Research Division.

The technical and support aspects involved in the preparation, certification, and issuance of this SRM were coordinated through the NIST Standard Reference Materials Program by T.E. Gills and J.S. Kane. Revision of this certificate was coordinated through the NIST Standard Reference Materials Program by B.S. MacDonald.

Willie E. May, Chief
Analytical Chemistry Division

John Rumble, Jr., Acting Chief
Standard Reference Materials Program

Gaithersburg, MD 20899
Certificate Issue Date: 18 January 2002
See Certificate Revision History on Last Page

INSTRUCTIONS FOR USE

Use: A minimum sample weight of 250 mg (dry weight - see Instructions for Drying) should be used for analytical determinations to be related to the certified values on this Certificate of Analysis.

To obtain the certified values, sample preparation procedures should be designed to effect complete dissolution. If volatile elements (i.e., Hg, As, Se) are to be determined, precautions should be taken in the dissolution of SRM 2711 to avoid volatilization losses.

Instructions for Drying: When nonvolatile elements are to be determined, samples should be dried for 2 h at 110 °C. Volatile elements (i.e., Hg, As, Se) should be determined on samples as received; separate samples should be dried as previously described, to obtain a correction factor for moisture. Correction for moisture is to be made to the data for volatile elements before comparing to the certified values. This procedure ensures that these elements are not lost during drying. The approximate weight loss on drying has been found to be in the range of 1.5 % to 2.2 %.

Source and Preparation of Material: The U.S. Geological Survey (USGS), under contract to the NIST, collected and processed the material for SRM 2711. The material is an agricultural soil collected in the till layer (upper 15.2 cm (6 in)) of a wheat field. The soil from a 3.05 m × 3.05 m (10 ft × 10 ft) area was shoveled into 0.114 m^3 (3 gal) plastic pails for shipment to the USGS laboratory for processing.

The material was spread on 30.5 cm × 61 cm (1 ft × 2 ft) polyethylene-lined drying trays in an air drying oven and dried for three days at room temperature. The material was then passed over a vibrating 2 mm screen to remove plant material, rocks, and large chunks of aggregated soil. Material remaining on the screen was deaggregated and rescreened. The combined material passing the screen was ground in a ball mill to pass a 74 µm screen and blended for 24 h. Twenty grab samples were taken and measured for the major oxides using X-ray fluorescence spectrometry and for several trace elements by using inductively coupled plasma atomic emission analysis to provide preliminary assessment of the homogeneity prior to bottling. The material was bottled into 50 g units and randomly selected bottles were taken for the final homogeneity testing.

Analysis: The homogeneity, using selected elements in the bottled material as indicators, was assessed using X-ray fluorescence spectrometry and neutron activation analysis. In a few cases, statistically significant differences were observed, and the variance due to material inhomogeneity is included in the overall uncertainty of the certified values. The estimated relative standard deviation is less than 3 % for those elements for which homogeneity was assessed.

Certified Values and Uncertainties: The certified values are weighted means of results from two or more analytical methods, or the mean of results from a single definitive method, except for mercury. Mercury certification is based on cold vapor atomic absorption spectrometry used by two different laboratories employing different methods of sample preparation prior to measurement. The weights for the weighted means were computed according to the iterative procedures of Paule and Mandel [1]. The stated uncertainty includes allowances for measurement imprecision, material variability, and differences among analytical methods. Each uncertainty is the sum of the half-width of a 95 % prediction interval and includes an allowance for systematic error among the methods used. In the absence of systematic error, a 95 % prediction interval predicts where the true concentrations of 95 % of the samples of this SRM lie. The certified values were corroborated by analyses from nine Polish laboratories cooperating on the certification under the direction of T. Plebanski and J. Lipinski, Polish Committee for Standardization Measures, and Quality Control. The Polish laboratory work was supported by the Maria Sklodowska-Curie Joint Fund.

Table 1. Certified Values

Element	Mass Fraction (%)	Element	Mass Fraction (µg/g)
Aluminum	6.53 ± 0.09	Antimony	19.4 ± 1.8
Calcium	2.88 ± 0.08	Arsenic	105 ± 8
Iron	2.89 ± 0.06	Barium	726 ± 38
Magnesium	1.05 ± 0.03	Cadmium	41.70 ± 0.25
Phosphorus	0.086 ± 0.007	Copper	114 ± 2
Potassium	2.45 ± 0.08	Lead	1162 ± 31
Silicon	30.44 ± 0.19	Manganese	638 ± 28
Sodium	1.14 ± 0.03	Mercury	6.25 ± 0.19
Sulfur	0.042 ± 0.001	Nickel	20.6 ± 1.1
Titanium	0.306 ± 0.023	Selenium	1.52 ± 0.14
		Silver	4.63 ± 0.39
		Strontium	245.3 ± 0.7
		Thallium	2.47 ± 0.15
		Vanadium	81.6 ± 2.9
		Zinc	350.4 ± 4.8

Noncertified Values: Noncertified values, shown in parentheses, are provided for information only. An element concentration value may not be certified, if a bias is suspected in one or more of the methods used for certification, or if two independent methods are not available.

Table 2. Noncertified Values

Element	Mass Fraction (%)	Element	Mass Fraction (µg/g)
Carbon	(2)	Bromine	(5)
		Cerium	(69)
		Cesium	(6.1)
		Chromium	(47)
		Cobalt	(10)
		Dysprosium	(5.6)
		Europium	(1.1)
		Gallium	(15)
		Gold	(.03)
		Hafnium	(7.3)
		Holmium	(1)
		Indium	(1.1)
		Iodine	(3)
		Lanthanum	(40)
		Molybdenum	(1.6)
		Neodymium	(31)
		Rubidium	(110)
		Samarium	(5.9)
		Scandium	(9)
		Thorium	(14)
		Tungsten	(3)
		Uranium	(2.6)
		Ytterbium	(2.7)
		Yttrium	(25)
		Zirconium	(230)

Table 3. Analytical Methods Used for the Analysis of SRM 2711

Element	Certification Methods *	Element	Certification Methods *
Ag	ID ICPMS; RNAA; **INAA**	Mo	**ID ICPMS**
Al	XRF1; XRF2; INAA; DCP; **ICP**	Na	INAA; FAES
As	RNAA; HYD AAS; **INAA**	Nd	**ICP**
Au	**INAA; FAAS**	Ni	ID ICPMS; ETAAS; **INAA**
Ba	XRF2; FAES; **ICP; INAA**	P	DCP; COLOR; XRF2; **ICP**
Br	**INAA**	Pb	ID TIMS; **POLAR; ICP**
C	**COUL**	Rb	**INAA**
Ca	XRF1; XRF2; DCP; INAA; **ICP**	S	ID TIMS
Cd	ID ICPMS; RNAA	Sb	INAA; ETAAS
Ce	**INAA; ICP**	Sc	**INAA; ICP**
Co	**INAA; ETAAS; ICP**	Se	RNAA; HYD AAS; **INAA**
Cr	**INAA; DCP; ICP**	Si	XRF1; XRF2; GRAV
Cs	**INAA**	Sm	**INAA**
Cu	RNAA; FAES; **ICP**	Sr	ID TIMS; **INAA; ICP**
Dy	**INAA**	Th	**ID TIMS; INAA; ICP**
Eu	**INAA**	Ti	INAA; XRF1; XRF2; DCP
Fe	XRF1; XRF2; DCP; **INAA**	Tl	ID TIMS; LEAFS
Ga	**INAA; ICP**	U	**ID TIMS**
Hf	**INAA**	V	INAA; ICP
Hg	CVAAS	W	**INAA**
Ho	**INAA**	Y	**ICP**
I	**INAA**	Yb	**INAA; ICP**
In	**INAA**	Zn	ID TIMS; **ICP; INAA; POLAR**
K	XRF1; XRF2; FAES; **ICP; INAA**	Zr	**INAA**
La	**INAA; ICP**		
Mg	XRF1; ICP		
Mn	INAA; ICP; XRF2; **XRF1**		

*Methods in **bold** were used to corroborate certification methods or to provide information values.

COLOR	Colorimetry; lithium metaborate fusion.
COUL	Combustion coulometry.
CVAAS	Cold vapor atomic absorption spectrometry.
DCP	Direct current plasma atomic emission spectrometry; lithium metaborate fusion.
ETAAS	Electrothermal atomic absorption spectrometry; mixed acid digestion.
FAAS	Flame atomic absorption spectrometry; mixed acid digestion, except for Au, leached with HBr-Br_2.
FAES	Flame atomic emission spectrometry; mixed acid digestion.
GRAV	Gravimetry; sodium carbonate fusion.
HYD AAS	Hydride generation atomic absorption spectrometry.
ICP	Inductively coupled plasma atomic emission spectrometry; mixed acid digestion.
ID ICPMS	Isotope dilution inductively coupled plasma mass spectrometry; mixed acid digestion.
ID TIMS	Isotope dilution thermal ionization mass spectrometry; mixed acid digestion.
INAA	Instrumental neutron activation analysis.
LEAFS	Laser enhanced atomic fluorescence spectrometry; mixed acid digestion.
POLAR	Polarography.
RNAA	Radiochemical neutron activation analysis; mixed acid digestion.
XRF1	Wavelength dispersive X-ray fluorescence on fused borate discs.
XRF2	Wavelength dispersive X-ray fluorescence spectrometry on pressed powder.

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REFERENCE

[1] Paule, R.C. and Mandel, J., *NBS Journal of Research 87*, pp. 377-385, (1982).

Certificate Revision History: 18 January 2002 (This revision reflects a change in the certification expiration date); 23 August 1993 (Addendum added); 30 October 1992 (Original certificate date).

Users of this SRM should ensure that the certificate in their possession is current. This can be accomplished by contacting the SRM Program at: telephone (301) 975-6776; fax (301) 926-4751; e-mail srminfo@nist.gov; or via the Internet http://www.nist.gov/srm.

Addendum to SRM Certificates
2709 San Joaquin Soil
2710 Montana Soil
2711 Montana Soil

Leachable Concentrations Using U.S. EPA Method 3050 for Flame Atomic Absorption Spectrometry (FAAS) and Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES)

The certified concentrations of constituent elements in essentially all National Institute of Standards and Technology (NIST) chemical composition Standard Reference Materials (SRMs) are given as total concentrations. The certified concentrations are based on measurements obtained by two or more independent methods or techniques. The measurement methods require complete sample decomposition, or the sample may be analyzed nondestructively. Where complete sample decomposition is required, it can be accomplished by digestion with mixed acids or by fusion. For mixed acid decomposition, hydrofluoric acid must be included in the acid mixture used to totally decompose siliceous materials, such as soils and sediments.

For a number of environmental monitoring purposes, the concentrations of labile or extractable fractions of elements are more useful than total concentrations. Concentrations of labile or extractable fractions are generally determined using relatively mild leach conditions, which are unlikely to totally decompose the sample. It should be noted that results obtained using the mild leach conditions are often erroneously depicted in reports as total concentrations. However, reported concentrations of labile or extractable fractions of elements are generally lower than total concentrations; recovery can be total if an element in a given sample is completely labile. Results are often presented as measured concentration in the leachate in comparison to the total or certified concentration. The recovery of an element as a percent of total concentration is a function of several factors such as the mode of occurrence in the sample, leach medium, leach time and temperature conditions, and pH of the sample-leach medium mixture. References [1] through [27] may be consulted for detailed discussions of these factors and their effect on leach results. Some of these references provide leach data for one or more reference materials.

In its monitoring programs, the U.S. Environmental Protection Agency (EPA) has established a number of leach methods for the determination of labile or extractable elements. They include Methods 3015, 3050, and 3051. A number of cooperating laboratories using the variation to U.S. EPA Method 3050 for Flame Atomic Absorption Spectrometry (FAAS) and Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES) measurements, have reported data for SRMs 2709, 2710, and 2711. This variation of the method uses hydrochloric acid in its final step, which is different from Method 3050 for ICP-MS and Hydride Generation-Atomic Absorption Spectrometry (HG-AAS) measurements. The data obtained are presented in Tables 1, 2, and 3 of this addendum. The names of the cooperating laboratories are listed in Table 4. Several laboratories provided replicate (3 to 6) analyses for each of the three soil SRMs. The number of results for a given element varied from only one to as many as nine, as indicated in the data presented in Tables 1 through 3. Because of the wide range of interlaboratory results for most elements, only the data range and median of the individual laboratory means are given. Ranges differ somewhat from those in Reference [26], since this addendum is based on a larger data set than had been available previously.

For SRMs 2710 and 2711, 17 laboratories provided data as part of contract work for the U.S. EPA. Each SRM was treated as a blind sample in one quarter of 1992. Since there was no within-laboratory replication of analysis in the design of the exercise, the 17-laboratory means of results were treated as single laboratory results from laboratories using replication, in establishing the median of the full data set. In a few cases, however, the contract laboratories mean was the only result available for a particular element (e.g., Antimony in SRM 2710). In others, the contract laboratories mean is also the median for the full leach data set (e.g., Arsenic in SRM 2710). An asterisk identifies those cases where the contract laboratories means are given as the median value.

Please note none of the values in Tables 1 through 3 are certified, but are given as information on the performance of the three soils when used to evaluate, or to provide quality control for Method 3050 followed by FAAS and ICP-AES measurements only. The data should not be used for any other purpose. **The certified values, provided as total concentrations, are the best estimate of the true concentrations.**

Gaithersburg, MD 20899
Addendum Issue Date: 18 January 2002

John Rumble, Jr., Acting Chief
Standard Reference Materials Program

Table 1. Leach Data from Cooperating Laboratories for Soil SRM 2709

Element	Range	Median	N	% Leach Recovery†
	Wt %			
Aluminum	2.0 - 3.1	2.6	5	35
Calcium	1.4 - 1.7	1.5	5	79
Iron	2.5 - 3.3	3.0	8	86
Magnesium	1.2 - 1.5	1.4	5	93
Phosphorus	0.05 - 0.07	0.07	3	100
Potassium	0.26 - 0.37	0.32	5	16
Silicon	--- ---	< 0.01	1	< 1
Sodium	0.063 - 0.11	0.068	4	6
Titanium	0.03 - 0.04	0.038	3	11
	mg/kg			
Antimony	--- ---	< 10	1	···
Arsenic	--- ---	< 20	2	···
Barium	392 - 400	398	2	41
Cadmium	--- ---	< 1	5	···
Chromium	60 - 115	79	5	61
Cobalt	10 - 15	12	5	90
Copper	26 - 40	32	7	92
Lead	12 - 18	13	5	69
Manganese	360 - 600	470	7	87
Molybdenum	--- ---	< 2	2	···
Nickel	65 - 90	78	7	89
Selenium	nr - nr	0.014	1	< 1
Strontium	100 - 112	101	3	44
Vanadium	51 - 70	62	3	55
Zinc	87 - 120	100	7	94

$$\dagger \ \% \text{ Leach Recovery} = 100 \times \left[\frac{\text{Median Value}}{\text{Certified/Information Value}} \right]$$

--- at or below the detection limit
··· no % Leach Recovery calculated
nr no range reported by the laboratory

Table 2. Leach Data from Cooperating Laboratories for Soil SRM 2710

Element	Range	Median	N	% Leach Recovery†
	Wt %			
Aluminum	1.2 - 2.6	1.8	6	28
Calcium	0.38 - 0.48	0.41	7	33
Iron	2.2 - 3.2	2.7	9	80
Magnesium	0.43 - 0.60	0.57	6	67
Phosphorus	0.106 - 0.11	0.11	2	100
Potassium	0.37 - 0.50	0.45	6	21
Silicon	--- ---	< 0.01	1	< 1
Sodium	0.049 - 0.062	0.054	5	5
Titanium	0.092 - 0.11	0.10	3	35
	mg/kg			
Antimony	3.4 - 12	7.9*	1*	21
Arsenic	490 - 600	590	3	94
Barium	300 - 400	360	3	51
Cadmium	13 - 26	20	8	92
Chromium	15 - 23	19	6	(49)
Cobalt	6.3 - 12	8.2	7	(82)
Copper	2400 - 3400	2700	8	92
Lead	4300 - 7000	5100	8	92
Manganese	6200 - 9000	7700	8	76
Mercury	27 - 37	32*	1*	98
Molybdenum	13 - 27	20	2	(100)
Nickel	8.8 - 15	10.1	8	71
Silver	24 - 30	28	3	79
Selenium	nr - nr	0.002	1	···
Strontium	94 - 110	100	3	(42)
Thallium	0.50 - 0.76	0.63*	1*	(48)
Vanadium	37 - 50	43	4	56
Zinc	5200 - 6900	5900	9	85

$$\dagger\ \%\ \text{Leach Recovery} = 100 \times \left[\frac{\text{Median Value}}{\text{Certified/Information Value}}\right]$$

( ) indicates that information value was used
--- at or below the detection limit
··· no % Leach Recovery could be calculated
nr no range reported by the laboratory
* U.S. EPA contact laboratories mean; treated as one laboratory since no within-laboratory replication; see text

Table 3. Leach Data from Cooperating Laboratories for Soil SRM 2711

Element	Range	Median	N	% Leach Recovery†
	Wt %			
Aluminum	1.2 - 2.3	1.8	5	28
Calcium	2.0 - 2.5	2.1	5	73
Iron	1.7 - 2.6	2.2	7	76
Magnesium	0.72 - 0.89	0.81	5	77
Phosphorus	0.06 - 0.09	0.088	3	100
Potassium	0.26 - 0.53	0.38	5	16
Silicon	--- ---	< 0.01	1	< 1
Sodium	0.020 - 0.029	0.026	4	2.3
Titanium	0.039 - 0.048	0.042	2	14
	mg/kg			
Antimony	··· ···	< 10	1	···
Arsenic	88 - 110	90	3	86
Barium	170 - 260	200	2	28
Cadmium	32 - 46	40	6	96
Chromium	15 - 25	20	4	(43)
Cobalt	7 - 12	8.2	5	(82)
Copper	91 - 110	100	6	88
Lead	930 - 1500	1100	7	95
Manganese	400 - 620	490*	7	77
Molybdenum	--- ---	< 2	2	···
Nickel	14 - 20	16	7	78
Silver	2.5 - 5.5	4.0	1	86
Selenium	nr - nr	0.009	1	< 1
Strontium	48 - 55	50	3	20
Vanadium	34 - 50	42	3	51
Zinc	290 - 340	310	7	89

$$\dagger\ \%\ \text{Leach Recovery} = 100 \times \left[\frac{\text{Median Value}}{\text{Certified/Information Value}}\right]$$

( ) indicates that information value was used
--- at or below the detection limit
··· no % Leach Recovery could be calculated
nr no range reported by the laboratory
* U.S. EPA contact laboratories mean; treated as one laboratory since no within-laboratory replication; see text

Table 4. Leach Study for Cooperating Laboratories

SRMs 2709, 2710, and 2711

S.A. Wilson; U.S. Geological Survey, Lakewood, CO, USA

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E. Gorecka; Polish Geological Institute, Warsaw, Poland

M. Paul; Research Institute of Vegetable Crops, Skierniewice, Poland

I. Matuszczyk; Forest Research Institute, Warsaw, Poland

Z. Jonca; Institute of Environmental Protection, Warsaw, Poland

B. Ksiazek; Geological Enterprise, Warsaw, Poland

I. Twardowska; Polish Academy of Sciences, Institute of Environmental Engineering, Zabrze, Poland

SRMs 2710 and 2711

L. Butler and D. Hillman; U.S. Environmental Protection Agency, Las Vegas, NV, and 17 contract laboratories

REFERENCES

[1] Gallagher, P.H. and Walsh, T., Proceedings of the Royal Irish Academy, **49B**, pp. 1-17, (1943).

[2] McKeague, J.A. and Day, J.A., Canadian Journal of Soil Science, **46**, pp. 13-22, (1966).

[3] Arshad, M.A., St. Arnaud, R.J., and Huang, P.M., Canadian Journal of Soil Science, **52**, pp. 19-26, (1972).

[4] Chao, T.T. and Zhou, L., Soil Science Society of America Journal, **47**, pp. 225-232, (1983).

[5] Olade, M.E. and Fletcher, K., Journal of Geochemical Exploration, **3**, pp. 337-344, (1974).

[6] Chao, T.T., Journal of Geochemical Exploration, **20**, pp. 101-135, (1984).

[7] Lepp, N.W., ed., Effect of Heavy Metal Pollution on Plants, Vol.1 Effects of Trace Metals on Plant Function, Applied Science Publishers, London, (1981).

[8] Sondag, F., Journal of Geochemical Exploration, **15**, pp. 645-652, (1981).

[9] Federal Register 40 CFR Part 136.

[10] Binstock, D.A., Grohse, P.M., Gaskill, A. Jr., Sellers, C., Kingston, H.M., and Jassie, L.B., Journal of Association of Official Analytical Chemists, **74(#2)**, pp. 360-366, (1991). (Data: SRMs 2704, 4355, 1086, 1634b on 2704)

[11] Kingston, H.M. and Walter, P.J., Spectroscopy, **7**, pp. 20-27, (1992).

[12] Martens, D.C., Chesters, G., and Peterson, L.A., Soil Science Society of American Proceedings, **29**, pp. 411-4 13, (1966).

[13] Trefry, J.H. and Metz, 5., Analytical Chemistry, **56**, pp. 745-749, (1984).

[14] Rendell, P.S., Batley, G.E., and Cameron, J.A., Environmental Science and Technology, **14**, pp. 314-318, (1980).

[15] Wilson, S.A., Unpublished Report to NIST Standard Reference Materials Program, (1992). (Data: SRMs 2709, 2710, 2711, and 2704).

[16] Lipinski, J., Unpublished Report to NIST Standard Reference Materials Program, (1992). (Data: SRMs 2709, 2710, 2711, and 2704).

[17] Butler, L. and Hillman, D., Unpublished Report to NIST Standard Reference Materials Program, Quarterly Blind Summary from CLP, (1992). (Data: SRM 2710, 17 laboratories).

[18] Kanm-iin, W.R., and Brandt, M.J., Spectroscopy, **4(#3)**, pp. 49-52, (1989). (Data: EPA solid QC sample).

[19] Harper, S.L., Walling, J.F., Holland, D.M., and Pranger, L.J., Analytical Chemistry, **55(#9)**, pp. 1553-1557, (1983). (Data: SRM 1648).

[20] Hewitt, A.D. and Reynolds, C.M., Atomic Spectroscopy, **11(#5)**, pp. 187-192, (1990). (Data: SRM 2704, RMA Soil Standard).

[21] Nieuwenliuize, J., Poley-Vos, C.H., van den Akker, A.H., and van Delft, W., Analyst, **116**, pp. 347-351, (1991). (Data: JAFA and BCR CRMs).

[22] Hewitt, A.D. and Cragin, J.H., Environmental Science and Technology, **25**, pp. 985-986, (1991).

[23] Hewitt, A.D. and Cragin, J.H., Environmental Science and Technology, **26**, p. 1848, (1992).

[24] Hewitt, A.D. and Cragin, J.H., U.S. Army Toxic and Hazardous Materials Agency Report CETHATS-CR-92061, (1992).

[25] Hewitt, A.D. and Reynolds, C.M., U.S. Army Toxic and Hazardous Materials Agency Report CETHATS-CR-90052, (1990).

[26] Rasberry, S.D. and Kane, J.S., American Environmental Laboratory, **2/93**, pp. 34-35, (1993). (Data: SRMs 2709, 2710, 2711; a subset of the data reported in this addendum).

[27] Kane, J.S., Wilson, S.D., Lipinski, J. and Butler, L., American Environmental Laboratory, **6/93**, pp. 14-15, (1993).

DEPARTMENT OF COMMERCE
UNITED STATES OF AMERICA

National Institute of Standards & Technology

Certificate of Analysis

Standard Reference Material® 2709a

San Joaquin Soil

Baseline Trace Element Concentrations

This Standard Reference Material (SRM) is intended primarily for use in the analysis of soils, sediments, or other materials of a similar matrix. One unit of SRM 2709a consists of 50 g of dried, powdered, agricultural soil.

Certified Values: The certified concentrations for 19 elements, expressed as mass fractions [1] on a dry-mass basis, are provided in Table 1. Certified values are based on results obtained from critically evaluated independent analytical techniques. A NIST certified value is a value for which NIST has the highest confidence in its accuracy in that all known or suspected sources of bias have been investigated or taken into account [2].

Reference Values: The reference values for 15 constituents, expressed as mass fractions on a dry-mass basis, are provided in Table 2. The reference values are based on results obtained from a single NIST analytical method. Reference values are non-certified values that are the best estimate of the true value; however, the values do not meet NIST criteria for certification and are provided with associated uncertainties that may not include all sources of uncertainty [2].

Information Values: The values for 10 elements are provided in Table 3 for information purposes only. These are non-certified values with no uncertainty assessed. The information values included in this certificate are based on results obtained from one NIST method.

Expiration of Certification: The certification of SRM 2709a is valid, within the measurement uncertainties specified, until **1 November 2018**, provided the SRM is handled in accordance with the instructions given in this certificate (see "Instructions for Use"). This certification is nullified if the SRM is damaged, contaminated, or otherwise modified.

Maintenance of SRM Certification: NIST will monitor this SRM over the period of its certification. If substantive technical changes occur that affect the certification before the expiration of this certificate, NIST will notify the purchaser. Registration (see attached sheet) will facilitate notification.

E.A. Mackey and R.R. Greenberg of the NIST Analytical Chemistry Division were responsible for coordination of the technical measurements leading to certification.

Statistical analyses were performed by J.H. Yen of the NIST Statistical Engineering Division.

The support aspects involved in the issuance of this SRM were coordinated through the NIST Measurement Services Division.

Stephen A. Wise, Chief
Analytical Chemistry Division

Gaithersburg, MD 20899
Certificate Issue Date: 7 April 2009

Robert L. Watters, Jr., Chief
Measurement Services Division

INSTRUCTIONS FOR USE

Sampling: The SRM should be thoroughly mixed by repeatedly inverting and rotating the bottle horizontally before removing a test portion for analysis. A minimum mass of 250 mg (dry mass - see *Instructions for Drying*) should be used for analytical determinations to be related to the mass fraction values in this Certificate of Analysis.

To obtain the certified values, sample preparation procedures should be designed to effect complete dissolution. If volatile elements (i.e., arsenic, mercury, selenium) are to be determined, precautions should be taken in the dissolution of SRM 2709a to avoid volatilization losses.

Drying: To relate measurements to the certified, reference, and information values that are expressed on a dry-mass basis, users should determine a drying correction at the time of each analysis. The recommended drying procedure is oven drying for 2 h at 110 °C. Note that analytical determination of volatile elements (i.e., arsenic, mercury, selenium) should be determined on samples as received; separate samples should be dried as previously described to obtain a correction factor for moisture. Correction for moisture is to be made to the data for volatile elements before comparing them to the certified values. This procedure ensures that these elements are not lost during drying. The mass loss on drying for this material as bottled was approximately 3%, but this value may change once the bottle is opened and the soil is exposed to air.

SOURCE, PREPARATION, AND ANALYSIS

Source and Preparation of Material[1]: The U.S. Geological Survey (USGS), under contract to NIST, collected and processed the soil for SRM 2709a with assistance from the U.S. Bureau of Reclamation's Sacramento CA office. The agricultural soil used to produce SRM 2709a was collected from a fallow field, in the central California San Joaquin Valley. Three separate collection sites were used to obtain the necessary amount of material. Each collection site covered an area of approximately 4 m^2. Prior to sample collection the area was scraped clean of surface vegetation. Collected material was transferred to 20 plastic-lined five-gallon plastic buckets and shipped to the USGS laboratory for processing. At USGS, the SRM 2709a soil was dried at room temperature, disaggregated, and sieved to remove coarse material (≥2 mm). The resulting soil was ball-milled in 50 kg portions, and then the entire batch of soil was transferred to a cross-flow V-blender for mixing. The blended soil was radiation sterilized prior to bottling. In the final preparation step the blended material was split into containers using a custom-designed spinning riffler, which was used to divide the material into smaller batches, and then used to apportion approximately 50 g into each pre-cleaned bottle.

Every 100th bottle was set aside for chemical analyses designed to assess material homogeneity using X-ray fluorescence spectrometry (XRF), inductively coupled plasma optical emission spectrometry (ICP-OES), and inductively coupled plasma mass spectrometry (ICP-MS) at the USGS. Homogeneity assessments were performed at NIST as well, and results indicated that additional processing was needed to achieve optimum homogeneity. The material from all bottles was combined, and then ground in batches between stainless steel plates for a time sufficient to produce a powder of which ≥95%, by mass, passed through a 200 mesh (74 µm) sieve. The resulting powder was blended, and 50 g portions were dispensed into bottles using the spinning riffler. Results from additional analyses indicated material homogeneity was acceptable (see below).

Analysis: The homogeneity was assessed for selected elements in the bottled material using X-ray fluorescence spectrometry and instrumental neutron activation analysis. In a few cases, statistically significant differences were observed, and the variance due to material inhomogeneity is included in the expanded uncertainties of the certified values. The estimated relative standard deviation for material inhomogeneity for most elements is ≤1 %, for calcium it is approximately 2 %, and for chromium it is approximately 3 %. Significant material heterogeneity was observed for mercury, for which a reference value with a prediction interval is provided; see Table 2.

Analyses of this material were performed at NIST (Gaithersburg, MD) and at the USGS (Denver, CO). Results from NIST were used to provide the certified, reference, and information values shown in Tables 1, 2, and 3 respectively. Results from the USGS were used to confirm those values. The analytical techniques used for each element are listed in Table 4; the analysts are listed in Tables 5 and 6.

---

[1] Certain commercial equipment, instruments, or materials are identified in this certificate in order to specify adequately the experimental procedure. Such identification does not imply recommendation or endorsement by the National Institute of Standards and Technology, nor does it imply that the materials or equipment identified are necessarily the best available for the purpose.

Table 1. Certified Values[(a)] (Dry-Mass Basis) for Selected Elements in SRM 2709a

Element	Mass Fraction (%)	Element	Mass Fraction (mg/kg)
Aluminum	7.37 ± 0.16	Antimony	1.55 ± 0.06
Calcium	1.91 ± 0.09	Barium	979 ± 28
Iron	3.36 ± 0.07	Cadmium	0.371 ± 0.002
Magnesium	1.46 ± 0.02	Chromium	130 ± 9
Phosphorus	0.0688 ± 0.0013	Cobalt	12.8 ± 0.2
Potassium	2.11 ± 0.06	Lead	17.3 ± 0.1
Silicon	30.3 ± 0.4	Manganese	529 ± 18
Sodium	1.22 ± 0.03	Strontium	239 ± 6
Titanium	0.336 ± 0.007	Vanadium	110 ± 11
		Zirconium	195 ± 46

(a) Certified values for all elements except cadmium and lead are the equally weighted means of results from two or three analytical methods. The uncertainty listed with each value is an expanded uncertainty about the mean, with coverage factor determined by the Student's t distribution, calculated by combining a between-method variance with a pooled within-method variance [3] following the ISO Guide [4]. A component for material heterogeneity is incorporated into the uncertainties of aluminum, calcium, chromium, manganese, and sodium. The certified values for cadmium and lead are each results from a single NIST method (isotope dilution (ID)-ICP-MS) for which a complete evaluation of all sources of uncertainty has been performed. The uncertainty for the certified value for cadmium and lead represents an expanded uncertainty with a coverage factor of 2, with uncertainty components combined following the ISO Guide [4].

Table 2. Reference Values[(a)] (Dry-Mass Basis) for Selected Elements in SRM 2709a

Element	Mass Fraction (mg/kg)
Arsenic	10.5 ± 0.3
Cerium	42 ± 1
Cesium	5.0 ± 0.1
Copper	33.9 ± 0.5
Europium	0.83 ± 0.02
Gadolinium	3.0 ± 0.1
Lanthanum	21.7 ± 0.4
Mercury[(b)]	0.9 ± 0.2
Nickel	85 ± 2
Rubidium	99 ± 3
Scandium	11.1 ± 0.1
Thallium	0.58 ± 0.01
Thorium	10.9 ± 0.2
Uranium	3.15 ± 0.05
Zinc	103 ± 4

(a) Reference values for all elements are based on results from one analytical method at NIST. Uncertainty values represent the expanded uncertainties which include the combined Type A and Type B with a coverage factor of 2, following the ISO Guide [4].

(b) The reference value for mercury represents the average value from analysis of portions from six bottles using ID-cold vapor (CV)-ICP-MS. Results indicate significant material heterogeneity; values ranged from 0.8 mg/kg to 1.1 mg/kg. The uncertainty for this reference value is in the form of a prediction interval.

Table 3. Information Values[a] (Dry Mass Basis) for Selected Elements in SRM 2709a

Element	Mass Fraction (mg/kg)
Boron	74
Dysprosium	3
Hafnium	4
Lutetium	0.3
Neodymium	17
Samarium	4
Selenium	1.5
Tantalum	0.7
Terbium	0.5
Ytterbium	2

[a] Information values are based on results from one analytical method at NIST.

Table 4. Methods Used for the Analysis of SRM 2709a

Element	Certification Methods	Element	Certification Methods
Al	INAA; XRF	Nd	INAA
As	INAA	Ni	ICP-MS
B	PGAA	P	ICP-OES; XRF
Ba	ICP-OES; INAA: XRF	Pb	ID-ICP-MS
Ca	INAA; XRF	Rb	INAA
Cd	ID-ICP-MS; PGAA	Sb	INAA; ICP-MS
Ce	INAA	Sc	INAA
Co	INAA; ICP-OES	Se	CCT-ICP-MS
Cr	INAA; XRF	Si	PGAA; XRF
Cs	INAA	Sm	INAA
Cu	ICP-MS	Sr	INAA; ICP-OES; XRF
Dy	INAA	Ta	INAA
Eu	INAA	Tb	INAA
Fe	INAA; PGAA; XRF	Th	INAA
Gd	PGAA	Ti	INAA; PGAA; XRF
Hf	INAA	Tl	ICP-MS
Hg	CV-ID-ICP-MS	U	ICP-MS
K	INAA; PGAA; XRF	V	INAA; XRF
La	INAA	Yb	INAA
Lu	INAA	Zn	INAA
Mg	INAA; XRF	Zr	INAA; XRF
Mn	INAA; PGAA; XRF		
Na	INAA; XRF		

NIST Methods of Analysis

CCT-ICP-MS	Collision Cell Inductively Coupled Plasma Mass Spectrometry
CV ID-ICP-MS	Cold Vapor Isotope Dilution Inductively Coupled Plasma Mass Spectrometry
ICP-MS	Inductively Coupled Plasma Mass Spectrometry
ICP-OES	Inductively Coupled Plasma Optical Emission Spectrometry
ID-ICP-MS	Isotope Dilution Inductively Coupled Plasma Mass Spectrometry
INAA	Instrumental Neutron Activation Analysis
PGAA	Prompt Gamma-Ray Activation Analysis
XRF	X-ray Fluorescence Spectrometry

USGS Methods of Analysis(a)

WD-XRF	Wavelength Dispersive X-ray Fluorescence Spectrometry
ICP-OES	Inductively Coupled Plasma Optical Emission Spectrometry
ICP-MS	Inductively Coupled Plasma Mass Spectrometry

(a) USGS Methods of Analysis were used to confirm results from certification methods.

Table 5. Participating NIST Analysts:

S.J. Christopher
R.M. Lindstrom
S.E. Long
E.A. Mackey
A.F. Marlow
K.E. Murphy
R.L. Paul
S.A. Rabb
J.R. Sieber
R.O. Spatz
R.S. Popelka-Filcoff
B.E. Tomlin
L.J. Wood
L.L. Yu
R. Zeisler

Table 6. Participating USGS Laboratory and Analysts

Laboratory	Analysts
U.S. Geological Survey Branch of Geochemistry Denver, CO, USA	M.G. Adams Z.A. Brown P.L. Lamothe J.E. Taggart S.A. Wilson

REFERENCES

[1] Thompson, A; Taylor, B.N.; *Guide for the Use of the International System of Units (SI)*, NIST Special Publication 811 (2008); available at http://physics.nist.gov/Pubs/

[2] May, W.E.; Gills, T.E.; Par*ris, R.; Beck, II, C.M.; Fassett, J.D.; Gettings, R.J.; Gre*enberg, R.R.; Guenther, F.R.; Kramer, G.; MacDonald, B.S.; Wise, S.A.; *Definitions of Terms and Modes Used at NIST for Value-Assignment of Reference Materials for Chemical Measurements*, NIST Specia*l Publication 260-136* (1999); available at http://www.cstl.nist.gov/nist839/NIST_special_publications.htm).

[3] Levenson, M.S.; Banks, D.L.; Eberhardt, K.R.; Gill, L.M.; Guthrie, W.F.; Liu, H.K.; Vangel, M.G.; Yen, J.H.; Zhang, N.F.; J. Res. NIST 105, pp. 571-579 (2000).

[4] ISO; *Guide to the Expression of Uncertainty in Measurement*, ISBN 92-67-10188-9, 1st ed.; International Organization for Standardization: Geneva, Switzerland (1993); see also Taylor, B.N.; Kuyatt, C.E.; *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*, NIST Technical Note 1297, U.S. Government Printing Office, Washington, DC (1994); available at http://physics.nist.gov/Pubs/.

Users of this SRM should ensure that the certificate in their possession is current. This can be accomplished by contacting the SRM Program at: telephone (301) 975-2200; fax (301) 926-4751; e-mail srminfo@nist.gov; or via the Internet at http://www.nist.gov/srm.

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Certified Reference Materials - Notes

NOTES

“The shortest distance between two points is under construction.” **-Noelie Alito-**

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Soil, Contaminated	SS-1		100 g	140-025-001
Soil, Contaminated	SS-2		100 g	140-025-002
Sludge, Sewage	BE-1		50 g	140-025-011
Water, Drinking, Low Level, Concentrate	EP-L-1	✓ ⑧	250 ml	140-025-031
Water, Drinking, High Level, Concentrate	EP-H-1	✓ ⑧	250 ml	140-025-032
Water, Drinking, High & Low	SET	✓ ⑧	250 ml	140-025-030
Water, Ground, Low Level, Concentrate	ES-L-1	✓ ⑧	250 ml	140-025-034
Water, Ground, High Level, Concentrate	ES-H-1	✓ ⑧	250 ml	140-025-035
Water, Ground, High & Low	SET	✓ ⑧	250 ml	140-025-033
Water, Waste, Low Level, Concentrate	EU-L-1	✓ ⑧	250 ml	140-025-037
Water, Waste, High Level, Concentrate	EU-H-1	✓ ⑧	250 ml	140-025-038
Water, Waste, High & Low	SET	✓ ⑧	250 ml	140-025-036
Oil, Used	HU-1		125 ml	140-025-041

*Agro***MAT^{TM} Standards**	Symbol	Code	Quantity	Catalog Number
Soil, Clay	AG-1		175 g	140-025-101
Soil, Sandy	AG-2		175 g	140-025-102
Compost	CP-1		100 g	140-025-111

⊗ *Glass Container*	⑥ *Poison*	③ *Flammable*
✓ *Dangerous Goods**	⑧ *Corrosive*	⑤ *Oxidant*

* as defined by :
* Hazardous Materials Regulations of the U.S. Department of Transportation, Tariff No. BOE-6000-R
* Canadian Transportation of Dangerous Goods Act and Regulations, Revision December 2000
* International Air Transport Association - Dangerous Goods Regulation, 40th Edition

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Contaminated Soil - SS-1

Parameter	EPA-3050A Digestion Values		Total Digestion Values	
	Consensus Value (ppm)	Confidence Interval (95%)	Consensus Value (ppm)	Confidence Interval (95%)
Ag	(1.9)	---	(3.4)	---
Al	9518	8417 - 10,619	40,106	36,686 - 43,526
As	18	17 - 19	17	13 - 21
B	(13)	---	---	---
Ba	102	96 - 108	401	356 - 446
Be	(0.5)	---	(1.2)	---
Ca	137,375	131,222 - 143,528	137,664	124,276 - 151,052
Cd	34	32 - 36	35	32 - 38
Ce	(32)	---	(36)	---
Co	28	26 - 30	32	30 - 34
Cr	64	55 - 73	110	97 - 123
Cu	690	657 - 723	720	691 - 749
Fe	20,406	19,037 - 21,775	29,161	27,360 - 30,962
Hg	(0.19)	---	(0.25)	---
K	1913	1553 - 2273	14,495	13,185 - 15,805
Li	11	9 - 13	(17)	---
Mg	6088	5710 - 6466	9710	8925 - 10,495
Mn	425	406 - 444	557	534 - 580
Mo	5	4.3 - 5.7	(8)	---
Na	217	177 - 257	9528	8363 - 10,693
Ni	231	218 - 244	239	215 - 263
P	1070	1021 - 1119	1188	1116 - 1260
Pb	233	219 - 247	253	227 - 279
S	(7843)	---	(7994)	---
Sb	(0.6)	---	(1.7)	---
Se	(1.6)	---	(1.8)	---
Sn	---	---	(4.3)	-----
Sr	202	195 - 209	332	308 - 356
Ti	248	186 - 310	1969	1782 - 2156
Tl	(0.5)	---	(0.9)	---
U	(21)	---	(21)	---
V	19	17 - 21	42	39 - 45
Y	(8)	---	(16)	---
Zn	6775	6467 - 7083	7290	6813 - 7767

Catalog Number	Code	Quantity
140-025-001		100 g

⊗ *Glass Container*	⑥ *Poison*	③ *Flammable*	* as defined by :
✓ *Dangerous Goods**	⑧ *Corrosive*	⑤ *Oxidant*	

* Hazardous Materials Regulations of the U.S. Department of Transportation, Tariff No. BOE-6000-R
* Canadian Transportation of Dangerous Goods Act and Regulations, Revision December 2000
* International Air Transport Association - Dangerous Goods Regulation, 40th Edition

*Digi*PREP MS - For Soil Testing

An acid resistant digestion system for multiple digestion applications:

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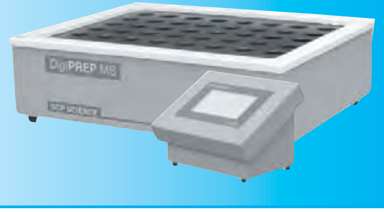


"Spring is when you feel like whistling even with a shoe full of slush." -Doug Larson-

Contaminated Soil - SS-2

Parameter	EPA-3050A Digestion Values Consensus Value (ppm)	EPA-3050A Digestion Values Confidence Interval (95%)	Total Digestion Values Consensus Value (ppm)	Total Digestion Values Confidence Interval (95%)
Ag	(1.3)	---	(3)	---
Al	13,265	12,114 - 14,416	44,853	37,791 - 51,915
As	75	65 - 85	78	62 - 94
B	(12)	---	---	---
Ba	215	202 - 228	650	594 - 706
Be	(0.7)	---	(4)	---
Ca	112,861	107,989 - 117,733	118,738	106,798 - 130,678
Cd	(2)	---	(2)	---
Ce	(71)	---	(79)	---
Co	12	11 - 13	14	13 - 15
Cr	34	30 - 38	58	51 - 65
Cu	191	182 - 200	198	189 - 207
Fe	21,046	19,597 - 22,495	29,070	27,262 - 30,878
Hg	(0.28)	---	(0.34)	---
K	3418	3066 - 3770	18,119	16,349 - 19,889
Li	14	12 - 16	(20)	---
Mg	11,065	10,459 - 11,671	14,225	12,995 - 15,455
Mn	457	433 - 481	577	545 - 609
Mo	(4)	---	(4)	---
Na	558	456 - 660	12,539	11,362 - 13,716
Ni	54	50 - 58	59	55 - 63
P	752	734 - 770	814	744 - 884
Pb	126	116 - 136	148	130 - 166
S	(2193)	---	(2254)	---
Sb	(0.8)	---	(6)	---
Se	(0.8)	---	(1)	---
Sn	---	---	(6)	---
Sr	214	202 - 226	382	351 - 413
Ti	850	742 - 958	2893	2664 - 3122
Tl	(0.3)	---	(0.6)	---
U	(1.3)	---	(2)	---
V	34	31 - 37	59	54 - 64
Y	(12)	---	(21)	---
Zn	467	444 - 490	509	479 - 539

Catalog Number	Code	Quanity
140-025-002		100 g

Sewage Sludge - BE-1

Parameter	Consensus Value (µg/g)	Confidence Interval (95%)
Ag	21	20 – 22
Al	43917	42324 – 45510
As	4.6	4.1 – 5.1
B	(9.9)	---
Ba	446	413 – 479
Be	0.21	0.17 – 0.25
Ca	28636	27185 – 30087
Cd	1.9	1.6 – 2.2
Co	2.3	2.1 – 2.5
Cr	34	31 – 37
Cu	408	392 – 424
Fe	8925	8478 – 9372
Hg	1.3	1.1 – 1.5
K	2273	2034 – 2512
Li	3.6	3.0 – 4.2
Mg	3808	3600 – 4016
Mn	213	205 – 221
Mo	6.4	5.9 – 6.9
Na	1459	1260 – 1658
Ni	14	13 – 15
P	29826	27906 – 31746
Pb	57	53 – 61
S	(8048)	---
Sb	(0.9)	---
Se	2.9	2.4 – 3.4
Sn	(16)	---
Sr	349	331 – 367
Ti	(91)	---
U	(2.1)	---
V	12	11.5 – 12.5
Zn	381	367 – 395

Catalog Number	Code	Quantity
140-025-011		50 g

⊗ *Glass Container*
✓ *Dangerous Goods**
⑥ *Poison*
⑧ *Corrosive*
③ *Flammable*
⑤ *Oxidant*

* as defined by :
- Hazardous Materials Regulations of the U.S. Department of Transportation, Tariff No. BOE-6000-R
- Canadian Transportation of Dangerous Goods Act and Regulations, Revision December 2000
International Air Transport Association - Dangerous Goods Regulation, 40th Edition

*pe*CHECK - Compliance Standards

- Compliance testing at reduced cost
- Large lot sizes ensure long term availability & repeatability
- Variable concentration levels to match your specific needs

Certified Reference Materials

*Enviro*MAT™

Waste Water EU-L-1 EU-H-1

	EU-L-1 After 1:100 Dilution		EU-H-1 After 1:50 Dilution	
Parameter	**Consensus Value (ppm)**	**Confidence Interval (95%)**	**Consensus Value (ppm)**	**Confidence Interval (95%)**
Al	0.15	0.12 – 0.18	0.45	0.43 – 0.47
As	0.21	0.20 – 0.22	0.86	0.81 –0.91
B	0.25	0.24 – 0.26	0.87	0.78 – 0.96
Ba	0.30	0.29 – 0.31	1.26	1.23 – 1.29
Be	0.03	0.029 – 0.031	0.52	0.50 – 0.54
Ca	4.03	3.91 – 4.15	40.6	39.8 – 41.4
Cd	0.06	0.058 – 0.062	0.31	0.30 – 0.32
Co	0.20	0.197 – 0.203	0.74	0.72 – 0.76
Cr	0.15	0.147 – 0.153	0.46	0.45 – 0.47
Cu	0.26	0.25 – 0.27	0.93	0.91 – 0.95
Fe	0.11	0.10 – 0.12	0.65	0.62 – 0.68
K	4.49	4.39 – 4.59	43.7	42.4 – 45.0
Mg	1.24	1.21 – 1.27	13.8	13.6 – 14.0
Mn	0.30	0.29 – 0.31	0.52	0.51 – 0.53
Mo	0.10	0.097 – 0.103	0.82	0.80 – 0.84
Na	10.4	10.2 – 10.6	43.0	42.2 – 43.8
Ni	0.20	0.196 – 0.204	0.88	0.86 – 0.90
P	2.67	2.58 – 2.76	12.7	12.1 – 13.3
Pb	0.10	0.098 – 0.102	0.73	0.72 – 0.74
Sb	0.06	0.05 – 0.07	0.63	0.60 – 0.66
Se	0.07	0.067 – 0.073	0.17	0.16 – 0.18
Sr	0.38	0.37 – 0.39	1.09	1.06 – 1.12
Tl	0.20	0.19 – 0.21	0.48	0.46 – 0.50
V	0.12	0.116 – 0.124	0.96	0.94 – 0.98
Zn	0.06	0.057 – 0.063	1.00	0.97 – 1.03

Catalog Number	Code	Quantity
140-025-037	✓ ⑧	250 ml
140-025-038	✓ ⑧	250 ml

Ground Water ES-L-1 ES-H-1

	ES-L-1 After 1:500 Dilution		ES-H-1 After 1:50 Dilution	
Parameter	**Consensus Value (ppm)**	**Confidence Interval (95%)**	**Consensus Value (ppm)**	**Confidence Interval (95%)**
Al	0.094	0.085 – 0.103	0.55	0.52 – 0.58
As	0.011	0.010 – 0.012	1.03	0.99 – 1.07
B	(0.036)	---	4.07	3.90 – 4.24
Ba	0.050	0.048 – 0.052	8.26	8.11 – 8.41
Be	0.052	0.051 – 0.053	0.53	0.52 – 0.54
Ca	0.25	0.24 – 0.26	13.9	13.5 – 14.3
Cd	0.010	0.009 – 0.011	0.51	0.50 – 0.52
Co	0.051	0.050 – 0.052	0.30	0.29 – 0.31
Cr	0.020	0.0196 – 0.0204	0.98	0.96 – 1.00
Cu	0.020	0.018 – 0.022	1.99	1.93 – 2.05
Fe	0.021	0.019 – 0.023	3.02	2.94 – 3.10
K	0.18	0.16 – 0.20	6.45	6.12 – 6.78
Li	0.050	0.049 – 0.051	0.25	0.24 – 0.26
Mg	0.110	0.105 – 0.115	9.11	8.99 – 9.23
Mn	0.096	0.093 – 0.099	0.79	0.77 – 0.81
Mo	0.011	0.010 – 0.012	1.03	1.02 – 1.04
Na	1.27	1.13 – 1.41	43.3	42.6 – 44.0
Ni	0.010	0.0096 – 0.0104	2.01	1.96 – 2.06
P	(0.005)	---	1.12	1.02 – 1.22
Pb	(0.002)	---	0.33	0.32 – 0.34
Sb	0.006	0.005 – 0.007	0.11	0.106 – 0.114
Se	(0.001)	---	0.077	0.074 – 0.080
Sr	0.121	0.116 – 0.126	2.53	2.50 – 2.56
Tl	0.071	0.068 – 0.074	0.104	0.102 – 0.106
U	0.050	0.049 – 0.051	0.49	0.47 – 0.51
V	0.010	0.009 – 0.011	2.02	1.98 – 2.06
Zn	0.021	0.020 – 0.022	2.00	1.95 – 2.05

Catalog Number	Code	Quantity
140-025-034	✓ ⑧	250 ml
140-025-035	✓ ⑧	250 ml

Drinking Water EP-L-1 EP-H-1

	EP-L-1 After 1:1000 Dilution		EP-H-1 After 1:100 Dilution	
Parameter	**Consensus Value (ppm)**	**Confidence Interval (95%)**	**Consensus Value (ppm)**	**Confidence Interval (95%)**
Al	0.26	0.24 – 0.28	0.92	0.88 – 0.96
As	0.027	0.025 – 0.029	0.40	0.38 – 0.42
B	0.20	0.18 – 0.22	9.88	9.51 – 10.25
Ba	0.021	0.020 – 0.022	2.01	1.97 – 2.05
Be	0.005	0.0049 – 0.0051	0.16	0.15 – 0.17
Ca	0.94	0.92 – 0.96	22.1	21.6 – 22.6
Cd	0.005	0.0048 – 0.0052	0.20	0.19 – 0.21
Co	0.026	0.025 – 0.027	0.095	0.092 – 0.098
Cr	0.035	0.034 – 0.036	0.68	0.66 – 0.70
Cu	0.040	0.038 – 0.042	0.50	0.49 – 0.51
Fe	0.068	0.063 – 0.073	1.48	1.43 – 1.53
K	0.84	0.79 – 0.89	12.8	12.3 – 13.3
Li	0.030	0.029 – 0.031	0.71	0.68 – 0.74
Mg	0.054	0.050 – 0.058	4.83	4.75 – 4.91
Mn	0.015	0.014 – 0.016	0.34	0.33 – 0.35
Mo	0.063	0.062 – 0.064	0.52	0.51 – 0.53
Na	0.68	0.58 – 0.78	21.6	21.2 – 22.0
Ni	0.051	0.050 – 0.052	0.83	0.80 – 0.86
P	(0.039)	---	0.42	0.40 – 0.44
Pb	0.009	0.008 – 0.010	0.63	0.61 – 0.65
Sb	0.031	0.029 – 0.033	0.21	0.20 – 0.22
Se	0.15	0.14 – 0.16	0.32	0.30 – 0.34
Sr	0.35	0.34 – 0.36	0.95	0.93 – 0.97
Tl	0.015	0.014 – 0.016	0.26	0.25 – 0.27
U	0.009	0.008 – 0.010	0.097	0.092 – 0.102
V	0.036	0.035 – 0.037	0.99	0.96 – 1.02
Zn	0.103	0.100 – 0.106	5.01	4.82 – 5.20

Catalog Number	Code	Quantity
140-025-031	✓ ⑧	250 ml
140-025-032	✓ ⑧	250 ml

⊗ *Glass Container*	⑥ *Poison*	③ *Flammable*
✓ *Dangerous Goods**	⑧ *Corrosive*	⑤ *Oxidant*

* as defined by :
- ⁎Hazardous Materials Regulations of the U.S. Department of Transportation, Tariff No. BOE-6000-R
- ⁎Canadian Transportation of Dangerous Goods Act and Regulations, Revision December 2000
- ⁎International Air Transport Association - Dangerous Goods Regulation, 40th Edition

"Example is contagious behavior." **-Charles Reade-**

Used Oil - HU-1

Parameter	Consensus Value (µg/g)	Confidence Interval (95%)
Ag	13	10 – 16
Al	14	11 – 17
Ba	9	8.5 – 9.5
Ca	72	67 – 77
Cd	15	14 – 16
Cr	15	13 – 17
Cu	3132	2906 – 3358
Fe	59	53 – 65
K	(11)	---
Mg	11	10 – 12
Mn	18	17 – 19
Mo	11	10 – 12
Na	(20)	---
Ni	45	42 – 48
P	(40)	---
Pb	20	19 – 21
Si	(10)	---
Sn	(305)	---
Ti	9	7 – 11
V	7	6.5 – 7.5
Zn	16	14 – 18

Catalog Number	Code	Quantity
140-025-041		125 ml

Save more with **MATPak**
Purchase any three MAT CRMs and save over 15%!

Compost - CP-1

Parameter	Unit	Consensus Value	Confidence Interval (95%)
Al - Total	mg/kg	7544	6838 - 8250
As - Total	mg/kg	5.5	3.6 - 7.4
C/N Ratio	---	(20.6)	---
Ca - Total	mg/kg	54393	51699 - 57087
Cd - Total	mg/kg	(1.6)	---
Co - Total	mg/kg	5.5	4.6 - 6.4
Cr - Total	mg/kg	41	35 - 47
Cu - Total	mg/kg	227	215 - 239
Fe - Total	mg/kg	17550	16923 - 18177
H_20	%	2.7	2.3 - 3.1
Hg - Total	mg/kg	0.6	0.52 - 0.68
K - Total	mg/kg	1334	1136 - 1532
Mg - Total	mg/kg	4493	4283 - 4703
Mn - Total	mg/kg	658	637 - 679
Mo - Total	mg/kg	(2.3)	---
N - Total	%	0.82	0.77 - 0.87
Na - Total	mg/kg	462	392 - 532
Ni - Total	mg/kg	30	27 - 33
NO_3 - N	mg/kg	797	702 - 892
Organic Matter	%	28	25 - 31
P - Total	mg/kg	6874	6615 - 7133
Pb - Total	mg/kg	33	31 - 35
pH	---	7.2	7.1 - 7.3
S - Total	mg/kg	2042	1783 - 2301
Se - Total	mg/kg	(0.8)	---
Zn - Total	mg/kg	240	232 - 248

Catalog Number	Code	Quantity
140-025-111		100 g

⊗ *Glass Container*
✓ *Dangerous Goods**
⑥ *Poison*
⑧ *Corrosive*
③ *Flammable*
⑤ *Oxidant*

* as defined by :
* Hazardous Materials Regulations of the U.S. Department of Transportation, Tariff No. BOE-6000-R
* Canadian Transportation of Dangerous Goods Act and Regulations, Revision December 2000
International Air Transport Association - Dangerous Goods Regulation, 40th Edition

Certified Reference Materials

*Agro*MAT™

			Clay Soil		Sandy Soil	
			AG-1		AG-2	
Parameter	**Method**	**Unit**	**Consensus Value**	**Confidence Interval (95%)**	**Consensus Value**	**Confidence Interval (95%)**
Phosphorus	Bray 1	ppm	34	27 – 41	22	17 – 27
	Mehlich III	ppm	52	49 – 55	21	19 – 23
	Olsen	ppm	38	34 – 42	15	12 – 18
Potassium	Ammonium Acetate	ppm	108	104 – 112	79	71 – 87
	Mehlich III	ppm	121	113 – 129	88	82 – 94
Calcium	Ammonium Acetate	ppm	2184	2075 – 2293	371	345 – 397
	Mehlich III	ppm	2580	2488 – 2672	468	433 – 503
Magnesium	Ammonium Acetate	ppm	249	237 – 261	27	20 – 34
	Mehlich III	ppm	298	286 – 310	39	34 – 44
Zinc	DTPA	ppm	0.9	0.8 – 1.0	1.6	1.5 – 1.7
	Mehlich III	ppm	2.1	2.0 – 2.2	3.8	3.6 – 4.0
Manganese	DTPA	ppm	14	12 – 16	33	27 – 39
	Mehlich III	ppm	140	132 – 148	214	199 – 229
Copper	DTPA	ppm	0.9	0.8 – 1.0	0.8	0.7 – 0.9
	Mehlich III	ppm	0.7	0.6 – 0.8	1.1	1.0 – 1.2
Iron	DTPA	ppm	57	48 – 66	96	74 – 118
	Mehlich III	ppm	546	511 – 581	481	456 – 506
Boron	Hot Water	ppm	0.4	0.3 – 0.5	0.3	0.2 – 0.4
	Mehlich III	ppm	0.7	0.5 – 0.9	0.4	0.2 – 0.6
Sodium	Ammonium Acetate	ppm	25	19 – 31	20	16 – 24
	Mehlich III	ppm	(31)	---	(25)	---
Sulfur	Mehlich III	ppm	(11)	---	(25)	---
Aluminum	Mehlich III	ppm	(913)	---	(1370)	---
pH	1 :1 Soil :Water	---	7.1	7.0 – 7.2	5.7	5.6 – 5.8
	1 :2 Soil :Water	---	7.1	6.9 – 7.3	5.7	5.5 – 5.9
	Saturated Paste	---	(7.1)	-----	(5.8)	---
	Buffer SMP	---	7.2	7.1 – 7.3	6.4	6.3 – 6.5
Organic Matter	LOI	%	2.7	2.4 – 3.0	3.2	2.9 – 3.5
	Walkley Black	%	2.3	2.1 – 2.5	2.5	2.3 – 2.7
Nitrogen as Nitrate	Cadmium Reduction	ppm	14	13 – 15	5	4 – 6
Soluble Salts	1 :1 Soil :Water	uS/cm	(256)	---	(78)	---
	1 :2 Soil :Water	uS/cm	171	151 – 191	72	58 – 86
	Saturated Paste	uS/cm	(562)	---	(228)	---

Catalog Number	Code	Quantity	Catalog Number	Code	Quantity
140-025-101		175 g	**140-025-102**		175 g

⊗ *Glass Container*	⑥ *Poison*	③ *Flammable*
✓ *Dangerous Goods**	⑧ *Corrosive*	⑤ *Oxidant*

* as defined by :
- Hazardous Materials Regulations of the U.S. Department of Transportation, Tariff No. BOE-6000-R
- Canadian Transportation of Dangerous Goods Act and Regulations, Revision December 2000
- International Air Transport Association - Dangerous Goods Regulation, 40th Edition

Instrument Control Kit - *Plasma*TEST ICP-AES

- Perfect for instrument compliance auditing
- A single product providing instrument testing QC for ICP-AES
- Monitor and document 7 different instrument parameters
- Detect operational & mechanical problems before analytical errors occur

“One should not be assigned one’s identity in society by the job slot one happens to fill.” **-Judith Martin-**

Certificate of Analysis: *Enviro*MAT™ Example

Certificate of Analysis

General Information

Sewage Sludge
Certified Reference Material BE-1

Sample

Organization responsible for the certification:

SCP SCIENCE
Manufacturing Division
21800 Clark Graham
Baie d’Urfé, QC, Canada
H9X 4B6

Date of receipt : ____________

Ph: (514) 457-0701 Fax: (514) 457-4499

Date of initial Certification: September 29, 1999
Date of last Verification: February 8, 2005

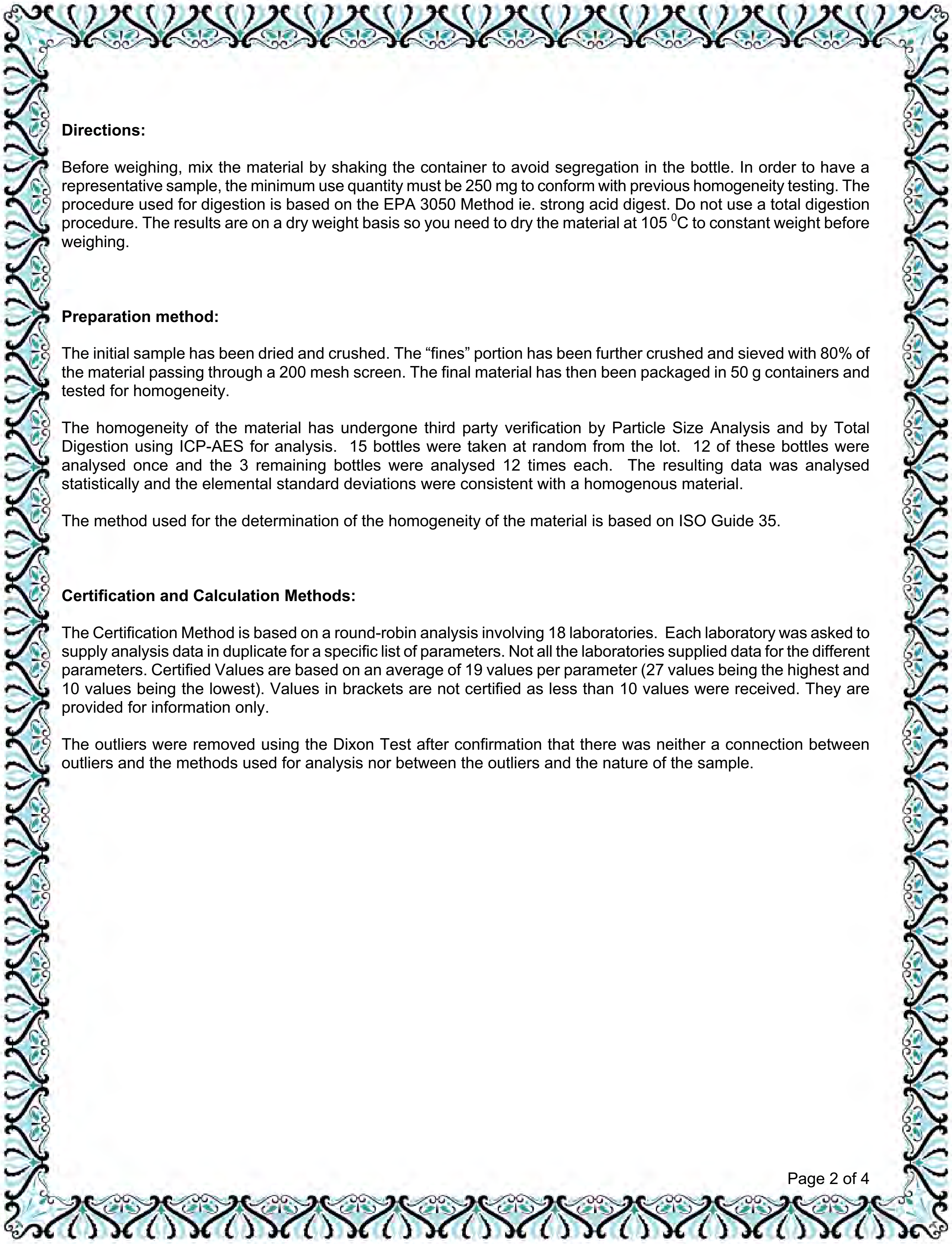
Description:

The Reference Standard BE-1 is a natural sewage sludge (not spiked or fortified) with a particle size of -200 mesh. It is designed to be used for quality control verification, internal standards validation or methods development for the analysis of the listed parameters using the indicated methods.

This certification is valid for 12 months from the shipping date or 24 months after the verification date, whichever comes first, provided the material is kept tightly capped and stored under normal laboratory conditions. **SCP SCIENCE** will monitor the stability of representative samples annually and, if any changes occur that invalidate this certification, **SCP SCIENCE** will notify purchasers.

Page 1 of 4

Certificate of Analysis: *Enviro*MAT™ Example



Directions:

Before weighing, mix the material by shaking the container to avoid segregation in the bottle. In order to have a representative sample, the minimum use quantity must be 250 mg to conform with previous homogeneity testing. The procedure used for digestion is based on the EPA 3050 Method ie. strong acid digest. Do not use a total digestion procedure. The results are on a dry weight basis so you need to dry the material at 105 ^{0}C to constant weight before weighing.

Preparation method:

The initial sample has been dried and crushed. The "fines" portion has been further crushed and sieved with 80% of the material passing through a 200 mesh screen. The final material has then been packaged in 50 g containers and tested for homogeneity.

The homogeneity of the material has undergone third party verification by Particle Size Analysis and by Total Digestion using ICP-AES for analysis. 15 bottles were taken at random from the lot. 12 of these bottles were analysed once and the 3 remaining bottles were analysed 12 times each. The resulting data was analysed statistically and the elemental standard deviations were consistent with a homogenous material.

The method used for the determination of the homogeneity of the material is based on ISO Guide 35.

Certification and Calculation Methods:

The Certification Method is based on a round-robin analysis involving 18 laboratories. Each laboratory was asked to supply analysis data in duplicate for a specific list of parameters. Not all the laboratories supplied data for the different parameters. Certified Values are based on an average of 19 values per parameter (27 values being the highest and 10 values being the lowest). Values in brackets are not certified as less than 10 values were received. They are provided for information only.

The outliers were removed using the Dixon Test after confirmation that there was neither a connection between outliers and the methods used for analysis nor between the outliers and the nature of the sample.

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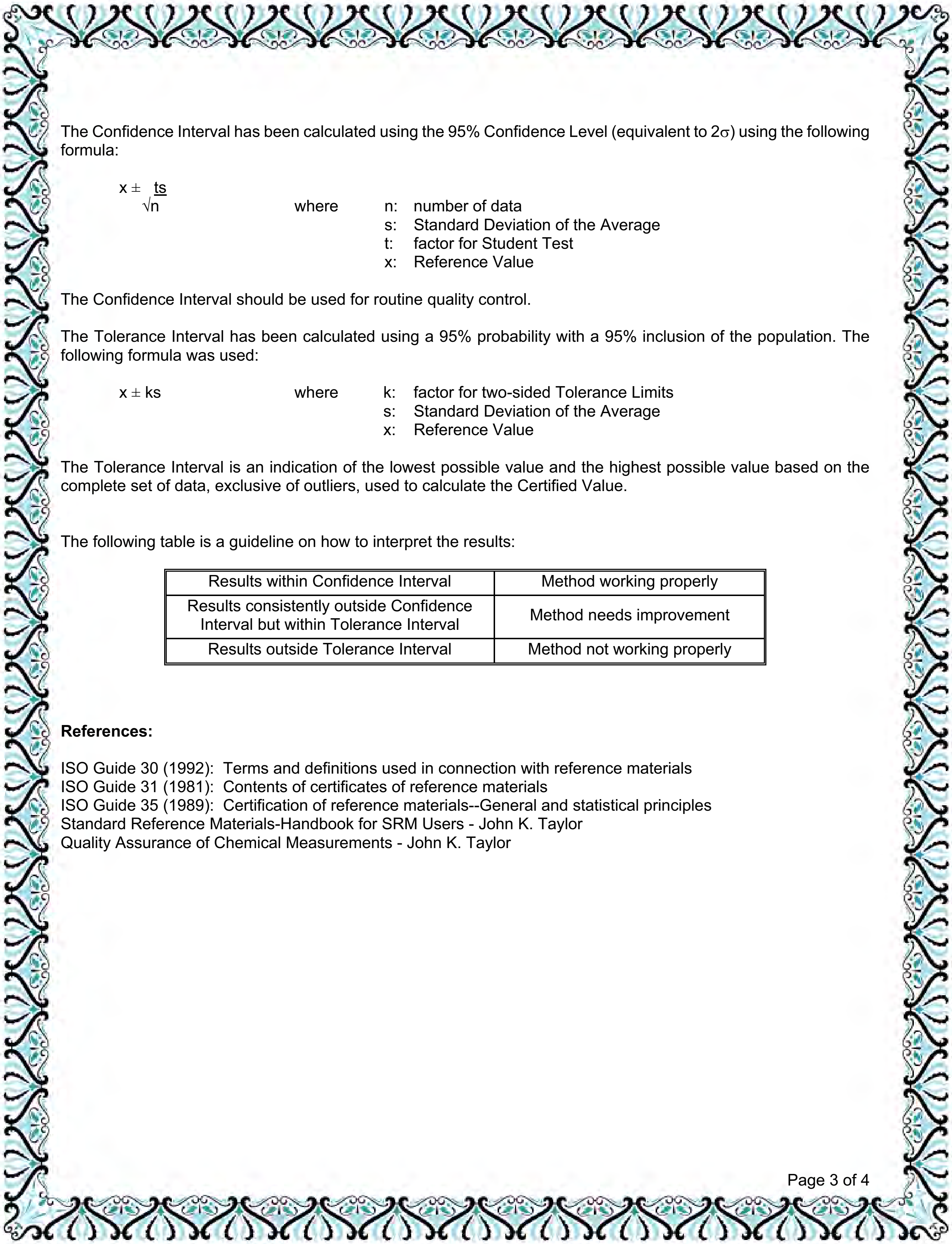
"The only place you can find success before work is in the dictionary." **-May V. Smith-**

Certificate of Analysis: *Enviro*MAT™ Example



The Confidence Interval has been calculated using the 95% Confidence Level (equivalent to 2σ) using the following formula:

$$x \pm \frac{ts}{\sqrt{n}}$$

where
n: number of data
s: Standard Deviation of the Average
t: factor for Student Test
x: Reference Value

The Confidence Interval should be used for routine quality control.

The Tolerance Interval has been calculated using a 95% probability with a 95% inclusion of the population. The following formula was used:

$$x \pm ks$$

where
k: factor for two-sided Tolerance Limits
s: Standard Deviation of the Average
x: Reference Value

The Tolerance Interval is an indication of the lowest possible value and the highest possible value based on the complete set of data, exclusive of outliers, used to calculate the Certified Value.

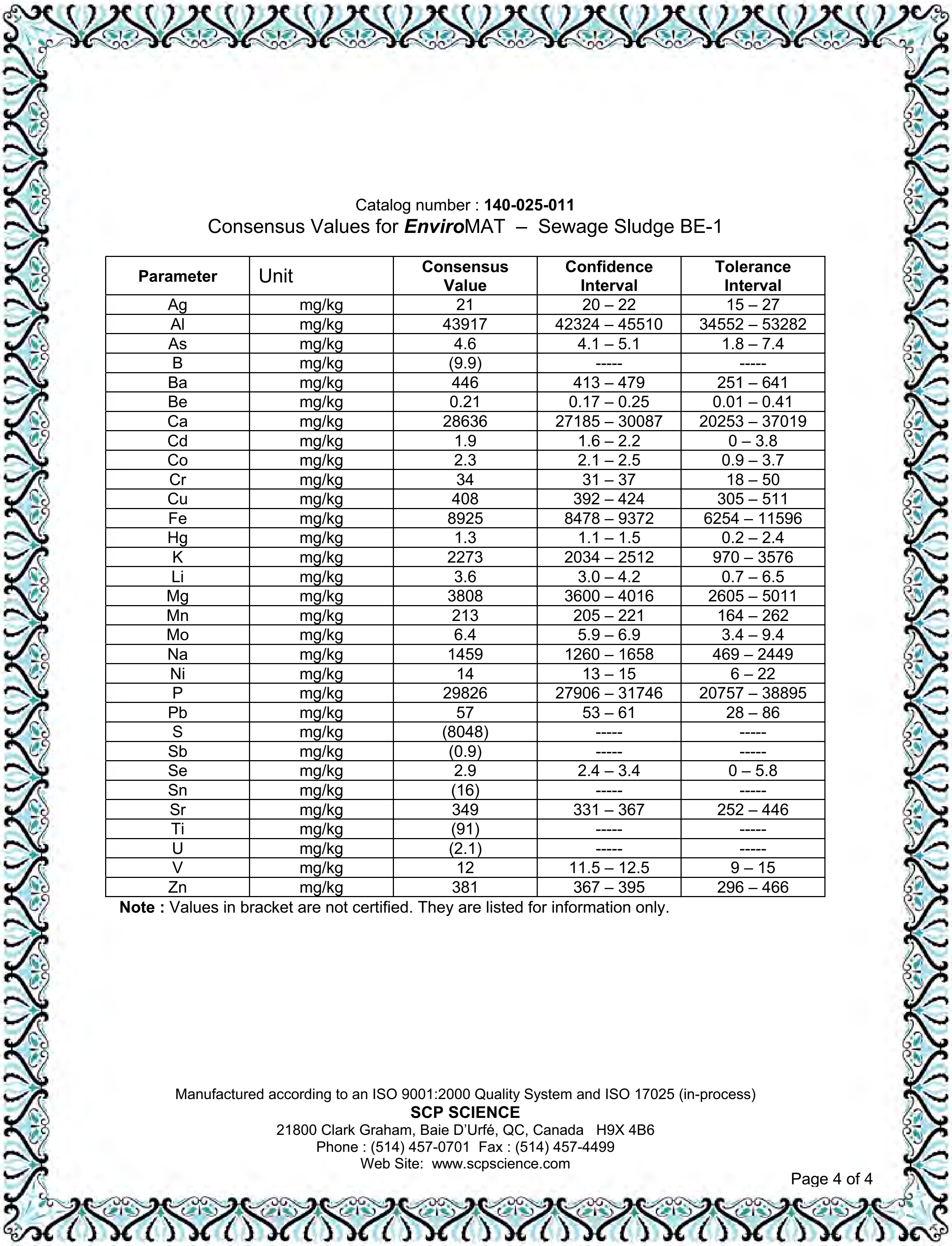
The following table is a guideline on how to interpret the results:

Results within Confidence Interval	Method working properly
Results consistently outside Confidence Interval but within Tolerance Interval	Method needs improvement
Results outside Tolerance Interval	Method not working properly

References:

ISO Guide 30 (1992): Terms and definitions used in connection with reference materials
ISO Guide 31 (1981): Contents of certificates of reference materials
ISO Guide 35 (1989): Certification of reference materials--General and statistical principles
Standard Reference Materials-Handbook for SRM Users - John K. Taylor
Quality Assurance of Chemical Measurements - John K. Taylor

Certificate of Analysis: *Enviro*MAT™ Example



Catalog number : **140-025-011**

Consensus Values for ***Enviro***MAT – Sewage Sludge BE-1

Parameter	Unit	Consensus Value	Confidence Interval	Tolerance Interval
Ag	mg/kg	21	20 – 22	15 – 27
Al	mg/kg	43917	42324 – 45510	34552 – 53282
As	mg/kg	4.6	4.1 – 5.1	1.8 – 7.4
B	mg/kg	(9.9)	-----	-----
Ba	mg/kg	446	413 – 479	251 – 641
Be	mg/kg	0.21	0.17 – 0.25	0.01 – 0.41
Ca	mg/kg	28636	27185 – 30087	20253 – 37019
Cd	mg/kg	1.9	1.6 – 2.2	0 – 3.8
Co	mg/kg	2.3	2.1 – 2.5	0.9 – 3.7
Cr	mg/kg	34	31 – 37	18 – 50
Cu	mg/kg	408	392 – 424	305 – 511
Fe	mg/kg	8925	8478 – 9372	6254 – 11596
Hg	mg/kg	1.3	1.1 – 1.5	0.2 – 2.4
K	mg/kg	2273	2034 – 2512	970 – 3576
Li	mg/kg	3.6	3.0 – 4.2	0.7 – 6.5
Mg	mg/kg	3808	3600 – 4016	2605 – 5011
Mn	mg/kg	213	205 – 221	164 – 262
Mo	mg/kg	6.4	5.9 – 6.9	3.4 – 9.4
Na	mg/kg	1459	1260 – 1658	469 – 2449
Ni	mg/kg	14	13 – 15	6 – 22
P	mg/kg	29826	27906 – 31746	20757 – 38895
Pb	mg/kg	57	53 – 61	28 – 86
S	mg/kg	(8048)	-----	-----
Sb	mg/kg	(0.9)	-----	-----
Se	mg/kg	2.9	2.4 – 3.4	0 – 5.8
Sn	mg/kg	(16)	-----	-----
Sr	mg/kg	349	331 – 367	252 – 446
Ti	mg/kg	(91)	-----	-----
U	mg/kg	(2.1)	-----	-----
V	mg/kg	12	11.5 – 12.5	9 – 15
Zn	mg/kg	381	367 – 395	296 – 466

Note : Values in bracket are not certified. They are listed for information only.

Manufactured according to an ISO 9001:2000 Quality System and ISO 17025 (in-process)
SCP SCIENCE
21800 Clark Graham, Baie D'Urfé, QC, Canada H9X 4B6
Phone : (514) 457-0701 Fax : (514) 457-4499
Web Site: www.scpscience.com

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"Nature, to be commanded, must be obeyed." -Francis Bacon-

June 1/10 ([illegible])

ERA

A Waters Company

Certificate of Analysis

Lot No. D067-540

Metals in Soil

Catalog No. 540
Issue Date: October 1, 2009
Revision Date: Original

Certification

Parameter	Total Concentration [1] (mg/kg)	Certified Value [2] (mg/kg)	Uncertainty [3]	QC PALs™ [4] (mg/kg)	PT PALs™ [5] (mg/kg)
aluminum	61100*	10700	5.1%	5080 - 16300	4950 - 16400
antimony	266	117	0.7%	D.L. - 281	26.4 - 296
arsenic	150	138	5.0%	114 - 162	97.1 - 179
barium	819	269	6.3%	213 - 325	199 - 340
beryllium	168	157	4.6%	131 - 184	118 - 196
boron	104	90.0	4.6%	64.8 - 115	49.8 - 130
cadmium	78.0	71.0	4.6%	58.9 - 83.0	52.0 - 90.0
calcium	17900*	9660	5.6%	8030 - 11300	7280 - 12000
chromium	330	105	6.0%	84.3 - 125	72.8 - 137
cobalt	157	142	4.5%	118 - 165	105 - 178
copper	121	110	6.2%	91.2 - 128	81.8 - 138
iron	34400*	19100	4.5%	9650 - 28500	8210 - 29800
lead	176	144	2.0%	117 - 171	105 - 182
magnesium	7410*	4410	5.5%	3320 - 5500	3100 - 5720
manganese	856	539	6.9%	444 - 635	416 - 661
mercury	25.5	25.3	11.0%	18.1 - 32.4	13.0 - 37.6
molybdenum	114	90.4	4.7%	70.9 - 110	62.8 - 118
nickel	149	130	5.7%	106 - 154	94.7 - 165
potassium	25000*	5000	4.6%	3580 - 6420	3320 - 6690
selenium	221	200	3.6%	160 - 240	137 - 263
silver	48.7	45.1	5.1%	29.9 - 60.3	29.9 - 60.3
sodium	13600*	653	6.1%	482 - 825	360 - 946
strontium	427	246	4.5%	200 - 293	175 - 319
thallium	181	161	4.2%	127 - 195	110 - 212
tin	179	160	4.8%	123 - 197	96.5 - 224
titanium	2920*	447	8.0%	176 - 718	42.6 - 853
vanadium	119	67.0	3.0%	45.6 - 88.4	38.7 - 95.2
zinc	264	223	5.0%	179 - 268	157 - 289

Please see footnotes on back

1. The **Total Concentrations** are equal to the background concentrations in the soil matrix (measured using neutron activation, XRF, and total digestion techniques) plus the amount of each analyte spiked onto the soil. For Trace Metals, the values listed are only "theoretical values" based upon the methodologies listed.

2. The **Certified Values** are equal to the mean recoveries for the parameters as determined in an interlaboratory round robin study based on all applicable digestion techniques reported in the study. The certified values are based on an "as received" basis, assuming 100% solids content.

3. The stated **Uncertainty** is the total propagated uncertainty at the 95% confidence interval. The uncertainty is based on the preparation and internal analytical verification of the product by ERA using a 3050 digestion procedure followed by ICP and/or ICP-MS analysis for the metals and a BrCl leach followed by CVAA analysis for Hg, multiplied by a coverage factor which is equal to the Student t factor at a 95% confidence interval at n-1 degrees of freedom.

4. The **QC Performance Acceptance Limits (QC PALs™)** are based on actual historical data collected in ERA's Proficiency Testing program. The **QC PALs™** reflect any inherent biases in the methods used to establish the limits and closely approximate a 95% confidence interval of the performance that experienced laboratories should achieve using accepted environmental methods. Use the **QC PALs™** to realistically evaluate your performance against your peers.

5. The **PT Performance Acceptance Limits (PT PALs™)** are calculated using the regression equations and fixed acceptance criteria specified in the NELAC proficiency testing requirements. Use the **PT PALs™** when analyzing this QC standard alongside USEPA and NELAC compliant PT standards. Please note that many PT study acceptance limits are concentration dependent (some non-linearly) and, therefore, the acceptance limits of this QC standard and any PT standard may differ relative to their difference in concentrations.

6. This standard **expires 6/2013. The certified values are monitored and purchasers will be notified of any significant** changes resulting in recertification or withdrawal of this certified reference material during the period of validity of this certificate.

If you have any questions or need technical assistance, please call ERA technical assistance at 1-800-372-0122 or email to info@eraqc.com.

Certifying Officer: Tom Widera

* These parameters are native matrix elements and are present at high concentrations in the unspiked soil. As methods 3050 and 3051 do not normally dissolve elements bound in silicate structures, the recoveries of these elements will be low relative to the recoveries of the elements that are primarily spiked onto the soil

NOTE: For laboratories that use internal standards in their analysis procedures, the following elements have been measured in this standard at the listed concentrations. (Note: these concentrations are for informational use only and do not represent "Certified Values". Ce - 46.2 mg/Kg; La - 25.6 mg/Kg; Y - 8.54 mg/Kg.)

ERA Lot#D064 HCl

	Target	Found	Rec. (%)
Aluminum	11000	8994.69	**81.8**
Antimony	81.5	231.17	**283.6**
Arsenic	158	149.22	**94.9**
Barium	348	327.74	**94.2**
Beryllium	106	95.76	**90.3**
Boron	136	120.44	**88.6**
Calcium	9650	9700	**100.5**
Cadmium	187	181.41	**97.0**
Chomium	89.5	85.78	**95.6**
Cobalt	277	281.92	**101.8**
Copper	129	118.35	**91.7**
Iron	18600	19071.11	**102.5**
Lead	172	166.20	**96.6**
Magnesium	5030	4719	**93.8**
Manganese	633	625.43	**98.8**
Mercury	7.34	7.55	**102.4**
Molybdenum	80.4	87.30	**108.6**
Nickel	99	95.99	**96.9**
Selenium	148	139.86	**94.7**
Silver	66.0	***67.81***	**102.7**
Strontium	176	155.03	**88.1**
Thallium	268.0	267.06	**99.7**
Tin	123.0	135.50	**110.2**
Titanium	448	334.43	**74.3**
Vanadium	194.0	192.77	**98.9**
Zinc	394.0	365.23	**92.3**

ERA Lot#D064 HCl

	Target	Found	Rec. (%)
Aluminum	11000	8890.01	80.8
Antimony	81.5	218.59	268.2
Arsenic	158	144.91	91.9
Barium	348	336.17	96.6
Beryllium	106	102.11	96.3
Boron	136	133.31	98.1
Calcium	9650	9812	101.7
Cadmium	187	176.47	94.4
Chomium	89.5	80.47	89.7
Cobalt	277	264.86	95.6
Copper	129	117.43	91.0
Iron	18600	17932.46	96.4
Lead	172	174.04	101.1
Magnesium	5030	4786	95.2
Manganese	633	606.20	95.7
Mercury	7.34	7.17	97.5
Molybdenum	80.4	78.12	97.2
Nickel	99	89.70	90.6
Selenium	148	136.87	92.4
Silver	66.0	***65.77***	99.6
Strontium	176	155.83	88.5
Thallium	268.0	260.92	97.4
Tin	123.0	126.42	102.8
Titanium	448	351.22	78.3
Vanadium	194.0	190.64	97.7
Zinc	394.0	342.67	86.6

ERA Lot#D064 HCl

	Target	Found	Rec. (%)
Aluminum	11000	9362.43	**85.1**
Antimony	81.5	244.35	**299.7**
Arsenic	158	155.18	**98.3**
Barium	348	311.78	**89.6**
Beryllium	106	91.27	**86.1**
Boron	136	103.53	**76.0**
Calcium	9650	9492	**98.4**
Cadmium	187	181.80	**97.2**
Chomium	89.5	78.89	**88.2**
Cobalt	277	272.06	**98.2**
Copper	129	113.10	**87.6**
Iron	18600	19145.96	**102.9**
Lead	172	154.10	**89.6**
Magnesium	5030	4403	**87.5**
Manganese	633	551.95	**87.2**
Mercury	7.34	7.64	**104.6**
Molybdenum	80.4	88.91	**110.6**
Nickel	99	92.05	**92.9**
Selenium	148	139.20	**94.0**
Silver	66.0	***63.18***	**95.7**
Strontium	176	148.99	**84.7**
Thallium	268.0	245.54	**91.6**
Tin	123.0	133.04	**108.1**
Titanium	448	345.02	**76.9**
Vanadium	194.0	180.95	**93.3**
Zinc	394.0	361.01	**91.3**

ERA Lot#D064 HCl

	Target	Found	Rec. (%)
Aluminum	11000	9361.20	**85.1**
Antimony	81.5	259.55	**318.4**
Arsenic	158	172.99	**109.5**
Barium	348	342.73	**98.5**
Beryllium	106	100.20	**94.5**
Boron	136	117.66	**86.5**
Calcium	9650	9764	**101.1**
Cadmium	187	186.26	**99.6**
Chomium	89.5	88.66	**98.6**
Cobalt	277	298.91	**107.9**
Copper	129	123.17	**95.5**
Iron	18600	19689.99	**105.8**
Lead	172	180.06	**104.7**
Magnesium	5030	4840	**96.2**
Manganese	633	638.28	**100.8**
Mercury	7.34	8.06	**111.0**
Molybdenum	80.4	89.86	**111.8**
Nickel	99	101.07	**102.1**
Selenium	148	152.73	**103.3**
Silver	66.0	***73.86***	**111.9**
Strontium	176	158.02	**89.8**
Thallium	268.0	267.41	**99.8**
Tin	123.0	143.93	**117.0**
Titanium	448	363.28	**81.0**
Vanadium	194.0	208.40	**106.6**
Zinc	394.0	398.43	**100.8**

ERA Lot#D064 HCl

	Target	Found	Rec. (%)
Aluminum	11000	6847.91	62.2
Antimony	81.5	230.48	282.8
Arsenic	158	149.01	95.1
Barium	348	310.15	89.1
Beryllium	106	96.99	91.5
Boron	136	113.93	83.8
Calcium	9650	9467	98.0
Cadmium	187	183.60	98.2
Chomium	89.5	81.68	91.2
Cobalt	277	280.98	101.4
Copper	129	120.21	93.2
Iron	18600	14263.73	76.6
Lead	172	161.52	93.9
Magnesium	5030	4011	79.7
Manganese	633	538.93	85.1
Mercury	7.34	7.05	96.2
Molybdenum	80.4	83.84	104.3
Nickel	99	94.35	95.3
Selenium	148	138.29	93.5
Silver	66.0	***64.51***	97.7
Strontium	176	151.27	85.9
Thallium	268.0	262.28	97.9
Tin	123.0	125.54	102.1
Titanium	448	291.09	64.9
Vanadium	194.0	183.68	94.6
Zinc	394.0	379.60	95.9

ERA Lot#D064 HCl

	Target	Found	Rec. (%)
Aluminum	11000	6879.58	62.5
Antimony	81.5	211.94	259.9
Arsenic	158	145.52	92.4
Barium	348	328.51	94.4
Beryllium	106	100.91	95.2
Boron	136	130.22	95.5
Calcium	9650	9244	95.8
Cadmium	187	180.34	96.4
Chomium	89.5	73.84	82.3
Cobalt	277	252.41	91.1
Copper	129	114.68	88.9
Iron	18600	14477.21	77.8
Lead	172	159.20	92.6
Magnesium	5030	4145	82.4
Manganese	633	578.56	91.4
Mercury	7.34	6.28	85.6
Molybdenum	80.4	72.73	90.4
Nickel	99	86.10	86.9
Selenium	148	144.00	97.0
Silver	66.0	***68.52***	103.8
Strontium	176	149.64	85.0
Thallium	268.0	240.93	89.9
Tin	123.0	114.03	92.7
Titanium	448	268.64	59.8
Vanadium	194.0	170.16	87.6
Zinc	394.0	367.25	92.8

ERA Lot#D064 HCl

	Target	Found	Rec. (%)
Aluminum	11000	9137.05	**83.1**
Antimony	81.5	253.87	**311.5**
Arsenic	158	161.53	**102.7**
Barium	348	345.80	**99.4**
Beryllium	106	96.02	**90.6**
Boron	136	107.32	**79.0**
Calcium	9650	9841	**101.9**
Cadmium	187	184.79	**98.8**
Chomium	89.5	83.97	**93.6**
Cobalt	277	289.86	**104.6**
Copper	129	122.73	**95.1**
Iron	18600	18519.32	**99.6**
Lead	172	168.62	**98.0**
Magnesium	5030	4669	**92.8**
Manganese	633	586.59	**92.7**
Mercury	7.34	6.86	**93.3**
Molybdenum	80.4	90.77	**112.9**
Nickel	99	98.08	**99.0**
Selenium	148	142.92	**96.5**
Silver	66.0	***70.15***	**106.3**
Strontium	176	148.87	**84.6**
Thallium	268.0	277.17	**103.4**
Tin	123.0	139.05	**113.1**
Titanium	448	359.32	**80.1**
Vanadium	194.0	196.31	**100.6**
Zinc	394.0	383.55	**96.9**

ERA Lot#D064 HCl

	Target	Found	Rec. (%)
Aluminum	11000	8858.08	80.5
Antimony	81.5	230.19	282.4
Arsenic	158	153.51	97.4
Barium	348	331.47	95.3
Beryllium	106	101.78	96.0
Boron	136	127.12	93.4
Calcium	9650	9237	95.8
Cadmium	187	183.61	98.2
Chomium	89.5	82.92	92.3
Cobalt	277	272.31	98.3
Copper	129	122.30	94.8
Iron	18600	18254.50	98.1
Lead	172	174.94	101.7
Magnesium	5030	4731	94.1
Manganese	633	631.40	99.7
Mercury	7.34	6.20	84.1
Molybdenum	80.4	81.76	101.7
Nickel	99	92.26	93.2
Selenium	148	145.19	98.0
Silver	66.0	***69.17***	104.8
Strontium	176	155.35	88.3
Thallium	268.0	266.94	99.6
Tin	123.0	127.61	103.8
Titanium	448	331.70	74.0
Vanadium	194.0	186.06	95.3
Zinc	394.0	375.54	94.9

Maxxam ID		GY2621		
Sampling Date		8/20/2010		
COC Number		B 100986	ERA Lot No. D067-540	
	Units	**ERA Sample #2**	**Target**	**% Recovery**
Metals				
Available Aluminum (Al)	mg/kg	8100	10700	76%
Available Antimony (Sb)	mg/kg	220	117	188%
Available Arsenic (As)	mg/kg	130	138	94%
Available Barium (Ba)	mg/kg	250	269	93%
Available Beryllium (Be)	mg/kg	150	157	96%
Available Bismuth (Bi)	mg/kg	<2		
Available Boron (B)	mg/kg	82	90	91%
Available Cadmium (Cd)	mg/kg	71	71	100%
Available Chromium (Cr)	mg/kg	100	105	95%
Available Cobalt (Co)	mg/kg	140	142	99%
Available Copper (Cu)	mg/kg	100	110	91%
Available Iron (Fe)	mg/kg	16000	19100	84%
Available Lead (Pb)	mg/kg	140	144	97%
Available Lithium (Li)	mg/kg	8		
Available Manganese (Mn)	mg/kg	550	539	102%
Available Molybdenum (Mo)	mg/kg	100	90.4	111%
Available Nickel (Ni)	mg/kg	130	130	100%
Available Rubidium (Rb)	mg/kg	23		
Available Selenium (Se)	mg/kg	200	200	100%
Available Silver (Ag)	mg/kg	49	45.1	109%
Available Strontium (Sr)	mg/kg	220	246	89%
Available Thallium (Tl)	mg/kg	160	161.0	99%
Available Tin (Sn)	mg/kg	170	160.0	106%
Available Uranium (U)	mg/kg	1.7		
Available Vanadium (V)	mg/kg	63	67.0	94%
Available Zinc (Zn)	mg/kg	220	223.0	99%

Maxxam ID		GY2620		
Sampling Date		8/20/2010		
COC Number		B 100986	ERA Lot No. D067-540	
	Units	**ERA Sample #1**	**Target**	**% Recovery**
Metals				
Available Aluminum (Al)	mg/kg	9000	10700	84%
Available Antimony (Sb)	mg/kg	230	117	197%
Available Arsenic (As)	mg/kg	130	138	94%
Available Barium (Ba)	mg/kg	260	269	97%
Available Beryllium (Be)	mg/kg	150	157	96%
Available Bismuth (Bi)	mg/kg	<2		
Available Boron (B)	mg/kg	90	90	100%
Available Cadmium (Cd)	mg/kg	71	71	100%
Available Chromium (Cr)	mg/kg	110	105	105%
Available Cobalt (Co)	mg/kg	140	142	99%
Available Copper (Cu)	mg/kg	110	110	100%
Available Iron (Fe)	mg/kg	17000	19100	89%
Available Lead (Pb)	mg/kg	140	144	97%
Available Lithium (Li)	mg/kg	9		
Available Manganese (Mn)	mg/kg	540	539	100%
Available Molybdenum (Mo)	mg/kg	100	90.4	111%
Available Nickel (Ni)	mg/kg	140	130	108%
Available Rubidium (Rb)	mg/kg	24		
Available Selenium (Se)	mg/kg	200	200	100%
Available Silver (Ag)	mg/kg	46	45.1	102%
Available Strontium (Sr)	mg/kg	220	246	89%
Available Thallium (Tl)	mg/kg	160	161.0	99%
Available Tin (Sn)	mg/kg	170	160.0	106%
Available Uranium (U)	mg/kg	1.7		
Available Vanadium (V)	mg/kg	70	67.0	104%
Available Zinc (Zn)	mg/kg	230	223.0	103%

APPENDIX F

FRESHWATER AND SEDIMENT DATA QUALITY ASSURANCE EVALUATION

APPENDIX F WATER AND SEDIMENT DATA QUALITY ASSURANCE EVALUATION

F-1.0 INTRODUCTION

Sediment and water chemistry data were collected from various stations located in Hendry Brook, Unnamed Brook, and Armstrong Brook in July of 2010 and September, 2011. All water and sediment samples were analyzed by Maxxam Analytics in Bedford, Nova Scotia. To ensure that sediment and water chemistry data used within the ERA are of acceptable quality, a sediment and water data quality assurance (QA) evaluation was conducted. The sediment and water data QA program consisted of the following elements:

- Internal laboratory QA/QC procedures and measures (including: QC standards, spiked blanks, method blanks, matrix spikes).
- Review of reportable detection limits.
- Review of total versus dissolved chemical concentrations in water samples.
- Approximately 10% of sediment and water samples were analyzed by Maxxam Analytics as laboratory duplicates.
- Five sediment and four water samples were submitted to Maxxam Analytics as blind field duplicates and analyzed by the lab as discrete sediment and water samples.

This data quality assurance report is organized as follows. Section F-2.0 provides a summary of the laboratory's internal QA/QC results for these data (which includes QC standards, spiked blanks, method blanks, and matrix spikes). Section F-3.0 provides commentary on the reportable detection limits (RDLs) that were achieved in the analyses. Section F-4.0 describes other laboratory quality assurance issues and items that were identified. Section F-5.0 describes and discusses laboratory and field duplicates. Section F-6.0 provides a summary of the QA review outcomes, as well as overall conclusions. Section F-7.0 provides a list of references cited.

F-2.0 INTERNAL LABORATORY QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES AND OUTCOMES

Internal laboratory quality assurance/quality control measures consist of QC standards, spiked blanks, method blanks, and matrix spikes analysis (laboratory duplicates are also part of the internal laboratory QA/QC measures, but these are described separately in Section 5.0). For the quality assurance review of all internal laboratory QA/QC procedures and outcomes, the acceptance criteria (or QC limits) used by the laboratory (*i.e.*, Maxxam Analytics) were the benchmarks of comparison. Maxxam defines these measures as follows:

- QC Standard: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
- Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
- Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.
- Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Further details on laboratory QA/QC with respect to each of these internal measures is provided in the laboratory Certificates of Analysis (Appendix D).

It should be recognized that Maxxam Analytics has internal QA/QC requirements that must be met to maintain accreditations for the analyses performed. Maxxam currently maintains accreditation to ISO/IEC 17025, through the Standards Council of Canada (SCC).

F-2.1 QC Standards

The criteria (QC limits) used by Maxxam Analytics for QC standards are 80%-120% (per cent recovery) for all water parameters (except reactive silica, for which a QC limit of 75%-125% is used), and 75%-125% (per cent recovery) for all sediment parameters.

The majority of parameters analyzed for in the water and sediment QC standard samples were within QC limits. Exceptions were as follows. However, these instances are considered to have a negligible impact on data quality, and there are considered to be no major issues with respect to analyte recovery in water or sediment samples.

- Maxxam Job Number: DB1E2550:
  - In one QC standard sediment sample, available Arsenic (As) had a per cent recovery of 126% and available Vanadium (V) had a per cent recovery of 132%. The laboratory notes indicated that the secondary RM was acceptable for these parameters.

  - In another QC standard sediment sample, available Vanadium (V) had a per cent recovery of 130%. The laboratory notes indicated that the secondary RM was acceptable.
  - In another QC standard sample, available Barium (Ba) had a per cent recovery of 128%; available Chromium (Cr) had a per cent recovery of 129% and available Vanadium (V) had a per cent recovery of 152%. The laboratory notes indicated that there was a data point with 2 SD for Ba, and a data point with 3 SD for Cr, but the secondary RM was acceptable for all three of these metals.

F-2.2 Spiked Blanks

The criteria (QC limits) used by Maxxam Analytics for spiked blanks are 80%-120% (per cent recovery) for all water parameters, and 75%-125% (per cent recovery) for all sediment parameters.

All parameters analyzed for in the spiked blank sediment samples were within QC limits, suggesting no issues with respect to analyte recovery in sediment samples.

The majority of parameters analyzed for in the water spiked blank samples were within QC limits. Exceptions were as follows. However, these instances are considered to have a negligible impact on data quality, and there are considered to be no major issues with respect to analyte recovery in water samples.

- Maxxam Job DB099031: Total Titanium (Ti) per cent recovery of 122% in one spiked blank water sample; Dissolved Titanium (Ti) per cent recovery of 134% in one spiked blank water sample. The recovery of 122%, although slightly outside QC limits, was considered by the laboratory to be within acceptance limits. For the recovery of 134%, laboratory notes indicated that this elevated recovery was due to a spiking solution artifact with no impact on sample data quality.

- Maxxam Job DB098030: Dissolved Titanium (Ti) per cent recovery of 133% in one spiked blank water sample. Laboratory notes indicated elevated recovery was due to a spiking solution artifact with no impact on sample data quality.

- Maxxam Job DB0B2321: Dissolved Bismuth (Bi) per cent recovery of 68% in one spiked blank water sample. Laboratory notes indicated low recovery due to instrument performance, with a minimal impact on data quality.

F-2.3 Method Blanks

For method blanks, the acceptance criteria for any analytical laboratory is a <RDL result. The majority of parameters analyzed for in method blank water and sediment samples are <RDLs. There were only a few exceptions, as follows. However, all of these instances are considered to have a negligible impact on data quality, as the detected concentrations of parameters in the blanks were either at, or just slightly above the RDL values[1], in all cases. It is not uncommon for there to be low level lab contamination for certain parameters, and this typically results in only minimal impacts to data quality. No sample results were blank corrected by the laboratory or by the Study Team.

- Maxxam Job DB098030: Dissolved Calcium (Ca) concentration of 120 µg/L (RDL=100 µg/L) in one water method blank sample.

- Maxxam Job DB098030: Conductivity of 1 µS/cm (RDL = 1 µS/cm) in one water method blank sample.

- Maxxam Job DB099031: Conductivity value of 1 µS/cm (RDL = 1 µS/cm) in one water method blank sample.

- Maxxam Job DB1E2798: Conductivity value of 1 µS/cm (RDL = 1 µS/cm) in one water method blank sample. Total Aluminum (Al) values of 6.7 µg/L; 5.9 µg/L; and 9.1 µg/L (RDL= 5.0 µg/L) in three water method blank samples. Laboratory notes indicated this was due to low level lab contamination, but that there was a minimal impact on data quality.

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[1] RDL values that were achieved for each parameter in each sample are provided in the laboratory Certificates of Analysis; Appendix D.

F-2.4 Matrix Spikes

The criteria (QC limits) used by Maxxam Analytics for matrix spike water samples is 80%-120% (per cent recovery) for RcAP and total and dissolved metal/metalloid parameters. For sediment metal and metalloid parameters, the QC limits are 75% to 125% (per cent recovery). No other parameters were included in sediment matrix spike sample analyses. The majority of parameters analyzed in matrix spike water and sediment samples were within QC limits, but there were also some exceptions, as indicated below. However, none of these exceptions are considered to have a major impact on data quality. In general, excursions outside the QC limits were marginal, which may indicate a slight potential for high or low bias, but the potential for significant bias in either direction was considered to be low.

There were some other reasons for matrix spike QA issues as well. In a number of cases, parameter per cent recovery in the matrix spike sample was not calculable because of high concentrations of that parameter in the parent sample, which made the relative difference between the spiked and unspiked concentrations insufficiently significant to permit a reliable recovery calculation.

While it is important to identify the degree of matrix interference that may affect analytical results, it is difficult to control for. Thus, given that most parameters analyzed in matrix spike sediment and water samples are within QC limits, there are no major data quality issues apparent in relation to matrix spikes and the degree of sample matrix interference. For some parameters, matrix interference can lead to sample dilution being required, which in turn, can lead to elevated RDLs (See Section F-3.0).

- Maxxam Job No. DB098030:
    - Dissolved Bismuth (Bi) per cent recovery of 64% in one matrix spike water sample. Laboratory notes indicated poor recovery due to sample matrix.
    - Dissolved Titanium (Ti) per cent recovery of 128% in one matrix spike water sample. Laboratory notes indicated elevated recovery was due to a spiking solution artifact, with no impact on sample data quality.
    - There were a number of instances where per cent recovery was not calculable for various parameters in water matrix spike samples. The affected parameters (with number of instances in brackets) are as follows: Total Calcium (1); Total Copper (1); Total Iron (1); Total Manganese (1); Total Strontium (1); Dissolved Barium (1); Dissolved Calcium (1); Dissolved Manganese (1); Dissolved Strontium (1); Total Alkalinity (1); Reactive Silica (1); and Total Organic Carbon (1).
    - There were a number of instances where per cent recovery was not calculable for various parameters in sediment matrix spike samples. The affected parameters (with number of instances in brackets) are as follows: Available Aluminum (1); Available Arsenic (1); Available Barium (1); Available Chromium (1); Available Cobalt (1); Available Copper (1); Available Iron (1); Available Lead (1); Available Lithium (1); Available Manganese (1); Available Nickel (1); Available Rubidium (1); Available Strontium (1); and Available Vanadium (1).

- Maxxam Job No. DB099031:
  - Dissolved Bismuth (Bi) per cent recovery of 71% in one matrix spike water sample. Laboratory notes indicated poor recovery due to sample matrix.
  - Dissolved Titanium (Ti) per cent recovery of 122% in one matrix spike water sample. Laboratory notes indicated recovery was within acceptable limits.
  - There were a number of instances where per cent recovery was not calculable for various parameters in water matrix spike samples. The affected parameters (with number of instances in brackets) are as follows: Total Barium (1); Total Calcium (1); Total Copper (1); Total Magnesium (1); Total Manganese (1); Total Molybdenum (1); Total Strontium (1); Dissolved Copper (1); Dissolved Strontium (1); Total Alkalinity (1); Reactive Silica (1); and Total Organic Carbon (1).
  - There were a number of instances where per cent recovery was not calculable for various parameters in sediment matrix spike samples. The affected parameters (with number of instances in brackets) are as follows: Available Aluminum (1); Available Arsenic (1); Available Barium (1); Available Chromium (1); Available Cobalt (1); Available Copper (1); Available Iron (1); Available Lead (1); Available Lithium (1); Available Manganese (1); Available Nickel (1); Available Rubidium (1); Available Strontium (1); and Available Vanadium (1).

- Maxxam Job No. DB0B2321:
  - Dissolved Aluminum (Al) per cent recovery of 129%, Dissolved Bismuth (Bi) per cent recovery of 73%, and Dissolved Strontium (Sr) per cent recovery of 128% in one matrix spike water sample. Laboratory notes indicated "violation is not applicable. Parameter not requested in the sample."
  - Total Bismuth (Bi) per cent recovery of 79% in one matrix spike water sample. Laboratory notes indicated low recovery due to sample matrix.
  - There were several instances where per cent recovery was not calculable for various parameters in water matrix spike samples. The affected parameters (with number of instances in brackets) are as follows: Dissolved Copper (1); Dissolved Manganese (1); Dissolved Sodium (2); Dissolved Zinc (1).

- Maxxam Job No. DB1E2798:
  - There were a number of instances where per cent recovery was not calculable for various parameters in water matrix spike samples. The affected parameters (with number of instances in brackets) are as follows: Total Barium (1); Total Boron (1); Total Calcium (2); Total Copper (1); Total Magnesium (1); Total Nickel (1); Total Sodium (3); Total Strontium (2); Total Zinc (1); Dissolved Calcium (2); Dissolved Manganese (1); Dissolved Sodium (1); Dissolved Strontium (1); Total Alkalinity (1); Total Organic Carbon (1).

- Maxxam Job Number: DB1E2550:
    - Available Mercury (Hg) per cent recovery of 126% in one matrix spike sediment sample. Laboratory notes indicated an elevated reporting limit due to sample matrix.
    - There were a number of instances where per cent recovery was not calculable for various parameters in sediment matrix spike samples. The affected parameters (with number of instances in brackets) are as follows: Available Aluminum (2); Available Arsenic (2); Available Barium (2); Available Chromium (2); Available Cobalt (2); Available Copper (2); Available Iron (2); Available Lead (2); Available Lithium (2); Available Manganese (2); Available Nickel (2); Available Strontium (2); Available Vanadium (2)

F-3.0 REPORTABLE DETECTION LIMITS (RDLS)

Review of the RDLs that were achieved in the water and sediment analyses indicates that typical and acceptable RDLs were attained for most parameters in the majority of samples.

There were eight instances of elevated RDLs for sediment parameters as follows: Available Iron typical RDL was elevated 10-fold in six sediment samples, Available Manganese typical RDL was elevated 10-fold in one sample, and Available Strontium typical RDL was elevated 10-fold in one sample.

There were twelve instances of elevated RDLs for water parameters as follows: Total Alkalinity typical RDL was elevated 6-fold in eight samples and elevated 2-fold in two samples, Colour typical RDL was elevated 6-fold in two samples.

In all of the samples affected by elevated RDLs, there were no issues associated with the achieved RDL for a parameter in a specific sample being higher than sediment or water quality guidelines.

In the analyses of sediment and water samples, it is not uncommon for some parameters in some samples to have elevated RDLs due to matrix effects. Overall, none of the recorded instances of elevated RDLs are considered to adversely impact water or sediment data quality.

F-4.0 OTHER DATA QUALITY ITEMS OR ISSUES

There were a few miscellaneous items noted within the laboratory Certificates of Analysis that relate to the water and sediment analytical results. These items are summarized below, with further details provided within the Certificates of Analysis (See Appendix D). None are considered to impact data quality.

There were seven water samples wherein RCAP ion balance was noted as being acceptable with respect to anion/cation agreement within 0.2 meq/L. In one water sample, it was noted that there was poor RCAP ion balance due to the sample matrix.

For one sediment sample (from Maxxam Job #: B1E2550), three grain size parameters in the laboratory duplicate sample had a recovery or RPD that was outside control limits. However, the laboratory noted that the overall quality control for this analysis met acceptability criteria.

F-4.1 Dissolved Concentrations > Total Concentrations in Water Samples

During the review of total element and dissolved element water chemistry data, it was noted that dissolved concentrations were occasionally higher than total recoverable concentrations for a number of metals and metalloids, in a number of samples. While this appears counterintuitive, there are a number of reasons why a dissolved element concentration can exceed its total recoverable concentration, as follows (from Maxxam Analytics, 2008):

- If samples to undergo dissolved analysis are acidified before filtration (acidification must occur after filtration). While this rarely an issue when qualified sampling and laboratory personnel are involved, errors can and do occur.

- If the incorrect acid (such as sulphuric acid) was used to preserve samples (nitric acid is preferred), or no acid was actually used to preserve the sample.

- Acidification-induced changes to stability of some metals and metalloids. Although it is a standard and required step in sample preparation, acidification of a sample can change the solubility of some elements (increase or decrease). Lack of acidification can also lead to changes in element solubility as the pH and DO levels, and redox conditions all change once a sample is collected from its medium.

- Some elements may occur in the sample near their solubility limits, and may precipitate out of solution or crystallize due to water evaporation that can occur while samples are processed. When samples are brought back to volume, these salts and precipitates may not always re-dissolve fully, or at all.

- Labelling errors.

- Sample matrix interference.

- If samples undergoing total recoverable and dissolved analyses were collected at different times or from a heterogeneous medium.

- Contamination during sample handling and processing. Dissolved analyses are typically more prone to sample contamination because of the filtration step. Leaching of metals or metalloids from filters can sometimes occur such that the dissolved concentrations of elements that are at low concentrations in the total recoverable analysis are much higher in the dissolved analysis. Other commonly noted reasons for contamination include: sample bottles and reagent (such as acids for sample preservation) vials; atmospheric contributions to samples during handling and processing; improper sample handling techniques; impurities in the acid used for sample preservation; gloves; sample cross-contamination if sampling equipment is not properly cleaned between samples.

- Measurement uncertainty. While not specific to dissolved analyses, there is always measurement uncertainty associated with every sample, where the "true concentration" lies within a range of values.

In light of these issues and items that can result in a dissolved concentration being > a total recoverable concentration, Maxxam automatically flags analytical results where this occurs, and conducts data quality assurance assuming that the total recoverable and dissolved parameter concentrations are pseudo-laboratory duplicates. Maxxam uses 5 times the RDL as a cutoff for calculating the relative per cent difference (RPD) (See Section F-5.0 for further information on RPDs). Where both dissolved and total recoverable results are greater than 5 x RDL, 20% RPD is used as the QC limit to evaluate if the dissolved and total results have a reasonable degree of measurement uncertainty. Where both dissolved and total recoverable results are less than 5 x RDL, 100% RPD is used as the QC limit. These calculations are interpreted as follows.

Although a dissolved result may exceed a total recoverable result for the same parameter in the same parent sample, it is not considered to be outside the measurement uncertainty if:

- Results of both dissolved and total recoverable analysis are > 5 x RDL, and RPD is <20%.

- Results of both dissolved and total recoverable analysis are <5 x RDL, and RPD is <100%.

When these criteria are met, it is considered that the dissolved concentration is truly greater than the total recoverable concentration.

It is also part of Maxxam's internal laboratory data quality assurance procedures to reanalyze all samples where a dissolved result exceeds a total recoverable result for the same parameter in the same parent sample. If reanalysis confirms the original results, Maxxam checks whether the sample was field or lab-filtered (if lab-filtered, Maxxam re-filters and reanalyzes). Given that there were some issues observed with matrix spikes, and elevated RDLs in some water samples, it is possible that matrix interference is responsible for some of the instances where a parameter's dissolved concentration was greater than its total recoverable concentration in the same parent sample. Laboratory Certificates of Analysis (Appendix D) do not indicate that any samples were reanalyzed for dissolved elements, and consequently, no dissolved analytical results were flagged by Maxxam as being potentially erroneous.

F-5.0 DUPLICATES

Duplicate samples provide a measure of the reproducibility (or precision) of the analyses performed on a sample. U.S. EPA (2004) defines a duplicate as a second aliquot of a sample that is treated the same as the original sample in order to determine the precision of the analytical method.

Two types of duplicate samples were evaluated in this project – laboratory duplicates and field duplicates. A laboratory duplicate is the same sample material (can be the same aliquot of a sample with non-destructive analyses, but is a different aliquot of the sample if the analytical method is destructive) being analyzed using the same analytical method and equipment. A field duplicate differs from a laboratory duplicate in that it is generated in the field (not the laboratory), and is not necessarily the same sample material as the original sample. Typically, field duplicates are collected adjacent to original samples in the field (*i.e.*, at the same general location) but can comprise the same sample material if the field duplicates are generated from composite samples that are mixed in the field. Because field duplicates can represent different sample material than the original samples and/or can often be subject to incomplete mixing of composite samples, it is not uncommon for there to be lower reproducibility (or precision) between a field duplicate and its original sample, relative to the precision obtained between a laboratory duplicate and its original sample.

F-5.1 Data Quality Objectives for Duplicates

Data quality objectives (DQOs) are important in determining whether or not the collected analytical data are of suitable quality for assessment purposes. In order to have a means of determining whether or not the analytical data for this project are of adequate quality in terms of duplicate samples, the DQOs described in U.S. EPA (2006) were used, with consideration also given to the DQOs typically used by the primary laboratory (Maxxam Analytics). These DQOs were applied equally to both laboratory and field duplicates.

The two main measures (or calculations) with respect to duplicate data quality assurance are relative per cent difference (RPD) and absolute difference (ABD). The general equation for the RPD calculation is as follows (from U.S. EPA, 2004):

$$\text{RPD} = \{|S-D| \div (S+D)/2)\} \times 100$$

Where,
RPD = Relative Per cent Difference
S = Sample Result (original)
D = Duplicate Result

The general equation for ABD is simply $|S-D|$.

RPD and ABD calculations are not performed when one or both corresponding sample values (in the original and the duplicate sample) are <RDLs. While U.S. EPA (2006) suggests that ABD be calculated when one sample value is measured and the other is <RDL, this is not considered reasonable as a <RDL result is an unknown value, and it is not appropriate to compare a known quantified value to an unknown, unquantified value. In situations where both the original sample and the duplicate sample have measured values >RDLs, the following decision rules are used to determine if RPD or ABD should be calculated (U.S. EPA, 2006; 2004). If analytical results in both of the samples are <5 times the reported detection limit (RDL), then only ABD is calculated. If analytical results in both of the samples are ≥5 times the RDL, then only RPD is calculated. Both the RPD and ABD are calculated if one sample is <5 times the RDL and the other sample is ≥5 times the RDL. It should be noted that U.S. EPA decision rules are based on contract-required quantitation limits (CRQLs), which are values set by the U.S. EPA for contract labs. It is not uncommon though for CRQLs to differ from achievable RDLs at a given laboratory. As there is no identified Canadian guidance that is similar to U.S. EPA (2006; 2004), the U.S. EPA decision rules are applied on the basis of the RDLs that were achieved by Maxxam, rather than CRQLs. This is consistent with U.S. EPA policy on data quality assurance which suggests replacing the CRQL with the method detection limit (MDL), which is generally analogous to the RDL, when the MDL is the higher value (U.S. EPA, 2006).

For laboratory and field duplicate water samples, U.S. EPA (2006) Standard Operating Procedures (SOP) permit a DQO for RPD of up to 20% (primary acceptance limit). The U.S. EPA considers RPD ≥20% and <100% to be acceptable for assessment or decision-making purposes, but stipulates that if either of the original sample or duplicate sample results that produced an RPD in this range are to be used for assessment purposes, that they be flagged as estimated values. U.S. EPA (2006) recommends the rejection of water samples when RPD is ≥100%. Maxxam Analytical utilizes a primary DQO of 25% for RPD between parameters in original and duplicate water samples, with the exception of TOC and dissolved chloride, where the DQO is 20%. As there is little difference between the RPD DQOs from U.S. EPA and Maxxam, and the Maxxam DQOs reflect historical performance of this particular laboratory, the primary RPD DQO used in the evaluation of water duplicates was 25%. Maxxam does not stipulate rejection limits, thus the U.S. EPA (2006) DQO was used (*i.e.*, rejection of water samples when RPD is ≥100%).

For ABD between an original water sample and its laboratory or field duplicate sample, the U.S. EPA (2006) permits a DQO up to 1 x RDL as the primary acceptance limit. The U.S. EPA (2006) considers an ABD between 1 x RDL and 2 x RDL to be acceptable for assessment purposes but stipulates that if either of the original sample or duplicate sample results that produced an ABD in this range are to be used for assessment purposes, that they be flagged as estimated values. U.S. EPA (2006) recommends the rejection of water samples when the ABD is ≥2 x RDL. Maxxam does not provide DQOs for ABD, thus, the U.S. EPA DQOs were used.

For laboratory and field duplicate sediment samples, U.S. EPA (2006) Standard Operating Procedures (SOP) permits a DQO for RPD of up to 35% as the primary acceptance limit. Maxxam Analytics utilizes the same DQO for RPD between original and duplicate sediment samples. The U.S. EPA considers RPDs between ≥35% and <120% to be acceptable for assessment purposes, but stipulates that if either of the original sample or duplicate sample results that produced an RPD in this range are to be used for assessment purposes, that they be flagged as estimated values. U.S. EPA (2006) recommends the rejection of sediment samples when RPDs are ≥120%. As Maxxam utilizes the same primary RPD DQO as the U.S. EPA, but does not stipulate rejection limits, U.S. EPA RPD DQOs were used in the evaluation of sediment duplicates.

For ABD between an original sediment sample and its laboratory or field duplicate sample, the U.S. EPA (2006) permits a DQO up to 2 x RDL as the primary acceptance limit. The U.S. EPA (2006) considers an ABD between 2 x RDL and 4 x RDL to be acceptable for assessment purposes, but stipulates that if either of the original sample or duplicate sample results that produced an ABD in this range are to be used for assessment purposes, that they be flagged as estimated values. U.S. EPA (2006) recommends the rejection of sediment samples when the ABD is ≥4 x RDL. Maxxam does not provide DQOs for ABD, thus, the U.S. EPA DQOs were used.

Outcomes of the data quality assurance evaluation pertaining to laboratory duplicates and field duplicates are described in the following sections. Detailed RPD and ABD results are available on request.

F-5.2 Laboratory Duplicate Results

For all possible parameter comparisons between original water samples and their corresponding laboratory duplicates (*i.e.*, 32 parameter comparisons could be made), the RPD and ABD DQOs (primary acceptance limits) were met.

For all possible parameter comparisons between original sediment samples and their corresponding laboratory duplicates (*i.e.*, 57 parameter comparisons could be made), the RPD and ABD DQOs (primary acceptance limits) were met.

Overall, it is considered that water and sediment data quality is acceptable with respect to laboratory duplicates.

F-5.3 Field Duplicate Results

Five sediment and four water field duplicate samples were analyzed by Maxxam Analytics. Table F-1 presents the number of instances (by parameter) in the comparisons between original sediment samples and their corresponding field duplicates wherein the RPD or ABD DQOs were not met. Shaded cells in Table F-1 indicate whether or not a given parameter comparison failed to meet rejection limits for RPD or ABD.

Table F-1 Number of Instances (By Parameter) in Comparisons between Original Sediment Samples and Sediment Field Duplicate Samples where the DQO Was Not Met (RPD of ≥35% or ABD ≥2 times the RDL)

Element	# of instances RPD DQO not met	#of instances ABS DQO not met
Available Lead (Pb) – UNNAMED-SED-2 SEDIMENT and QA/QC-1 (SED); HESED-4 and QA/QC-1	2	0
Available Zinc (Zn) - UNNAMED-SED-2 SEDIMENT and QA/QC-1 (SED); HESED-4 and QA/QC-1	2	0
Available Arsenic (As) - HESED-4 and QA/QC-1	1	0
Available Barium (Ba) - HESED-4 and QA/QC-1	1	0
Available Chromium (Cr) - HESED-4 and QA/QC-1	1	0
Available Copper (Cu) - HESED-4 and QA/QC-1	1	0
Available Lithium (Li) - HESED-4 and QA/QC-1	1	0
Available Rubidium (Rb) - HESED-4 and QA/QC-1	1	1
Available Vanadium (V) - HESED-4 and QA/QC-1	1	0

Notes:
RPD=relative per cent difference; ABD=absolute difference; DQO=data quality objective.
Shaded cell indicates that rejection criteria were exceeded (either ≥120% RPD or ≥4*RDL for ABD).
Parameters that met the RPD or ABD DQOs in all comparisons between original samples and field duplicate samples are not included in this table.

Of the 91 possible parameter comparisons that could be made between original and field duplicate sediment samples, Table F-1 shows that there were only twelve instances wherein the RPD and/or ABD DQOs were not met (12/91 or 13% total RPD and ABD DQO failures). For these instances, the sediment concentrations were flagged as an estimate if they were used for assessment purposes, unless rejection limits were exceeded, in which case the parameter concentrations in the affected samples were considered for rejection. However, no parameter comparisons between original sediment samples and their field duplicates exceeded rejection limits.

Overall, it is considered that sediment data quality is acceptable with respect to field duplicates.

Table F-2 presents the number of instances (by parameter) in the comparisons between original water samples and their corresponding field duplicates wherein the RPD or ABD DQOs were not met. Shaded cells in Table F-2 indicate whether or not a given parameter comparison failed to meet rejection limits for RPD or ABD.

Table F-2 Number of Instances (By Parameter) in Comparisons between Original Water Samples and Water Field Duplicate Samples where the DQO Was Not Met (RPD of ≥25% or ABD ≥1 x RDL)

Element	# of instances RPD DQO not met	#of instances ABS DQO not met[a]
Dissolved Cadmium (Cd) - UNNAMED-SED-2 SURFACE WATER and QA/QC-1 (WATER)	1	1
Dissolved Lead (Pb) - UNNAMED-SED-2 SURFACE WATER and QA/QC-1 (WATER)	1	1
Total Cadmium (Cd) – HENDRY-SED-2 SURFACE WATER and QA/QC-2 (WATER)	0	1
Total Lead (Pb) - HENDRY-SED-2 SURFACE WATER and QA/QC-2 (WATER)	0	1
Dissolved Aluminum (Al) - ARMSTRONG-SED-2 (WATER) and QA/QC-3 (WATER); HESED-4 and QA/QC-1	2	1
Dissolved Calcium (Ca) - HESED-4 and QA/QC-1	1	0
Dissolved Magnesium (Mg) - HESED-4 and QA/QC-1	1	0
Dissolved Manganese (Mn) - HESED-4 and QA/QC-1	1	1
Dissolved Potassium (K) - HESED-4 and QA/QC-1	0	1
Dissolved Strontium (Sr) - HESED-4 and QA/QC-1	1	0
Total Aluminum (Al) - HESED-4 and QA/QC-1	1	0

Element	# of instances RPD DQO not met	#of instances ABS DQO not met[a]
Total Calcium (Ca) - HESED-4 and QA/QC-1	1	0
Total Iron (Fe) - HESED-4 and QA/QC-1	1	1
Total Manganese (Mn) - HESED-4 and QA/QC-1	1	0
Total Potassium (K) - HESED-4 and QA/QC-1	1	1
Total Strontium (Sr) - HESED-4 and QA/QC-1	1	0

Notes:
RPD=relative per cent difference; ABD=absolute difference; DQO=data quality objective.
Shaded cell indicates that rejection criteria were exceeded (either ≥100% RPD or ≥2 x RDL for ABD).
Parameters that met the RPD or ABD DQOs in all comparisons between original samples and field duplicate samples are not included in this table.

Of the 154 possible parameter comparisons that could be made between original and field duplicate water samples, Table F-2 shows that there were 23 instances wherein the RPD and/or ABD DQOs were not met (23/154 or 15% total RPD and ABD DQO failures). For all parameters where these DQOs were not met, concentrations were flagged as estimates if they were used for assessment purposes, unless rejection limits were exceeded, in which case the parameter concentrations in the affected samples were considered for rejection. As shown in Table F-2, rejection limits for RPD and ABD were exceeded in two and four instances, respectively. These instances were closely examined to determine if including the affected samples would adversely impact the data used within the ecological risk assessment (ERA) study. Upon review, it was decided to reanalyze the UNNAMED-SED-2 SURFACE WATER sample for total recoverable and dissolved elements, which included lead and cadmium. Another water sample - UNNAMED-SED1-SURFACE WATER, was also submitted for reanalysis, but not for data quality assurance reasons. Rather, this sample was reanalyzed to confirm an apparent elevated total and dissolved lead concentration.

Although there was poor reproducibility for a number of parameters in HESED-4 and its field duplicate (QA/QC-1), review of the chemistry data and internal laboratory quality control/assurance information for both samples did not reveal a need for reanalysis of either sample. Rather, it was considered likely that the differences between these two samples reflects sample heterogeneity that is not unexpected in the sampling of flowing surface water.

Quality assurance checks were conducted on the two reanalyzed samples to confirm that data were acceptable for use in the ERA. Since only two samples were reanalyzed, the quality assurance evaluation was limited to internal laboratory QA/QC measures (See Section 2.0 for a description of these measures). The outcomes were as follows:

- QC standard samples were not analyzed in conjunction with the reanalyzed water samples.

- All parameters measured in spiked blank samples were within QC limits (80% to 120%), with the exception of bismuth in one spiked blank sample, where the recovery was 68%. Laboratory notes indicated that the low recovery was due to instrument performance, and that there was a minimal impact on data quality. Thus, there were considered to be no issues with respect to analyte recovery in the reanalyzed samples.

- Analysis of method blank samples produced <RDL results for all parameters, indicating no issues related to laboratory contamination.

- Most parameters analyzed in matrix spike samples were within QC limits (80% to 120%), but there were some exceptions as follows. Overall, none of these exceptions were considered to significantly affect data quality, and matrix interference in the matrix spike samples is considered to be low.
    - One matrix spike water sample had a Dissolved Aluminum (Al) per cent recovery of 129%, a Dissolved Bismuth (Bi) per cent recovery of 73%, and a Dissolved Strontium per cent recovery of 128%. These recoveries were considered acceptable as they are only marginally outside the QC limits. In this same matrix spike sample, per cent recovery was not calculable for the following parameters: Dissolved Copper (Cu), Dissolved Sodium (Na), and Dissolved Zinc (Zn).
    - In a second matrix spike water sample, Total Bismuth (Bi) per cent recovery was 79%, which is just slightly below the QC limits, and considered to be acceptable for this parameter. Laboratory notes indicated that the slightly low recovery was due to the sample matrix. In this same matrix spike sample, per cent recovery was not calculable for the following parameters: Total Manganese (Mn), and Total Sodium (Na).

- Review of the RDLs for the reanalyzed samples indicates that typical and acceptable RDLs were attained for all parameters measured.

- A review of the total recoverable versus dissolved element concentrations in the reanalyzed samples shows no different pattern than that previously observed between dissolved and total element concentrations in all other water samples.

Given these outcomes, the data from the two reanalyzed samples were considered acceptable for ERA purposes and were used in place of the previous (or initial) sample results.

F-6.0 SUMMARY AND CONCLUSIONS

The outcomes of the water and sediment data QA evaluation (including the two reanalyzed water samples) are summarized as follows. While the evaluation identified some issues related to QA/QC measures, the overall conclusion on data quality is that all data collected within the 2010 and 2011 sampling and analytical programs are considered acceptable for use in the current ERA. Any data quality issues that were identified as being potentially significant were considered during the use and interpretation of these data.

- The majority of parameters analyzed for in the water and sediment QC standard samples were within QC limits. None of the instances where the QC limits were not met are considered to impact data quality, and there are considered to be no major issues with respect to analyte recovery in water or sediment samples.

- All parameters analyzed in sediment spiked blank samples and the majority of parameters analyzed in water spiked blank samples were within the QC limits used by Maxxam Analytics. While there were a few exceptions for the water spiked blank samples, none are considered to significantly impact data quality, and it is considered that there are no major issues apparent with respect to analyte recovery.

- The majority of parameters analyzed in method blank water and sediment samples are <RDLs. While there were a few exceptions in water method blank samples, none are considered to have a significant impact on data quality (*i.e.*, with respect to laboratory contamination), as the detected concentrations of parameters in the blanks were either at, or just slightly above the RDL values, in all cases.

- The majority of parameters analyzed in matrix spike water and sediment samples are within the QC limits used by Maxxam Analytics. While there some exceptions, none are considered to significantly impact data quality, and there are no major issues apparent with respect to sample matrix interference.

- Review of the RDLs that were achieved in the water and sediment analyses indicates that for the most part, typical and acceptable RDLs were achieved for the majority of samples. In those samples that were affected by elevated RDLs, there were no issues associated with the achieved RDL for a specific sample being higher than sediment or water quality guidelines. Overall, none of the recorded instances of elevated RDLs are considered to adversely affect data quality.

- During the review of total element and dissolved element water chemistry data, it was noted that dissolved concentrations were occasionally higher than total recoverable concentrations for a number of metals and metalloids, in a number of samples. There are a number of reasons why this can occur (See Section F-4.1). It is part of Maxxam's internal laboratory data quality assurance procedures to reanalyze all samples where a dissolved result exceeds a total recoverable result for the same parameter in the same parent sample. If reanalysis confirms the original results, Maxxam checks whether the sample was field or lab-filtered (if lab-filtered, Maxxam re-filters and reanalyzes). Given that there were some issues observed with matrix spikes and elevated RDLs in some water samples, it is possible that matrix interference is responsible for some of the instances where a parameter's dissolved concentration was greater than its total recoverable concentration in the same parent sample. Laboratory Certificates of Analysis (Appendix D) do not indicate that any samples were reanalyzed for dissolved elements, and consequently, no dissolved analytical results were flagged by Maxxam as being potentially erroneous. Thus, there is no reason to reject any samples where a dissolved parameter concentration was higher than its total recoverable concentration.

- For all possible parameter comparisons between original water and sediment samples and their corresponding laboratory duplicates, the RPD and ABD DQOs (primary acceptance limits) were met. Thus, it is considered that water and sediment data quality is acceptable with respect to laboratory duplicates.

- With respect to sediment field duplicates, of the 91 possible parameter comparisons that could be made between original and field duplicate sediment samples, there were twelve instances wherein the RPD and/or ABD DQOs were not met (12/91 or 13% total RPD and ABD DQO failures). For these instances, the sediment concentrations were flagged as an estimate if they were used for assessment purposes, unless rejection limits were exceeded, in which case the parameter concentrations in the affected samples were considered for rejection. However, no parameter comparisons between original sediment samples and their field duplicates exceeded rejection limits. Overall, it is considered that sediment data quality is acceptable with respect to field duplicates.

- With respect to water field duplicates, of the 154 possible parameter comparisons that could be made between original and field duplicate water samples, there were 23 instances wherein the RPD and/or ABD DQOs were not met (23/154 or 15% total RPD and ABD DQO failures). For all parameters where these DQOs were not met, concentrations were flagged as estimates if they were used for assessment purposes, unless rejection limits were exceeded, in which case the parameter concentrations in the affected samples were considered for rejection. Rejection limits for RPD and ABD were exceeded in two and four instances, respectively. These instances were closely examined to determine if including the affected samples would adversely impact the data used within the ecological risk assessment (ERA) study. Upon review, it was decided to reanalyze the UNNAMED-SED-2 SURFACE WATER sample for total recoverable and dissolved elements, which included lead and cadmium. Another water sample - UNNAMED-SED1-SURFACE WATER, was also submitted for reanalysis, but not for data quality assurance reasons. Rather, this sample was reanalyzed to confirm an apparent elevated total and dissolved lead concentration. Quality assurance evaluation for the reanalyzed samples indicated that data are acceptable for use in the ERA. Although there was poor reproducibility for a number of parameters in HESED-4 and its field duplicate (QA/QC-1), review of the chemistry data and internal laboratory quality control/assurance information for both samples did not reveal a need for reanalysis of either sample. Rather, it was considered likely that the differences between these two samples reflect sample heterogeneity that is not unexpected in the sampling of flowing surface water.

In general, none of the instances where DQOs for field duplicates were not met are surprising. Variability arising from the sub-sampling of non-homogenous matrices such as sediments and water is a common occurrence.

F-7.0 REFERENCES

Maxxam Analytics Inc. 2008. Dissolved versus Total Metal Analysis. Solutions. Environmental Services. Accessed on February 2, 2010 at http://www.maxxam.ca/content_man/admin/document/DISSBC0708.pdf

U.S. EPA. 2006. Validation of Metals for the Contract Laboratory Program (CLP) based on SOW ILMO5.3 (SOP Revision 13). Data Assessment and Contract Compliance Review. Standard Operating Procedure. U.S. EPA Region 2. SOP; HW – 2. Revision 13. Appendix A.1. September, 2006.

U.S. EPA. 2004. USEPA Contract Laboratory Program. National Functional Guidelines for Inorganic Data Review. Final. Office of Superfund Remediation and Technology Innovation (OSRTI), U.S. Environmental Protection Agency. Washington, DC. OSWER 9240.1-45. EPA 540-R-04-004. October, 2004

APPENDIX G

IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN (COPCS) FOR TERRESTRIAL RECEPTORS

APPENDIX G IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN (COPCS) FOR TERRESTRIAL RECEPTORS

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APPENDIX G IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN (COPCS) FOR TERRESTRIAL RECEPTORS

G-1.0 INTRODUCTION

In this appendix, the identification of COPCs for terrestrial ecological receptors (including mammals, birds, plants and soil invertebrates) is focused on. COPC identification for aquatic receptors is presented separately in Appendix H. It is common for some elements of COPC identification to be conducted separately for terrestrial and aquatic components of an ERA (and often separately for major ecological receptor groups as well), because COPCs may vary depending upon the receptors that are selected for evaluation, and the environmental media that are likely to be impacted by the different sources of COPCs. Differences in receptors, such as relevant pathways and routes of exposure, habitat availability and utilization, and chemical sensitivity, can often result in different COPC for different receptor groups.

In any risk assessment involving metals (such as the current ERA), the speciation or chemical forms of the substances likely to be released to the surrounding environment is an important consideration. Given the smelting process at the Glencore facility, metal species potentially released to environmental media likely consist of soluble oxides, sulphates, and various salts (such as chlorides, other halides), the relative proportions of which would depend on the composition of feed materials, process conditions, and the degree of oxidation and other reactions that occur within ambient environmental media, as well as the presence of other major anions in these media that metals/metalloids may associate or form complexes with. Where possible, the likely speciation of metals was considered within the COPC identification process.

Other considerations in the COPC identification process included the essential nutrient status, and the environmental fate and behaviour properties, of candidate COPCs, as well as the potential for these substances to bioaccumulate and/or biomagnify in terrestrial food webs.

G-2.0 COPC IDENTIFICATION FOR TERRESTRIAL ORGANISMS

Soil is the primary medium of concern for terrestrial-based ERA since wildlife receptors are directly (*e.g.*, soil ingestion, soil contact) or indirectly (*e.g.*, ingestion of plants and soil invertebrates) exposed to chemicals found within the soil matrix.

Soil samples (from the Principal sampling area and reference area) were collected by Conestoga Rovers & Associates (CRA) in July-August of 2009 and analyzed by Maxxam Analytics in Bedford, Nova Scotia. All bulk soil samples were air dried and sieved at 2 mm, and portions were digested following EPA Method 3050B. The digested solutions were diluted to volume for available metals analysis by ICP-MS. Maxxam Analytics is an accredited laboratory for all soil analyses that were conducted. Within the Principal sampling area, soil samples were collected from 61 stations in a radial pattern around the smelter complex. This program was limited to sampling on undeveloped lands held by Glencore and Crown lands. As a consequence of land ownership issues, the majority of soil samples were collected south of the smelter facility. Twenty-three soil samples were also collected from the reference area. The reference area stations were on undeveloped Crown lands with similar underlying geology (to the extent possible, but recognizing that geological zones in northeastern New Brunswick are inherently patchy and variable), and similar ecoregions and ecosites to the Principal sampling area, located 20-30 km west-southwest of the smelter facility (which is also upwind of the prevailing winds in the Belledune area). Soil sample collection consisted primarily of surface samples (*i.e.*, A layer: 0 to 5 cm) which were collected and analyzed at all Principal sampling area and reference area stations, but deeper soil profile samples (B layer: 5 to 15 cm; and, C layer: 15 to 30 cm) were also collected at selected stations. Further information regarding the soil sampling and analytical programs and protocols is provided in Appendix A.

All raw analytical data provided to Intrinsik by Maxxam for both soil sampling events (as well as the associated quality assurance reports) were carefully reviewed and evaluated by Intrinsik. Overall, all soil data are considered to be of acceptable quality and appropriate for use in an ERA. A soil data quality assurance evaluation is provided in Appendix E.

Some of the analytical data collected during the soil sampling programs measured parameters and/or substances that are not generally considered in the selection of COPCs (*i.e.*, pH and organic carbon). While these parameters may influence or modify the bioavailability and toxicity of metal or metalloid COPCs, and can be important in developing and interpreting exposure and risk estimates, they are not typically considered directly in the COPC identification step of ecological risk assessments (with the exception of the use of pH data for iron and aluminum soil quality benchmarks developed by the U.S. EPA (See: http://www.epa.gov/ecotox/ecossl/)). This is because such parameters are primarily modifiers of bioavailability and toxicity (rather than causes of toxicity). Also, such parameters typically lack health or risk-based ecological benchmarks that media concentrations can be compared against.

The identification of COPCs for terrestrial organisms involved a four step process, as follows:

1. Comparisons of soil chemistry data to regulatory environmental soil quality benchmarks and reference area soil chemistry data;
2. Determining the frequency of exceedance of soil chemistry data over the "final screening benchmark" (described below);
3. Two sample statistical comparison tests conducted between Principal sampling area and reference area soil chemistry datasets, where deemed necessary; and,
4. Further considerations (where/if deemed necessary), such as: toxicological issues (including availability of ecotoxicity data), COPCs identified in previous studies of the Belledune and surrounding area, smelter feed material chemistry data, smelter stack emissions data, potential non-smelter industrial sources of COPCs, geochemical relationships, statistical relationships, supplementary reference soil chemistry data, local geology, and spatial distribution patterns of soil chemical concentrations.

All these approaches are commonly used in site and risk assessments to identify COPCs and/or help distinguish natural soil element concentrations from those that have been influenced by anthropogenic activities. Details regarding the four step COPC identification process and the outcomes of these steps are provided in the subsequent sections.

The COPC identification process that was applied to the Principal sampling area soil chemistry data is considered robust and defensible, and is based on approaches that are commonly used in site and risk assessments to identify COPCs and help distinguish natural soil chemical concentrations from those that have been influenced by anthropogenic activities. It is also considered to be a conservative approach, as both simple comparisons of maximum Principal sampling area soil concentrations to soil guidelines and/or reference concentration statistics, and statistical comparison tests are prone to a high false positive (type I error) rate (Myers and Thorbjornsen, 2004; Leadon *et al*., 2007; CalEPA, 1997; U.S. EPA, 2001; 2002). Some reasons why these approaches tend to have a high rate of false positives is that trace element distributions in soil tend to have very large ranges (two or three orders of magnitude are not uncommon), and are highly right-skewed, often having, or resembling lognormal distributions. The accurate characterization of the upper tails of such skewed distributions requires a large number of background samples, which are often not available. The probability of false positives increases if the site dataset is larger than the background dataset (which is common, and is the case in the current investigation). In addition, statistical tests treat each analyte as an independently behaving entity, and do not consider the geochemical context in which each element occurs (Myers and Thorbjornsen, 2004). The U.S. EPA (2001) notes that a type I error (false positive) is less serious than a Type II error (false negative) when selecting COPCs, and the use of approaches that favour type I errors are inherently more protective of human and environmental health.

COPCs selected based on this screening process were used in preliminary ERA modelling. Based on preliminary ERA outcomes, supplementary soil sampling within a 0-2 km radius of the smelter complex was conducted in August 2010 (N=17). This soil sampling event was conducted to refine exposure estimates in the ERA (particularly due to limited number of 2009 soil samples within 2 km of the smelter) and to take advantage of recommended field studies that were occurring at that time (*i.e.*, vegetation survey, soil invertebrate sampling). These supplementary soil data (comprised entirely of A layer (0-5 cm) samples) were reviewed and screened with the same COPC identification process as the 2009 data set. However, this exercise was conducted mainly to confirm/validate the COPCs identified herein (*i.e.*, which are based on the primary July-August 2009 soil chemistry dataset), and as such, a written description with tabular outcomes for the steps within the COPC identification process conducted on the August 2010 soil dataset, is not provided. Rather, a summary of this supplemental soil chemistry data is provided in Section G-3.1 of this Appendix, with the raw analytical soil chemistry data from this sampling event provided in Appendix D. Summarized outcomes of the COPC identification process that was applied to the August 2010 soil chemistry dataset are provided in Section G-3.1 of this appendix.

G-2.1 Step 1: Comparisons of Soil Chemistry Data to Regulatory Environmental Soil Quality Benchmarks and Reference Area Soil Chemistry Data

The first step of the COPC identification process involved comparing Principal sampling area soil chemistry data to available soil quality benchmarks protective of ecological receptors and to reference area soil chemistry data.

Prior to making comparisons, all chemicals that were found at detectable concentrations (*i.e.*, greater than or equal to the reportable detection limit (RDL)) in one or more surface soil samples, were short-listed for screening against reference area soil chemistry data and ecological health-based soil quality benchmarks. Chemicals that were below the RDL were excluded from further consideration if typical and/or acceptable RDLs for the given analytical method were achieved (See Appendix E). This is standard practice when selecting COPCs for an ERA. For chemicals in which there was a mix of detectable and non-detectable concentrations, all non-detectable concentrations were conservatively assumed to equal the laboratory's RDL for the purposes of calculating summary statistics. This is the most conservative way to treat a <RDL result for a given sample and will not underestimate the actual concentration that may be present in that sample. Furthermore, the RDLs for some elements in some soil samples were elevated (See Appendix E for further details on soil data quality). Thus, substituting the full RDL

values for the <RDL entries in a given substance's dataset biases the calculation of summary statistics high, which increases the conservatism within the COPC identification process.

When identifying COPCs in soil, it is standard practice to select for further assessment only those chemicals having a maximum concentration in site or study area soil which exceeds both the concentrations identified in the reference area, and the environmental health-based soil quality benchmark. It is a general assumption in all risk assessment studies that there is a low to negligible likelihood for potential adverse effects when maximum soil chemical concentrations are below the environmental health-based soil quality benchmarks and/or reference area soil concentrations. Soil chemistry data that meets these conditions are typically considered to require no further evaluation or action. While the maximum concentration is widely considered the most appropriate and conservative point of comparison to regulatory soil quality benchmarks and reference area concentrations, other summary statistics were also calculated for measurable substances in the chemistry dataset.

Chemicals with maximum soil concentrations from all three depths of measurement that exceeded both the environmental health-based soil quality benchmark and the reference soil concentration statistic were carried forward into the subsequent screening step – determination of the frequency of exceedance of Principal sampling area soil concentrations over the "final screening benchmark". Chemicals were also carried forward for further evaluation if no soil quality benchmark was identified, and the maximum soil concentration was greater than the reference area soil concentration statistic.

The specific ecological health-based soil quality benchmarks that were considered are as follows, presented in the preferential order of their application. The current CCME (Canadian Council of Ministers of the Environment) environmental soil quality guidelines for a residential/parkland land use[1] were preferentially used as the soil quality

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[1] Much of the Study Area is forest or field wild lands with a number of streams, creeks and wetland areas. CCME does not currently have a clear land use designation for such areas with respect to soil quality guidelines. CCME (1996; 2006) state that the residential/parkland (r/p) land use category does not include wild lands except buffer zones between residential and recreational (*e.g.*, campground) areas. The CCME agricultural (ag) land use definition includes habitat for resident and transitory wildlife as well as native flora. However, under this definition, 'land' is always preceded by 'agricultural'. Neither the residential/parkland nor agricultural land use definitions from CCME completely apply to the Study Area. The majority of the Study Area is not currently used for agricultural purposes, nor is it a buffer zone between residential and recreational lands. For most metals and metalloids with CCME soil quality guidelines available, the land use classification makes no difference as the soil quality benchmarks are often the same value for both the ag and r/p land use categories (although there are exceptions).

Recent guidance from BC MOE (2008) and Alberta Environment (AENV, 2009) include definitions for new land use categories of "wild lands", and "natural areas", respectively. These categories are for lands with the primary purpose of supporting natural ecosystems, including ecological reserves, natural parks, benchmarks (*i.e.,* CCME, 2007 Update 7.1). For chemicals with CCME soil guidelines available, the lowest of the environmental guidelines derived for the various exposure pathways or ecological receptors was selected, where appropriate. For chemicals where a CCME guideline was not available, U.S. EPA Ecological Soil Screening Levels (EcoSSLs) were selected as the next preferential benchmark for comparison purposes (http://www.epa.gov/ecotox/ecossl/index.html). If a U.S. EPA EcoSSL was not available for a given chemical, then other available environmental soil quality benchmarks were used, including Alberta Environment (2009) ecological protection values for direct soil contact or nutrient/energy cycling, whichever was lower; soil benchmarks derived by Efroymson *et al*. (1997a,b); or CCME (1991) interim remediation criteria for soil. The CCME (1991) criteria were considered only when no other values were available, because the scientific basis for these values is outdated and poorly documented, which limits confidence in their application.

It is important to recognize that generic ecological health-based soil quality benchmarks are derived by regulatory agencies to be intentionally conservative and protective. Exceedance of these benchmarks does not imply there is a risk of adverse ecological effects; rather, it suggests that further evaluation of those chemicals is warranted (such as risk assessment, further data collection, *etc.*). This is especially true for metals and metalloids, many of which have essential nutritional and physiological roles in terrestrial biota. It is equally important, when interpreting ecological health-based soil quality benchmark exceedances, to consider the body of literature regarding acclimation and adaptation of terrestrial organisms to metals in soil and/or food items. It is well established that populations chronically exposed to metals often show an enhanced tolerance relative to populations with no, or lower metals exposure (Kapustka *et al*., 2004). This increased tolerance can be due to either acclimation (shifting of tolerance within the genetically defined limit of the organism) or adaptation (modification of the limits of an organism through changes in heritable genetic material) (ICMM, 2007). Increased metals tolerance has been documented for many species of terrestrial and aquatic plants, animals and microbes. For the most part, acclimation and/or adaptation to metals has been demonstrated primarily at the population level, but studies of pollution-

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wetlands, woodlands, forests, tundra, muskeg and meadows. BC MOE (2008) has established a policy for wild lands to enable the development of soil quality standards for wild land sites. This policy is that urban parkland (essentially the same as residential/parkland) soil standards apply to the top three meters of soil at wild land sites, with commercial soil standards being applicable to the ≥3 m soil profile at wild land sites. Similarly, Alberta Environment (2009) surface soil remediation guidelines for natural areas default to r/p guidelines at this time.

Given that BC MOE and AENV both default to r/p soil quality guidelines for wild lands or natural areas, and given that the Study Area for the ERA is composed primarily of wild land or natural areas, only r/p soil quality guidelines were considered in the COPC identification process.

induced community tolerance have also documented these phenomena at the community level at various metals-contaminated sites. This often manifests as community re-structuring where tolerant species displace less tolerant species. The topic of acclimation and adaptation to metals is described further in Kapustka *et al*., (2004), ICMM (2007), Chapman (2008), and Newman and Clements (2008).

G-2.1.1 Reference Soil Chemistry Data and Selection of the Reference Soil Concentration Statistic

As mentioned previously, reference area data were collected from undeveloped Crown lands with similar underlying geology, and similar ecoregions and ecosites to the Principal sampling area, located 20-30 km west-southwest of the smelter facility (which is also upwind of the prevailing winds in the Belledune area).

An important decision when identifying COPCs in soil is the selection of the reference (or background) area soil concentration that will be compared against the site or study area soil chemistry data. The choice of the reference soil concentration statistic is largely arbitrary and is based on professional judgment. While there is some regulatory guidance on selecting the reference area chemical concentration statistic, a number of different values are recommended by various regulatory agencies. Review of a number of government reports and guidance documents that address this issue, across a variety of jurisdictions in North America, reveals that a majority of jurisdictions prefer or endorse the use of the 90th percentile to represent reference data. While the 90th percentile appears to be among the most frequently recommended value, various other statistics are also recommended by regulatory agencies (such as: median, multiples of the median, upper 95% confidence limit on the arithmetic mean (UCLM95), 60th percentile, 80th percentile, 95th percentile, 97.5th percentile, and even the maxima for small data sets (WESA, 2005; Washington DOE, 1992; Wyoming DEQ, 2004; MOEE, 1993). A number of agencies suggest that the choice of the reference concentration statistic should be based on the distribution of the reference area dataset (*e.g.,* normal, lognormal, non-parametric) and the sample size, rather than some arbitrary rule that may not be statistically valid in all situations. Within the U.S. EPA, two times the arithmetic mean background concentration has been used for many years in the Superfund program (Akin, 1991, U.S. EPA, 2000), where the site maxima is compared to two times the arithmetic mean of the background concentration. In the United States, it has also been common in the past to use the mean plus two or three standard deviations as the background statistic. These values have been commonly used as “upper limits of background” or tolerance limits (Breckenridge and Crockett, 1995). Tannenbaum (2003) notes that comparisons of site maxima to two times the arithmetic mean of the background soil data is still commonly used by the U.S. EPA, and is an approach that should identify all true COPCs, while dismissing chemicals that are most likely inconsequential.

Overall, regulatory guidance documents suggest that upper percentiles of the reference dataset can be compared to the maximum site concentration. However, if the sample size is small in the background or reference dataset, it is generally recognized that a measure of central tendency is more appropriate than an upper percentile, or even upper confidence or tolerance limits (CalEPA, 1997). Many guidance documents and literature suggest that if central tendency measures are to be used as the background soil statistic, the median is better than the mean given the typical lognormal distribution of elements in soil. This is because a median is less influenced by extreme values (or a skewed distribution) than the mean.

Given the above considerations, it was considered reasonable to select the lower of either the 90th percentile or two times the arithmetic mean as the reference soil concentration statistic in the current ERA, so long as the sample size is considered to be sufficiently large. Selecting the lower of either of these two metrics allows for a conservative screening process. For the A layer (0-5 cm) reference soil chemistry dataset, N=23. This was considered a sufficient sample size to utilize either the 90th percentile or two times the arithmetic mean as the reference soil concentration statistic. However, N=10 for the B layer (5-15 cm) and C layer (15-30 cm) reference soil chemistry datasets. These sample sizes are not sufficient to select the lower of either the 90th percentile or two times the arithmetic mean as the reference soil concentration statistic. Rather, for the B and C layer reference soil chemistry datasets, the median was used as the reference concentration statistic.

G-2.1.2 Step 1 Outcomes

A Layer (0-5cm)

Table G-1 provides a comparison of the maximum A layer (0-5 cm) Principal sampling area soil concentrations to regulatory environmental health-based soil quality benchmarks, and to A layer reference soil concentration statistics. In the A layer Principal sampling area soil samples; all target analytes except bismuth were measurable in one or more samples. Thus, bismuth was excluded from further evaluation. In the A layer reference area soil chemistry dataset, antimony, bismuth, and tin were not measurable in any samples.

As noted previously, chemicals for which the maximum Principal sampling area soil concentrations were below the applicable soil quality benchmarks or reference soil concentration statistics were not carried forward. Only chemicals with maximum Principal sampling area soil concentrations exceeding both the applicable soil quality benchmark (or having no benchmark available) and the reference soil concentration statistic are considered further.

Table G-1 Comparison of Principal Sampling Area A Layer (0-5 cm) Surface Soil Concentrations to Environmental Soil Quality Benchmarks and Reference Area Soil Concentration Statistics

Metal	Maximum Measured Principal Sampling Area Soil Concentration (mg/kg)[a]	Reference Area Soil Concentration Statistic (mg/kg)[b]	Environmental Soil Quality Benchmark (mg/kg)
Aluminum (Al)	44000	22600	Soil pH<5.5[c]
Antimony (Sb)	14	2	0.27[d]
Arsenic (As)	310	5	17[e]
Barium (Ba)	300	118	330[d]
Beryllium (Be)	2	2	21[d]
Boron (B)	6	5	NBA
Cadmium (Cd)	7.2	1.5	10[e]
Chromium (Cr)	140	29.6	52[e]
Cobalt (Co)	78	13.6	13[d]
Copper (Cu)	77	15.8	63[e]
Iron (Fe)	89000	38400	Soil pH<5 or >8[f]
Lead (Pb)	740	67.6	300[e]
Lithium (Li)	48	14.7	2[g]
Manganese (Mn)	5900	1360	220[d]
Molybdenum (Mo)	8	2	4[h]
Nickel (Ni)	89	28.6	50[e]
Rubidium (Rb)	15	8	NBA
Selenium (Se)	4	2	1[e]
Silver (Ag)	1.7	0.5	4.2[d]
Strontium (Sr)	45	32	NBA
Thallium (Tl)	1.5	0.3	1.4[e]
Tin (Sn)	26	2	5[h]
Uranium (U)	5.1	1.2	500[e]
Vanadium (V)	510	64.4	130[e]
Zinc (Zn)	1800	71.6	200[e]

Notes:

NBA = no benchmark available.

Bolded chemicals are those for which the maximum measured soil concentration exceeds the reference soil concentration statistic.

Shaded chemicals are those for which the maximum measured soil concentration exceeds the environmental soil quality benchmark. Chemicals are also shaded if no environmental soil quality benchmarks were identified.

a N=61. Values presented are measured maxima. While some samples may have elevated RDLs that are higher than the measured maxima, it is not generally appropriate to utilize an unknown value (such as that represented by an elevated RDL) in a COPC identification process[2].

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[2] In all cases where an elevated RDL for a given chemical was rejected as a plausible maxima, the entire dataset for that chemical was examined to determine if it was at all likely that an elevated RDL could be at, or near a maxima. For example, if the elevated RDL was much higher than any measured concentration or other RDLs achieved in other samples, then it was considered unrepresentative of potential maximum concentrations.

b N=23. Value presented is lowest of the 90th percentile or two times the arithmetic mean, unless a substance was not measured above the RDL in any reference soil sample. In that event, the reference concentration statistic is the typical RDL value that is regularly achieved by the laboratory.

c U.S. EPA (2003a) reports that total or available aluminum in soils is not a suitable or reliable predictor of toxicity and bioaccumulation , and recommends that aluminum be carried forward for further evaluation as a COPC at sites where the soil pH is <5.5. The average Principal sampling area soil pH was 5.1 (N=7), with 5/7 samples having a soil pH <5.5. Thus, aluminum was carried forward for further evaluation as a COPC.

d U.S. EPA EcoSSLs (http://www.epa.gov/ecotox/ecossl/index.html); selected benchmarks are the lowest of the plant, soil or wildlife EcoSSL.

e CCME (2007). Update 7.1. Canadian Soil Quality Guidelines (Environmental Soil Quality Guidelines; Residential/Parkland land use categories); selected benchmarks are the lowest of the soil contact guideline, soil and food ingestion guideline or the nutrient and energy cycling check guideline.

f U.S. EPA (2003b) reports that identifying a specific benchmark for iron in soils is difficult since iron's bioavailability to plants and resulting toxicity are dependent upon site-specific soil conditions such as pH, Eh, and moisture. U.S. EPA recommends that the site-specific measured pH and Eh (collected in the field) be used to determine the expected valence state of iron and associated chemical compounds, and the resulting bioavailability and toxicity in the environmental setting. In well-aerated soils between pH 5 and 8, the iron demand of plants is higher than the amount available. Thus, plants have evolved various mechanisms to enhance iron uptake. Under these soil conditions, iron is not expected to be toxic to plants. The main concern from an ecological risk perspective is not the direct chemical toxicity of iron, but the effect of iron as a mediator in the geochemistry of other (potentially toxic) metals. While the average soil pH in Principal sampling area soil samples was 5.1 (N=7), 4/7 samples had a pH <5. Thus, iron was carried forward for further evaluation as a COPC.

g Efroymson *et al*. (1997a) soil screening benchmark for phytotoxicity.

h AENV (2009). Alberta Environment Tier 1 Surface Soil Remediation Guidelines (Ecological soil remediation guideline; Natural Areas land use category). While AENV has a natural areas land use designation, there is currently no procedure for deriving soil quality benchmarks for this land use. Rather, for metals and metalloids, residential/parkland soil quality guidelines are the default values for the natural areas land use category. The selected benchmarks are the lowest of the direct soil contact guidelines, soil and food ingestion guidelines, or the nutrient and energy cycling check guidelines.

Table G-1 shows that a large number of the chemicals included in the soil analytical program have maximum soil concentrations that are greater than both the available environmental health-based soil quality benchmark (or, no soil benchmark was identified) and the reference soil concentration statistic. The soil maxima for all chemicals except beryllium exceeded the corresponding reference concentration statistic. Only those chemicals with maximum soil concentrations above both the environmental soil quality benchmark (or with no identified benchmark) and the reference soil concentration statistic were carried forward into the subsequent screening step – determination of the frequency of exceedance of Principal sampling area soil concentrations over the final screening benchmark (FSB).

As shown in Table G-1, barium, beryllium, cadmium, silver, and uranium are excluded from further consideration as the maximum soil concentrations are below the applicable environmental soil quality benchmarks or do not exceed the reference soil concentration statistic. These chemicals were not considered further.

The following chemicals were carried forward into the subsequent screening step (determination of the frequency of exceedance of Principal sampling area soil concentrations over the FSB):

- Aluminum
- Antimony
- Arsenic
- Boron
- Chromium
- Cobalt
- Copper
- Iron
- Lead
- Lithium
- Manganese
- Molybdenum
- Nickel
- Rubidium
- Selenium
- Strontium
- Thallium
- Tin
- Vanadium
- Zinc

Of these substances, boron, rubidium, and strontium are carried forward for further consideration on the basis of no environmental soil quality benchmarks being identified, and exceedance of the soil maxima over their corresponding reference concentration statistics.

With respect to aluminum and iron, the basis for these substances being carried forward for further evaluation is exceedance of the maxima over the reference soil concentration statistic, and the soil pH in the Principal sampling area A layer soil samples being <5.5 and <5.0, as per the U.S. EPA (2003a,b) EcoSSL values for these two substances. There are currently no concentration-based environmental soil quality benchmarks for aluminum or iron. In the seven Principal sampling area A layer soil samples that were analyzed for soil pH, the average soil pH was 5.1, and 4/7 samples had a pH <5.

Although insufficient pH data are available from the soil sampling/analytical program to conduct statistical comparison tests between Principal sampling area A layer soil pH data (N=7) and reference area A layer soil pH data (N=3; pH = 6.17, 4.53, and 4.17), the pH levels are similar between these areas.

B Layer (5-15 cm) and C Layer (15-30 cm)

While the A layer (0-5 cm) is the depth range that is most likely to show any off-site impacts that may have occurred as a result of smelter operations, it is possible that chemicals depositing onto off-site surface soils could have leached or migrated vertically within the soil profiles. Thus, the same COPC identification process that was conducted on soil chemistry data from the A layer was also conducted on data for the B and C layers, to determine if potential off-site impacts extend into these deeper soil layers.

Tables G-2 and G-3 provide a comparison of the B layer (5-15 cm) and C layer (15-30 cm) Principal sampling area soil chemistry data to their respective reference soil concentration statistics and to regulatory environmental health-based soil quality benchmarks. Several target analytes were not measurable in any of the B and C layer Principal sampling area soil samples (*i.e.*, B layer: antimony, beryllium, bismuth, and tin; C layer: bismuth, boron and tin), and were therefore excluded from further consideration. In the B and C layer reference area datasets, there were also several target analytes that were not measurable in any of the soil samples (*i.e.*, B layer: antimony, bismuth, boron, selenium, tin; C layer: antimony, bismuth, boron, selenium, silver, tin).

Table G-2 Comparison of Principal Sampling Area B Layer (5-15 cm) Surface Soil Concentrations to Environmental Soil Quality Benchmarks and Reference Area Soil Concentration Statistics

Chemical	Maximum Measured Principal Sampling Area Soil Concentration[a] (mg/kg)	Reference Area Soil Concentration Statistic[b] (mg/kg)	Environmental Soil Quality Benchmark (mg/kg)
Aluminum (Al)	43000	23000	Soil pH<5.5[c]
Arsenic (As)	120	3.5	17[e]
Barium (Ba)	390	50.5	330[d]
Boron (B)	5	5	NBA
Cadmium(Cd)	4	0.3	10[e]
Chromium (Cr)	120	23	52[e]
Cobalt (Co)	34	11	13[d]
Copper (Cu)	80	11	63[e]
Iron (Fe)	83000	33500	Soil pH<5 or >8[f]
Lead (Pb)	110	11	300[e]
Lithium (Li)	36	12.5	2[g]
Manganese (Mn)	3700	435	220[d]
Molybdenum (Mo)	6	2	4[h]
Nickel (Ni)	53	17	50[e]
Rubidium (Rb)	13	6	NBA
Selenium (Se)	8	2	1[e]
Silver (Ag)	1	0.5	4.2[d]
Strontium (Sr)	60	6	NBA
Thallium (Tl)	0.3	0.1	1.4[e]
Uranium (U)	7.9	0.45	500[e]
Vanadium (V)	210	54.5	130[e]
Zinc (Zn)	600	61.5	200[e]

Notes:
NBA = no benchmark available.
Antimony, beryllium, bismuth and tin not detected in Principal sampling area B layer samples.
Bolded chemicals are those for which the maximum measured soil concentration exceeds the reference soil concentration statistic.
Shaded chemicals are those for which the maximum measured soil concentration exceeds the environmental soil quality benchmark. Chemicals are also shaded if no environmental soil quality benchmarks were identified.

a N=20. Values presented are measured maxima. While some samples may have elevated RDLs that are higher than the measured maxima, it is not generally appropriate to utilize an unknown value (such as that represented by an elevated RDL) in a COPC identification process[3].

b N=10. Value presented is the median reference area soil concentration, unless a substance was not measured above the RDL in any reference soil sample. In that event, the reference concentration statistic is the typical RDL value that is regularly achieved by the laboratory.

c U.S. EPA (2003a) reports that total or available aluminum in soils is not a suitable or reliable predictor of toxicity and bioaccumulation and recommends that aluminum be carried forward for further evaluation as a COPC at sites where the soil pH is <5.5. Only A layer soil pH data are available at this time (where average soil pH was 5.1; N=7). In the absence of B and C layer soil pH data, it was assumed that A layer soil pH represents B and C layer soil pH. Thus, aluminum was carried forward for further evaluation as a COPC.

d U.S. EPA EcoSSLs (http://www.epa.gov/ecotox/ecossl/index.html); selected benchmarks are the lower of the plant, soil or wildlife EcoSSL.

e CCME (2007). Update 7.1. Canadian Soil Quality Guidelines (Environmental Soil Quality Guidelines; Residential/Parkland land use categories); selected benchmarks are the lower of the soil contact guideline, soil and food ingestion guideline or the nutrient and energy cycling check guideline.

f U.S. EPA (2003b) reports that identifying a specific benchmark for iron in soils is difficult since iron's bioavailability to plants and resulting toxicity are dependent upon site-specific soil conditions such as pH, Eh, and moisture. U.S. EPA recommends that the site-specific measured pH and Eh (collected in the field) be used to determine the expected valence state of iron and associated chemical compounds, and the resulting bioavailability and toxicity in the environmental setting. In well-aerated soils between pH 5 and 8, the iron demand of plants is higher than the amount available. Thus, plants have evolved various mechanisms to enhance iron uptake. Under these soil conditions, iron is not expected to be toxic to plants. The main concern from an ecological risk perspective is not the direct chemical toxicity of iron, but the effect of iron as a mediator in the geochemistry of other (potentially toxic) metals. Only A layer soil pH data are available at this time (where average soil pH was 5.1; N=7, but 4/7 samples had a pH <5). In the absence of B and C layer soil pH data, it was assumed that A layer soil pH represents B and C layer soil pH. Thus, iron was carried forward for further evaluation as a COPC.

g Efroymson *et al*. (1997a) soil screening benchmark for phytotoxicity.

h AENV (2009). Alberta Environment Tier 1 Surface Soil Remediation Guidelines (Ecological soil remediation guideline; Natural Areas land use category). While AENV has a natural areas land use designation, there is currently no procedure for deriving soil quality benchmarks for this land use. Rather, for metals and metalloids, residential/parkland soil quality guidelines are the default values for the natural areas land use category. The selected benchmarks are the lower of the direct soil contact guidelines, soil and food ingestion guidelines, or the nutrient and energy cycling check guidelines.

Table G-3 Comparison of Principal Sampling Area C Layer (15-30 cm) Surface Soil Concentrations to Environmental Soil Quality Benchmarks and Reference Area Soil Concentration Statistics

Chemical	Maximum Measured Principal Sampling Area Soil Concentration[a] (mg/kg)	Reference Area Soil Concentration Statistic[b] (mg/kg)	Environmental Soil Quality Benchmark (mg/kg)
Aluminum (Al)	40000	27000	Soil pH<5.5[c]
Antimony (Sb)	2	2	0.27[d]
Arsenic (As)	180	3	17[e]
Barium (Ba)	600	55	330[d]
Beryllium (Be)	3	2	21[d]
Cadmium(Cd)	2.7	0.3	10[e]
Chromium (Cr)	180	35.5	52[e]
Cobalt (Co)	49	14.5	13[d]
Copper (Cu)	86	13	63[e]
Iron (Fe)	92000	35500	Soil pH<5 or >8[f]
Lead (Pb)	69	11	300[e]
Lithium (Li)	38	17.5	2[g]
Manganese (Mn)	5500	405	220[d]
Molybdenum (Mo)	8	2	4[h]
Nickel (Ni)	60	29.5	50[e]
Rubidium (Rb)	12	6.5	NBA
Selenium (Se)	5	2	1[e]
Silver (Ag)	1.3	0.5	4.2[d]
Strontium (Sr)	23	6	NBA
Thallium (Tl)	0.3	0.1	1.4[e]
Uranium (U)	9.4	0.5	500[e]
Vanadium (V)	190	57	130[e]
Zinc (Zn)	540	58.5	200[e]

Notes:
NBA = no benchmark available.
Bismuth, boron and tin not detected in Principal sampling area C layer samples.
Bolded chemicals are those for which the maximum measured soil concentration exceeds the reference soil concentration statistic.
Shaded chemicals are those for which the maximum measured soil concentration exceeds the environmental soil quality benchmark. Chemicals are also shaded if no environmental soil quality benchmarks were identified.

a N=20. Values presented are measured maxima. While some samples may have elevated RDLs that are higher than the measured maxima, it is not generally appropriate to utilize an unknown value (such as that represented by an elevated RDL) in a COPC identification process[3].

b N=10. Value presented is the median reference area soil concentration, unless a substance was not measured above the RDL in any reference soil sample. In that event, the reference concentration statistic is the typical RDL value that is regularly achieved by the laboratory.

c U.S. EPA (2003a) reports that total or available aluminum in soils is not a suitable or reliable predictor of toxicity and bioaccumulation and recommends that aluminum be carried forward for further evaluation as a COPC at sites where the soil pH is <5.5. Only A layer soil pH data are available at this time (where average soil pH was 5.1; N=7). In the absence of B and C layer soil pH data, it was assumed that A layer soil pH represents B and C layer soil pH. Thus, aluminum was carried forward for further evaluation as a COPC.

d U.S. EPA EcoSSLs (http://www.epa.gov/ecotox/ecossl/index.html); selected benchmarks are the lower of the plant, soil or wildlife EcoSSL.

e CCME (2007). Update 7.1. Canadian Soil Quality Guidelines (Environmental Soil Quality Guidelines; Residential/Parkland land use categories); selected benchmarks are the lower of the soil contact guideline, soil and food ingestion guideline or the nutrient and energy cycling check guideline.

f U.S. EPA (2003b) reports that identifying a specific benchmark for iron in soils is difficult since iron's bioavailability to plants and resulting toxicity are dependent upon site-specific soil conditions such as pH, Eh, and moisture. U.S. EPA recommends that the site-specific measured pH and Eh (collected in the field) be used to determine the expected valence state of iron and associated chemical compounds, and the resulting bioavailability and toxicity in the environmental setting. In well-aerated soils between pH 5 and 8, the iron demand of plants is higher than the amount available. Thus, plants have evolved various mechanisms to enhance iron uptake. Under these soil conditions, iron is not expected to be toxic to plants. The main concern from an ecological risk perspective is not the direct chemical toxicity of iron, but the effect of iron as a mediator in the geochemistry of other (potentially toxic) metals. Only A layer soil pH data are available at this time (where average soil pH was 5.1; N=7, but 4/7 samples had a pH <5). In the absence of B and C layer soil pH data, it was assumed that A layer soil pH represents B and C layer soil pH. Thus, iron was carried forward for further evaluation as a COPC.

g Efroymson *et al*. (1997a) soil screening benchmark for phytotoxicity.

h AENV (2009). Alberta Environment Tier 1 Surface Soil Remediation Guidelines (Ecological soil remediation guideline; Natural Areas land use category). While AENV has a natural areas land use designation, there is currently no procedure for deriving soil quality benchmarks for this land use. Rather, for metals and metalloids, residential/parkland soil quality guidelines are the default values for the natural areas land use category. The selected benchmarks are the lower of the direct soil contact guidelines, soil and food ingestion guidelines, or the nutrient and energy cycling check guidelines.

Tables G-2 and G-3 show that sixteen of the chemicals included in the soil analytical program have maximum Principal sampling area B and C layer soil concentrations that exceed both the available environmental health-based soil quality benchmark (or, no soil benchmark was identified) and the reference soil concentration statistic (*i.e.,* the median in this case). All were carried forward into the subsequent screening step – determination of the frequency of exceedance of Principal sampling area B and C layer soil concentrations over the FSB. These sixteen chemicals are as follows:

- Aluminum
- Arsenic
- Barium
- Chromium
- Cobalt
- Copper
- Iron
- Lithium
- Manganese
- Molybdenum
- Nickel
- Rubidium
- Selenium
- Strontium
- Vanadium
- Zinc

The other chemicals listed in Tables G-2 and G-3 were excluded from further consideration on the basis of maximum Principal sampling area soil concentrations being below the applicable environmental soil quality benchmarks, and/or reference soil concentration statistics (*i.e*., antimony, beryllium, boron, cadmium, lead, silver, thallium, uranium).

G-2.1.3 Step 2 Outcomes

The final screening benchmark (FSB) is the higher value of either the reference soil concentration statistic or the applicable environmental soil quality benchmark (as both values must be exceeded in order for a chemical to be retained as a COPC).

The frequency of exceedance over the FSB was calculated for each chemical by dividing the number of Principal sampling area soil samples that exceed the FSB by the total number of Principal sampling area soil samples, and then expressing the resulting value as a percentage. A significance level of 5% was used where possible[3], as this is a common significance level that is used in many statistical tests. Chemicals that displayed a frequency of exceedance over the FSB of 5% or greater were carried forward into the next step of the COPC identification process (*i.e.,* statistical comparison tests).

A Layer (0-5 cm)

Table G-4 presents the frequency of exceedance of the A layer soil concentrations over the FSB for the chemicals carried forward from Step 1. Table G-4 also includes additional summary statistics for the concentrations of these chemicals in A layer soil samples (*i.e.,* minimum, maximum, arithmetic mean, median, and 90th percentile).

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[3] There is no consistent regulatory guidance on a cut-off value to use when considering the frequency of detection and exceedance over benchmarks in a COPC identification process. However, a value of 5% is often used in practice as it is consistent with the significance level in typical statistical comparison testing. Also, within the Superfund program, the U.S. EPA has used a 5% cut-off value for detection frequency to eliminate chemicals from further consideration since the early 1990s. U.S. Navy (2003) ERA guidance also supports the use of a 5% cut-off value when considering detection and benchmark exceedance frequency, but cautions that one must consider the sample size when choosing a cut-off value (as 5% is not appropriate if one has a sample size of <20; in these cases, professional judgement is used to determine if frequency considerations are appropriate and what an alternate cut-off value could be). The U.S. Navy also cautions that one must consider the spatial distribution of the chemicals of interest, when deciding whether or not to eliminate chemicals from consideration on the basis of detection or benchmark exceedance frequency.

For COPC identification within the B and C layer Study Area soil chemistry datasets, it was necessary to use a significance level of 10% given that N=20.

Table G-4 Principal Sampling Area A Layer (0-5 cm) Surface Soil Concentration Summary Statistics and Frequency of Exceedance Over Final Screening Benchmark

Chemical	Minimum Concentration (mg/kg)	Maximum Measured Concentration (mg/kg)	Median Concentration (mg/kg)	Arithmetic Mean Concentration (mg/kg)	90th Percentile (mg/kg)	Final Screening Benchmark (FSB)[a] (mg/kg)	Frequency of Exceedance over FSB (%)
Aluminum (Al)	2900	44000	14000	16231	27000	22600[b]	18.0%
Antimony (Sb)	<2	14	2	2.4	3	2	11.5%
Arsenic (As)	<2	310	15	32.8	64	17	41.0%
Boron (B)	<5	6	5	5	5	5	3.3%
Chromium (Cr)	7	140	29	39.7	76	52	19.7%
Cobalt (Co)	2	78	9	11.6	22	13.6	23.0%
Copper (Cu)	4	77	15	18.7	35	63	1.6%
Iron (Fe)	4600	89000	29000	29792	41000	38400[b]	16.4%
Lead (Pb)	10	740	73	110	240	300	6.6%
Lithium (Li)	<2	48	14	14.4	24	14.7	47.5%
Manganese (Mn)	53	5900	450	1128	3100	1360	23.0%
Molybdenum (Mo)	<2	8	2	2.2	2	4	3.3%
Nickel (Ni)	6	89	20	25.1	43	50	8.2%
Rubidium (Rb)	<2	15	8	7.3	11	8	36.1%
Selenium (Se)	<2	4	2	2.1	2	2	3.3%
Strontium (Sr)	<5	45	8	12.6	24	32	9.8%
Thallium (Tl)	<0.1	1.5	0.3	0.4	0.8	1.4	1.6%
Tin (Sn)	<2	26	2	2.7	2	5	4.9%
Vanadium (V)	14	510	60	75.4	120	130	9.8%
Zinc (Zn)	17	1800	94	154	310	200	18.0%

Notes: N = 61; Frequency of exceedance percentages are all rounded to one decimal place; Shaded chemicals are those for which the frequency of exceedance over the FSB was greater than 5%. These chemicals were carried forward into the subsequent screening step (*i.e.*, statistical comparison tests).

[a] Final Screening Benchmark (FSB) is the higher value of either the reference soil concentration statistic (which is the lower of either the 90th percentile, or two times the mean, unless a substance was not measured above the RDL in any reference area soil sample, in which case the typical laboratory RDL becomes the reference concentration statistic), or the applicable environmental soil quality benchmark (see Table G-1).

[b] As aluminum and iron have no concentration-based soil quality benchmarks available, the FSB defaults to the reference concentration statistic.

From the information presented in Table G-4, the following chemicals are carried forward into the subsequent screening step (*i.e.*, statistical comparison tests), as their frequency of exceedance over the FSB was greater than 5%.

- Aluminum
- Antimony
- Arsenic
- Chromium
- Cobalt
- Iron
- Lead
- Lithium
- Manganese
- Nickel
- Rubidium
- Strontium
- Vanadium
- Zinc

Boron, copper, molybdenum, selenium, thallium, and tin are excluded from further consideration as the frequency of exceedance for these substances over their respective FSB values is less than 5%.

B Layer (5-15 cm) and C Layer (15-30 cm)

Tables G-5 and G-6 present the frequency of exceedance of Principal sampling area B and C layer soil concentrations over the FSB for the chemicals carried forward from Step 1. These tables also include additional summary statistics for the concentrations of these chemicals in the B and C layers of Principal sampling area soil (*i.e.,* minimum, maximum, arithmetic mean, median, and 90th percentile).

Table G-5 Principal Sampling Area B Layer (5-15 cm) Surface Soil Concentration Summary Statistics and Frequency of Exceedance Over Final Screening Benchmark

Chemical	Minimum Concentration (mg/kg)	Maximum Measured Concentration (mg/kg)	Median Concentration (mg/kg)	Arithmetic Mean Concentration (mg/kg)	90th Percentile (mg/kg)	Final Screening Benchmark [a] (mg/kg)	Frequency of Exceedance over Final Screening Benchmark (FSB) (%)
Aluminum (Al)	10000	43000	18500	19500	28200	23000[b]	20%
Arsenic (As)	3	120	16.5	26.4	47.1	17	45%
Barium (Ba)	26	390	65.5	90.3	145	330	5%
Chromium (Cr)	22	120	43	43.8	57.1	52	20%
Cobalt (Co)	2	34	11	12.4	17.1	13	30%
Copper (Cu)	5	80	14	18.6	33.2	63	5%
Iron (Fe)	5500	83000	34500	34925	45100	33500[b]	55%
Lithium (Li)	6	36	21	21.3	31.3	12.5	95%
Manganese (Mn)	210	3700	475	770	1670	435	55%
Molybdenum (Mo)	<2	6	2	2.4	3.2	4	10%
Nickel (Ni)	15	53	27	29.7	40	50	5%
Rubidium (Rb)	3	13	7	6.9	9.2	6	55%
Selenium (Se)	<2	8	2	2.3	2	2	5%
Strontium (Sr)	<5	60	6	12	22.1	6	45%
Vanadium (V)	27	210	58.5	72.1	111	130	5%
Zinc (Zn)	45	600	80.5	128	279	200	15%

Notes:
N = 20.
Shaded chemicals are those for which the frequency of exceedance over the FSB was greater than 10%. These chemicals were carried forward into the subsequent screening step (*i.e.*, statistical comparison tests).

a Final Screening Benchmark (FSB) is the higher value of either the reference soil concentration statistic (which is the median in this case , unless a substance was not measured above the RDL in any reference area soil sample, in which case the typical laboratory RDL becomes the reference concentration statistic), or the applicable environmental soil quality benchmark (see Table G-2).

b As aluminum and iron have no concentration-based soil quality benchmarks available, the FSB defaults to the reference concentration statistic.

Table G-6 Principal Sampling Area C Layer (15-30 cm) Surface Soil Concentration Summary Statistics and Frequency of Exceedance over Final Screening Benchmark

Chemical	Minimum Concentration (mg/kg)	Maximum Measured Concentration (mg/kg)	Median Concentration (mg/kg)	Arithmetic Mean Concentration (mg/kg)	90th Percentile (mg/kg)	Final Screening Benchmark [a] (mg/kg)	Frequency of Exceedance over Final Screening Benchmark (FSB) (%)
Aluminum (Al)	9600	40000	22500	22430	35200	27000[b]	20%
Arsenic (As)	2	180	18.5	36.4	66.5	17	55%
Barium (Ba)	22	600	53.5	90.1	103	330	5%
Chromium (Cr)	19	180	48	53.2	73.7	52	40%
Cobalt (Co)	8	49	14	15.4	18.1	14.5	40%
Copper (Cu)	4	86	17	20.3	30.2	63	5%
Iron (Fe)	15000	92000	35500	36300	48100	35500[b]	50%
Lithium (Li)	14	38	23.5	25.1	35.1	17.5	90%
Manganese (Mn)	200	5500	505	748	690	405	80%
Molybdenum (Mo)	<2	8	2	2.7	5.2	4	15%
Nickel (Ni)	22	60	42	41.4	54.1	50	25%
Rubidium (Rb)	3	12	6	6.5	10.1	6.5	45%
Selenium (Se)	<2	5	2	2.2	2	2	5%
Strontium (Sr)	<5	23	5.5	9.0	10.4	6	35%
Vanadium (V)	25	190	52	64.7	111	130	5%
Zinc (Zn)	35	540	73	131	323	200	20%

N = 20.

Shaded chemicals are those for which the frequency of exceedance over the FSB was greater than 10%. These chemicals were carried forward into the subsequent screening step (*i.e.*, statistical comparison tests).

[a] Final Screening Benchmark (FSB) is the higher value of either the reference soil concentration statistic (which is the median in this case , unless a substance was not measured above the RDL in any reference area soil sample, in which case the typical laboratory RDL becomes the reference concentration statistic), or the applicable environmental soil quality benchmark (see Table G-3).

[b] As aluminum and iron have no concentration-based soil quality benchmarks available, the FSB defaults to the reference concentration statistic.

From the information presented in Tables G-5 and G-6, the following chemicals are carried forward into the subsequent screening step (*i.e.*, statistical comparison tests), as their frequency of exceedance of Principal sampling area soil concentrations over the FSB was greater than 10%.

B Layer

- Aluminum
- Arsenic
- Chromium
- Cobalt
- Iron
- Lithium
- Manganese
- Rubidium
- Strontium
- Zinc

In B layer Principal sampling area soil, barium, copper, molybdenum, nickel, selenium, and vanadium are excluded from further consideration as the frequency of exceedance for these substances over their respective FSB values is less than 10%.

C Layer

- Aluminum
- Arsenic
- Chromium
- Cobalt
- Iron
- Lithium
- Manganese
- Molybdenum
- Nickel
- Rubidium
- Strontium
- Zinc

In C layer Principal sampling area soil, barium, copper, selenium, and vanadium are excluded from further consideration as the frequency of exceedance for these substances over their respective FSB values is less than 10%.

G-2.1.4 Step 3 Outcomes

For chemicals that were carried forward into the statistical comparison tests, the following tasks were conducted. First, goodness of fit tests were performed on the Principal sampling area and reference area soil chemistry datasets to determine if the data distributions were parametric (*e.g.*, normal, lognormal) or non-parametric. It is important to determine the type of distribution as many statistical comparison tests are only appropriate to use if the distribution is of a certain type. Second, statistical two-sample comparison tests were conducted between the Principal sampling area and reference area soil chemistry datasets to determine if there were statistically significant differences between these datasets. These tests were conducted using the U.S. EPA statistical software ProUCL 4.00.04. If the distributions in both the Principal sampling area and reference area datasets for the chemical of interest were parametric at the 5% significance level, then two-sample t-tests were conducted. ProUCL 4.00.04 performs two types of t-tests simultaneously (Student t-test and Satterthwaite t-test). Determining which of these two tests is most appropriate depends on whether or not the variance in the two datasets being compared is approximately equal. If the variance is roughly equal, the Student t-test results are recommended, while the Satterthwaite t-test results are recommended if the variance between the two datasets is not equal. The selected null hypothesis used for these tests was that the means in the two datasets were equal. If the distribution(s) in one or both of the Principal sampling area and reference area datasets for a chemical of interest were non-parametric at the 5% significance level, then the Wilcoxon Mann Whitney (WMW) test was performed. In these tests, the selected null hypothesis was that the means or medians in the two datasets were equal. Any chemicals with Principal sampling area soil concentrations that were significantly greater than the reference area soil concentrations (based on the outcome of t-tests or WMW test) were carried forward into the final step of the COPC identification process, if considered necessary.

A Layer (0-5 cm)

A summary of the statistical comparison test outcomes for the A layer (0-5 cm) soil chemistry data is presented in Table G-7. Any chemicals with Principal sampling area A layer soil concentrations that were significantly greater than the reference area A layer soil concentrations (based on the outcome of t-tests or WMW test) were carried forward for further consideration.

Table G-7 Outcomes of Statistical Comparison Tests Conducted Between Principal Sampling Area and Reference Area A Layer (0-5 cm) Soil Chemistry Datasets

Chemical	Principal Sampling Area versus Reference Area Outcomes
Aluminum (Al)	NSD
Antimony	PSA>REF[a]
Arsenic	PSA>REF
Chromium (Cr)	PSA>REF
Cobalt (Co)	NSD
Iron (Fe)	PSA>REF
Lead (Pb)	PSA>REF
Lithium (Li)	PSA>REF
Manganese (Mn)	NSD
Nickel (Ni)	PSA>REF
Rubidium (Rb)	PSA>REF
Strontium (Sr)	NSD
Vanadium (V)	PSA>REF
Zinc (Zn)	PSA>REF

Notes:
PSA= Principal Sampling Area; REF = Reference Area; NSD = no significant difference; '>' implies greater than by a level that is statistically significant.
Shading indicates PSA soil chemical concentrations are significantly greater than those in reference areas.
a Insufficient samples in one or more datasets with quantified (>RDL) concentrations to conduct statistical comparison tests. In these cases, the range, mean, median and detection frequency were qualitatively compared. Statistical significance cannot be determined in these comparisons.

Based on the outcomes of the statistical comparison tests, the following chemicals in Principal sampling area A layer soil were identified as candidate COPCs for the ERA.

- Antimony
- Arsenic
- Chromium
- Iron
- Lead
- Lithium
- Nickel
- Rubidium
- Vanadium
- Zinc

As indicated in Table G-7, there were insufficient soil samples with quantified (>RDL) concentrations to conduct statistical comparison tests for antimony. However, antimony was <RDL in all reference area samples, and was present above the RDL in 10 Principal sampling area soil samples (detection frequency of 16.4%), with a concentration range of <2 to 14 mg/kg (mean = 2.4 mg/kg; median = 2 mg/kg – assuming all <RDL values are present at the RDL). Although statistical significance cannot be determined, antimony is clearly present at higher concentrations in Principal sampling area A layer soil samples than it is in reference area A layer soil samples. As such, antimony was retained as a candidate COPC.

B Layer (5-15 cm) and C Layer (15-30 cm)

Summaries of the statistical comparison test outcomes for the B layer (0-5 cm) and C layer (15-30 cm) soil chemistry data are presented in Tables G-8 and G-9, respectively. Any chemicals with Principal sampling area B and C layer soil concentrations that were significantly greater than the reference area B and C layer soil concentrations (based on the outcome of t-tests or WMW test) were carried forward for further consideration.

Table G-8 Outcomes of Statistical Comparison Tests Conducted Between Principal Sampling Area and Reference Area B Layer (5-15 cm) Soil Chemistry Datasets

Chemical	**Principal Sampling Area versus Reference Area Outcomes**
Aluminum	NSD
Arsenic	PSA>REF
Chromium	PSA>REF
Cobalt	NSD
Iron	NSD
Lithium	PSA>REF
Manganese	NSD
Rubidium	NSD
Strontium	ND[a]
Zinc	NSD

Notes:
PSA= Principal Sampling Area; REF = Reference Area; NSD = no significant difference; ND = no difference; '>' implies greater than by a level that is statistically significant.
Shading indicates PSA soil chemical concentrations are significantly greater than those in reference areas.
a Insufficient samples in one or more datasets with quantified (>RDL) concentrations to conduct statistical comparison tests. In these cases, the range, mean, median and detection frequency were qualitatively compared. Statistical significance cannot be determined in these comparisons.

Based on the outcomes of the statistical comparison tests, the following chemicals in Principal sampling area B layer soils were identified as candidate COPCs for the ERA.

- Arsenic
- Chromium
- Lithium

With respect to strontium, there were insufficient soil samples with quantified (>RDL) concentrations to conduct statistical comparison tests. However, the mean and median concentrations are higher in the B layer reference area soil chemistry dataset than in the B layer Principal sampling area soil chemistry dataset, and the ranges for both datasets overlap. Detection frequency was similar between datasets (55% for Principal sampling area and 40% for reference area). Given these considerations, as well as the fact that strontium was not identified as a COPC in A layer Principal sampling area soils, strontium was excluded from further consideration in B layer Principal sampling area soils.

Table G-9 Outcomes of Statistical Comparison Tests Conducted Between Principal Sampling Area and Reference Area C Layer (15-30 cm) Soil Chemistry Datasets

Chemical	**Principal Sampling Area versus Reference Area Outcomes**
Aluminum	PSA<REF
Arsenic	PSA>REF
Chromium	NSD
Cobalt	NSD
Iron	NSD
Lithium	PSA>REF
Manganese	NSD
Molybdenum	PSA>REF[a]
Nickel	PSA>REF
Rubidium	NSD
Strontium	NSD
Zinc	NSD

Notes:
PSA= Principal Sampling Area; REF = Reference Area; NSD = no significant difference; '>' implies greater than by a level that is statistically significant.
Shading indicates PSA soil chemical concentrations are significantly greater than those in reference areas.
a Insufficient samples in one or more datasets with quantified (>RDL) concentrations to conduct statistical comparison tests. In these cases, the range, mean, median and detection frequency were qualitatively compared. Statistical significance cannot be determined in these comparisons

Based on the outcomes of the statistical comparison tests, the following chemicals in Principal sampling area C layer soils are identified as candidate COPCs for the ERA.

- Arsenic
- Lithium
- Nickel

With respect to molybdenum in the C layer of Principal sampling area soils, there were insufficient soil samples with quantified (>RDL) concentrations to conduct statistical comparison tests. The mean and median concentrations are slightly higher in the C layer Principal sampling area soil chemistry dataset, relative to the C layer reference area soil chemistry dataset, and the Principal sampling area dataset also ranges slightly higher than the reference area dataset (<2 to 8 mg/kg for Principal sampling area versus <2 to 3 mg/kg in reference areas). Detection frequency was the same between datasets (*i.e.*, 20%). Given these considerations, and the fact that molybdenum was not identified as a COPC in either the A or B layer of Principal sampling area soils, this substance was excluded from further consideration.

G-2.1.5 Summary of Step 1, 2 and 3 COPC Identification Outcomes for A, B, and C Layer Principal Sampling Area Soils

Table G-10 summarizes the outcomes of the first three steps of the COPC identification process that was conducted on A, B and C layer Principal sampling area soil chemistry data.

Table G-10 Candidate COPCs in A, B, and C Layer Principal Sampling Area Soil

A Layer (0-5 cm)	B Layer (5-15 cm)	C Layer (15-30 cm)
Antimony Arsenic Chromium Iron Lead Lithium Nickel Rubidium Vanadium Zinc	Arsenic Chromium Lithium	Arsenic Lithium Nickel

G-2.1.6 Further Considerations

Based on what is known about emissions from the Glencore smelter, and from previous studies of the Belledune area, the list of candidate COPCs that was generated from the first three steps of the COPC identification process (Table G-10) contains some unexpected chemicals. This may reflect other industrial sources of some chemicals, as well as natural geological enrichment.

To further determine if the chemicals listed in Table G-10 merit inclusion in the ERA as COPCs, a number of items were evaluated, including: toxicological considerations (which includes the availability of ecotoxicity data); smelter stack elemental emissions data; findings from previous studies conducted in the Belledune area; spatial distribution patterns of soil chemical concentrations; outcomes of air dispersion modelling studies; potential non-smelter industrial sources of COPCs; local geological influences; and statistical relationships.

The chemicals most in question with respect to being associated with the Glencore smelter are: chromium, iron, lithium, nickel, rubidium, and vanadium. The following subsections therefore focus on these six elements.

Toxicological Considerations

Two of the six questionable COPCs (rubidium and lithium) have a paucity of ecotoxicity data available. For these substances, no suitable avian or mammalian TRVs were identified within the scientific and regulatory literature. In addition, no ecological soil quality benchmarks for any ecological receptor group were identified for rubidium. While phytotoxicity and soil microbe/microbial process-based soil benchmarks were identified for lithium (Efroymson *et al*., 1997a,b), with the lower of these (*i.e*.., the phytotoxicity benchmark) used in Step 1 of the COPC Identification process, these benchmarks are based on very limited data. Thus, there is a high degree of uncertainty regarding how representative and protective these benchmarks are. Literature searches revealed there is very little reliable published ecotoxicity data for lithium. For substances with no, or very weak ecotoxicity data available, quantitative evaluation within an ERA is not possible.

With respect to iron, numerous previous ERA studies conducted by the Study Team have consistently shown that this substance rarely drives the potential for metals-induced toxicity or risk to ecological receptors. Rather, it is well established that iron functions more as a modifier of the bioavailability and toxicity of other metals and metalloids, as opposed to being a direct risk or toxicity concern. It is also well established that iron is an essential element for nutrition and physiological function in all terrestrial and aquatic organisms, and its uptake, metabolism, and elimination are physiologically regulated. As a consequence, extreme exposure to iron would typically be necessary to induce adverse health effects. The measured concentrations of iron in Principal sampling area soils are not considered to represent a situation of extreme iron exposure.

Smelter Stack Emissions Data

Based on stack emissions testing data from 2006 to 2009 (provided to Intrinsik by Glencore); the principal substances emitted from the smelter are lead and arsenic. Emissions of these two substances (combined) comprise nearly two thirds of the total elemental emissions from the smelter facility from 2006 to 2009. Stack emissions of iron from the smelter are also fairly substantial and comprise roughly 8-9% of the total elemental emissions from the facility from 2006 to 2009. Zinc is another major emission from the smelter, and comprises roughly 4% of the total elemental emissions from the facility from 2006 to 2009. Given the mineralogical properties of the materials processed at the smelter (mainly sulfides, such as pyrite and related minerals), the relative magnitude of the emissions of lead, arsenic, zinc and iron from the smelter are expected.

For chromium, lithium, nickel, and vanadium, smelter stack emissions are consistently low, and each substance comprises <0.5% of the total elemental emissions from 2006 to 2009. Rubidium has only been tested in stack emissions in 2009, and the stack test results to date indicate very low emissions of this substance. The rubidium emission rates from most stacks were non-detectable, and from the stacks where rubidium emissions were measurable, the emission rates were similarly low or lower than those reported for chromium, lithium, nickel, and vanadium.

Overall, the reported stack emissions data for chromium, lithium, nickel, rubidium, and vanadium suggest a low likelihood that the smelter is responsible for elevated soil concentrations of these elements within the Principal sampling area. For iron, the stack emissions data suggest that the smelter could account for elevated iron soil concentrations in the Principal sampling area. However, iron is a major element in all soils, and natural soil concentrations are in the g/kg range. Thus, incremental additions to soil from the deposition of smelter emissions are likely indistinguishable from existing natural iron soil concentrations.

Findings from Previous Studies

There have been many previous studies conducted in the Belledune area (*e.g.*, routine environmental monitoring by smelter personnel, human health risk assessment studies, environmental site assessments, *etc*.), and the majority of these studies collected and evaluated soil chemistry data. All previous studies conducted in the Belledune area (and the soil chemistry data associated with them) were available to the Study Team. While these previous studies were not ecological risk assessments, none reported substantially elevated soil concentrations of chromium, lithium, iron, nickel, rubidium, or vanadium, within the greater Belledune area, and none identified any of these elements as chemicals of interest that required more detailed evaluation.

Spatial Distribution Patterns of Soil Concentrations

With most point sources of air emissions, it is typical to observe the greatest degree of deposition of major emitted substances within a few km of the source (subject to facility-specific, topographic and meteorological factors). Available air dispersion/deposition modelling studies of the Glencore smelter emissions (in 2010 and 1991) have shown that the highest ground level air concentrations and highest rates of atmospheric deposition tend to occur within 3 km of the smelter facility (A.J. Chandler & Associates, 2010; Concord Environmental, 1991). Attachment I-1 to Appendix I provides the report and appendices for the air dispersion/deposition modelling study conducted by A.J. Chandler & Associates (2010). For many of the substances modelled in these air dispersion studies, the maximum points of impingement occurred either in the Baie des Chaleurs, or near the coastline within 1 to 2 km of the smelter facility. Although the Concord Environmental (1991) air dispersion study is older, it was validated with measured air quality monitoring data, and was found to produce realistic results. Figures G-1 and G-2 show the deposition patterns and rates for arsenic and lead emissions, generated from the 2010 air dispersion modelling study (A.J. Chandler & Associates, 2010). Both figures clearly show that the areas with the greatest potential for deposition of lead and arsenic (the two principal elemental emissions from the smelter) lie near the coastline with substantial deposition occurring in the Baie, and the areas of highest land deposition occurring within 2 km of the smelter. These figures also show that there is essentially no significant deposition of smelter emissions from the southwest to southeast directions beyond a distance of 3 km from the smelter (the 2010 air dispersion modelling study is described and discussed further in Appendix I).

The predicted lack of significant deposition of smelter emissions across the southwest to southeast directions (beyond a distance of 3 km from the smelter) is especially important when maps showing the spatial locations and A layer soil concentrations of chromium, nickel, and vanadium[4] are examined (Figures G-3 to G-5)[5]. These figures all demonstrate that concentrations either increase with increasing distance from the smelter, or are generally similar at all distances from the smelter (out to 7 km). These are patterns that are contrary to what is typically observed if soil concentrations of a particular element are influenced by the deposition of emissions from a point source.

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[4] Iron, lithium, and rubidium A layer soil concentrations were not plotted given the paucity of ecotoxicity data for rubidium and lithium, and the well established role of iron as a modifier rather than a cause of toxicity (which essentially precludes the assessment of these substances in an ERA).

[5] These figures also show which samples exceed their respective CCME environmental soil quality guideline values.

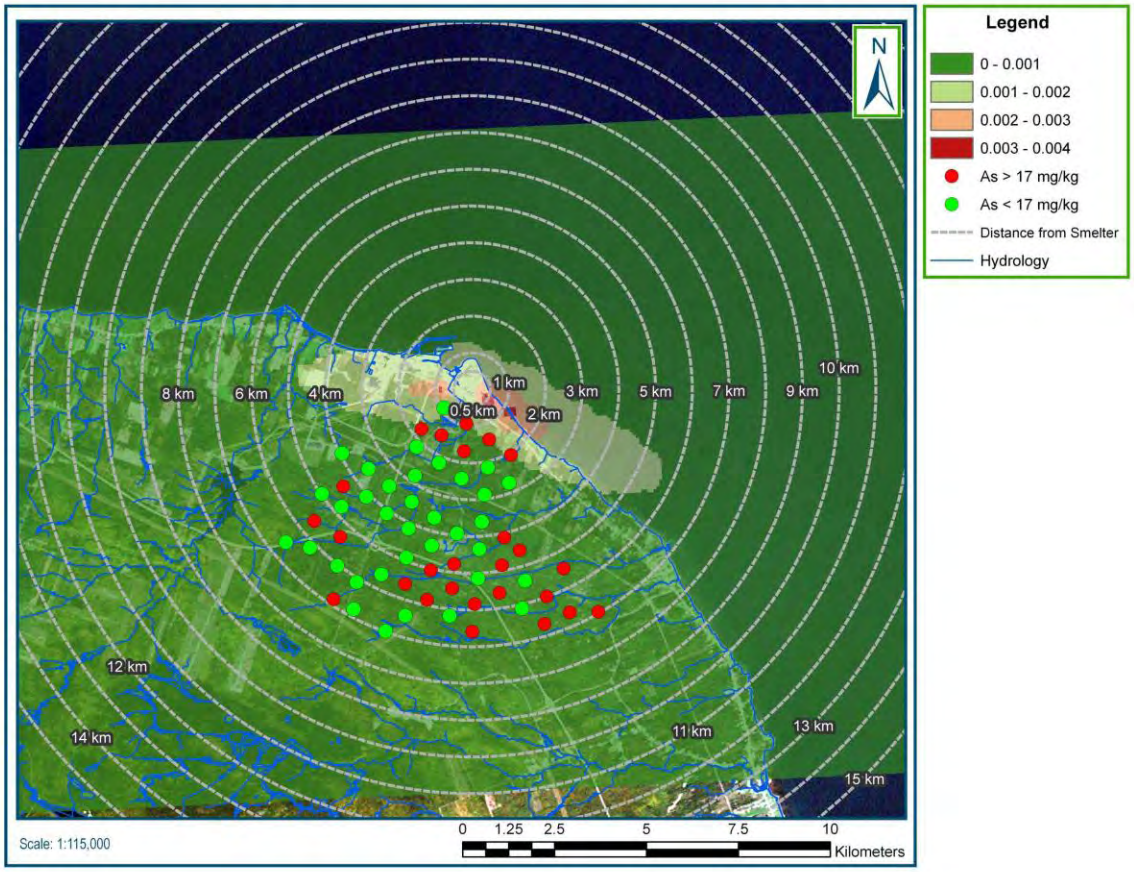

Figure G-1 Air Dispersion and Deposition Modelling Results for Arsenic

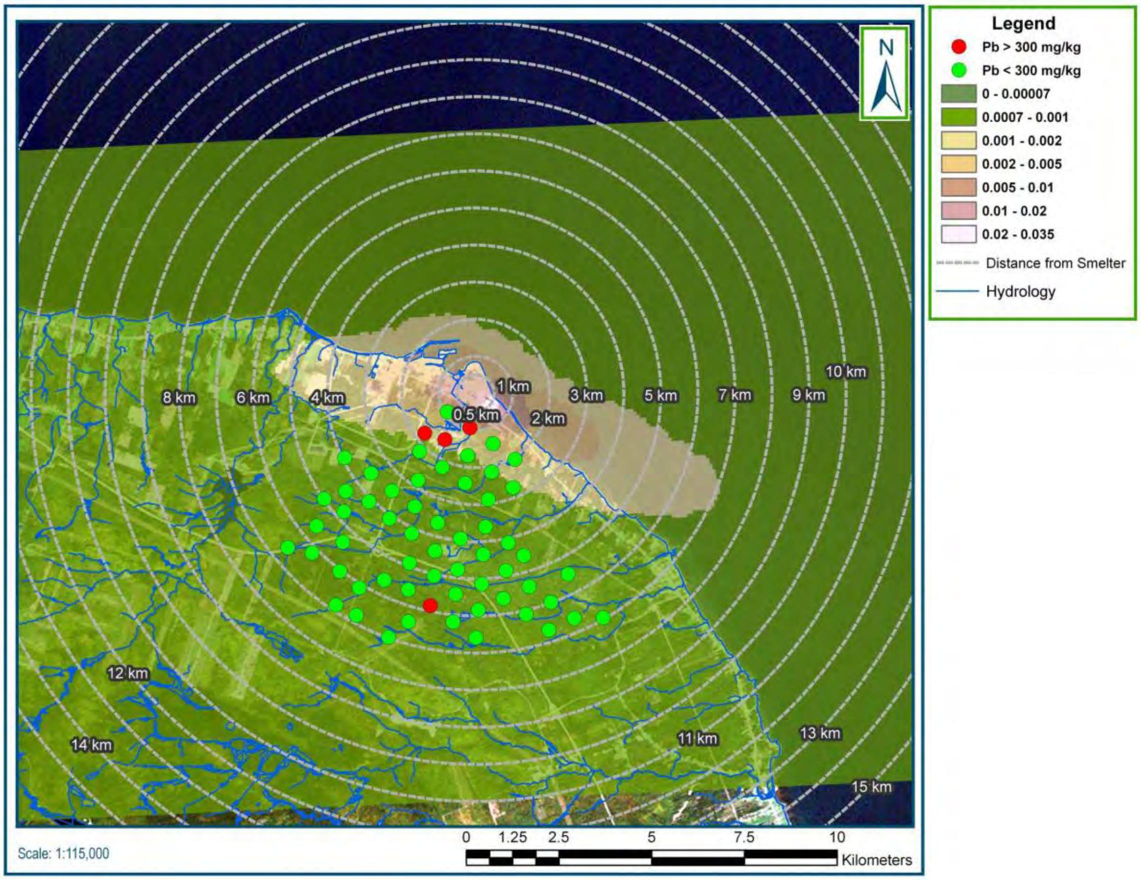

Figure G-2 Air Dispersion and Deposition Modelling Results for Lead

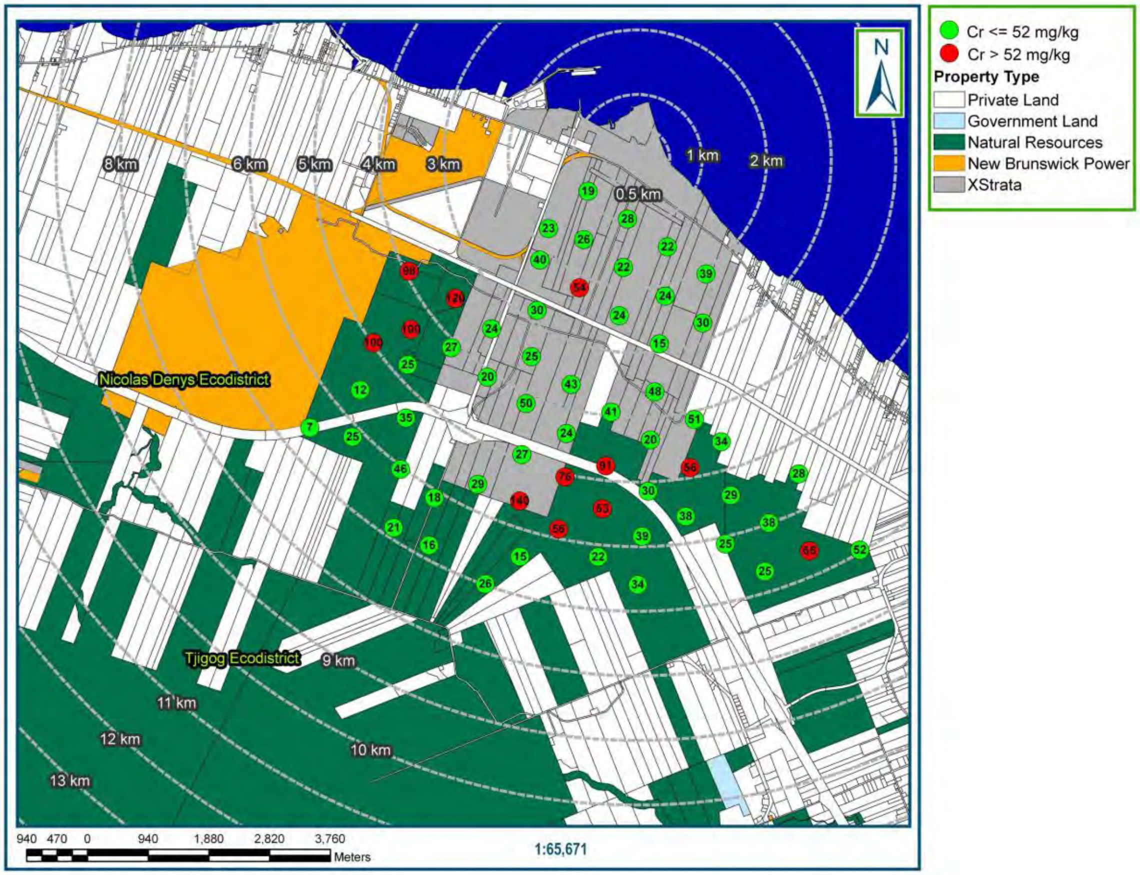

Figure G-3 A Layer (0-5 cm) Soil Concentrations of Chromium (Total) in Relation to CCME Soil Quality Guideline for the Protection of Environmental Health (52 mg/kg)

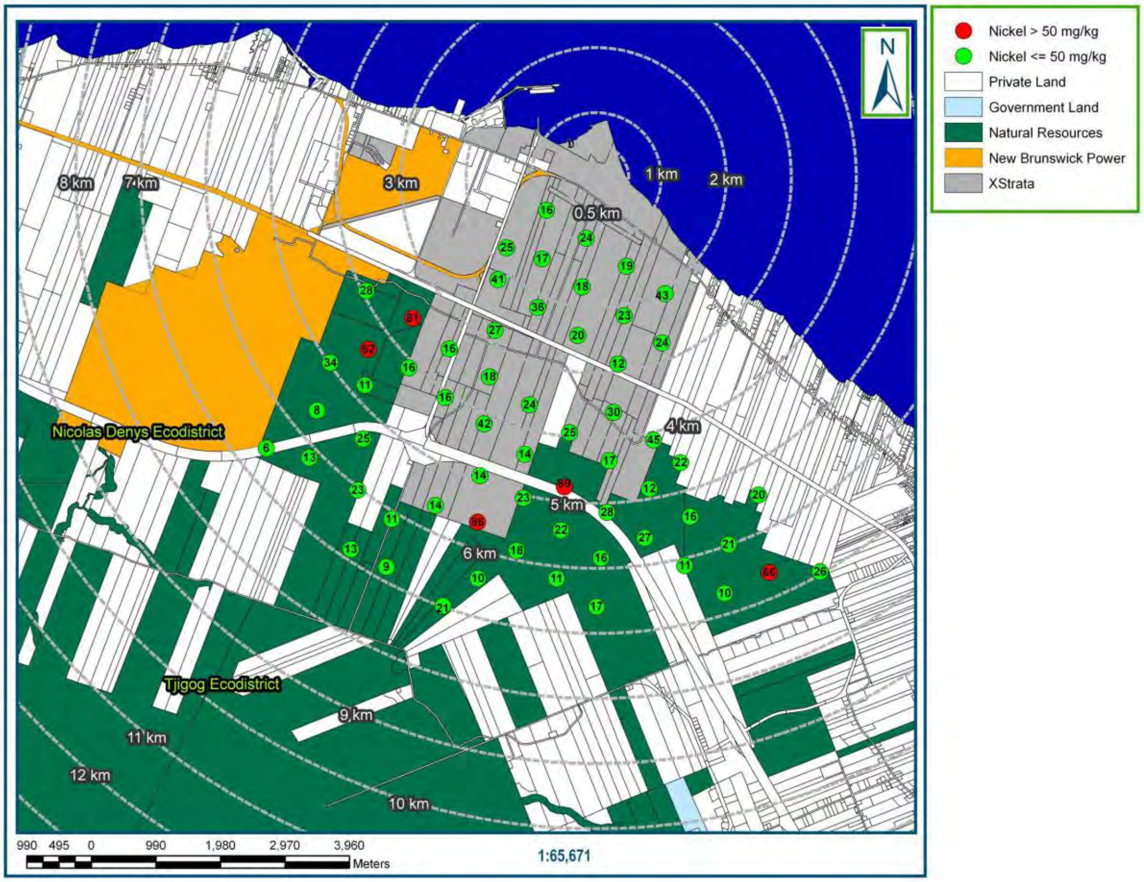

Figure G-4 A Layer (0-5 cm) Soil Concentrations of Nickel in Relation to CCME Soil Quality Guideline for the Protection of Environmental Health (50 mg/kg)

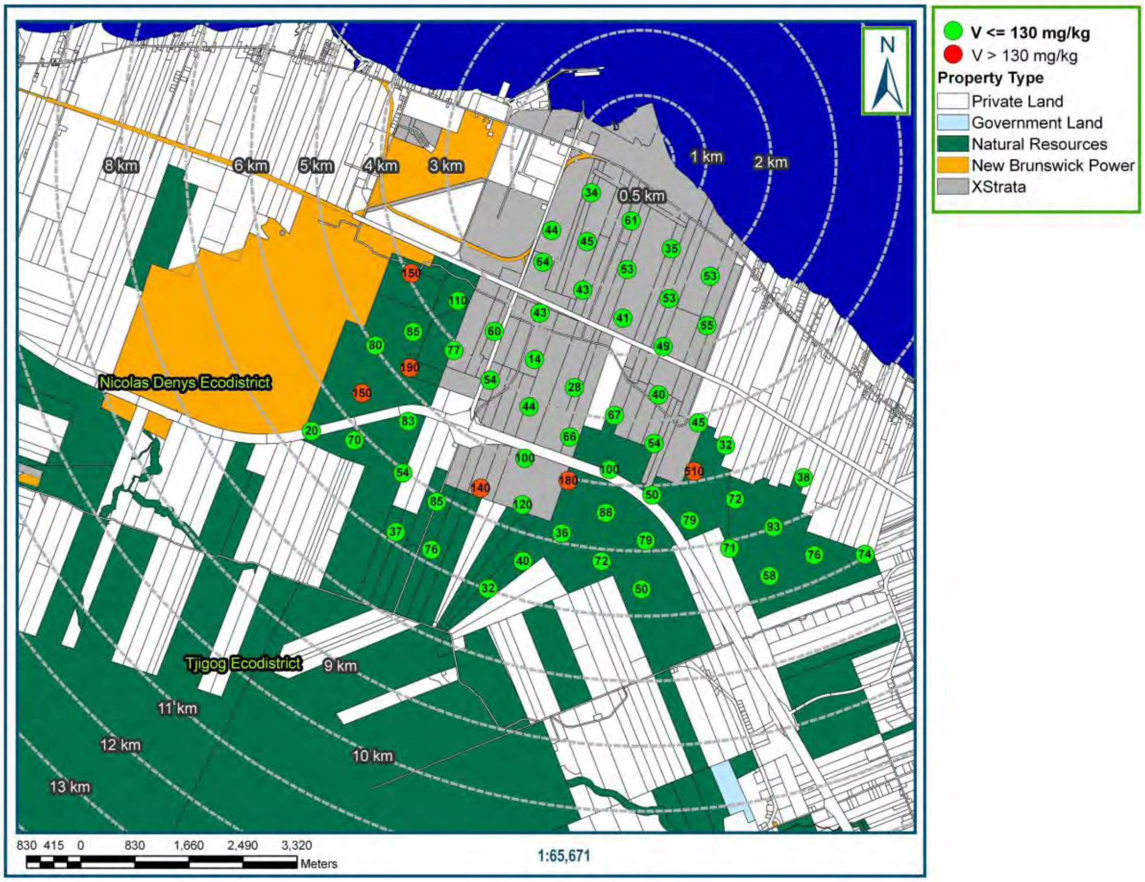

Figure G-5 A Layer (0-5 cm) Soil Concentrations of Vanadium in Relation to CCME Soil Quality Guideline for the Protection of Environmental Health (130mg/kg)

Natural Geological Influences

As part of establishing an ERA study boundary (See Appendix I), an experienced geologist with extensive expertise in the geology and mineralogy of the Belledune area (and northeastern New Brunswick in general) was retained to address issues regarding some potentially anomalous results for a number of elements in areas that are >4 km from the smelter, and to the south of the smelter. Some of the information contained in the geologists' report (*i.e.*, McCutcheon, 2010) is also helpful in confirming whether or not soil concentrations of some of the candidate COPCs are primarily due to natural geological enrichment. The 4 km point was noted by the geologist to approximately separate two main groups of rocks – the Ordovician Fournier Group, and the Silurian Chaleurs Group. Among the elements considered in the geologists' report were nickel, vanadium and chromium. It was concluded that elevated (or anomalous) soil concentrations of nickel, vanadium and chromium (*i.e.*, those that exceed CCME environmental soil quality guidelines) at distances within and outside the 4 km radius line can largely be attributed to a bedrock source, rather than anthropogenic contamination. As shown in Figures G-3 to G-5, many of the higher soil concentrations of nickel, vanadium and chromium are located outside the 4 km radius. The full geologist's report is provided in Attachment I-2 to Appendix I.

Statistical Relationships in the Principal Sampling Area Soil Chemistry Data

To determine if soil concentrations of chromium, iron, lithium, nickel, rubidium, and vanadium are related to soil concentrations of arsenic, lead and zinc (these latter three elements are well established as being the major trace metal/metalloid emissions from the Glencore smelter), correlation analysis was conducted[6]. This analysis was conducted on A layer (0-5 cm) soil data as it is the largest dataset of soil chemistry data that are available at this time, and atmospheric deposition sources (such as a smelter) tend to primarily impact the top few centimeters of the soil profile.

Pearson correlation coefficients were first calculated between arsenic, lead and zinc soil concentrations within 3 km, and within 4 km of the smelter to confirm the expected high degree of correlation between these three major emitted substances. As anticipated, soil concentrations of these three substances both within 3 km and within 4 km of the smelter showed a strong and statistically significant positive correlation with each other (See Table G-11). As mentioned previously, with most point sources of air emissions, it is typical to observe the greatest degree of deposition of the major emitted substances within a few km of the source.

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[6] While iron is also a major emitted substance from the smelter, correlation analysis using iron soil concentrations could not be conducted as iron was among the six questionable candidate COPCs.

Following confirmation of significant and strong positive correlations between soil concentrations of arsenic, lead and zinc at distances of 3-4 km from the smelter, Pearson correlation coefficients were then calculated between arsenic, lead and zinc soil concentrations, and the soil concentrations of chromium, iron, lithium, nickel, rubidium, and vanadium. This was conducted for four distance categories, as follows:

- Within 3 km of the smelter.
- >3 km of the smelter.
- Within 4 km of the smelter
- >4 km from the smelter

The hypothesis underlying the correlation analysis was that if there was a weakly positive (or positive but statistically insignificant) or a negative correlation between soil concentrations of arsenic, lead and zinc, and the soil concentrations of chromium, iron, lithium, nickel, rubidium, and vanadium, then it would be considered unlikely that Principal sampling area soil concentrations of these six "questionable" COPCs are associated with smelter emissions.

The Pearson correlation coefficient ("r") measures the strength of an assumed linear relationship between two variables. Values close to 1 indicate positive correlation (as one variable increases, so does the other), while values close to -1 indicate negative correlation (as one variable increases, the other decreases). When two variables are independent of each other, the correlation coefficient will be at or close to 0. To determine if a Pearson correlation coefficient indicated a significant weak or strong correlation (positive or negative), critical values for r were obtained from standard statistical reference resources. Specifically, assuming a two tailed test (which is appropriate when there is no *a priori* hypothesis to the direction of the correlation, which is the case herein), and degrees of freedom (*df*) of 59 (*i.e.*, N-2), the critical r value at a 5% significance level is 0.25. Critical r values are absolute values and reflect the strength of the association, not the direction, thus they apply equally to positive or negative r values. The critical r value of 0.25 is the minimum r value for there to be 95% confidence that a relationship exists between soil concentrations of two elements. Thus, if the r value presented in Table G-11 is $> |0.25|$, there is considered to be a statistically significant relationship ($p<0.05$). If the r value presented in Table G-11 is $\leq |0.25|$, then there is considered to be no statistically significant relationship ($p>0.05$).

Table G-11 Pearson Correlation Coefficients (r) for Candidate COPC Pairs in Principal Sampling Area A Layer Soil Chemistry Data

Element	**Arsenic**[a]	**Lead**[a]	**Zinc**[a]
Within 3 km of smelter			
Chromium	-0.089	-0.23	-0.12
Iron	0.14	0.27	0.38
Lithium	0.15	-0.26	-0.17
Nickel	0.012	-0.29	-0.23
Rubidium	0.17	0.031	0.095
Vanadium	-0.11	-0.046	-0.071
Lead	0.77	xx	xx
Zinc	0.73	0.91	xx
Within 4 km of smelter			
Chromium	-0.24	-0.30	-0.11
Iron	0.18	0.073	0.26
Lithium	0.12	-0.20	0.0081
Nickel	-0.060	-0.27	-0.087
Rubidium	0.37	0.16	0.19
Vanadium	-0.16	-0.19	-0.067
Lead	0.78	xx	xx
Zinc	0.74	0.88	xx
>3 km from smelter			
Chromium	0.29	-0.0004	0.32
Iron	0.31	-0.13	0.27
Lithium	0.17	-0.28	0.38
Nickel	0.17	-0.083	0.44
Rubidium	-0.0002	-0.25	0.13
Vanadium	0.087	-0.004	0.048
Lead	0.39	xx	xx
Zinc	0.32	0.44	xx
>4 km from smelter			
Chromium	0.39	-0.0050	0.26
Iron	0.30	-0.053	0.26
Lithium	0.21	-0.25	0.30
Nickel	0.22	-0.081	0.37
Rubidium	-0.041	-0.23	0.12
Vanadium	0.074	0.047	0.037
Lead	0.48	xx	xx
Zinc	0.35	0.50	xx

Notes: xx = redundant calculation. The July-August 2009 soil sampling program sampled out to a 7 km radius from the smelter.

Shaded cells denote a statistically significant correlation coefficient (r).

[a] Principal smelter emission.

As shown in Table G-11, significant positive correlations exist between soil concentrations of arsenic, lead, and zinc at all distances considered. However, the strength of the correlations between these three major emitted elements is notably weaker at both >3 km and >4 km distances from the smelter, relative to those within 3 or 4 km of the smelter. This suggests that these three elements are highly correlated to each other in the sampled areas that are most likely to incur atmospheric deposition of smelter emissions. The weaker, though still significant correlation between these three elements at the >3 and 4 km distances likely reflects natural geological enrichment. Lead, arsenic and zinc often occur together in sulphide mineral deposits (which are common in the Principal sampling area, and at many other locations in northeastern New Brunswick), and it is not surprising to find significant positive correlations between soil concentrations of these three elements.

The following bullets briefly discuss the r values calculated between arsenic, lead and zinc soil concentrations, and the soil concentrations of chromium, iron, lithium, nickel, rubidium, and vanadium.

- Chromium: There were negative correlations between chromium-arsenic, chromium-lead, and chromium-zinc at both <3 km and <4 km from the smelter. The negative chromium-lead association was significant at <4 km from the smelter. At distances >3 km and > 4 km from the smelter, the chromium-lead correlation remains negative (almost independent), but the arsenic-chromium and zinc-chromium correlations are significantly positive. This likely reflects natural geology near and outside the 4 km radius as previously noted (see Appendix I).

- Iron: There were significant positive correlations between lead and iron and zinc and iron within 3 km of the smelter, and between zinc and iron (but not lead and iron) within 4 km of the smelter. There were no significant positive correlations between arsenic and iron within 3 or 4 km of the smelter, but the iron-arsenic correlation was positive and significant at distances >3 and >4 km from the smelter. As it is well established that arsenic readily associates with iron-containing minerals in soils in the absence of anthropogenic contamination, it is not surprising to find significant correlations at distances where smelter impacts are likely minor or negligible. At >3 and >4 km from the smelter iron correlates negatively with lead, but has marginally significant positive correlations with zinc.

- Lithium: The correlations between lithium-arsenic, lithium-lead and lithium-zinc are either weakly positive (not significant) or negative within 3 km and 4 km of the smelter. At distances of >3 km and >4 km from the smelter, lithium-arsenic and lithium-lead correlations remain weakly positive (not significant) or negative. The zinc-lithium correlation though is significantly positive at both the >3 km and >4 km distances from the smelter.

- Nickel: The correlations between nickel-arsenic, nickel-lead and nickel-zinc are either weakly positive (not significant) or negative within 3 km and 4 km of the smelter. At distances of >3 km and >4 km from the smelter, lithium-arsenic and lithium-lead correlations remain weakly positive (not significant) or negative. The zinc-nickel correlation though is significantly positive at both the >3 km and >4 km distances from the smelter. This likely reflects natural geology near and outside the 4 km radius as previously noted (see Appendix I).

- Rubidium: The correlations between rubidium-arsenic, rubidium-lead and rubidium-zinc are weakly positive (not significant) within 3 km of the smelter. Within 4 km of the smelter, correlations between rubidium-lead and rubidium-zinc are also weakly positive (not significant), but the rubidium-arsenic correlation is significantly positive with 4 km. At distances of >3 km and >4 km from the smelter, the correlations between rubidium and arsenic, lead and zinc are either weakly positive (not significant) or negative.

- Vanadium: The correlations between vanadium-arsenic, vanadium-lead and vanadium-zinc are negative within 3 km and 4 km of the smelter. At distances of >3 km and >4 km from the smelter, the correlations between vanadium and arsenic, lead and zinc are weakly positive (not significant) with one negative association for vanadium-lead at the >3 km distance from the smelter. This likely reflects natural geology near and outside the 4 km radius as previously noted (see Appendix I).

Some of the Pearson correlation coefficients (r values) are close to zero and suggest independency between some element pairs (*i.e.*, arsenic and rubidium at >3 km from smelter; lead and chromium at >3 km and >4 km from smelter; lead and vanadium at >3 km from smelter; zinc and lithium within 4 km of smelter).

Given that the Belledune facility has operated mainly as a primary lead smelter over its history, lead is the major marker of smelter impacts to soil (this has been demonstrated in previous studies of the Belledune area). Soil concentrations of lead in A layer samples have the poorest correlation with A layer soil concentrations of chromium, iron, lithium, nickel, rubidium, and vanadium. In other words, relative to the correlations of soil concentrations of these six questionable COPCs with arsenic and zinc soil concentrations, the correlations with lead soil concentrations were more strongly negative, and if positive, had a lower frequency of being statistically significant.

Recognizing that there is variability in the strength and direction of correlation across the element pairs that were evaluated in Table G-11, as well as the potential for some associations to be significant by chance or due to uncharacterized geochemical relationships, on balance, the correlation coefficients presented in Table G-11 suggest that Principal sampling area A layer soil concentrations of arsenic, lead and zinc are, for the most part, weakly or negatively correlated to soil concentrations of chromium, iron, lithium, nickel, rubidium, and vanadium. This finding is supported by the other information considered within this section, and suggests that the soil concentrations of these six elements likely reflect natural geological enrichment or industrial sources other than the smelter.

While Table G-11 focuses on A layer soil concentrations, chromium and lithium in the B layer, and lithium and nickel in the C layer, were also excluded from further consideration on the following basis:

- These substances were excluded from further consideration in A layer Principal sampling area soil samples, and A layer soil samples would be more likely to show impacts of atmospheric deposition than B and C layer soil samples.
- B and C layer soil concentrations of these substances largely fell within the same ranges as the A layer soil concentrations.
- The geologist's report (McCutcheon, 2010) concluded that elevated (or anomalous) soil concentrations of nickel, vanadium and chromium (*i.e*., those that exceed CCME environmental soil quality guidelines) at distances within and outside the 4 km radius line, can largely be attributed to a bedrock source, rather than anthropogenic contamination.

G-3.0 SUMMARY OF COPCS SELECTED FOR THE ERA

Based on the screening procedures and other considerations described above (Section G-2.0), the following chemicals were identified as COPCs based on the 2009 soil sampling data.

<u>A Layer (0-5 cm)</u>

- Antimony
- Arsenic
- Lead
- Zinc

<u>B Layer (5-15 cm) and C Layer (15-30 cm)</u>

- Arsenic

As previously mentioned, supplementary soil sampling within a 0-2 km radius of the smelter complex was conducted in August 2010 (N=17) based on preliminary ERA outcomes. These supplementary soil data (A layer samples only) were reviewed and screened with the same COPC identification process used for the 2009 data with the intent to confirm/validate the COPCs identified based on the 2009 data. A summary of the 2010 data and results of the screening of the 2010 data are provide in Section G-3.1 with the final COPCs selected for the ERA being presented in Section G-3.2.

G-3.1 COPC Identification Outcomes for 2010 Soil Chemistry Data

Table G-12 presents selected summary statistics for the August 2010 supplementary A Layer (0-5 cm) soil samples.

Table G-12 Summary Statistics for August 2010 Supplementary A Layer (0-5 cm) Soil Chemistry Data; mg/kg

Chemical	Min	Max	90th Percentile	95th Percentile	Arithmetic Mean
Aluminum	1900	16000	14000	14400	9910
Antimony	<2	11	6.8	8.6	3.7
Arsenic	5	50	37.6	42	21.1
Barium	22	230	152	182	85.4
Beryllium	<2	<2	<2	<2	<2
Bismuth	<2	7	3.8	5.4	2.5
Boron	<5	6	5	5.2	5.1
Cadmium	1	16	9.1	10.6	5.0
Chromium	6	31	29.8	31	20.9
Cobalt	1	17	11.4	13	7.6
Copper	6	99	40	54.2	28.7
Iron	3100	39000	29200	32600	22600
Lead	51	1600	866	1200	395
Lithium	<2	19	17.4	18.2	11.7
Manganese	56	1300	1114	1300	581
Molybdenum	<2	<2	<2	<2	<2
Nickel	4	37	27.8	30.6	17
Rubidium	<2	11	10	10.2	7.6
Selenium	<2	<2	<2	<2	<2
Silver	<0.5	2.9	1.4	2.1	0.82
Strontium	<5	48	32.4	48.4	12.5
Thallium	0.3	6.2	5.3	6.0	1.8
Tin	<2	10	5.8	7.6	3.2
Uranium	0.2	9	0.74	2.4	1
Vanadium	17	72	60.4	63.2	46
Zinc	35	480	338	448	184

As mentioned previously, the August 2010 soil chemistry dataset (which were comprised entirely of A layer (0-5 cm) samples) underwent the same COPC identification process as the July-August, 2009 dataset. However, only the first three steps of the process were conducted.

This screening exercise confirmed antimony, arsenic, lead and zinc as COPCs, but also identified bismuth, lithium, rubidium, tin, and thallium as possible COPCs.

Some of the supplementary soil samples (from August 2010; collected within a 2 km radius of the smelter) had thallium concentrations which were higher than those in the July-August 2009 soil chemistry dataset, such that thallium screened on as a COPC. This was not a surprising outcome, as thallium is known to be released from the smelter, and was one of the COPCs in the Shore Road Soil Study (Intrinsik Environmental Sciences *et al*., 2008).

Bismuth, lithium, rubidium, and tin were not evaluated as COPCs in the ERA. The rationale for their exclusion is provided in the following bullets:

- Bismuth: This element was only measurable in 5/17 supplementary soil samples (29%). It screened on as a possible COPC primarily because the FSB value was the RDL, since bismuth was non-detectable in all reference area soil samples, and no environmental soil quality benchmarks exist. No reliable ecotoxicity data were identified for bismuth for any major ecological receptor group, which makes its evaluation within an ERA difficult. Bismuth is also emitted from the smelter at very low rates (based on smelter stack test program data). Given these considerations, bismuth is not considered to pose an ecological concern relative to the major COPCs (antimony, arsenic, lead and zinc), and was excluded from further consideration.

- Lithium and Rubidium: These elements were measurable in most of the Principal sampling area and supplementary Study boundary soil samples (in both the July-August, 2009 and August 2010 datasets) and reference area samples. As demonstrated in Section G-2.1.5, the presence of lithium and rubidium in Principal sampling area soils does not appear to be smelter-related. Although these elements screened on as possible COPCs (on the basis of statistical comparison tests, which compare the central tendency of two datasets), the range of lithium and rubidium soil concentrations in the supplementary soil samples and the reference area samples are virtually the same. In addition, the ranges from the Principal sampling area and reference area datasets are well within typical New Brunswick soil concentration ranges for lithium and rubidium reported in Loro (1996; 1997). Furthermore, both lithium and rubidium lack reliable ecotoxicity data for any major ecological receptor group, which makes their evaluation within an ERA difficult. Given these considerations, lithium and rubidium are not considered to pose an ecological concern relative to the major COPCs (antimony, arsenic, lead and zinc), and were excluded from further consideration.

- Tin: This element was measurable in 9/17 supplementary soil samples (53%), and was not measurable in any of the reference area soil samples. It screened on as a possible COPC primarily because the FSB value was the RDL, since tin was non-detectable in all reference area soil samples, and no environmental soil quality benchmarks exist. The measured tin soil concentrations in the supplementary soil samples largely fall within typical New Brunswick soil concentration ranges reported in Loro (1996; 1997). No reliable ecotoxicity data were identified for tin for any major ecological receptor group, which makes its evaluation within an ERA difficult. Tin is also emitted from the smelter at very low rates (based on smelter stack test program data). Given these considerations, tin is not considered to pose an ecological concern relative to the major COPCs (antimony, arsenic, lead and zinc), and was excluded from further consideration.

G-3.2 Consideration of Bioaccumulative Chemicals

Following screening of the 2010 soil data, a review of the 2009 / 2010 soil data in conjunction with the 2010 soil invertebrate data was conducted to identify if any metals should be added back onto the COPC list, based on bioaccumulative potential.

Following this review it was determined that cadmium would be included as a COPC. Cadmium has been reported to bioaccumulate in all levels of the terrestrial food chain (ATSDR, 2008). Other metals which are considered potentially bioaccumulative in the terrestrial environment (i.e., lead, selenium, thallium) were either already included in the COPC list or were determined not to be of concern based on soil and soil invertebrate data (e.g., concentrations were similar to reference area concentrations).

G-3.3 Final COPCs in Soil for Terrestrial Receptors

Based on the screening procedures and other considerations described above (Section G-2.0), the following chemicals were identified as COPCs in soil, and were carried forward for evaluation in the ERA.

- Antimony
- Arsenic
- Cadmium
- Lead
- Thallium
- Zinc

G-4.0 SPECIAL CONSIDERATIONS FOR AIR

In addition to the COPCs identified in soil, one substance was also identified as a COPC in air only (*i.e.*, sulphur dioxide). Sulphur dioxide was evaluated in the ERA as the Glencore smelter releases this substance to ambient air, and terrestrial vegetation is well known to be sensitive to sulphur dioxide-induced effects. Apart from metals/metalloids emissions (which occur in particulate matter emissions), sulphur dioxide is the only other substance emitted to ambient air that requires annual reporting to NBDOE on an annual basis (as per the Approval to Operate I-6186). Ambient air monitoring data for sulphur dioxide exist from several stations located near the smelter.

G-4.1 Final COPCs in Air for Terrestrial Receptors

Based on the evaluation of the data, SO_2 was selected as a COPC in air for terrestrial receptors and were carried forward for evaluation in the ERA.

G-5.0 REFERENCES

AENV (Alberta Environment). 2009. Alberta Tier 1 Soil and Groundwater Remediation Guidelines. Alberta Environment, Climate Change, Air, and Land Policy Branch, Environmental Assurance Division, Edmonton, Alberta.

A.J. Chandler & Associates. 2010. Air Dispersion and Deposition Modelling of Xstrata Zinc Smelter Air Emissions. Prepared for: Intrinsik Environmental Sciences Inc.

Akin, E.W. 1991. Supplemental Region IV Risk Assessment Guidance. U.S. EPA Region IV, Atlanta, Georgia. March, 1991. Cited In: Suter II, 1995.

Breckenridge, R.P., and Crockett, A.B. 1995. Engineering Forum Issue. Determination of Background Concentrations of Inorganics in Soils and Sediments at Hazardous Waste Sites. United States Environmental Protection Agency, Office of Research and Development, Office of Solid Waste and Emergency Response. EPA/540/S-06/500. December, 1995.

CalEPA. 1997. Selecting Inorganic Constituents of Chemicals of Potential Concern at Risk Assessments at Hazardous Waste Sites and Permitted Facilities. Final Policy. Prepared by: Human and Ecological Risk Division, Department of Toxic Substances Control, California Environmental Protection Agency. February, 1997.

CCME. 2007. Update 7.1. Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

CCME (Canadian Council of Ministers of the Environment). 1991. Interim Canadian Environmental Quality Criteria for Contaminated Sites. Prepared by the CCME Subcommittee on Environmental Quality Criteria for Contaminated Sites, National Contaminated Sites Remediation Program. Report # EPC-CS34.

Chapman, P. 2008. Perspective: Environmental risks of inorganic metals and metalloids: A continuing, evolving scientific odyssey. HERA 14:5-40.

Concord Environmental. 1991. A Dispersion and Deposition Modelling Study of Emissions from the Smelting and Fertilizer Division of Brunswick Mining and Smelting Corporation Ltd. CEC J2270. Concord Environmental Corporation. June, 1991.

Efroymson, R.A., M.E. Will, and G.W. Suter II, 1997a. Toxicological Benchmarks for Potential Contaminants of Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Processes. ES/ER/TM-126/R2, Oak Ridge National Laboratory, Oak Ridge, TN.

Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten, 1997b. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. ES/ER/TM-85/R3, Oak Ridge National Laboratory, Oak Ridge, TN.

ICMM. 2007. Metals Environmental Risk Assessment Guidance (MERAG). International Council on Mining and Metals. http://www.icmm.com/uploads/1538MERAG.pdf

Intrinsik Environmental Sciences et al. 2008. The Shore Road Soil Study, Belledune, New Brunswick. June, 2008. Prepared for: Xstrata Zinc. Prepared by: Intrinsik Environmental Sciences Inc., Conestoga Rovers & Associates, Globaltox, and Genivar.

Kapustka, L., Clements, W.H., Ziccardi, L., Paquin, P.R., Sprenger, M., and Wall, D. 2004. Issue Paper on the Ecological Effects of Metals. Submitted to: U.S. Environmental Protection Agency, Risk Assessment Forum.

Leadon, C.J., McDonnell, T.R., Laer, J., and Barclift, D. 2007. Calculating Background Levels for Ecological Risk Parameters in Toxic Harbour Sediment. Soil and Sediment Contamination 16:433-350.

Loro, P. 1996. Heavy metals in agricultural soils of New Brunswick. NB Agriculture and Rural Development, Adaptive Research Reports. Vol. 18. pp. 1-14.

Loro, P. 1997. Heavy metal levels in the surface soils of New Brunswick. NB Agriculture and Rural Development, Adaptive Research Reports. Vol. 10. pp. 1-10.

McCutcheon, S.R. 2010. Comments on Phase I Soil Sampling Results Near Belledune, N.B. for Intrinsik Environmental Sciences Inc. McCutcheon GeoConsulting. July, 2010

MOEE. 1993. Typical Range of Chemical Parameters in Soil, Vegetation, Moss Bags and Snow. Ontario Ministry of Environment and Energy.

Myers, J., and Thorbjornsen, K. 2004. Identifying Metals Contamination in Soil: A Geochemical Approach. Soil and Sediment Contamination 13:1-16.

Newman, M.C., and Clements, W.H. 2008. Ecotoxicology: A Comprehensive Treatment. CRC Press. Taylor & Francis Group. Boca Raton, FL.

Suter II, G.W. 1995. Guide for Performing Screening Ecological Risk Assessments at DOE Facilities. Environmental Restoration Risk Assessment Program. Prepared for: U.S. Department of Energy, Office of Environmental Management.

Tannenbaum. L.V. 2003. Understanding Background in Hazardous Waste Site Risk Assessments: Getting Back to Basics. Human and Ecological Risk Assessment 9:1599-1607.

U.S. EPA. 2000. Supplemental Guidance to RAGS: Region 4 Bulletins, Human Health Risk Assessment Bulletins. EPA Region 4, originally published November 1995, Website version last updated May 2000. URL: http://www.epa.gov/region4/waste/ots/healtbul.htm

U.S. EPA. 2001. Guidance for Characterizing Background Chemicals in Soil at Superfund Sites. External Review Draft. United States Environmental Protection Agency, Office of Emergency and Remedial Response. EPA 540-R-01-003. OSWER 9285.7-41. June, 2001.

U.S. EPA. 2002. Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites. United States Environmental Protection Agency, Office of Emergency and Remedial Response. EPA 540-R-01-003. OSWER 9285.7-41. September, 2002.

U.S. EPA. 2003a. Ecological Screening Level for Aluminum: Interim Final. OSWER Directive 9285.7-60. URL: http://www.epa.gov/ecotox/ecossl/pdf/eco-ssl_aluminum.pdf

U.S. EPA. 2003b. Ecological Screening Level for Iron: Interim Final. OSWER Directive 9285.7-69. URL: http://www.epa.gov/ecotox/ecossl/pdf/eco-ssl_iron.pdf

Washington DOE. 1992. Statistical Guidance for Ecology Site Managers. Washington State Department of Ecology. Cited in Wyoming DEQ, 2004.

WESA. 2005. Incorporating Background Soil Quality into Risk Assessment. Water and Earth Science Associates Ltd. Prepared for: Health Canada. August, 2005.

Wyoming DEQ. 2004. Fact Sheet #24. Establishing Site-Specific Background Metals Concentrations in Soil. June, 2004.

APPENDIX H

IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN FOR AQUATIC RECEPTORS

APPENDIX H IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN (COPCS) FOR AQUATIC RECEPTORS

H-1.0 INTRODUCTION

This Appendix is focused on COPC identification for aquatic freshwater receptors. The identification of COPCs for terrestrial receptors is described separately in Appendix G. Marine aquatic receptors will be addressed in a forthcoming marine ERA study.

H-1.1 Data Collection

Surface water and sediment samples were collected from two brooks within the ERA Study boundary (*i.e.,* Hendry and Unnamed brooks) and one reference location brook (*i.e.,* Armstrong Brook, located approximately 10 km west of the smelter complex and upwind of the prevailing wind direction), in two separate sampling events: July, 2010 and September, 2011 (See Appendix I for information regarding how the Study boundary was established). Given the proximity of Hendry and Unnamed brooks to the smelter complex and slag disposal area, they are considered to be the most likely fresh water bodies in the Belledune area to display adverse effects from smelter activities. Figure H-1 shows the locations of sampling stations in these three brooks. While there are other small brooks within the ERA Study boundary, these water bodies currently receive drainage from specific areas related to smelter operations (such as the slag pile) and are routinely monitored as part of the Approval to Operate. Thus, these specific water bodies are not included in the ERA.

The data collected from Hendry and Unnamed brooks in the July, 2010 and September, 2011sampling events underwent separate COPC identification processes.

As mentioned, reference freshwater surface water and sediment chemistry data were collected from a local brook (*i.e.*, Armstrong Brook) that is located approximately 10 km west of the smelter complex, and upwind of the prevailing wind direction. As the sample size from Armstrong Brook was limited (N=5 in each of the July, 2010 and September, 2011 sampling events), additional freshwater stream/brook reference data were also used. The ERA Study Team was involved in, or is otherwise aware of, other studies in northeastern New Brunswick that collected freshwater stream/brook reference surface water and sediment data (all using the same or similar protocols and analyses as those used for Unnamed, Hendry and Armstrong brooks). To bolster the reference surface water and sediment chemistry datasets, the decision was made to pool the Armstrong Brook data with the reference data from these other locations. All of these other locations are in wildlands areas that are known to be un-impacted by industrial activities, or other obvious sources of metals. Further details on these additional reference streams and their water and sediment chemistry data are provided in separate reports (*i.e.*, Intrinsik Environmental Sciences Inc., 2009; 2010a). Pooling the Armstrong Brook surface water and sediment chemistry data with the data from these other reference northeastern New Brunswick streams and brooks, increased the reference surface water and sediment sample size to 67 and 25, respectively, for most parameters, and provided more robust datasets of reference surface water and sediment concentrations for use in COPC identification.

While it is acknowledged that some of these other reference streams and brooks may be in areas with different underlying geology, and/or in different ecoregions or ecosites than Unnamed and Hendry brooks (whereas Armstrong Brook was selected based on similar underlying geology and ecoregion/ecosites as these two Study boundary brooks), all are considered representative of surface water and sediment chemistry in northeastern New Brunswick watercourses, in the absence of long term smelter emissions and deposition. It is important to recognize that the distribution of geological formations (and their corresponding mineral deposits) as well as the distribution of ecoregions and ecosites in northeastern New Brunswick is naturally variable and fragmented. Thus, the occurrence and potential exposures of many species of aquatic organisms within a given area could clearly encompass more than one geological zone, and/or more than one ecoregion or ecosite.

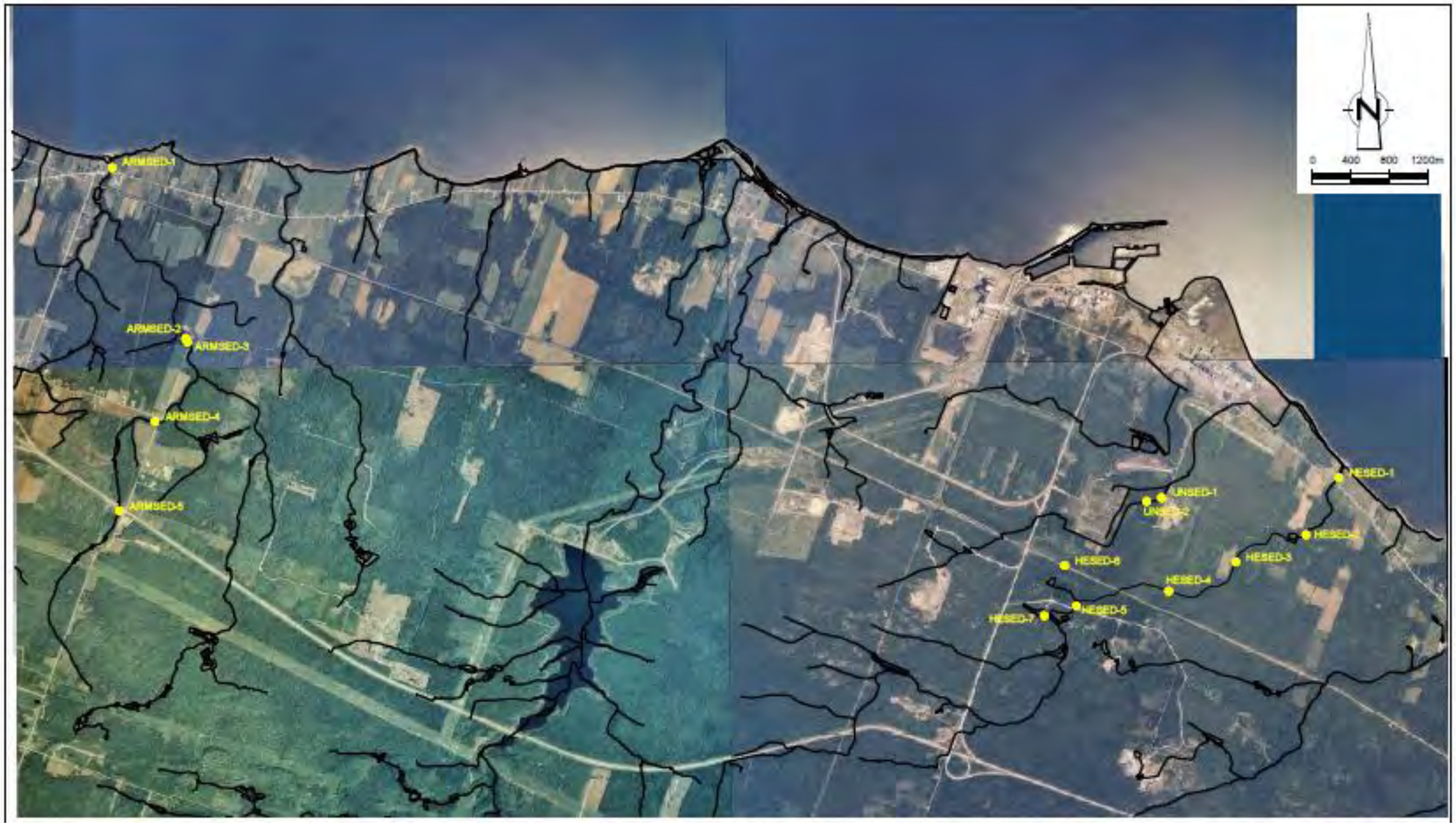

Figure H-1 Location of Unnamed, Hendry and Armstrong (reference) Brooks with Sampling Stations Identified (Figure provided by Conestoga Rovers & Associates)

All surface water and sediment samples from Unnamed, Hendry and Armstrong brooks were collected by Conestoga Rovers & Associates (CRA) in July, 2010 and September, 2011, and submitted to Maxxam Analytics (Bedford, NS) for chemical analyses. Surface water and sediment data from the other reference brooks and streams were collected from the summer of 2008 to the summer of 2010 by various contractors, using the same or similar protocols and analyses as those used for Unnamed, Hendry and Armstrong brooks. All data from these other reference water bodies were also analyzed at Maxxam Analytics (Bedford, NS).

Maxxam is an accredited laboratory for all analyses that were performed on water and sediment samples. All raw analytical data provided to Intrinsik by Maxxam (as well as the associated quality assurance reports) were carefully reviewed by Intrinsik and underwent a data quality assurance evaluation. Overall, all Study boundary and reference surface water and sediment data are considered to be of acceptable quality, and appropriate for use in an ERA. A description and discussion of the data quality assurance evaluation of Unnamed, Hendry and Armstrong brook water and sediment data is provided in Appendix F. Water and sediment data quality assurance evaluations for the other reference water bodies were conducted in association with other studies, and are not provided in the documentation for the current ERA (but are available within the following documentation: Intrinsik Environmental Sciences Inc., 2009; 2010a,b). Further details of the surface water and sediment sampling and analytical programs are provided in Appendix C. Surface water and sediment chemistry data summaries for Hendry Brook, Unnamed Brook, and Armstrong Brook are presented in Section 5 of the main report, with the raw analytical chemistry data provided in Appendix D.

The primary target analytes in Unnamed and Hendry Brook (and the reference streams and brooks) are metals and metalloids, as these substances are the major chemicals of interest in relation to potential impacts on water and sediment quality in the Belledune area.

H-2.0 COPC IDENTIFICATION FOR AQUATIC RECEPTORS

Surface water and sediment data from Unnamed Brook and Hendry Brook were screened to identify COPCs for freshwater aquatic receptors. The screening of surface water data is described in Section H-2.1, and the screening of sediment data is described in Section H-2.2.

COPC identification was conducted separately for the following broad freshwater aquatic receptor groups:

- freshwater brook pelagic aquatic life
- freshwater brook benthic aquatic life

It is often necessary to separately identify COPCs for major ecological receptor groups, because COPCs may vary depending upon the receptors and/or habitats that are under evaluation, and the environmental media that are likely to be impacted by the different sources of COPCs. Differences between receptors (such as relevant pathways and routes of exposure, habitat availability and utilization, chemical sensitivity), can often result in different chemicals of potential concern for different receptor groups.

Some of the analytical data for water and sediment samples include parameters and/or substances that are not typically considered in the selection of COPCs for aquatic receptors. This includes various common or major ions (*e.g.*, calcium, magnesium, sodium, phosphorus, potassium, phosphate, nitrates/nitrites/ammonia, *etc.*), and general water quality parameters measured in water (as part of the RCAP analysis, including pH, conductivity, hardness, alkalinity, turbidity, *etc.*). Many of the common or major ions are also essential nutrients; thus, their uptake and excretion are physiologically regulated in aquatic organisms, such that extreme exposure would typically be necessary to overcome homeostatic or compensatory mechanisms within the organism, and produce adverse effects. While these parameters and substances may influence or modify the bioavailability and toxicity of metals or metalloids, and can be important in developing and interpreting exposure and risk estimates, they are not typically considered directly in the COPC identification step of ERAs (with the exception of sites where these chemicals are facility related). This is because such parameters and substances are generally modifiers of bioavailability and toxicity (rather than causes of toxicity), and reflect common or ubiquitous substances that are present in water and sediments. Also, many of these parameters lack health or risk-based ecological benchmarks that media concentrations can be compared against.

In any risk assessment involving metals and metalloids (such as the current ERA), the speciation or chemical forms of the substances likely to be released to the surrounding environment is an important consideration. Given the smelting process at the Glencore facility, metal and metalloid species potentially released to environmental media would likely consist of soluble oxides, sulphates, and various salts (such as chlorides, other halides). The relative proportions of these chemical species would depend on the composition of feed materials, process conditions, and the degree of oxidation and other reactions that occur within ambient environmental media, as well as the presence of other major anions in these media that metals/metalloids may associate or form complexes with. Where possible, the likely speciation of metals and metalloids was considered within the COPC identification process.

Other considerations throughout the COPC identification process included essential nutrient status, and the environmental fate and behaviour properties of candidate COPCs, as well as the potential for these substances to bioaccumulate and/or biomagnify in aquatic or terrestrial food webs.

H-2.1 Screening of Unnamed Brook and Hendry Brook Surface Water Data to Identify Chemicals of Potential Concern (COPC) for Freshwater Aquatic Receptors

H-2.1.1 Surface Water Data Screening Approach

For Unnamed Brook and Hendry Brook (*i.e.*, Study boundary) surface water data, the identification of COPCs involved the following approach:

i) Comparisons of surface water chemistry data (expressed as the total recoverable element) to regulatory water quality benchmarks for the protection of freshwater aquatic life, and to reference area surface water chemistry data (both of which were also expressed as the total recoverable element); and,

ii) Comparisons of surface water chemistry data (expressed as the dissolved element) to regulatory water quality benchmarks for the protection of freshwater aquatic life and to reference area surface water chemistry data (both of which were also expressed as the dissolved element).

These approaches are commonly used in aquatic risk assessments to identify COPCs and help distinguish natural surface water chemical concentrations from those that have been influenced by anthropogenic activities.

As noted above, both total recoverable element and dissolved element water chemistry data were collected. The difference between these two types of data is that dissolved data reflects use of a 0.4 to 0.45 µm membrane filter to remove the majority of suspended particulate matter from the water sample, although hydrates and complexed metals and metalloids remain in the sample (Pendergast *et al*., 1996). No filter is used in the total recoverable element analysis. Otherwise, the sample preparation and analytical techniques are the same for total recoverable and dissolved element water chemistry analysis.

Both total recoverable and dissolved element chemistry data were collected as the analysis of the total recoverable element overestimates the quantity that is actually bioavailable to aquatic organisms in the water column. “Dissolved element” is a more appropriate parameter to evaluate, as it is the dissolved or soluble fraction of metals and metalloids in water that is the portion which is actually available for uptake into an aquatic organism. “Total recoverable element” – which is often referred to as “available or acid-extractable element” represents the amount of an element in solution that is recoverable after weak acid digestion (such as nitric acid or various combinations of nitric acid and other extractants such as hydrogen peroxide, HCl, *etc*.) and would include the elements sorbed to suspended particulate material, but not the elements that comprise the structure of the particulate material matrices. Element chemistry data can also be expressed as the “total element”, which refers to the total amount of an element in solution after strong acid digestion (such as HF, HCl, perchloric acid, *etc*.), and would include both the elements sorbed to suspended particulate material, as well as the elements that comprise the structure of the particulate material matrices (this type of digestion procedure was not utilized on surface water samples in the current ERA).

In 1993, the U.S. EPA changed their policy with respect to the basis of comparison to water quality benchmark values, from total recoverable element to dissolved element (Prothro, 1993; U.S. EPA, 1993). Thus, the U.S. EPA recommends using dissolved element concentrations to measure compliance with water quality benchmarks. The rationale for this policy decision is that the dissolved element concentration more closely approximates an element’s bioavailability and toxicity in the water column, than does the total recoverable or total element concentration. The majority of existing Canadian water quality guidelines for metals (*e.g*., CCME, BC MOE, Ontario MOE, *etc*.) are based on the total recoverable element. However, the most recent Canadian water quality guideline protocol (CCME, 2007) includes the use of dissolved element data (where available) and the application of approaches that utilize dissolved element concentrations such as the Biotic Ligand Model (BLM).

Prior to making comparisons, the surface water chemistry data from Unnamed and Hendry brooks were pooled. Pooling the data ensures that the datasets are of a sufficiently robust sample size for comparisons (*i.e*., to water quality benchmarks and to reference water chemistry data) to be meaningful. If individual brook data were considered separately, the resulting sample sizes would be small, and there would be lower statistical power in the comparisons performed, which would reduce confidence in the COPCs that are identified. While the surface water data for Hendry and Unnamed brooks were pooled for each sampling event (i.e., July 2010, and September, 2011), the data for both sampling events were not pooled together. Rather, the data from each sampling event underwent separate COPC identification processes (*i.e.,* COPC identification was conducted using the Hendry and Unnamed brook data from the July, 2010 event, and from the September, 2011 event). As noted previously, reference surface water chemistry data from a number of northeastern New Brunswick streams and brooks were also pooled with the Armstrong Brook data to provide a larger and more robust dataset for COPC identification.

Also prior to making comparisons, all chemicals that were measured in Unnamed Brook and Hendry Brook surface water at detectable concentrations (*i.e.*, greater than or equal to the reportable detection limit (RDL)) in one or more samples, were short-listed for screening against reference area water chemistry data and water quality benchmarks. Chemicals that were below the RDL in all surface water samples were excluded from further consideration. For chemicals in which there was a mix of detectable and non-detectable concentrations in water samples, all non-detectable concentrations were conservatively assumed to equal the laboratory's RDL for the purposes of calculating summary statistics. This is the most conservative way to treat a <RDL result for a given sample and will not underestimate the actual concentration that may be present in that sample. However, the RDLs for some elements in some surface water samples were elevated (See Appendix F for further details on surface water (and sediment) data quality). In these cases, substituting the full RDL value for the <RDL entries in a given substance's dataset can bias the calculation of summary statistics high, which increases the conservatism within the COPC identification process. Typically, COPC identification does not rely on unquantified or unknown values, such as RDLs, to represent maximum concentrations. This is because maximum values are routinely used to make decisions regarding COPC identification in all risk assessments, and it is considered inappropriate to use uncertain estimates when more accurate measured values exist. Nonetheless, it is possible in some cases that RDL values can represent maxima if the RDL value for a given parameter is the highest value obtained, and it is similar to the measured concentrations for that parameter. In many cases when the RDL is the highest value obtained in a dataset, it is generally not the typical RDL value for the parameter, but is elevated due to matrix interference or other analytical issues. If an elevated RDL is markedly higher than all measured concentrations for the parameter, then its use as a hypothetical maxima is questionable, and is likely inappropriate.

For total recoverable element-based water quality benchmarks, the current CCME (Canadian Council of Ministers of the Environment) Canadian freshwater water quality guidelines for the protection of aquatic life were preferentially used (*i.e.,* CCME; http://ceqg-rcqe.ccme.ca/). For chemicals where a CCME guideline was not available, available freshwater water quality benchmarks from a number of other Canadian and American jurisdictions were considered, including: MOE (1999); BC MOE (http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html); Nagpal *et al*., (2006); and MacDonald *et al*., (1999)[1]. These jurisdictions were selected as they do provide guideline values for some substances which are lacking CCME guidelines.

For dissolved element-based water quality benchmarks, the U.S. EPA (2011) National Recommended Ambient Water Quality Criteria were preferentially used. If there were chemicals lacking dissolved criteria from the U.S. EPA, available water quality

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[1] If McDonald *et al*., (1999) was used to identify total or dissolved element freshwater water quality benchmarks, documentation from the originating agency was accessed and reviewed to ensure that the most current values were used.

benchmarks from other jurisdictions were considered, including: VROM (2001), and MacDonald *et al*, (1999)[1].

It is important to recognize that generic water quality benchmarks are derived by regulatory agencies to be intentionally conservative and protective. Exceedance of these benchmarks does not necessarily imply there is a risk of adverse health effects; rather, it suggests that further evaluation of those chemicals is warranted (such as risk assessment, further data collection *etc*.). This is especially true for metals and metalloids, many of which have essential nutritional and physiological roles in aquatic biota. It is equally important, when interpreting water quality benchmark exceedances, to consider the body of literature regarding acclimation and adaptation of aquatic organisms to metals/metalloids in water, sediment and/or food items. It is well established that populations chronically exposed to metals and metalloids often show an enhanced tolerance relative to populations with no, or lower exposure (Kapustka *et al*., 2004). This increased tolerance can be due to either acclimation (shifting of tolerance within the genetically defined limit of the organism) or adaptation (modification of the limits of an organism through changes in heritable genetic material) (ICMM, 2007). Increased tolerance has been documented for many species of terrestrial and aquatic plants, animals and microbes. For the most part, acclimation and/or adaptation to metals and metalloids has been demonstrated primarily at the population level, but studies of pollution-induced community tolerance have also documented these phenomena at the community level at various contaminated sites. This often manifests as community re-structuring where tolerant species displace less tolerant species. The topic of acclimation and adaptation to metals and metalloids is described further in Kapustka *et al*., (2004), ICMM (2007); Chapman (2008), and Newman and Clements (2008).

An important decision when identifying COPCs in water (and sediments) is the selection of the reference (or background) area concentration that will be compared against the site or study area media chemistry data. The choice of the "reference concentration statistic" is largely arbitrary and is based on professional judgment. While there is some regulatory guidance on selecting this statistic, a number of different values are recommended by various regulatory agencies. Review of a number of government reports and guidance documents that address this issue, across a variety of jurisdictions in North America, reveals that a majority of jurisdictions prefer or endorse the use of the 90th percentile. While the 90th percentile appears to be among the most frequently recommended value, various other statistics are also recommended by regulatory agencies (such as: median, multiples of the median, upper 95% confidence limit on the arithmetic mean (UCLM95), 60th percentile, 80th percentile, 95th percentile, 97.5th percentile, and even the maxima for small data sets (WESA, 2005; Washington DOE, 1992; Wyoming DEQ, 2004; MOEE, 1993). A number of agencies suggest that the choice of the reference concentration statistic should be based on the distribution of the reference area dataset (*e.g.,* normal, lognormal, non-parametric) and the sample size, rather than some arbitrary rule that may not be statistically valid in all situations. Within the U.S. EPA, two times the arithmetic mean background concentration has been used for many years in the Superfund program (Akin, 1991, U.S. EPA, 2000), where the site maxima is compared to two times the arithmetic mean of the background concentration. In the United States, it has also been common in the past to use the mean plus two or three standard deviations as the background statistic. These values have been commonly used as “upper limits of background” or tolerance limits (Breckenridge and Crockett, 1995). Tannenbaum (2003) notes that comparisons of site maxima to two times the arithmetic mean of the background data is still commonly used by the U.S. EPA, and is an approach that should identify all true COPCs, while dismissing chemicals that are most likely inconsequential.

Overall, regulatory guidance documents suggest that upper percentiles of the reference dataset can be compared to the maximum site concentration. However, if the sample size is small in the background or reference dataset, it is generally recognized that a measure of central tendency is more appropriate than an upper percentile, or even upper confidence or tolerance limits (CalEPA, 1997). Many guidance documents and papers within the scientific literature suggest that if central tendency measures are to be used as the reference or background concentration statistic, the median is better than the mean given the typical lognormal distribution of elements in environmental media. This is because a median is less influenced by extreme values (or a skewed distribution) than the mean.

Given the above considerations, it was considered reasonable to select the lower of either the 90th percentile or two times the arithmetic mean as the reference surface water (and sediment) concentration statistic in the current ERA, so long as the sample size is considered to be sufficiently large. For the reference surface water chemistry dataset, N is >60, which is a more than sufficient sample size to utilize the lower of either the 90th percentile or two times the arithmetic mean as the reference concentration statistic. Selecting the lower of these two metrics ensures a conservative assessment in the screening process. However, for chemicals where all reference area surface water samples contained non-detectable concentrations, the typical RDL was used as the reference surface water concentration statistic.

It is standard practice when identifying COPCs in surface water to select only those chemicals having a maximum surface water concentration in site or study area water bodies that exceed both the concentrations identified in the reference area(s) and the water quality benchmark. It is assumed that there is a low to negligible likelihood for potential adverse effects when maximum water concentrations are below the water quality benchmarks and/or reference area surface water concentrations. Water chemistry data that meet these conditions are typically considered to require no further evaluation or action.

When comparing total recoverable and dissolved element surface water chemistry data to water quality benchmarks, it is important to recognize that the benchmark values for a number of substances differ according to water hardness (expressed as calcium carbonate) or pH. Thus, for those chemicals where the benchmark value is pH or hardness-dependent, focusing simply on the maximum water concentration is not necessarily appropriate, as lower concentrations of the chemical of interest could potentially be more toxic if the hardness or pH in such samples is sufficiently low. Therefore, for all substances where the water quality benchmark is hardness or pH-dependent, the criteria for potentially carrying a substance forward was exceedance of the hardness or pH-specific benchmarks in one or more water samples. For those substances where aquatic toxicity is not modified by hardness or pH, it is appropriate to directly compare the maxima to the corresponding benchmark value.

In summary, the surface water COPC identification process occurred as follows:

- Chemicals with maximum measured Study boundary (*i.e.*, Unnamed Brook and Hendry Brook) surface water concentrations (expressed as the total recoverable element) that exceeded both the water quality benchmark and the reference surface water concentration statistic (both expressed as the total recoverable element) were carried forward to the subsequent screening step – comparison of dissolved surface water maxima to water quality benchmarks and reference water concentrations expressed as the dissolved element. Chemicals were also carried forward for further evaluation if no water quality benchmark was identified, and the maximum surface water concentration exceeded the reference surface water concentration statistic (all expressed as the total recoverable element).

- Chemicals with maximum Study boundary surface water concentrations (expressed as the dissolved element) that exceeded both the water quality benchmark and the reference water concentration statistic (both expressed as the dissolved element), or had no water quality benchmark identified, and the maximum dissolved surface water concentration exceeded the reference dissolved surface water concentration statistic, were carried forward for further evaluation within the ERA.

Calculations of frequency of detection, frequency of exceedance over water quality benchmarks and/or reference concentration statistics, and statistical comparison tests between Study boundary and reference area water chemistry datasets were not conducted. The rationale for not proceeding with these additional screening steps (which are relatively common to COPC identification in soil and sediments) is that Study boundary surface water data is based on only two sampling events, and a relatively small sample size (i.e., N=9 for July, 2010 event, and N=10 for September, 2011 event). In addition, water chemistry data tends to have a higher spatial and temporal variability than sediment or soil chemistry data. Given these considerations, the available surface water data is not sufficiently robust for COPC identification to proceed beyond the above steps. However, the screening steps that were conducted are considered to be conservative, as simple comparisons of maximum media concentrations to benchmarks and/or reference concentration statistics, are prone to a high false positive (type I error) rate (Myers and Thorbjornsen, 2004; Leadon *et al*., 2007; CalEPA, 1997; U.S. EPA, 2001; 2002). This means there is a high potential that chemicals will be identified as COPCs that are not truly of ecological concern.

H-2.1.2 Surface Water Data Screening Outcomes

H-2.1.2.1 Surface Water Data Screening Outcomes (July, 2010 Sampling Event)

In the Study boundary brooks (i.e., Unnamed Brook and Hendry Brook), a number of substances were not measurable (*i.e*., <RDL) in any of the collected surface water samples that underwent analysis for total recoverable elements (*i.e*., unfiltered). These elements, as follows, were therefore excluded from further consideration: antimony, beryllium, bismuth, chromium, cobalt, molybdenum, nickel, selenium, silver, thallium, tin, and vanadium.

In the pooled total recoverable elements reference surface water chemistry dataset, the following substances were <RDL in all samples: antimony, beryllium, bismuth, selenium, tin, and vanadium. Thus, for these substances, the reference concentration statistic was the typical RDL value that the laboratory achieves on a regular basis (not an elevated RDL).

Table H-1 provides a comparison of the maximum measured Study boundary surface water concentrations to reference water concentration statistics and to regulatory freshwater water quality benchmarks (all expressed as the total recoverable element).

Table H-1 Comparison of Study Boundary Maximum Surface Water Concentrations to Reference Area Surface Water Concentration Statistics and Freshwater Water Quality Benchmarks; Total Recoverable Element (unfiltered analysis); July, 2010 Sampling Event

Parameter	Maximum Measured Surface Water Concentration[a] (µg/L)	Reference Area Surface Water Concentration Statistic[b] (µg/L)	Water Quality Benchmark (µg/L)
Aluminum (Al)	139	370	100[c]
Arsenic (As)	1.8	3.8	5[d]
Barium (Ba)	151	23.7	5000[e]
Boron (B)	16.1	6.6	1200[f]
Cadmium (Cd)	0.10*	0.053	Hardness-dependent[g]
Copper (Cu)	2.4	2.2	Hardness-dependent[h]
Iron (Fe)	482	2463	300[d]
Lead (Pb)	4.7*	1.6	Hardness-dependent[i]
Manganese (Mn)	3880	706	Hardness-dependent[j]
Strontium (Sr)	311	59.5	21000[k]
Titanium (Ti)	2.9	6.8	2000[l]
Uranium (U)	0.24	0.31	15[m]
Zinc (Zn)	33.8	30.9	30[d]

Notes:

Bolded chemicals are those for which the maximum measured surface water concentration exceeds the reference surface water concentration statistic.

Shaded chemicals are those for which the maximum measured surface water concentration exceeds the water quality benchmark. Chemicals are also shaded if no water quality benchmarks were identified.

* One of the July 2010 surface water samples contained higher total and dissolved cadmium and lead concentrations. However, this particular sample (i.e., Unnamed-Sed1-Surface Water) was reanalyzed due to concerns about data quality (See Appendix F). In particular, this sample was reanalyzed to confirm apparent anomalously elevated total and dissolved concentrations of a few elements. The reanalyzed sample had considerably lower cadmium and lead concentrations (total and dissolved) than the original sample. It is standard practice when a sample is reanalyzed to accept the reanalyzed results over the original results.

a N=9. Values are the measured maxima if the water quality benchmarks for the substances are not influenced by pH or hardness. If the benchmarks are hardness or pH-dependent, then the value presented is the highest concentration that exceeded its sample-specific benchmark after accounting or adjusting for sample-specific hardness or pH. This value is not necessarily the maximum measured concentration. In addition, some samples had elevated RDLs for some parameters that are higher than the measured maxima. However, it is not generally appropriate to utilize an unknown value (such as an elevated RDL) in a COPC identification process[2].

b N=62 (pooled reference area data). Value presented is lowest of the 90th percentile or two times the arithmetic mean, unless a substance was not measured above the RDL in any reference surface

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[2] In all cases where an elevated RDL for a given chemical was rejected as a plausible maxima, the entire dataset for that chemical was examined to determine if it was at all likely that an elevated RDL could be at, or near a maxima. For example, if the elevated RDL was much higher than any measured concentration or other RDLs achieved in other samples, then it was considered unrepresentative of potential maximum concentrations.

water sample. In that event, the reference concentration statistic is the typical RDL value that is regularly achieved by the laboratory.

c CCME; http://ceqg-rcqe.ccme.ca/. The aluminum freshwater aquatic life water quality guideline is 5 µg/L if pH is <6.5, and is 100 µg/L if pH ≥6.5. The pH was >6.5 in all Study boundary surface water samples.

d CCME; http://ceqg-rcqe.ccme.ca/.

e Nagpal *et al*., (2006). Maximum water quality guideline.

f BC MOE; http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html.

g CCME; http://ceqg-rcqe.ccme.ca/. The cadmium freshwater aquatic life water quality guideline is hardness-dependent and is estimated using the following equation: Cd WQG (µg/L) = 10^(0.86*(LOG(hardness, in mg/L)-3.2). Using this equation and the hardness data for each Study boundary surface water sample, the range of sample-specific Cd water quality guideline values was 0.016 to 0.1 µg/L. Seven of the nine Study boundary surface water samples exceeded their respective sample-specific cadmium water quality guideline values.

h CCME; http://ceqg-rcqe.ccme.ca/. The copper freshwater aquatic life water quality guideline is hardness-dependent. The CCME guideline values for copper at different hardness ranges are as follows: 2 µg/L at hardness of 0-120 mg/L (as $CaCO_3$); 3 µg/L at hardness of 120-180 mg/L (as $CaCO_3$); and 4 µg/L at hardness of >180 mg/L (as $CaCO_3$). Hardness in Unnamed and Hendry brooks ranges from 44 to 360 mg/L. Thus, the applicable guideline value ranged from 2 to 4 µg/L across Study boundary surface water samples. Only one sample exceeded its respective sample-specific copper water quality guideline value.

i CCME; http://ceqg-rcqe.ccme.ca/. The lead freshwater aquatic life water quality guideline is hardness-dependent. The CCME guideline values for lead at different hardness ranges are as follows: 1 µg/L at hardness of 0-60 mg/L (as $CaCO_3$); 2 µg/L at hardness of 60-120 mg/L (as $CaCO_3$); 4 µg/L at hardness of 120-180 mg/L (as $CaCO_3$); 7 µg/L at hardness of >180 mg/L (as $CaCO_3$). Hardness in Unnamed and Hendry brooks ranges from 44 to 360 mg/L. Thus, the applicable guideline value ranged from 1 to 7 µg/L across Study boundary surface water samples. Only two samples exceeded their respective sample-specific lead water quality guideline values.

j BC MOE (http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html) acute freshwater water quality guideline. The chronic guideline value from BC MOE is not used as it is only applicable to 5 weekly samples collected over 30 days. The manganese water quality guideline value is hardness-dependent and is estimated using the following equation: Mn WQG (µg/L) = ((0.01102*hardness, in mg/L)+0.54)*1000). Using this equation and the hardness data for each Study boundary surface water sample, the range of sample-specific Mn water quality guideline values was 1025 to 4507 µg/L. Only one sample exceeded its respective sample-specific manganese water quality guideline value.

k Michigan Department of Natural Resources and Environment (MDNRE, 2010) Rule 57 Water Quality Value. Final Chronic Value.

l BC MOE; http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html. Median threshold level for *Scenedesmus.*

m CCME; http://ceqg-rcqe.ccme.ca/. Long term exposure water quality guideline.

Given the information presented in Table H-1, the following chemicals in Study boundary surface water were carried forward into the comparisons of maximum measured surface water chemistry data to reference water concentration statistics and regulatory freshwater water quality benchmarks (all expressed as the dissolved element). Table H-2 presents these comparisons.

- Cadmium
- Copper
- Lead
- Manganese
- Zinc

In the Study boundary brooks (Unnamed Brook and Hendry Brook), the following substances were not measurable (<RDL) in any of the collected water samples that underwent dissolved element analysis (*i.e.*, filtered), and were therefore excluded from further consideration: antimony, beryllium, bismuth, chromium, cobalt, copper, molybdenum, nickel, selenium, silver, titanium, tin, thallium, and vanadium. Most of these substances had also not been measurable in the surface water samples analyzed for the total recoverable element. Copper was one of the candidate COPCs carried forward on the basis of the comparisons presented in Table H-1, but given that it was <RDL in all of the Study boundary surface water samples that underwent dissolved analyses, it is not considered further.

In the pooled dissolved elements reference surface water chemistry dataset, the following substances were <RDL in all samples: antimony, beryllium, bismuth, chromium, selenium, silver, tin, and vanadium. Thus, for these substances, the reference concentration statistic was the typical RDL value that the laboratory achieves on a regular basis (not an elevated RDL).

Table H-2 Comparison of Study Boundary Maximum Surface Water Concentrations to Reference Area Surface Water Concentration Statistics and Freshwater Water Quality Benchmarks; Dissolved Element (filtered analysis); July, 2010 Sampling Event

Parameter	**Maximum Measured Surface Water Concentration[a] (µg/L)**	**Reference Area Surface Water Concentration Statistic[b] (µg/L)**	**Water Quality Benchmark[c] (µg/L)**
Cadmium (Cd)	0.06	0.054	Hardness-dependent [CMC: 0.91-6.98] [CCC: 0.14-0.60]
Lead (Pb)	1.2	0.89	Hardness-dependent [CMC: 26.1-252] [CCC: 1.02-9.82]
Manganese (Mn)	3200	638	NBA
Zinc (Zn)	7	27.3	Hardness-dependent [CMC: 58.5-347] [CCC: 58.9-350]

Notes:

NBA = no benchmark available.

Bolded chemicals are those for which the maximum measured surface water concentration exceeds the reference surface water concentration statistic.

Shaded chemicals are those for which the maximum measured surface water concentration exceeds the water quality benchmark. Chemicals are also shaded if no water quality benchmarks were identified.

[a] N=9. Values are the measured maxima if the water quality benchmarks for the substances are not influenced by pH or hardness. If the benchmarks are hardness or pH-dependent, then the value presented is the highest concentration that exceeded its sample-specific benchmark after accounting or adjusting for sample-specific hardness or pH. This value is not necessarily the maximum measured concentration.

[b] N=62 (pooled reference area data). Value presented is lowest of the 90th percentile or two times the arithmetic mean, unless a substance was not measured above the RDL in any reference surface water sample. In that event, the reference concentration statistic is the typical RDL value that is regularly achieved by the laboratory.

[c] U.S. EPA (2011). Current National Recommended Water Quality Criteria (expressed as dissolved metal in the water column). CMC = criterion maximum concentration. CCC = criterion continuous concentration. The dissolved water quality criteria for cadmium, lead, and zinc are hardness-dependent and are estimated using the equations for CMC and CCC provided in U.S. EPA (2011). These equations and the resulting sample-specific criteria for these candidate COPCs in Study boundary surface water samples are provided below in Table H-3, which follows this table. The ranges for the sample-specific CMC and CCC values are provided above (in this table) for each COPC.

Table H-3 Sample-Specific CMC and CCC Values for Cadmium, Lead, and Zinc in Study Boundary Surface Water Samples; July, 2010 Sampling Event

Chemical and Sample ID	Hardness (mg/L)	Water Concentration (µg/L)	Criterion Maximum Concentration (CMC)			Criterion Continuous Concentration (CCC)		
			CF	$\exp\{m_A[\mathit{ln}(\text{hardness})] + b_A\}$	CMC (µg/L)	CF	$\exp\{m_C[\mathit{ln}(\text{hardness})] + b_C\}$	CCC (µg/L)
Cadmium								
UNNAMED-SED-1	360	0.04	0.89	7.84	6.98	0.86	0.70	0.60
UNNAMED-SED-2	180	0.04	0.92	3.88	3.56	0.88	0.42	0.37
HENDRY-SED-1	63	0.04	0.96	1.33	1.28	0.93	0.19	0.18
HENDRY-SED-2	61	0.03	0.96	1.29	1.25	0.93	0.19	0.17
HENDRY-SED-3	58	0.04	0.97	1.23	1.19	0.93	0.18	0.17
HENDRY-SED-4	53	0.03	0.97	1.12	1.09	0.94	0.17	0.16
HENDRY-SED-5	44	*<0.02*	0.98	0.93	0.91	0.94	0.15	0.14
HENDRY-SED-6	85	0.02	0.95	1.81	1.72	0.92	0.24	0.22
HENDRY-SED-7	45	0.06	0.98	0.95	0.93	0.94	0.15	0.14
Lead								
UNNAMED-SED-1	360	*<0.5*	0.60	416.97	252.00	0.60	16.25	9.82
UNNAMED-SED-2	180	*<0.5*	0.71	172.54	121.70	0.71	6.72	4.74
HENDRY-SED-1	63	0.9	0.86	45.34	38.92	0.86	1.77	1.52
HENDRY-SED-2	61	0.9	0.86	43.52	37.56	0.86	1.70	1.46
HENDRY-SED-3	58	1.0	0.87	40.81	35.52	0.87	1.59	1.38
HENDRY-SED-4	53	0.7	0.88	36.39	32.15	0.88	1.42	1.25
HENDRY-SED-5	44	*<0.5*	0.91	28.71	26.14	0.91	1.12	1.02
HENDRY-SED-6	85	1.0	0.81	66.39	54.08	0.81	2.59	2.11
HENDRY-SED-7	45	1.2	0.91	29.54	26.81	0.91	1.15	1.04
Zinc								
UNNAMED-SED-1	360	*<5*	0.98	354.71	346.90	0.99	354.71	349.74
UNNAMED-SED-2	180	*<5*	0.98	197.16	192.82	0.99	197.16	194.40
HENDRY-SED-1	63	5	0.98	81.00	79.22	0.99	81.00	79.87
HENDRY-SED-2	61	*<5*	0.98	78.82	77.08	0.99	78.82	77.71

Chemical and Sample ID	**Hardness (mg/L)**	**Water Concentration (µg/L)**	**Criterion Maximum Concentration (CMC)**			**Criterion Continuous Concentration (CCC)**		
			CF	**exp{m_A[*ln*(hardness)] + b_A}**	**CMC (µg/L)**	**CF**	**exp{m_C[*ln*(hardness)] + b_C}**	**CCC (µg/L)**
HENDRY-SED-3	58	*<5*	0.98	75.52	73.86	0.99	75.52	74.46
HENDRY-SED-4	53	5	0.98	69.97	68.43	0.99	69.97	68.99
HENDRY-SED-5	44	*<5*	0.98	59.76	58.45	0.99	59.76	58.92
HENDRY-SED-6	85	6	0.98	104.40	102.11	0.99	104.40	102.94
HENDRY-SED-7	45	7	0.98	60.91	59.57	0.99	60.91	60.06

Notes:
CMC (dissolved) = exp{m_A[ln(hardness, mg/L)]+b_A}x CF.
CCC = (dissolved) = exp{m_C[ln(hardness, mg/L)]+b_C}x CF.
CF = freshwater conversion factor. U.S. EPA (2011) Appendix A and B provides the CF values or equations to derive the CF values.
The $m_{A,}$ $m_{C,}$ $b_{A,}$ and b_C terms are provided in U.S. EPA (2011) Appendix B.
a Entries in *red and italics* indicate concentrations below the RDL. For these samples, the reported RDL value is assumed to be the measured concentration.
Bolded entries in the Water Concentration column exceed the CMC, while shaded entries in this column exceed the CCC.

Based on the comparisons conducted in Tables H-2 and H-3, the following chemicals were identified as the final COPCs in Study boundary surface water (*i.e.*, Unnamed Brook and Hendry Brook) for the July, 2010 sampling event.

- Lead
- Manganese

H-2.1.2.2 Surface Water Data Screening Outcomes (September, 2011 Sampling Event)

In the Study boundary brooks (Unnamed Brook and Hendry Brook), a number of substances were not measurable (*i.e.*, <RDL) in any of the collected surface water samples that underwent analysis for total recoverable elements (*i.e.*, unfiltered). These elements, as follows, were therefore excluded from further consideration: antimony, beryllium, bismuth, boron, chromium, copper, molybdenum, nickel, selenium, silver, thallium, tin, and vanadium.

In the pooled total recoverable elements reference surface water chemistry dataset, the following substances were <RDL in all samples: antimony, beryllium, bismuth, selenium, tin, and vanadium. Thus, for these substances, the reference concentration statistic was the typical RDL value that the laboratory achieves on a regular basis (not an elevated RDL).

Table H-4 provides a comparison of the maximum measured Study boundary surface water concentrations to reference water concentration statistics and to regulatory freshwater water quality benchmarks (all expressed as the total recoverable element).

Table H-4 Comparison of Study Boundary Maximum Surface Water Concentrations to Reference Area Surface Water Concentration Statistics and Freshwater Water Quality Benchmarks; Total Recoverable Element (unfiltered analysis); September, 2011 Sampling Event

Parameter	Maximum Measured Surface Water Concentration[a] (µg/L)	Reference Area Surface Water Concentration Statistic[b] (µg/L)	Water Quality Benchmark (µg/L)
Aluminum (Al)	354	363	100[c]
Arsenic (As)	1.4	3.54	5[d]
Barium (Ba)	174	29.4	5000[e]
Cadmium (Cd)	0.061	0.051	Hardness-dependent[f]
Cobalt (Co)	0.53	1.48	0.9 / 110[g]
Iron (Fe)	1450	2329	300[d]
Lead (Pb)	1.5	1.55	Hardness-dependent[h]
Manganese (Mn)	5370	660	Hardness-dependent[i]
Strontium (Sr)	285	62.5	21000[j]
Titanium (Ti)	6.3	6.68	2000[k]
Uranium (U)	0.2	0.29	15[l]
Zinc (Zn)	7.8	29.3	30[d]

Notes:

Bolded chemicals are those for which the maximum measured surface water concentration exceeds the reference surface water concentration statistic.

Shaded chemicals are those for which the maximum measured surface water concentration exceeds the water quality benchmark. Chemicals are also shaded if no water quality benchmarks were identified.

a N=10. Values are the measured maxima if the water quality benchmarks for the substances are not influenced by pH or hardness. If the benchmarks are hardness or pH-dependent, then the value presented is the highest concentration that exceeded its sample-specific benchmark after accounting or adjusting for sample-specific hardness or pH. This value is not necessarily the maximum measured concentration. In addition, some samples had elevated RDLs for some parameters that are higher than the measured maxima. However, it is not generally appropriate to utilize an unknown value (such as an elevated RDL) in a COPC identification process[2].

b N=67 (pooled reference area data). Value presented is lowest of the 90th percentile or two times the arithmetic mean, unless a substance was not measured above the RDL in any reference surface water sample. In that event, the reference concentration statistic is the typical RDL value that is regularly achieved by the laboratory.

c CCME; http://ceqg-rcqe.ccme.ca/. The aluminum freshwater aquatic life water quality guideline is 5 µg/L if pH is <6.5, and is 100 µg/L if pH ≥6.5. The pH was >6.5 in all Study boundary surface water samples.

d CCME; http://ceqg-rcqe.ccme.ca/.

e Nagpal *et al*., (2006). Maximum water quality guideline.

f CCME; http://ceqg-rcqe.ccme.ca/. The cadmium freshwater aquatic life water quality guideline is hardness-dependent and is estimated using the following equation: Cd WQG (µg/L) = 10^(0.86*(LOG(hardness, in mg/L)-3.2). Using this equation and the hardness data for each Study boundary surface water sample, the range of sample-specific Cd water quality guideline values was 0.013 to 0.1 µg/L. Six of the ten Study boundary surface water samples exceeded their respective sample-specific cadmium water quality guideline values.

g MOE (1999) provides a Provincial Water Quality Objective (PWQO) for cobalt of 0.9 µg/L, while BC MOE (http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html) lists a maximum freshwater water quality guideline of 110 µg/L.

h CCME;http://ceqg-rcqe.ccme.ca/. The lead freshwater aquatic life water quality guideline is hardness-dependent. The CCME guideline values for lead at different hardness ranges are as follows: 1 µg/L at hardness of 0-60 mg/L (as $CaCO_3$); 2 µg/L at hardness of 60-120 mg/L (as $CaCO_3$); 4 µg/L at hardness of 120-180 mg/L (as $CaCO_3$); 7 µg/L at hardness of >180 mg/L (as $CaCO_3$). Hardness in Unnamed and Hendry brooks ranges from 35 to 360 mg/L. Thus, the applicable guideline value ranged from 1 to 7 µg/L across Study boundary surface water samples. No samples exceeded their respective sample-specific lead water quality guideline values.

i BC MOE (http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html) acute freshwater water quality guideline. The chronic guideline value from BC MOE is not used as it is only applicable to 5 weekly samples collected over 30 days. The manganese water quality guideline value is hardness-dependent and is estimated using the following equation: Mn WQG (µg/L) = ((0.01102*hardness, in mg/L)+0.54)*1000). Using this equation and the hardness data for each Study boundary surface water sample, the range of sample-specific Mn water quality guideline values was 926 to 4507 µg/L. Only one sample exceeded its respective sample-specific manganese water quality guideline value.

j Michigan Department of Natural Resources and Environment (MDNRE, 2010) Rule 57 Water Quality Value. Final Chronic Value.

k BC MOE; http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html. Median threshold level for *Scenedesmus.*

l CCME; http://ceqg-rcqe.ccme.ca/. Long term exposure water quality guideline.

Given the information presented in Table H-4, the following chemicals in Study boundary surface water were carried forward into the comparisons of maximum measured surface water chemistry data to reference water concentration statistics and regulatory freshwater water quality benchmarks (all expressed as the dissolved element). Table H-5 presents these comparisons.

- Cadmium
- Manganese

In the Study boundary brooks (Unnamed Brook and Hendry Brook), the following substances were not measurable (<RDL) in any of the collected water samples that underwent dissolved element analysis (*i.e.*, filtered), and were therefore excluded from further consideration: antimony, beryllium, bismuth, boron, chromium, lead, molybdenum, selenium, silver, thallium, tin, titanium, and vanadium. Most of these elements had also not been measurable in the surface water samples analyzed for the total recoverable element. Dissolved copper was measured at the RDL value (i.e., 2 µg/L) in one surface water sample, but all other samples contained dissolved copper concentrations that were less than the RDL. Given this, and considering that total recoverable copper was not measurable in any of the surface water samples from Study boundary brooks, copper is excluded from further evaluation.

In the pooled dissolved elements reference surface water chemistry dataset, the following substances were <RDL in all samples: antimony, beryllium, bismuth, boron, chromium, lead, molybdenum, selenium, silver, thallium, tin, titanium, and vanadium. Thus, for these substances, the reference concentration statistic was the typical RDL value that the laboratory achieves on a regular basis (not an elevated RDL).

Table H-5 Comparison of Study Boundary Maximum Surface Water Concentrations to Reference Area Surface Water Concentration Statistics and Freshwater Water Quality Benchmarks; Dissolved Element (filtered analysis); September, 2011 Sampling Event

Parameter	**Maximum Measured Surface Water Concentration[a] (µg/L)**	**Reference Area Surface Water Concentration Statistic[b] (µg/L)**	**Water Quality Benchmark[c] (µg/L)**
Cadmium (Cd)	0.057	0.050	Hardness-dependent [CMC: 0.72-6.98] [CCC: 0.12-0.60]
Manganese (Mn)	4920	596	NBA

Notes:
NBA = no benchmark available.
Bolded chemicals are those for which the maximum measured surface water concentration exceeds the reference surface water concentration statistic.
Shaded chemicals are those for which the maximum measured surface water concentration exceeds the water quality benchmark. Chemicals are also shaded if no water quality benchmarks were identified.

a N=10. Values are the measured maxima if the water quality benchmarks for the substance are not influenced by pH or hardness. If the benchmarks are hardness or pH-dependent, then the value presented is the highest concentration that exceeded its sample-specific benchmark after accounting or adjusting for sample-specific hardness or pH. This value is not necessarily the maximum measured concentration.

b N=67 (pooled reference area data). Value presented is lowest of the 90th percentile or two times the arithmetic mean, unless a substance was not measured above the RDL in any reference surface water sample. In that event, the reference concentration statistic is the typical RDL value that is regularly achieved by the laboratory.

c U.S. EPA (2011). Current National Recommended Water Quality Criteria (expressed as dissolved metal in the water column). CMC = criterion maximum concentration. CCC = criterion continuous concentration. The dissolved water quality criteria for cadmium are hardness-dependent and are estimated using the equations for CMC and CCC provided in U.S. EPA (2011). These equations and the resulting sample-specific criteria for cadmium in Study boundary surface water samples are provided below in Table H-6, which follows this table. The ranges for the sample-specific CMC and CCC values are provided above (in this table).

Table H-6 Sample-Specific CMC and CCC Values for Cadmium in Study Boundary Surface Water Samples; September, 2011 Sampling Event

Chemical and Sample ID	**Hardness (mg/L)**	**Water Concentration (µg/L)**	**Criterion Maximum Concentration (CMC)**			**Criterion Continuous Concentration (CCC)**		
			CF	**exp{m_A[*ln*(hardness)] + b_A}**	**CMC (µg/L)**	**CF**	**exp{m_C[*ln*(hardness)] + b_C}**	**CCC (µg/L)**
Cadmium								
HENDRY-SED-1	59	0.027	0.97	1.25	1.21	0.93	0.18	0.17
HENDRY-SED-2	56	0.026	0.97	1.18	1.15	0.93	0.18	0.16
HENDRY-SED-3	53	*0.017*	0.97	1.12	1.09	0.94	0.17	0.16
HENDRY-SED-4	52	*0.017*	0.97	1.10	1.07	0.94	0.17	0.16
HENDRY-SED-5	39	0.018	0.98	0.82	0.81	0.95	0.13	0.13
HENDRY-SED-6	81	*0.017*	0.95	1.72	1.64	0.92	0.23	0.21
HENDRY-SED-7	35	0.021	0.99	0.73	0.72	0.95	0.12	0.12
UNNAMED-SED-1	360	0.032	0.89	7.84	6.98	0.86	0.70	0.60
UNNAMED-SED-2	200	0.036	0.92	4.32	3.95	0.88	0.45	0.40
UNNAMED-SED-3	150	0.057	0.93	3.22	2.99	0.89	0.37	0.33

Notes:
CMC (dissolved) = exp{m_A[ln(hardness, mg/L)]+b_A}x CF.
CCC = (dissolved) = exp{m_C[ln(hardness, mg/L)]+b_C}x CF.
CF = freshwater conversion factor. U.S. EPA (2011) Appendix A and B provides the CF values or equations to derive the CF values.
The m_A, m_C, b_A, and b_C terms are provided in U.S. EPA (2011) Appendix B.

a Entries in *red and italics* indicate concentrations below the RDL. For these samples, the reported RDL value is assumed to be the measured concentration.

Bolded entries in the Water Concentration column exceed the CMC, while shaded entries in this column exceed the CCC.

Based on the comparisons conducted in Tables H-5 and H-6, the following chemicals were identified as the final COPCs in Study boundary surface water (*i.e.*, Unnamed Brook and Hendry Brook) for the September, 2011 sampling event.

- Manganese

Summary

Based on the comparisons conducted in Tables H-1 through H-6, the following substances were identified as the final COPCs in Study boundary surface water (*i.e.*, Unnamed Brook and Hendry Brook) for both the July, 2010 and September, 2011 sampling events.

- Lead (July, 2010 sampling event only).
- Manganese (both sampling events).

H-2.2 Screening of Unnamed Brook and Hendry Brook Sediment Chemistry Data to Identify Chemicals of Potential Concern (COPC) to Freshwater Aquatic Receptors

H-2.2.1 Sediment Data Screening Approach

For Unnamed Brook and Hendry Brook (*i.e.*, Study boundary) sediment chemistry data, the identification of COPCs involved the following approach, which is similar to the approach used for identifying COPCs for terrestrial receptors from soil chemistry data (See Appendix G). As is the case for soils, the steps within the sediment screening approach are commonly used in site and risk assessments to identify COPCs and help distinguish natural sediment chemical concentrations from those that have been influenced by anthropogenic activities.

i) Comparisons of sediment chemistry data to regulatory sediment quality benchmarks and reference area sediment chemistry data; and,

ii) Two sample statistical comparison tests conducted between Study boundary and reference area sediment chemistry datasets, where necessary.

Prior to making comparisons, the sediment chemistry data from Unnamed and Hendry brooks were pooled. Pooling the data ensures that the datasets are of a sufficiently robust sample size for comparisons (*i.e.*, to sediment quality benchmarks and to reference sediment chemistry data) to be meaningful. If individual brook data were considered separately, the resulting sample sizes would be small, and there would be lower statistical power in the comparisons performed, which would reduce confidence in the COPCs that are identified. The data for Hendry and Unnamed Brooks were pooled for each sampling event (i.e., July 2010, and September, 2011), but the data for both sampling events were not pooled together. Rather, the data from each sampling event underwent separate COPC identification processes. As noted previously, reference sediment chemistry data from a number of northeastern New Brunswick streams and brooks were also pooled to provide a larger and more robust dataset for COPC identification.

Also prior to making comparisons, all chemicals that were measured in Unnamed Brook and Hendry Brook sediments at detectable concentrations (*i.e.*, greater than or equal to the reportable detection limit (RDL)) in one or more samples, were short-listed for screening against reference area sediment chemistry data and sediment quality benchmarks. Chemicals that were below the RDL in all sediment samples were excluded from further consideration. For chemicals with a mix of detectable and non-detectable concentrations in Study boundary sediment samples, all non-detectable concentrations were conservatively assumed to equal the laboratory's RDL for the purposes of calculating summary statistics. As previously discussed in Section H-2.1.1, this is the most conservative way to treat a <RDL result for a given sample and will not underestimate the actual concentration that may be present in that sample. The discussion provided in Section H-2.1.1 regarding the handling of <RDL values in the COPC identification process applies equally to sediments as it does to surface water.

The current CCME (Canadian Council of Ministers of the Environment) Canadian freshwater sediment quality guidelines for the protection of aquatic life were preferentially used as sediment quality benchmarks (*i.e.,* CCME; http://ceqg-rcqe.ccme.ca/). For substances where a CCME guideline was not available, freshwater sediment quality benchmarks from a number of other Canadian and American jurisdictions were considered, including: MOE (2008); Nagpal *et al*., (2006); NOAA (1999); NY DEC (1994), and MacDonald *et al*., (1999)[3]. There was no pre-determined hierarchy for the application of sediment quality benchmarks from jurisdictions other than CCME. Rather, professional judgment was used to select benchmarks that are as similar as possible to the two types of sediment quality guidelines that CCME derives. For example, the CCME ISQG is similar to a threshold effect level (TEL), a lowest effect level (LEL), and an effects range low (ERL), while the CCME PEL is similar to a severe effect level (SEL), an effects range median (ERM), and a frequent effects level (FEL).

PEL and similar sediment quality guidelines were given preference over LEL or ISQG sediment quality guidelines, or similar. The rationale for this follows. First, PEL (and similar) sediment quality guidelines can be considered population level benchmarks, as they rely primarily on the modified National Status and Trends Program (NSTP) approach, which in turn relies heavily on field data that demonstrates associations between sediment chemical concentrations and biological effects (CCME, 1995). This information is often referred to as “co-occurrence” sediment data. The NSTP approach uses a weight of evidence process to support the development of sediment guidelines. This approach can be applied to a wide variety of chemicals, and to virtually any sediment type that occurs in freshwater, estuarine, and marine environments (CCME, 1995). In the NSTP approach, information relating to sediment concentrations and effects is compiled from numerous geographic locations throughout North America, for many different species and biological end points. Much of the information compiled is field-collected data that considers complex mixtures of chemicals (and thus their interactive effects), various sediment types (*i.e.*, with different particle sizes and concentrations of substances), and varying conditions of bioavailability. These data are entered into a Biological Effects Database for Sediments, or BEDS. Sediment quality guidelines are then statistically derived from the BEDS. For example, the PEL is calculated as the square root of the product (*i.e.*, the geometric mean) of the 50th percentile concentration of the effect data set and the 85th percentile concentration of the no-effect data set. The PEL represents the lower limit of the range of chemical concentrations that is usually, or always associated with adverse biological effects (CCME, 1995).

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[3] If McDonald *et al*., (1999) was used to identify freshwater sediment quality benchmarks, documentation from the originating agency was accessed and reviewed to ensure that the most current values were used.

Furthermore, the past experience of the study team in numerous ERAs of contaminated sediments has shown that the LEL or ISQG, and other similar values, are highly conservative, and their exceedance often does not correlate well with other endpoints that are commonly evaluated in aquatic risk assessments (*e.g.*, sediment bioassay results and benthic community parameters). In practice, exceedance of the PEL (and similar benchmarks) is the more realistic indicator of a potential for population level adverse effects. This is supported by a study by Long *et al*., (1998), who examined the predictive ability of marine sediment quality guidelines, and noted that PELs are considerably better at predicting the likelihood for toxicity than TELs or similar guideline values, such as ISQGs. NOAA (1999) notes that effects range median values are better indicators of adverse effects than effects range low values. Similarly, MDEP (2006) states there is no evidence of significant risk of harm to benthic organisms when sediment concentrations are below probable effect levels.

However, it must be recognized that PELs and similar benchmarks are generic, with no consideration given to site-specific populations/communities or sediment conditions that influence bioavailability. Furthermore, for PELs and similar benchmarks, it is typically noted in regulatory guidance documents that these values cannot be considered toxicity thresholds. There is no assurance that sediment concentrations below these benchmarks will not be toxic, nor is there assurance that sediment concentrations above these benchmarks will be toxic. Thus, rather than providing an indication of toxicity, the most appropriate use of sediment quality guidelines is to rank or prioritize sites and chemicals of concern, and identify those sites or chemicals that may require further evaluation.

As for the COPC identification processes for Study boundary surface water and soils, it is important to consider that many metals and metalloids have essential nutritional and physiological roles in sediment biota. The body of literature regarding acclimation and adaptation of benthic organisms to metals and metalloids in sediments is also important to consider.

Previously, Section H-2.1.1 addressed issues and considerations regarding the selection of reference concentration statistics for surface water in COPC identification. Reference concentration statistics must also be developed for chemicals that occur in Study boundary sediments. The same rationale for selection of surface water reference concentration statistics applies equally to sediment reference concentration statistics. Thus, it was considered reasonable to select the lower of either the 90th percentile or two times the arithmetic mean as the reference sediment concentration statistic, so long as the sample size is considered to be sufficiently large. The sample size (N) for the pooled reference sediment chemistry dataset in July, 2010 was 20 for all substances except lithium, rubidium and tin (where N=11). The sample size (N) for the pooled reference sediment chemistry dataset in September, 2011 was 25 for all substances except lithium, rubidium and tin (where N=16). These sample sizes are considered sufficient to utilize the lower of either the 90th percentile or two times the arithmetic mean as the reference concentration statistic. However, for chemicals where all reference area sediment samples contained non-detectable concentrations, the typical RDL was used as the reference sediment concentration statistic.

As occurs for the identification of COPCs in surface water, it is standard practice to select as COPCs, only those chemicals having a maximum concentration in site or study area sediments which exceeds both the reference concentration statistic, and the sediment quality benchmark. It is assumed that there is a low to negligible likelihood for potential adverse effects when maximum sediment chemical concentrations are below the sediment quality benchmarks and/or reference area sediment concentrations. Sediment chemistry data that meets these conditions are typically considered to require no further evaluation or action.

Chemicals with maximum Study boundary sediment concentrations that exceeded both the sediment quality benchmark and the reference sediment concentration statistic were carried forward to the subsequent screening step - statistical comparison tests. Chemicals were also carried forward if no sediment quality benchmark was identified, and the maximum sediment concentration was greater than the reference area sediment concentration statistic.

Calculations of frequency of detection, and/or frequency of exceedance over sediment quality benchmarks and/or sediment reference concentration statistics were not conducted as part of the sediment COPC identification process, as the small sample size (N=9 and N=10 in July, 2010, and September, 2011, respectively) makes it difficult to select a reasonable and robust cut-off value or significance level (*e.g.*, if even one of the nine samples from July 2010 exceeded either its reference concentration statistic or sediment quality benchmark, the frequency of exceedance would be 11.1%). This is higher than the typical cut-off value of 5% used by U.S. EPA and the U.S Navy in their chemical screening procedures[4].

For chemicals that were carried forward into the statistical comparison tests, the following tasks were conducted.

- First, goodness of fit tests were performed on the Study boundary and reference area sediment chemistry datasets for these chemicals to determine if the data distributions were parametric (*e.g.*, normal, lognormal) or non-parametric. It is important to determine the type of distribution as many statistical comparison tests are only appropriate to use if the distribution is of a certain type.

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[4] There is no consistent regulatory guidance on a cut-off value to use when considering the frequency of detection and exceedance over benchmarks in a COPC identification process. However, a value of 5% is often used in practice as it is consistent with the significance level in typical statistical comparison testing. Also, within the Superfund program, the U.S. EPA has used a 5% cut-off value for detection frequency to eliminate chemicals from further consideration since the early 1990s. U.S. Navy (2003) ERA guidance also supports the use of a 5% cut-off value when considering detection and benchmark exceedance frequency, but cautions that one must consider the sample size when choosing a cut-off value (as 5% is not appropriate if one has a sample size of <20; in these cases, professional judgement is used to determine if frequency considerations are appropriate and what an alternate cut-off value could be). The U.S. Navy also cautions that one must consider the spatial distribution of the chemicals of interest, when deciding whether or not to eliminate chemicals from consideration on the basis of detection or benchmark exceedance frequency.

- Second, the sample sizes for the Study boundary and reference area sediment chemistry datasets were considered, as statistical comparison tests typically require a minimum sample size of 8-10.

- Third, if sample sizes were adequate, statistical 2-sample comparison tests were conducted between the Study boundary and reference area sediment chemistry datasets to determine if there were statistically significant differences between these datasets. These tests were conducted using the U.S. EPA statistical software ProUCL 4.00.04. If the distributions in both the Study boundary and reference area datasets for the chemical of interest were parametric at the 5% significance level, then 2 sample t-tests were conducted. ProUCL 4.00.04 performs two types of t-tests simultaneously (Student t-test and Welch-Satterthwaite t-test). Determining which of these two tests is most appropriate depends on whether or not the variance in the two datasets being compared is approximately equal. If the variance is roughly equal, the Student t-test results are recommended, while the Welch-Satterthwaite t-test results are recommended if the variance between the two datasets is not equal. The selected null hypothesis used for these tests was that the means in the two datasets were equal. If the distribution(s) in one or both of the Study boundary and reference area datasets for the chemical of interest were non-parametric at the 5% significance level, then the Wilcoxon Mann Whitney (WMW) test was performed. In these tests, the selected null hypothesis was that the means/medians in the two datasets were equal.

Any chemicals with Study boundary sediment concentrations that were significantly greater than the reference area sediment concentrations (based on the outcome of t-tests or WMW test) were carried forward as COPCs, and evaluated further.

The COPC identification process that was applied to the Study boundary sediment chemistry data is considered robust and defensible, and is based on approaches that are commonly used in site and risk assessments to identify COPCs, and help distinguish natural sediment chemical concentrations from those that have been influenced by anthropogenic activities. It is also considered to be a conservative approach, as both simple comparisons of maximum sediment concentrations to sediment quality benchmarks and/or reference concentration statistics, and statistical comparison tests are prone to a high false positive (type I error) rate (Myers and Thorbjornsen, 2004; Leadon *et al*., 2007; CalEPA, 1997; U.S. EPA, 2001; 2002). Some reasons why these approaches tend to have a high rate of false positives is that trace element distributions in sediments tend to have very large ranges (two or three orders of magnitude are not uncommon), and are highly right-skewed, often having, or resembling lognormal distributions. The accurate characterization of the upper tails of such skewed distributions requires a large number of background samples, which are often not available. The probability of false positives increases if the site dataset is larger than the background dataset. In addition, statistical tests treat each analyte as an independently behaving entity, and do not consider the geochemical context in which each element occurs (Myers and Thorbjornsen, 2004). The U.S. EPA (2001) notes that a type I error (false positive) is less serious than a type II error (false negative) when selecting COPCs, and the use of approaches that favour type I errors are inherently more protective of environmental (and human) health.

H-2.2.2 Sediment Data Screening Outcomes

H-2.2.2.1 Sediment Data Screening Outcomes (July, 2010 Sampling Event)

In the Study boundary sediment chemistry dataset, beryllium, bismuth and boron were <RDL in all samples, and are therefore excluded from further consideration.

In the pooled reference area sediment chemistry dataset, the following substances were <RDL in all samples: antimony, beryllium, bismuth, and boron. Thus, for these substances, the reference sediment concentration statistic was the typical RDL value that the laboratory achieves on a regular basis (not an elevated RDL).

Table H-7 provides a comparison of the maximum measured Study boundary sediment concentrations to reference sediment concentration statistics and to regulatory freshwater sediment quality benchmarks (all of which are based on the available element, as determined using ICP-MS analysis and an EPA 3050B acid digestion).

Table H-7 Comparison of Study Boundary Maximum Sediment Concentrations to Reference Area Sediment Concentration Statistics and Freshwater Sediment Quality Benchmarks; July, 2010 Sampling Event

Parameter	**Maximum Measured Study Boundary Sediment Concentration[a] (mg/kg)**	**Reference Area Sediment Concentration Statistic[b] (mg/kg)**	**Sediment Quality Benchmark (mg/kg)**
Aluminum (Al)	26000	17200	58000[c]
Antimony (Sb)	5	2	25[d]
Arsenic (As)	43	15.6	17[e]
Barium (Ba)	1600	165	NBA
Cadmium (Cd)	4.4	0.8	3.5[e]
Chromium (Cr)	66	45.2	90[e]
Cobalt (Co)	34	20.4	50[f]
Copper (Cu)	39	36.2	197[e]
Iron (Fe)	75000	36000	43766[g]
Lead (Pb)	160	32.3	91.3[e]
Lithium (Li)	51	19	NBA
Manganese (Mn)	26000	2370	1100[h]
Molybdenum (Mo)	2	2	NBA
Nickel (Ni)	49	64.2	75[g]
Rubidium (Rb)	11	9	NBA
Selenium (Se)	2	2.1	5[i]
Silver (Ag)	0.6	0.5	3.7[j]

Parameter	Maximum Measured Study Boundary Sediment Concentration[a] (mg/kg)	Reference Area Sediment Concentration Statistic[b] (mg/kg)	Sediment Quality Benchmark (mg/kg)
Strontium (Sr)	39	37.3	NBA
Thallium (Tl)	1.4	0.2	NBA
Tin (Sn)	7	2	NBA
Uranium (U)	1.1	2.61	NBA
Vanadium (V)	80	38	NBA
Zinc (Zn)	760	140	315[e]

Notes:
NBA = no benchmark available.
Bolded chemicals are those for which the maximum measured sediment concentration exceeds the reference sediment concentration statistic.
Shaded chemicals are those for which the maximum measured sediment concentration exceeds the PEL or similar sediment quality benchmark. Chemicals are also shaded if no sediment quality benchmarks were identified.

[a] N=9.

[b] N=20 (pooled reference area data) except for Li, Rb, Sn, where N=11. Value presented is lowest of the 90th percentile or two times the arithmetic mean, unless a substance was not measured above the RDL in any reference surface water sample. In that event, the reference concentration statistic is the typical RDL value that is regularly achieved by the laboratory.

[c] Effects Range Median (ERM) for *H. Azteca* - 28 day test; Ingersoll *et al*., (1996).

[d] NY DEC (1994) Severe Effect Level (SEL).

[e] CCME(http://ceqg-rcqe.ccme.ca/). Probable Effect Levels (PELs).

[f] MOE (2008); open water disposal criterion.

[g] Nagpal *et al*., (2006) Severe Effect Levels (SELs).

[h] MOE (2008) Severe Effect Level (SEL).

[i] Nagpal *et al*., (2006) sediment quality guideline.

[j] NOAA (1999) Effects Range Median (ERM).

As shown in Table H-7, maximum sediment concentrations of most target analytes exceed their sediment reference concentration statistics (molybdenum, nickel, selenium and uranium are the only exceptions). Several substances exceed their respective sediment quality benchmarks (PELs, or similar benchmarks), and several substances have maxima which exceed their respective reference concentration statistics, but lack regulatory freshwater sediment quality benchmarks (*i.e*., barium, lithium, rubidium, strontium, thallium, tin, and vanadium).

The following chemicals in Study boundary sediments were carried forward into the subsequent screening step – statistical comparison tests.

- Arsenic
- Barium
- Cadmium
- Iron
- Lead
- Lithium
- Manganese
- Rubidium
- Strontium
- Thallium
- Tin
- Vanadium
- Zinc

As described previously, the statistical comparison tests consisted of either 2 sample t-tests or Wilcoxon Mann Whitney tests (depending on the data distribution) conducted between the Study boundary and reference area sediment chemistry datasets. All tests were conducted using the U.S. EPA statistical software, ProUCL 4.00.04. Any chemicals with Study boundary sediment concentrations that were significantly greater than the reference area sediment concentrations (based on the outcome of t-tests or WMW test) were carried forward as COPCs, and evaluated further. Table H-8 presents the outcome of the statistical comparison tests.

Table H-8 Outcome of Statistical Comparison Tests between Study Boundary and Reference Area Sediment Chemistry Datasets; July, 2010 Sampling Event

Parameter	**Statistical Test Outcome**
Arsenic	NSD
Barium	SB>Ref
Cadmium	SB>Ref
Iron	SB>Ref
Lead	SB>Ref
Lithium	SB>Ref
Manganese	NSD
Rubidium	NSD
Strontium	NSD
Thallium	SB>Ref
Tin[a]	SB>Ref
Vanadium	SB>Ref
Zinc	SB>Ref

Notes:

N=9 for Study boundary sediment chemistry data; N=20 for pooled reference area sediment chemistry data except for Li, Rb, Sn, where N=11.

SB = Study Boundary; Ref = reference area; ">" indicates significantly greater than; NSD = no significant difference.

[a] For tin, there were not enough samples with measured concentrations above the RDL to conduct statistical comparison tests. However, the maximum, mean and median tin concentrations in Study boundary brook sediments were higher than those in reference brook/stream sediments.

Based on the outcome of the statistical comparison tests, the following chemicals within Study boundary sediments were identified as COPCs, and evaluated further.

- Barium
- Cadmium
- Iron
- Lead
- Lithium
- Thallium
- Tin
- Vanadium
- Zinc

H-2.2.2.2 Sediment Data Screening Outcomes (September, 2011 Sampling Event)

In the Study boundary sediment chemistry dataset, beryllium, bismuth and boron were <RDL in all samples, and are therefore excluded from further consideration.

In the pooled reference area sediment chemistry dataset, the following substances were <RDL in all samples: antimony, beryllium, bismuth, and boron. Thus, for these substances, the reference sediment concentration statistic was the typical RDL value that the laboratory achieves on a regular basis (not an elevated RDL).

Table H-9 provides a comparison of the maximum measured Study boundary sediment concentrations to reference sediment concentration statistics and to regulatory freshwater sediment quality benchmarks (all of which are based on the available element, as determined using ICP-MS analysis and an EPA 3050B acid digestion).

Table H-9 Comparison of Study Boundary Maximum Sediment Concentrations to Reference Area Sediment Concentration Statistics and Freshwater Sediment Quality Benchmarks; September, 2011 Sampling Event

Parameter	**Maximum Measured Study Boundary Sediment Concentration[a] (mg/kg)**	**Reference Area Sediment Concentration Statistic[b] (mg/kg)**	**Sediment Quality Benchmark (mg/kg)**
Aluminum (Al)	32000	18200	58000[c]
Antimony (Sb)	5	2	25[d]
Arsenic (As)	54	14.2	17[e]
Barium (Ba)	18000	156	NBA
Cadmium (Cd)	4.3	0.76	3.5[e]
Chromium (Cr)	82	43.2	90[e]
Cobalt (Co)	34	21.8	50[f]
Copper (Cu)	39	32.6	197[e]
Iron (Fe)	120000	40400	43766[g]
Lead (Pb)	150	29.4	91.3[e]
Lithium (Li)	48	21.5	NBA
Manganese (Mn)	45000	2220	1100[h]
Molybdenum (Mo)	3	2	NBA
Nickel (Ni)	60	65.2	75[g]
Rubidium (Rb)	15	10.5	NBA
Selenium (Se)	2	2	5[i]
Silver (Ag)	0.7	0.5	3.7[j]
Strontium (Sr)	46	35.4	NBA
Thallium (Tl)	1.4	0.2	NBA
Tin (Sn)	8	2	NBA
Uranium (U)	0.8	2.3	NBA

Parameter	Maximum Measured Study Boundary Sediment Concentration[a] (mg/kg)	Reference Area Sediment Concentration Statistic[b] (mg/kg)	Sediment Quality Benchmark (mg/kg)
Vanadium (V)	99	41.2	NBA
Zinc (Zn)	680	206	315[e]

Notes:
NBA = no benchmark available.
Bolded chemicals are those for which the maximum measured sediment concentration exceeds the reference sediment concentration statistic.
Shaded chemicals are those for which the maximum measured sediment concentration exceeds the PEL or similar sediment quality benchmark. Chemicals are also shaded if no sediment quality benchmarks were identified.
a N=10.
b N=25 (pooled reference area data) except for Li, Rb, Sn, where N=16. Value presented is lowest of the 90th percentile or two times the arithmetic mean, unless a substance was not measured above the RDL in any reference surface water sample. In that event, the reference concentration statistic is the typical RDL value that is regularly achieved by the laboratory.
c Effects Range Median (ERM) for *H. Azteca* - 28 day test; Ingersoll *et al*., (1996).
d NY DEC (1994) Severe Effect Level (SEL).
e CCME (http://ceqg-rcqe.ccme.ca/). Probable Effect Levels (PELs).
f MOE (2008); open water disposal criterion.
g Nagpal *et al*., (2006) Severe Effect Levels (SELs).
h MOE (2008) Severe Effect Level (SEL).
i Nagpal *et al*., (2006) sediment quality guideline.
j NOAA (1999) Effects Range Median (ERM).

As shown in Table H-9, maximum sediment concentrations of most target analytes exceed their sediment reference concentration statistics (nickel, selenium and uranium are the only exceptions). Several substances exceed their respective sediment quality benchmarks (PELs, or similar benchmarks), and several substances have maxima which exceed their respective reference concentration statistics, but lack regulatory freshwater sediment quality benchmarks (*i.e.*, barium, lithium, molybdenum, rubidium, strontium, thallium, tin, and vanadium).

The following chemicals in Study boundary sediments were carried forward into the subsequent screening step – statistical comparison tests.

- Arsenic
- Barium
- Cadmium
- Iron
- Lead
- Lithium
- Manganese
- Molybdenum
- Rubidium
- Strontium
- Thallium
- Tin
- Vanadium
- Zinc

As described previously, any chemicals with Study boundary sediment concentrations that were significantly greater than the reference area sediment concentrations (based on the outcome of t-tests or WMW test) were carried forward as COPCs, and evaluated further. Table H-10 presents the outcome of the statistical comparison tests.

Table H-10 Outcome of Statistical Comparison Tests between Study Boundary and Reference Area Sediment Chemistry Datasets; September, 2011 Sampling Event

Parameter	Statistical Test Outcome
Arsenic	SB>Ref
Barium	NSD
Cadmium	SB>Ref
Iron	SB>Ref
Lead	SB>Ref
Lithium	SB>Ref
Manganese	NSD
Molybdenum[a]	ND
Rubidium	NSD
Strontium	NSD
Thallium	SB>Ref
Tin[a]	SB>Ref
Vanadium	SB>Ref
Zinc	SB>Ref

Notes:

N=10 for Study boundary sediment chemistry data; N=25 for pooled reference area sediment chemistry data except for Li, Rb, Sn, where N=16.

SB = Study Boundary; Ref = reference area; ">" indicates significantly greater than; NSD = no significant difference; ND = no difference.

a For molybdenum and tin, there were not enough samples with measured concentrations above the RDL to conduct statistical comparison tests. However, the maximum, mean and median tin concentrations in Study boundary brook sediments were higher than those in reference brook/stream sediments. For molybdenum, the maximum, mean and median concentrations in Study boundary brook sediments were less than those in reference brook/stream sediments.

Based on the outcome of the statistical comparison tests, the following chemicals within Study boundary sediments were identified as COPCs, and evaluated further.

- Arsenic
- Cadmium
- Iron
- Lead
- Lithium
- Thallium
- Tin
- Vanadium
- Zinc

Summary

Based on the comparisons presented in Tables H-7 to H-10, the following chemicals were identified as the final COPCs in Study boundary brook sediments for both the July, 2010 and September, 2011 sampling events.

- Arsenic (September, 2011 sampling event only)
- Barium (July, 2010 sampling event only)
- Cadmium (both sampling events)
- Iron (both sampling events)
- Lead (both sampling events)
- Lithium (both sampling events)
- Thallium (both sampling events)
- Tin (both sampling events)
- Vanadium (both sampling events)
- Zinc (both sampling events)

H-3.0 REFERENCES

Akin, E.W. 1991. Supplemental Region IV Risk Assessment Guidance. U.S. EPA Region IV, Atlanta, Georgia. March, 1991. Cited In: Suter II, 1995.

Breckenridge, R.P., and Crockett, A.B. 1995. Engineering Forum Issue. Determination of Background Concentrations of Inorganics in Soils and Sediments at Hazardous Waste Sites. United States Environmental Protection Agency, Office of Research and Development, Office of Solid Waste and Emergency Response. EPA/540/S-06/500. December, 1995.

CalEPA. 1997. Selecting Inorganic Constituents of Chemicals of Potential Concern at Risk Assessments at Hazardous Waste Sites and Permitted Facilities. Final Policy. Prepared by: Human and Ecological Risk Division, Department of Toxic Substances Control, California Environmental Protection Agency. February, 1997.

CCME. 1995. Protocol for the derivation of Canadian sediment quality guidelines for the protection of aquatic life. CCME-EPC-98E. Prepared by Environment Canada, Guidelines Division, Technical Secretariat of the CCME Task Group on Water Quality Guidelines, Ottawa.

Chapman, P.M. 2008. Environmental risks of inorganic metals and metalloids: A continuing, evolving scientific odyssey. Human Ecol Risk Assess. 14:5-40.

ICMM. 2007. Metals Environmental Risk Assessment Guidance (MERAG). International Council on Mining and Metals. http://www.icmm.com/uploads/1538MERAG.pdf

Ingersoll, C.G., Haverland, P.S., Brunson, E.L., Canfield, F.J., Dwyer, C.E., Henke, N.E., Kemble, D.R., and Fox, R.G. 1996. Calculation and evaluation of sediment effect concentrations for the amphipod *Hyalella azteca* and the midge *Chironomus riparius*. J. Great Lakes Research.22(3):602-623. Cited in: MacDonald *et al*., 1999.

Intrinsik Environmental Sciences Inc. 2009. Preliminary Ecological Risk Assessment, Brunswick Mines: Results of Phase II Sampling Program and Proposed Approach for Phase III. Final Report. Prepared for: Xstrata Zinc. June, 2009.

Intrinsik Environmental Sciences Inc. 2010a. Ecological Risk Assessment of Fugitive Dusting from Tailings, Brunswick Mine No. 12. Prepared for: Xstrata Zinc. December, 2010.

Intrinsik Environmental Sciences Inc. 2010b. Data Quality Assurance Report for Little River Water and Sediment Sampling/Analysis Programs Conducted in 2008 and 2009. Final Report. May, 2010. Prepared for: Mr. Ken Glasbergen, LGL Ltd.

Kapustka, L., Clements, W.H., Ziccardi, L., Paquin, P.R., Sprenger, M., and Wall, D. 2004. Issue Paper on the Ecological Effects of Metals. Submitted to: U.S. Environmental Protection Agency, Risk Assessment Forum.

Leadon, C.J., McDonnell, T.R., Laer, J., and Barclift, D. 2007. Calculating background levels for ecological risk parameters in toxic harbour sediment. Soil and Sediment Contamination. 16:433-350.

Long, E.R., Field, L.J., and MacDonald, D.D. 1998. Predicting toxicity in marine sediments with numerical sediment quality guidelines. Environ Toxicol Chem. 17(4):714–727.

MacDonald, D.D., Berger, T., Wood, K., Brown, J., Johnsen, T., Haines, M.L., Brydges, K., MacDonald, M.J., Smith, S.L. and Shaw, D.P. 1999. A Compendium of Environmental Quality Benchmarks. Appendix 2-5 A summary of the available water quality criteria and guidelines for the protection of marine and estuarine aquatic life. Prepared for Environment Canada. GBEI/EC-99-001.

MDEP. 2006. Technical Update. Revised Sediment Screening Values. Massachusetts Department of Environmental Protection, Office of Research and Standards. http://www.mass.gov/dep/water/laws/ecoturss.pdf

MDNRE. 2010. Michigan Department of Natural Resources and Environment. Rule 57 Water Quality Values. http://www.michigan.gov/deq/0,1607,7-135-3313_3686_3728-11383--,00.html.

MOE. 2008. Guidelines for Identifying, Assessing and Managing Contaminated Sediments in Ontario: An Integrated Approach. Ontario Ministry of Environment. May, 2008. PIBS 6658e.

MOE. 1999. Water Management Policies Guidelines and Provincial Water Quality Objectives of the Ministry of the Environment of Energy. July 1994. Revised February, 1999.

MOEE. 1993. Typical Range of Chemical Parameters in Soil, Vegetation, Moss Bags and Snow. Ontario Ministry of Environment and Energy.

Myers, J., and Thorbjornsen, K. 2004. Identifying metals contamination in soil: a geochemical approach. Soil and Sediment Contamination 13:1-16.

Nagpal, N.K., L.W. Pommen, and L.G. Swain. 2006. A Compendium of Working Water Quality Guidelines for British Columbia. Science and Information Branch, Ministry of Environment. URL: http://www.env.gov.bc.ca/wat/wq/BCguidelines/working.html.

Newman. M.C., and Clements, W.H. 2008. Ecotoxicology. A Comprehensive Treatment. CRC Press. New York.

NOAA. 1999. Sediment Quality Guidelines Developed for the National Status and Trends Program. National Oceanic and Atmospheric Administration. June, 1999.

NY DEC. 1994. Technical Guidance for Screening Contaminated Sediments. New York State Department of Environmental Conservation, Division of Fish, Wildlife, and Marine Resources.

Pendergast, J.F., Ausley, L.W., Bro-Rasmussen, F., Cappel, C.R., Delos, C., Dorward-King, E.J., Ethier, G., Hansen, D.J., LeBlanc, N.E., Lee, C.M., and Viteri, A. 1996. Chapter 3. Regulatory practice for metals. In: Bergman, H.L., and Dorward-King, E.J. Eds. 1997. Reassessment of metals criteria for aquatic life protection. Priorities for Research and Implementation. SETAC Technical Publications Series. SETAC Press. ISBN 1-880611-04x.

Prothro, M.G. 1993. Office of water policy and technical guidance on interpretation and implementation of aquatic metals criteria. Memorandum from Acting Assistant Administrator for Water. Washington, DC. U.S. EPA Office of Water. Cited in: Pendergast *et al*., 1996.

Tannenbaum. L.V. 2003. Understanding background in hazardous waste site risk assessments: getting back to basics. Human Ecol Risk Assess. 9:1599-1607.

Suter II, G.W. 1995. Guide for Performing Screening Ecological Risk Assessments at DOE Facilities. Environmental Restoration Risk Assessment Program. Prepared for: U.S. Department of Energy, Office of Environmental Management.

U.S. EPA. 2011. Current National Recommended Water Quality Criteria. http://www.epa.gov/waterscience/criteria/wqcriteria.html.

U.S. EPA. 2002. Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites. United States Environmental Protection Agency, Office of Emergency and Remedial Response. EPA 540-R-01-003. OSWER 9285.7-41. September, 2002.

U.S. EPA. 2001. Guidance for Characterizing Background Chemicals in Soil at Superfund Sites. External Review Draft. United States Environmental Protection Agency, Office of Emergency and Remedial Response. EPA 540-R-01-003. OSWER 9285.7-41. June, 2001.

U.S. EPA. 2000. Supplemental Guidance to RAGS: Region 4 Bulletins, Human Health Risk Assessment Bulletins. EPA Region 4, originally published November 1995, Website version last updated May 2000. URL: http://www.epa.gov/region4/waste/ots/healtbul.htm

U.S. EPA. 1993. Water Quality Criteria: aquatic life criteria for metals. Federal Register 58(108):32131-32133.

VROM. 2001. Environmental Quality Standards in the Netherlands 1999. A Review of Environmental Quality Standards and the Policy Framework in the Netherlands. Ministry of Housing, Spatial Planning and the Environment. Directorate-General for Environmental Protection. ISBN 90 14 08189 8.

Washington DOE. 1992. Statistical Guidance for Ecology Site Managers. Washington State Department of Ecology. Cited in Wyoming DEQ, 2004.

WESA. 2005. Incorporating Background Soil Quality into Risk Assessment. Water and Earth Science Associates Ltd. Prepared for: Health Canada. August, 2005.

Wyoming DEQ. 2004. Fact Sheet #24. Establishing Site-Specific Background Metals Concentrations in Soil. June, 2004.

APPENDIX I

ESTABLISHMENT OF ERA SPATIAL STUDY BOUNDARY

APPENDIX I ESTABLISHMENT OF ERA SPATIAL STUDY BOUNDARY

I-1.0 INTRODUCTION

The delineation of study boundaries for wide area ERAs is typically an iterative process that involves a number of steps to identify and successively refine the spatial extent of the area(s) that require detailed investigation. Such an iterative approach was followed in the current ERA. The key steps, or sequence of events, in establishing the Study boundary for the ERA were as follows. Each of these steps is described and discussed in the subsequent sections.

1) Review of previous studies conducted in the Belledune area.
2) Review of 2009 soil survey of Glencore and Crown lands within a 7 km radius of the smelter complex (*i.e.,* Principal sampling area).
3) Consideration of COPC identification outcomes for the terrestrial ERA and detailed review of soil chemistry data.
4) Consideration of supporting air dispersion and deposition modelling outcomes.
5) Consideration of supporting geological information.

I-2.0 KEY STEPS/SEQUENCE OF EVENTS IN ESTABLISHING THE ERA STUDY BOUNDARY

I-2.1 Review of Previous Studies Conducted in the Belledune Area

An important early step in any study boundary delineation process is to review available studies that previously determined the spatial extent of contamination in environmental media (primarily soil in this case), and/or established study areas or other specific locations of interest, that were focused on within these assessments.

The previous studies (and other information sources) that were reviewed are as follows:

- Shore Road Soil Study (Intrinsik Environmental Sciences *et al*., 2008).
- Glencore Environmental Effects Monitoring (EEM) program data and annual reports of the EEM program.
- Glencore 3 km grid sampling from 2004. This sampling program consisted of lead X-ray Fluorescence (XRF) analysis of soils.
- Assessment of Biodiversity Near Canadian Operations, Brunswick Smelter, New Brunswick (LGL Ltd., 2008).
- Belledune Area Health Study (Goss-Gilroy *et al*., 2005). As this study relied on existing media chemistry data available at the time (*i.e*., no sampling occurred in relation to this study), the review focused on compiled information relating to wind direction (and frequency), and air dispersion modelling outcomes.
- Other relevant studies and data related to off-site soil analyses, forage or other vegetation analyses, and wildlife surveys.

In general, the outcomes of these previous studies suggested that soil impacts from the deposition of smelter emissions are likely restricted to an area within a few km radius of the smelter complex. Although not all of the previous studies or programs collected soil data (and the soil data collected for some of these studies/programs did not provide comprehensive spatial coverage of all areas potentially influenced by smelter emissions, and were generally limited to selected metals of interest), it was consistently found that lead and arsenic[1] concentrations in soil were below Canadian Council of Ministers of the Environment (CCME) soil quality guidelines for the protection of environmental health, beyond a distance of 2 to 4 km from the smelter (CCME environmental health based guidelines are 300 mg Pb/kg soil and 17 mg As/kg soil). There were some exceptions though, mainly in areas that have natural geological arsenic enrichment. There were also some other notable exceptions in areas where smelter-related materials were transported by means other than atmospheric dispersion and deposition of stack emissions (such as off-site use of smelter equipment, historical use of slag as a skid control agent, incidental losses from transporting concentrate). Such areas underwent soil excavation and replacement with clean imported soil in 2008-2009, if lead was present at concentrations greater than 500 mg/kg (a human health based risk management concentration; see Intrinsik Environmental Sciences *et al*., 2008 for further details). In all cases, the properties that underwent soil corrective action were residential, and were not areas of substantive ecological habitat.

Wind direction and frequency data reported in Goss-Gilroy *et al*., (2005) indicated that wind predominantly blows from the west (22 – 25% of the time) and west north west (17% of the time), followed by winds from the east-south-east direction (approximately 10% of the time). Thus, the prevailing winds would mostly carry smelter emissions either out to sea (in the Baie des Chaleurs), or along the coastline, in a predominantly easterly-south-easterly direction. The wind direction and frequency data reported by Goss-Gilroy *et al*., (2005) were confirmed by reviewing the data posted on Environment Canada's National Climate Data and Information Archive (http://climate.weatheroffice.gc.ca/climateData/canada_e.html) for meteorological stations in the vicinity of Belledune.

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[1] Lead and arsenic are known to be the major substances emitted from the smelter. Lead is considered the best marker for smelter soil impacts due to its tendency to bind to organic carbon in surficial soils. Arsenic is also a reasonably good marker of smelter impacts, but can be confounded by areas with natural geological enrichment of arsenic.

I-2.2 Soil Survey of Glencore and Crown Lands within a 7 km Radius of the Smelter Complex

Considering the outcomes and the scope/objectives of the previous studies (listed in Section I-2.1), as well as local wind direction and frequency data, a soil sampling program was developed and initiated in 2009. The goal of this program was to capture, as best as possible, the areas potentially affected by atmospheric deposition of smelter emissions.

Using the data and outcomes from the aforementioned studies as a guide, a 7 km radius around the smelter site (hereafter referred to as the Principal sampling area) was conservatively selected to investigate whether or not soils in ecological areas (*i.e.,* undeveloped properties that do not have a current residential, commercial, or industrial land use) surrounding the smelter may be potentially influenced by the historical deposition of smelter emissions.

Soil sampling within the Principal sampling area was limited by property ownership (*i.e.*, sampling was restricted to Glencore and New Brunswick Department of Natural Resources owned lands, or Crown Lands; privately held lands were not sampled). Active industrial lands owned by Glencore were also excluded from sampling. In addition, certain areas due east and due west of the smelter were also excluded from the soil sampling program, as these particular areas had been extensively sampled previously in the Shore Road Soil Study (Intrinsik Environmental Sciences *et al*., 2008), and can largely be characterized as residential, recreational and agricultural land use. These areas were not re-sampled as sufficient soil chemistry data (collected using similar protocols to those used in the current ERA) pre-existed.

As it is known that forest canopy cover can influence soil metal/metalloid concentrations (*e.g*., interception of atmospheric deposition, pulse releases of chemicals retained in foliage during senescence, high organic carbon content of forest floor can sequester certain metals), the candidate sampling stations within the Principal sampling area were reviewed to examine forest type, composition, developmental stage and percent canopy closure (based on GIS mapping conducted for a previous biodiversity study that considered an 8 km radius of the smelter; LGL, 2008). Candidate soil sampling locations were examined by LGL Limited in relation to these forest metrics. LGL's review focused on whether or not the candidate sampling locations were areas that would likely be influenced by canopy cover effects and/or sequestration of metals/metalloids in forest floor soils. The review concluded that such areas were adequately captured in the 2009 soil sampling plan, and that the sampling locations provided good coverage of mature forest locations (See Appendix B for further details).

An equilateral triangle grid-based sampling design was selected for the 2009 soil sampling program. Soil samples were collected at the node of each grid intersection (or as close to this location as was feasible). A distance of 750 m between grid nodes was selected. The grid was laid over the land within a 7 km radius of the smelter site (*i.e.,* the Principal sampling area), excluding private lands (which included NB Power-owned lands), active industrial lands owned by Glencore, and areas that were already sufficiently characterized from previous soil surveys.

The soil sampling protocol that was used in the 2009 program is described in detail in Appendix A, and further details pertaining to soil sampling for the ERA are provided in the main ERA report (Section 3.0). Briefly, surface soil samples were taken from a depth of 0 to 5 cm from each of the 84 sampling locations (*i.e.*, 61 within the Principle sampling area, and 23 within the reference area). Twenty stations within the Principle sampling area were cored (0 – 5 cm; 5 – 15 cm and 15 – 30 cm depth samples) to examine soil chemistry with depth. Ten reference area stations were similarly cored. For all soil sampling, a composite sampling approach was used where each composite sample consisted of five sub-samples collected at equal distances from each other over a “W” pattern in a 20 m by 20 m area (the mid-sampling point of the W was located in the centre of the 20 m x 20 m block). The five sub-samples were homogenized in the field, and one sample representing the composited sub-samples was submitted for analysis (*i.e.*, U.S. EPA 3050b and ICP-MS for available metals/metalloids analysis (all samples); 10% of all soil samples were also analyzed for pH and total organic carbon).

The reference area stations were located on undeveloped Crown lands with similar underlying geology, and similar ecoregions and ecosites to the Principal sampling area, located roughly 20 to 30 km west-southwest of the smelter facility (which is also upwind of the prevailing wind direction in the Belledune area).

Figure I-1 shows the Principal sampling area with soil sampling station locations, and Figure I-2 shows the location of the reference area, relative to the Principal sampling area (also with soil sampling station locations). The location of the smelter complex in these figures is at the innermost radii.

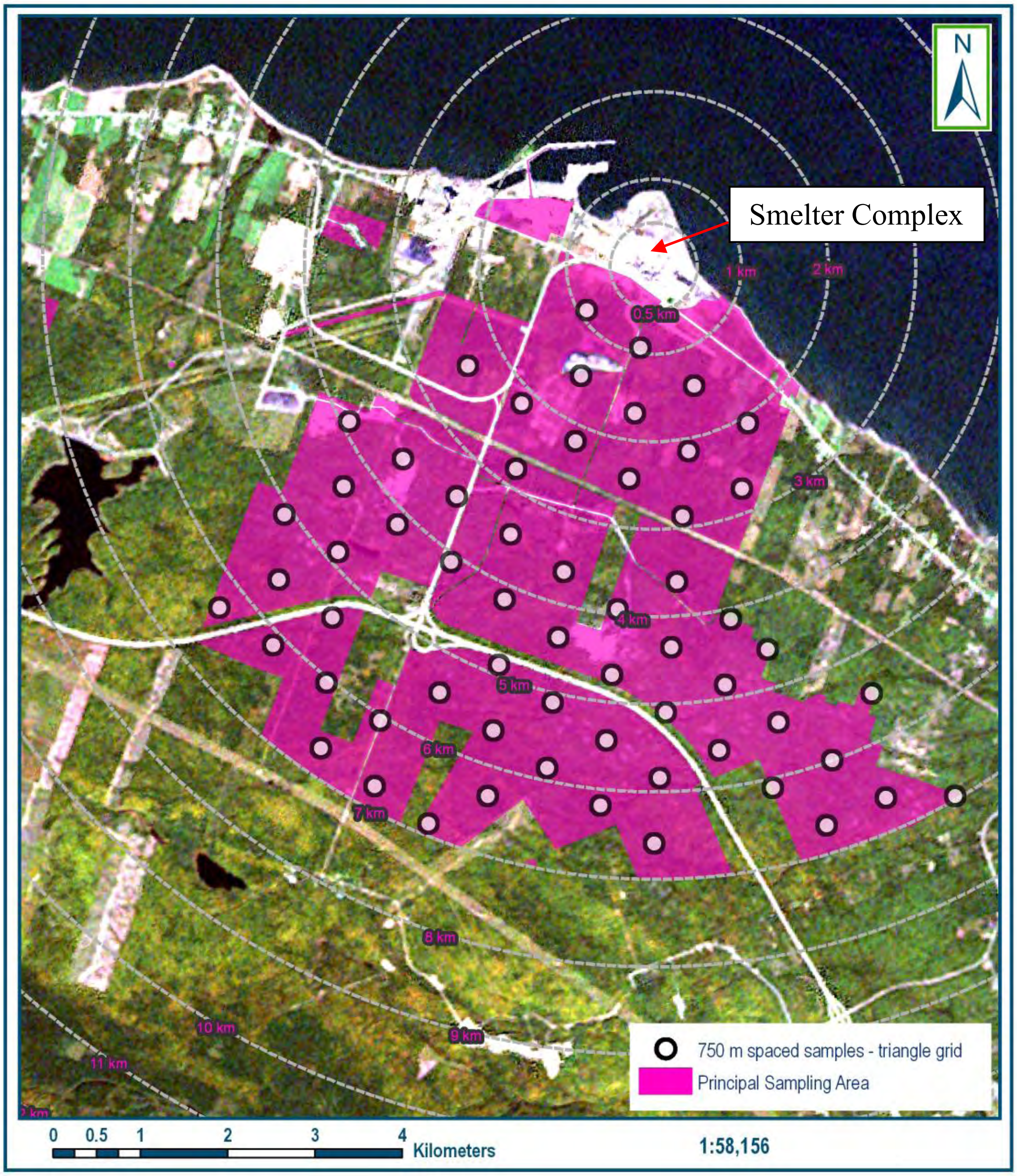

Figure I-1 Principal Sampling Area and Soil Sampling Station Locations in the Vicinity of the Glencore Smelter, Belledune, New Brunswick

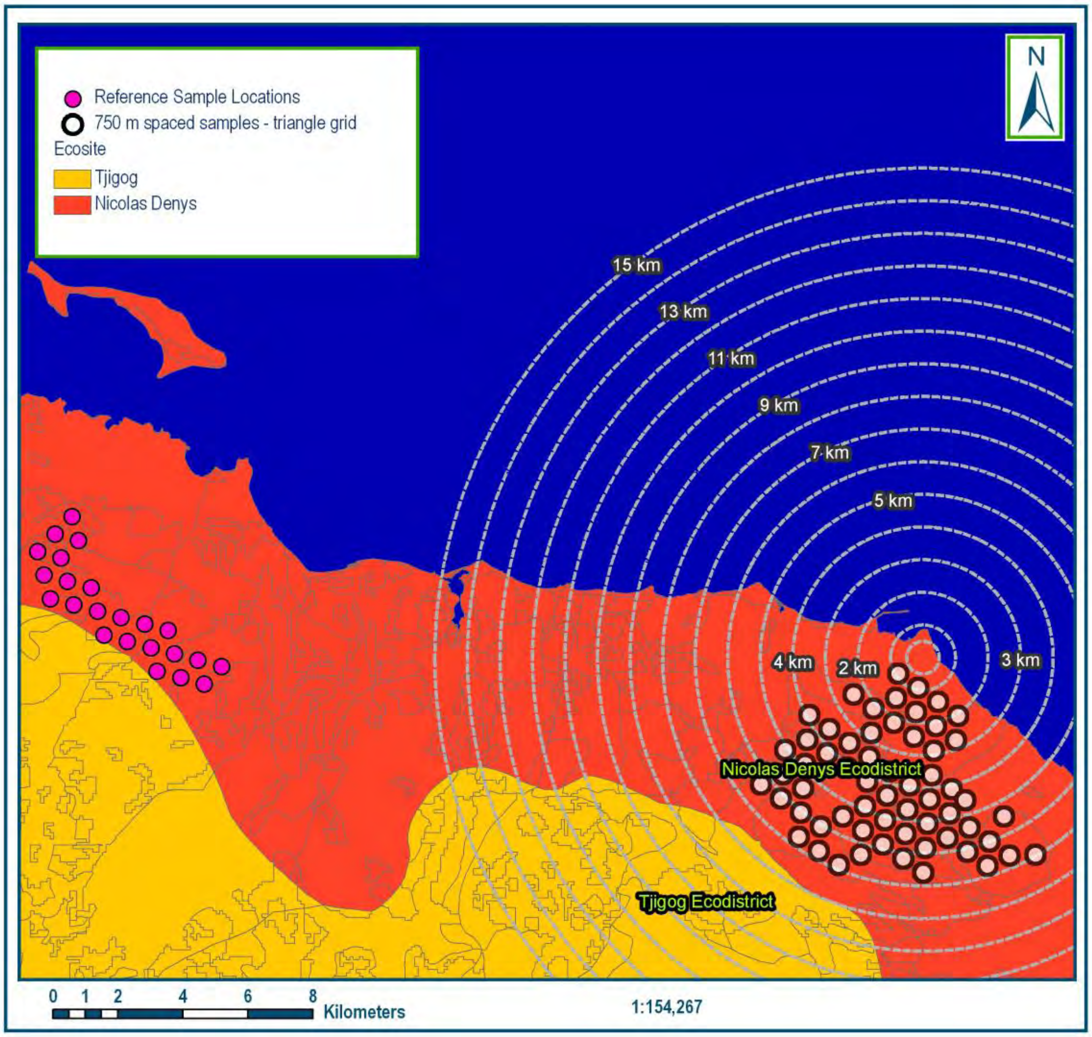

Figure I-2 Reference Area Soil Sampling Station Locations Relative to the Principal Sampling Area and Local Ecodistricts

I-2.3 Consideration of COPC Identification Outcomes for the Terrestrial ERA and Detailed Review of 2009 Soil Chemistry Data

In wide area ERAs (such as the current Study), the COPC identification process is often linked to the procedures which delineate spatial study boundaries. This is because elevated concentrations of chemicals in environmental media that are associated with a given source will always occur over some definable spatial area.

As discussed in Appendix G, the initial list of candidate COPCs that was generated from the first three steps of the COPC identification process (See Table G-10) contained several unexpected chemicals, given what is known about emissions from the Glencore smelter. Some of the items/issues considered in refining the list of COPCs down to what became the final COPCs (*i.e.*, antimony, arsenic, cadmium, lead, thallium, and zinc) were also helpful and relevant towards establishing the spatial study boundary for the ERA (specifically: smelter stack elemental emissions data; spatial distribution patterns of soil chemical concentrations; outcomes of air dispersion and deposition modelling studies; geological review of soil chemistry data; correlation analysis of soil chemistry data). Both the air dispersion and deposition modelling study, and the geological review were supplementary investigations that were specifically conducted as part of efforts to refine the initial COPC identification process, and to aid in delineating the ERA study boundary. These two evaluations are described further in Sections I-2.4 and I-2.5.

Overall, the outcomes of COPC identification and detailed review of the 2009 soil chemistry data indicated that not all areas sampled within the Principle sampling area required further study in the ERA. The most pertinent study boundary-related findings that arose from the detailed soil data review and the items/issues considered in determining the final list of COPCs were as follows (see Appendix G for further details):

- Several substances that were initially identified as candidate COPCs were considered unlikely to be associated with smelter emissions (*i.e.*, chromium, iron, lithium, nickel, rubidium, and vanadium), mostly on the basis of very low stack emission rates from the smelter, and/or poor correlations between soil concentrations of these six elements and soil concentrations of major stack emissions (such as arsenic, lead and zinc). Thus, areas with elevated soil concentrations of these six substances may reflect natural enrichment, or other sources, rather than the atmospheric deposition of smelter emissions.

- Maps showing the spatial locations and A layer (0 to 5 cm) soil concentrations of chromium, nickel, and vanadium demonstrate that soil concentrations generally increase with increasing distance from the smelter, or are similar at all distances from the smelter (out to 7 km), with no clear concentration gradient. This was also the case for lithium, iron and rubidium. In particular, all exceedances over soil quality benchmarks for nickel and vanadium occurred at distances greater than 3 km from the smelter, with no exceedances within 3 km. These are patterns that are contrary to what is typically observed if soil concentrations of a particular element are influenced by the deposition of emissions from a point source.

Figures I-3 to I-5 present maps showing the A layer (0-5 cm) soil concentrations of chromium, nickel, and vanadium throughout the Principal sampling area, in relation to their corresponding CCME environmental health-based soil quality guidelines[2].

- The outcomes of the correlation analysis conducted on the 2009 soil chemistry data (see Appendix G) showed that Principal sampling area A layer soil concentrations of the major smelter emissions (*i.e.,* arsenic, lead and zinc) are, for the most part, weakly (meaning positive but not statistically significant) or negatively correlated to soil concentrations of chromium, iron, lithium, nickel, rubidium, and vanadium. Thus, areas with elevated soil concentrations of these 6 substances, that do not have elevated soil concentrations of lead, arsenic, or zinc, are likely not influenced by the deposition of smelter emissions, but rather, may reflect natural enrichment or other sources.

- For the substances that were identified as the final COPCs (*i.e.,* antimony, arsenic, cadmium, lead, thallium, zinc), exceedances of CCME environmental health-based soil quality guidelines generally occurred very close to the smelter property (*i.e.*, 0 to 3 km, with the exception of arsenic, which is addressed in Sections I-2.4 and I-2.5).

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[2] Iron, lithium, and rubidium A layer soil concentrations were not plotted as no concentration-based environmental soil quality benchmarks were identified for these substances. Furthermore, these substances were excluded from consideration as COPCs on the basis of either no identified toxicity data (lithium, rubidium), or a well established role as a modifier rather than a cause of toxicity (iron).

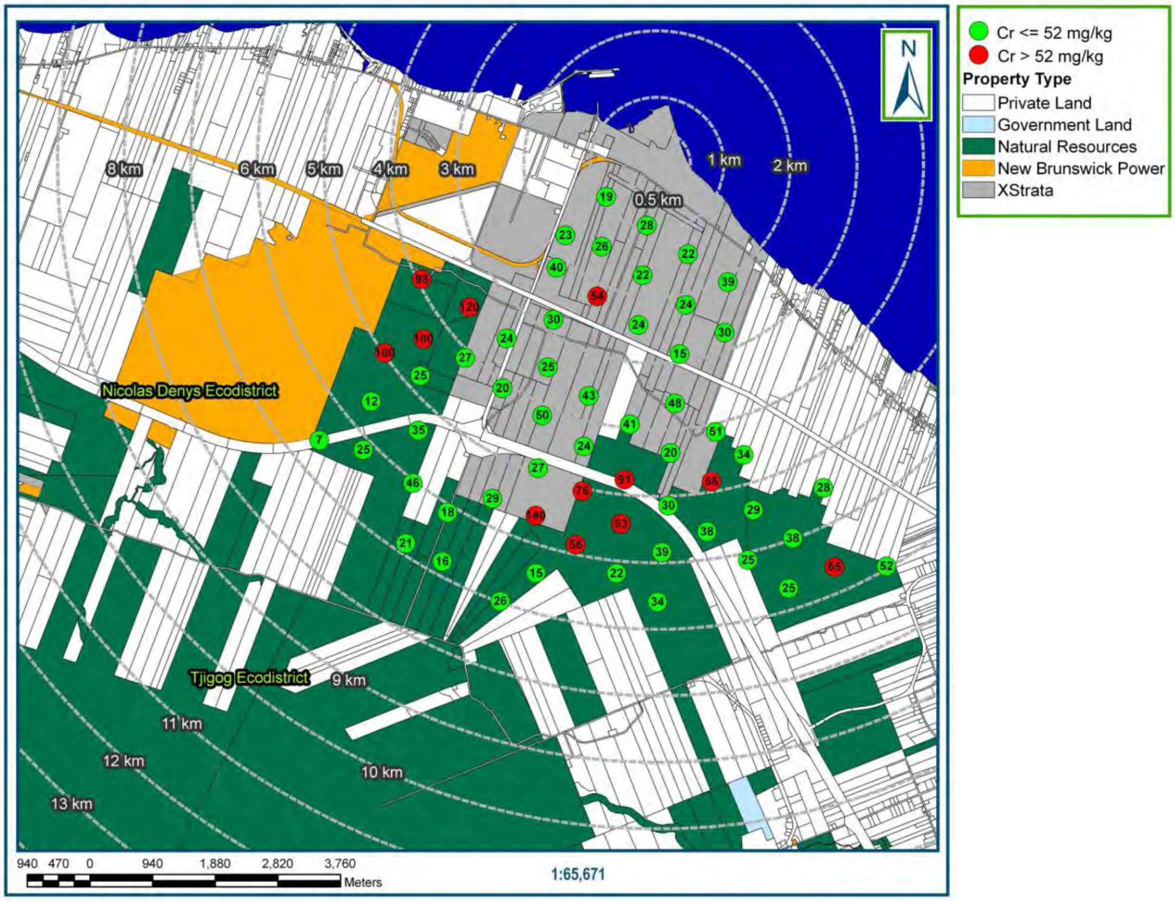

Figure I-3 A Layer (0-5 cm) Soil Concentrations of Chromium (Total) in Relation to CCME Soil Quality Guideline for the Protection of Environmental Health (52 mg/kg)

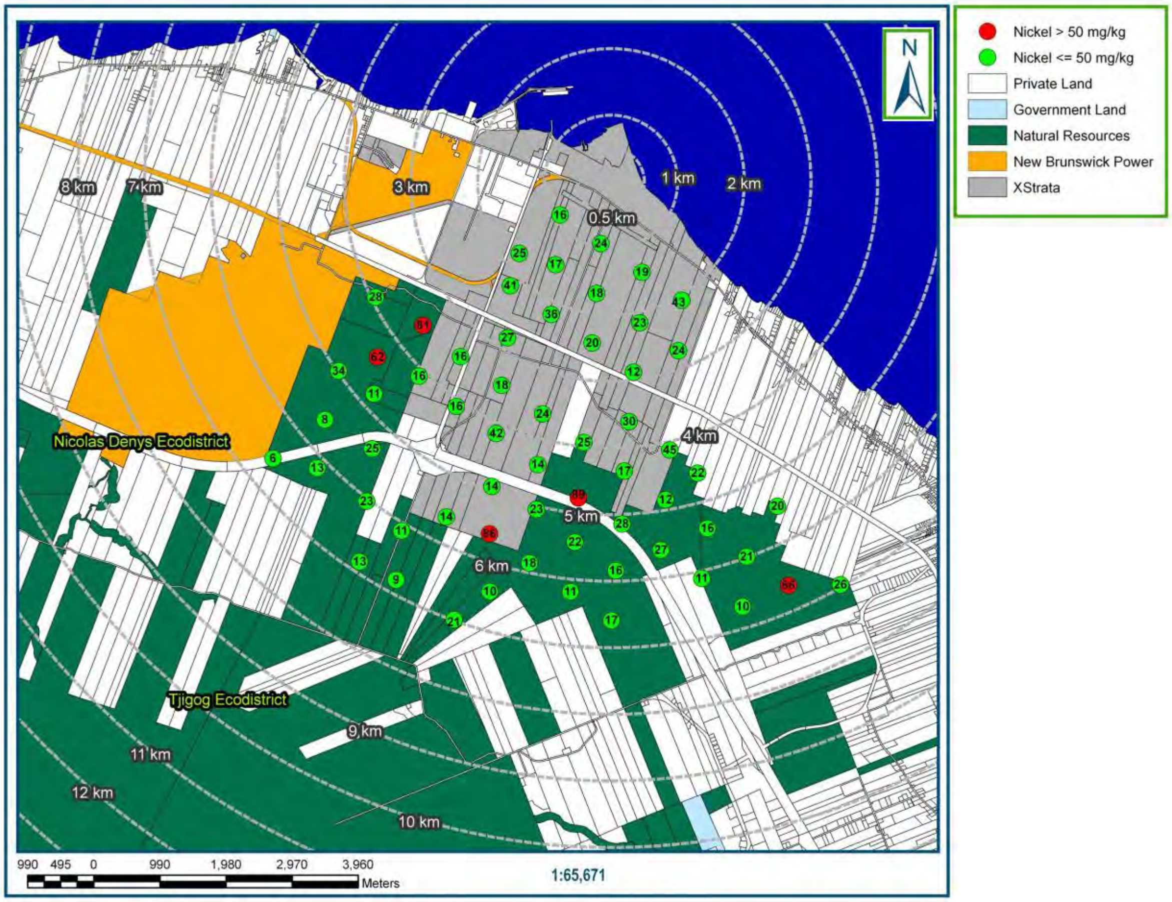

Figure I-4 A Layer (0-5 cm) Soil Concentrations of Nickel in Relation to CCME Soil Quality Guideline for the Protection of Environmental Health (50 mg/kg)

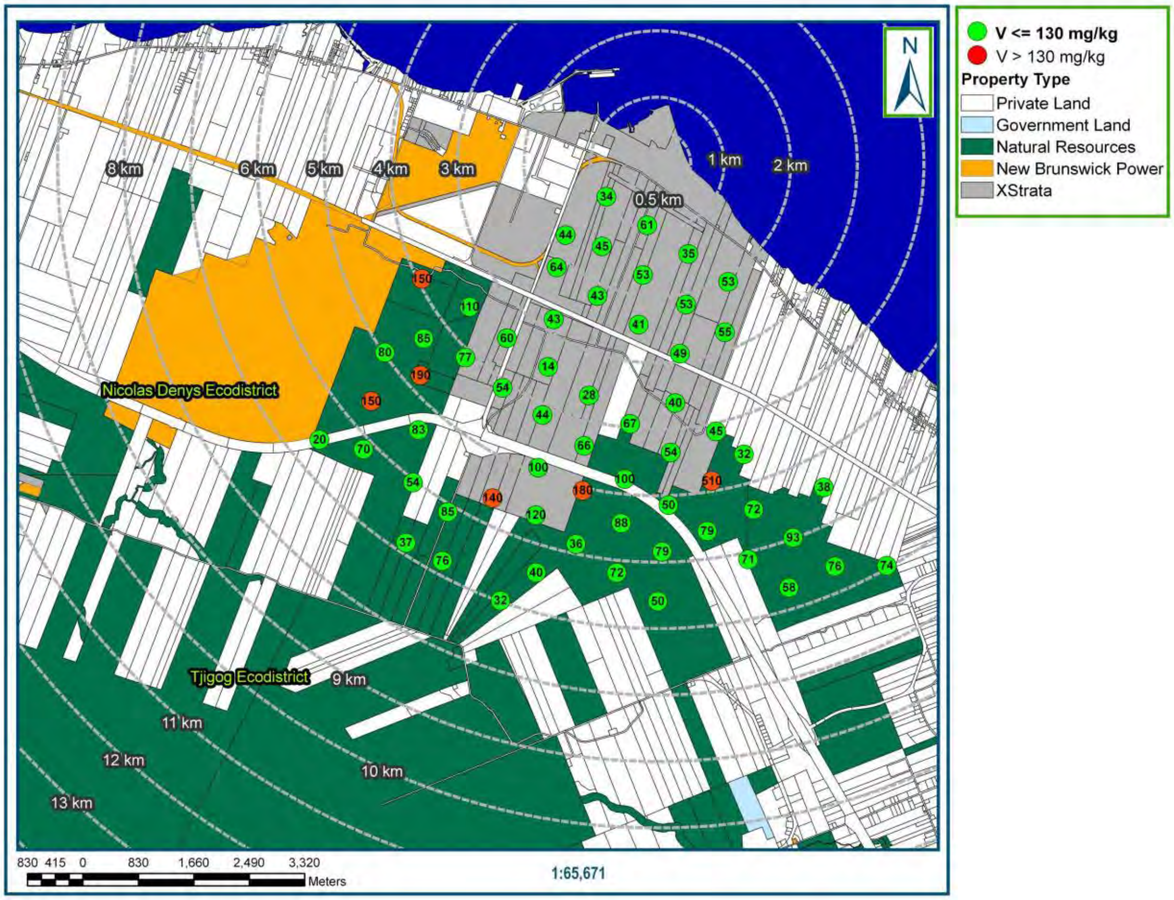

Figure I-5 A Layer (0-5 cm) Soil Concentrations of Vanadium in Relation to CCME Soil Quality Guideline for the Protection of Environmental Health (130mg/kg)

I-2.4 Air Dispersion and Deposition Modelling Outcomes

With most point sources of air emissions, it is typical to observe the greatest degree of deposition of major emitted substances within a few km of the source (subject to facility-specific, topographic and meteorological factors). Available air dispersion/deposition modelling studies of the Glencore smelter emissions (in 2010 by A.J. Chandler & Associates, and in 1991 by Concord Environmental) have shown that the highest ground level air concentrations, and highest rates of atmospheric deposition, tend to occur within 3 km of the smelter facility. For the particulate bound substances modelled in these studies (which would include all metals and metalloids), the maximum points of impingement occurred either in the Baie des Chaleurs, or near the coastline within 1 to 2 km of the smelter facility. Although the Concord Environmental air dispersion study is older, it was validated with measured air quality monitoring data, and was found to produce realistic results.

Figures I-6 and I-7 show the deposition patterns (*i.e.,* the oblong "cloud" along the coast) for arsenic and lead emissions from the 2010 air dispersion and deposition modelling study (conducted by A.J. Chandler & Associates). The units for arsenic and lead deposition in Figures I-6 and I-7 are g/m^2/day. Both figures show that the areas with the greatest potential for deposition of lead and arsenic (the two principal elemental emissions from the smelter) lie near the coastline with substantial deposition occurring in the Baie des Chaleurs, and the areas of highest land deposition occurring within 2 km of the smelter. These figures also show that there is essentially negligible deposition of smelter emissions from the southwest to southeast directions beyond a distance of 3 km from the smelter. The 2010 air dispersion and deposition modelling study is described and discussed further in Attachment I-1 to this appendix.

Figures I-6 and I-7 also show which samples exceeded the CCME environmental soil quality guidelines for lead and arsenic. With arsenic, there is an unusual pattern with a cluster of exceedances within roughly 2 km of the smelter, then no exceedances between 2 and 3 km, then a number of exceedances primarily in the southeast quadrant, between 4 and 7 km from the smelter (See Figure I-6). In addition, many of the soil concentrations in this distance category are higher than those within 2 km of the smelter. This pattern for arsenic suggests the influence of naturally elevated concentrations at distances > 4 km from the smelter.

To investigate the potential influence of natural geological enrichment (for arsenic, and several other elements), an experienced geologist with extensive expertise in the geology and mineralogy of the Belledune area (and northeastern New Brunswick in general) was retained. The outcomes of the geologist's report are briefly summarized in Section I-2.5 (below), and the full report is provided as Attachment I-2 to this appendix.

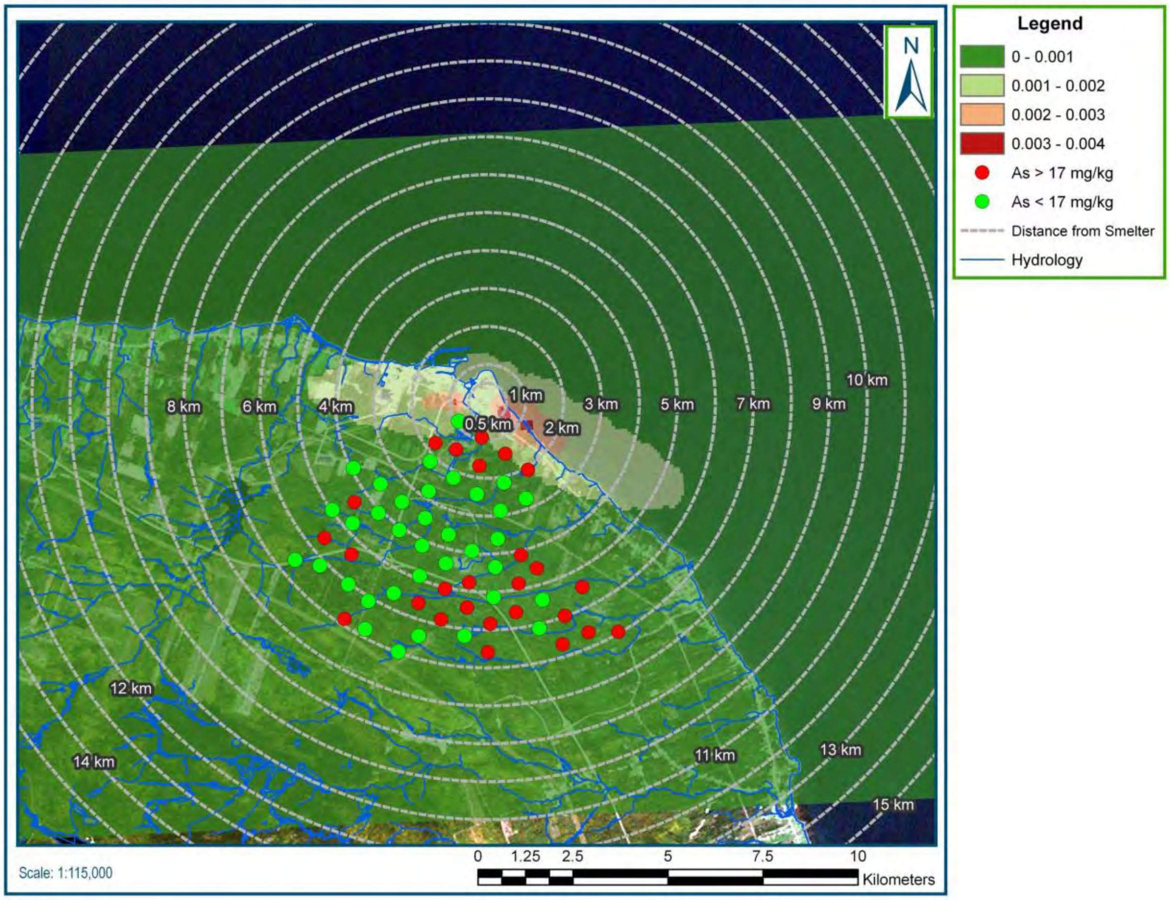

Figure I-6 **Air Dispersion and Deposition Modelling Results for Arsenic ($g/m^2/day$), with 2009 Arsenic Soil Sampling Results Relative to CCME Environmental Soil Quality Guideline (17 mg/kg)**

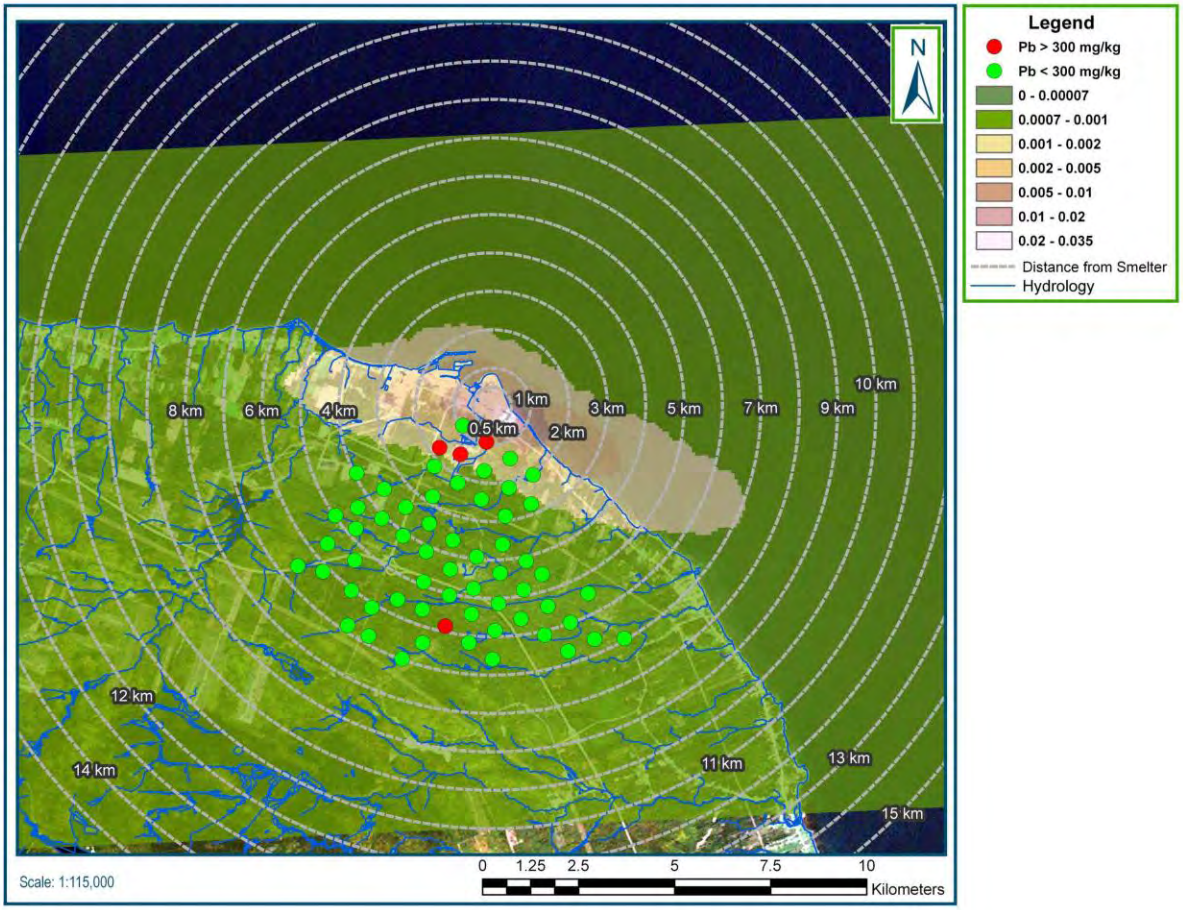

Figure I-7 Air Dispersion and Deposition Modelling Results for Lead (g/m^2/day), with 2009 Lead Soil Sampling Results Relative to CCME Environmental Soil Quality Guideline (300 mg/kg)

I-2.5 Geological Considerations

As previously mentioned, an experienced geologist with extensive expertise in the geology and mineralogy of the Belledune area (and northeastern New Brunswick in general) was retained to address issues regarding some potentially anomalous results for arsenic, as well as a number of other elements, in areas that are >4 km from the smelter, and to the south of the smelter (which is not in the direction of prevailing winds). The 4 km point was noted by the geologist to approximately separate two main groups of rocks – the Ordovician Fournier Group, and the Silurian Chaleurs Group. The elements considered in the geologist's report were arsenic, chromium, lead, nickel, vanadium and zinc. The following paragraphs summarize the conclusions of the geologist with respect to these elements. Further details are provided within the full geologist's report (McCutcheon, 2010), which is provided as Attachment I-2 to this appendix.

Arsenic

Given the unusual soil concentration pattern observed for arsenic in the 2009 soil chemistry dataset, this substance was focused on in the geologist's report. Figure I-8 shows the A layer (0 to 5 cm) arsenic soil concentrations overlaid onto a map of bedrock geology.

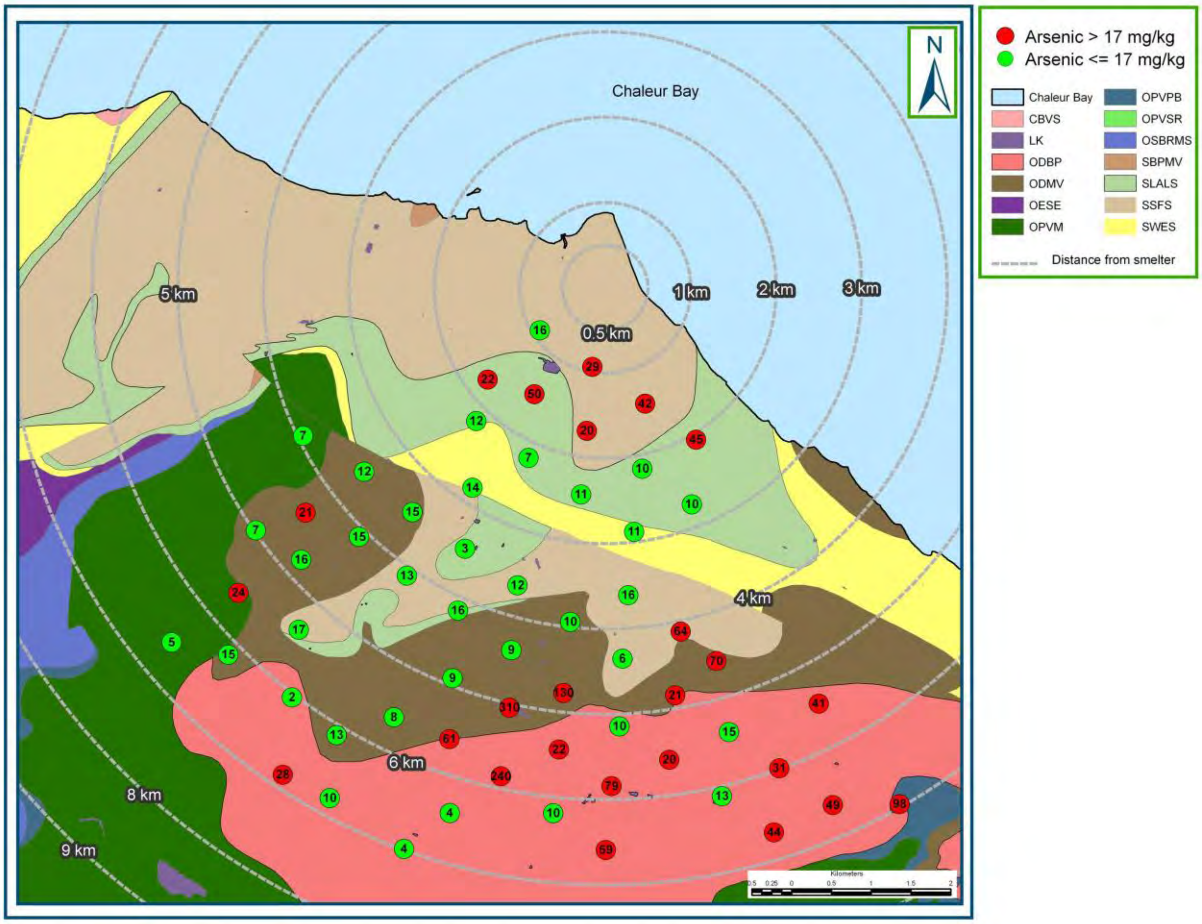

Figure I-8 **Arsenic A Layer (0 to 5 cm) Soil Concentrations in Principal Sampling Area Overlaid Onto New Brunswick Bedrock Geology Map Layer**

In reviewing the 19 measured occurrences of arsenic soil concentrations at >4 km from the smelter that exceeded the CCME environmental soil quality guideline (termed 'anomalous As values' in the geologist's report), it was concluded by the geologist that most, if not all of these occurrences were related to a bedrock source. The majority of these anomalous values were in areas of documented arsenic-bearing mineral occurrences (as listed within the New Brunswick Mineral Occurrence Database; http://drne-mrne.gnb.ca/mineraloccurrence/). A recent report from Natural Resources Canada has also documented naturally elevated arsenic soil concentrations in many areas of New Brunswick, including the lands within the Principal sampling area (*i.e.*, Klassen *et al.*, 2009). In addition, geochemical surveys conducted in the 1960s documented frequent instances of naturally elevated arsenic concentrations in stream sediments in numerous watercourses across northeastern New Brunswick (Boyle *et al.*, 1966).

Further support for the geologist's conclusions comes from performing calculations of the theoretically possible surface soil concentrations that could occur due to deposition of smelter arsenic emissions. For example, using U.S. EPA (2005) algorithms for calculating soil loading rates and incremental bulk soil concentrations, assuming a 2 cm mixing zone, using the maximum predicted arsenic deposition rate (0.004 g As/m^2/day; see Figure I-6), assuming no losses of arsenic from soil once deposited, and assuming 100 years of deposition at the maximum rate, the predicted arsenic soil concentration in the top two cm of soil is 13 mg/kg. This is well below the majority of the measured arsenic soil concentrations at distances >4 km from the smelter, even when this incremental soil concentration is added to the maximum reference area soil concentration (which could be considered a theoretical baseline concentration). Given that this example calculation is highly conservative (*i.e.*, the smelter has not operated for 100 years - rather, it has operated for roughly 44 years; there would be some soil losses of arsenic; not all arsenic would remain in the top two cm; and, the predicted deposition rate at >4 km is roughly ¼ of the maximum predicted deposition rate), it is implausible that the deposition of smelter emissions at distances >4 km could account for the observed elevated arsenic soil concentrations in these areas.

Lead

The single measured occurrence of a lead soil concentration at >4 km from the smelter that exceeded the CCME environmental soil quality guideline (*i.e.*, soil concentration was 340 mg/kg, and termed 'anomalous Pb value' in the geologist's report), could not be attributed to a known New Brunswick mineral occurrence or bedrock source. However, as illustrated above for arsenic, calculations of the theoretically possible surface soil concentrations that could occur due to deposition of smelter lead emissions, shows that it is implausible that the deposition of smelter emissions at distances >4 km could account for the observed elevated lead soil concentration at this location. For example, using U.S. EPA (2005) algorithms for calculating soil loading rates and incremental bulk soil concentrations, assuming a 2 cm mixing zone, using the maximum predicted lead deposition rate (0.035 g Pb/m^2/day; see Figure I-7), assuming no losses of lead from soil once deposited, and assuming 100 years of deposition at the maximum rate, the predicted lead soil concentration in the top two cm of soil is 117 mg/kg. Even when this incremental soil concentration is added to the maximum reference area soil concentration (87 mg/kg; which could be considered a theoretical baseline concentration), the resultant concentration is less than what was measured at this location (*i.e.*, 204 mg/kg estimated versus 340 mg/kg measured). Given that this example calculation is highly conservative (*i.e.*, the smelter has not operated for 100 years - rather, it has operated for roughly 44 years; there would be some soil losses of lead; not all lead would remain in the top two cm; and, the predicted deposition rate at >4 km is over 30 times lower than the maximum predicted deposition rate), it is implausible that the deposition of lead emissions from the smelter could account for the observed soil concentration of 340 mg/kg at this location. Rather, this measured soil concentration likely reflects an undocumented occurrence of lead-bearing minerals.

Zinc

In reviewing the 5 measured occurrences of zinc soil concentrations at >4 km from the smelter that exceeded the CCME environmental soil quality guideline (termed 'anomalous Zn values' in the geologist's report), it was concluded by the geologist that all of these occurrences were related to a bedrock source. All anomalous Zn values were in areas of documented copper-zinc or granite-related zinc-bearing mineral deposits (as listed within the New Brunswick Mineral Occurrence Database; http://drne-mrne.gnb.ca/mineraloccurrence/).

Chromium, Nickel and Vanadium

The geologist's report concluded that elevated (or anomalous) soil concentrations of nickel, vanadium and chromium (*i.e.*, those that exceed CCME environmental soil quality guidelines) at distances within, and outside the 4 km radius line, can largely be attributed to a bedrock source, rather than anthropogenic contamination.

I-3.0 SUMMARY

The outcomes of each of the steps considered in establishing the ERA study boundary indicate that the areas requiring further ecological study, in relation to deposition of smelter emissions, are restricted to within a 3 to 4 km radius of the smelter. There is a high degree of confidence in this finding as the outcomes of each step support the outcomes of other steps.

Given that the soil concentrations of COPCs (antimony, arsenic, cadmium, lead, thallium, zinc; See Appendix G) between 3 and 4 km are lower than those within a 0 to 3 km radius, a final ERA study boundary of 0 to 3 km from the smelter was selected. It is believed that this study boundary is realistic, is well supported by the available studies and data, and will not "dilute" the soil concentration statistics evaluated in the ERA. For example, if a larger/wider boundary was selected, the calculated exposure point concentrations for the COPCs would be lower due to the inclusion of lower soil concentrations at the >3 km distances. This could lead to potential underestimation of exposures and risks.

I-4.0 REFERENCES

A.J. Chandler & Associates. 2010. Air Dispersion and Deposition Modelling of Xstrata Zinc Smelter Air Emissions. Prepared for: Intrinsik Environmental Sciences Inc.

Boyle, R.W., Tupper, W.M., Lynch, J., Friedrich, G., Ziauddin, M., Shafiquillah, M., Carter, M., and Bygrave, K. 1966. Geochemistry of Pb, Zn, Cu, As, Sb, Mo, Sn, W, Ag, Ni, Co, Cr, Ba and Mn in the waters and stream sediments of the Bathurst-Jacquet River District, New Brunswick. 21 P/12, 21 P/13, 21 O/9E, 21 O/16E. Geological Survey of Canada, Department of Mines and Technical Surveys. Paper 65-42.

Concord Environmental. 1991. A Dispersion and Deposition Modelling Study of Emissions from the Smelting and Fertilizer Division of Brunswick Mining and Smelting Corporation Ltd. CEC J2270. Concord Environmental Corporation. June, 1991.

Goss Gilroy Inc., Environmental & Occupational Health+Plus, and Senes Consultants Limited. 2005. Belledune Area Health Study: Summary Report and Appendices. Prepared for the Department of Health and Wellness, Government of New Brunswick.

Intrinsik Environmental Sciences *et al.* 2008. The Shore Road Soil Study, Belledune, New Brunswick. June, 2008. Prepared for: Xstrata Zinc. Prepared by: Intrinsik Environmental Sciences Inc., Conestoga Rovers & Associates, Globaltox, and Genivar.

Klassen, R.A., Douma, S.L., Ford, A., Rencz, A., and Grunsky, E. 2009. Geoscience modelling of relative variation in natural arsenic hazard potential in New Brunswick. Geological Survey of Canada. Current Research 2009-7. 9 pp.

LGL Ltd. 2008. Assessment of Biodiversity near Canadian Operations. Brunswick Smelter, New Brunswick. October, 2008. LGL Project #TA4547.

McCutcheon, S.R. 2010. Comments on Phase I Soil Sampling Results Near Belledune, N.B. for Intrinsik Environmental Sciences Inc. McCutcheon GeoConsulting. July, 2010.

U.S. EPA. 2005. Human Health Risk Assessment Protocol (HHRAP) for Hazardous Waste Combustion Facilities, Final. Chapter 5. Estimating Media Concentrations. http://www.epa.gov/osw/hazard/tsd/td/combust/finalmact/ssra/05hhrap5.pdf

APPENDIX J

RECEPTOR AND EXPOSURE MODEL PARAMETERS AND ASSUMPTIONS FOR TERRESTRIAL AND AVIAN RECEPTORS

APPENDIX J RECEPTOR AND EXPOSURE MODEL PARAMETERS AND ASSUMPTIONS FOR TERRESTRIAL AND AVIAN RECEPTORS

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J-1.0 INTRODUCTION

The purpose of this appendix is to describe the general approach, methods and data used to deterministically estimate exposure of terrestrial and avian wildlife to the chemicals of potential concern (COPC). An example of the exposure modeling parameters and results is provided in Attachment J-1 to this Appendix.

This section begins with a description of the exposure model that was used to estimate total daily intake of COPC by selected ecological receptors (Section J-2.0). Input parameters for the exposure model were established using life history information for the receptors (Section J-3.0) and measured and estimated chemical concentrations of various site media (Section J-4.0). Figure J.1-1 depicts the framework for the exposure assessment.

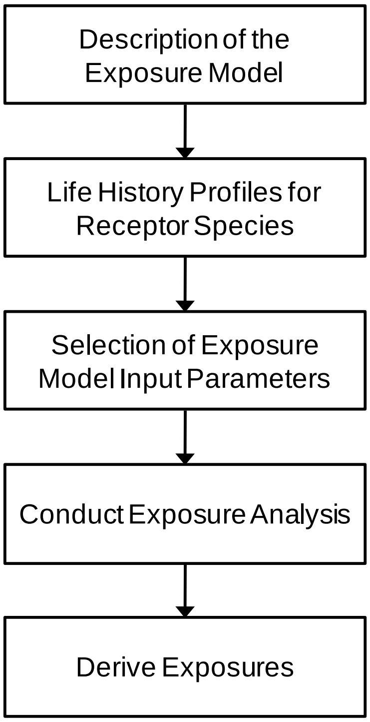

Figure J.1-1 Framework Used to Model Exposure of Wildlife Species to Contaminants of Potential Concern (COPCs)

J-2.0 WILDLIFE EXPOSURE MODEL

Wildlife exposure modeling relied on the use of a total daily intake (TDI) model. The primary focus of the model is on ingestion of food items (soil and water), which are generally principle sources of COPC exposure for wildlife (Moore and Caux, 1997; Moore *et al.*, 1999). The wildlife exposure model follows the general form:

$$TDI_{diet} = PT * \sum_{k=1}^{k} (NFIR_k * C_k) \qquad \text{Equation 1}$$

where,

TDI_{diet} is the total daily intake from food (mg/kg bw/day),

PT is the proportion of time in the contaminated area (unitless),

$NFIR$ is the normalized food intake rate (kg dw/kg bw/day),

C_k is the concentration of the contaminant in each dietary item (k) (mg/kg dw), and

k is the number of individual food items in the diet (unitless),

This general exposure model was customized for each ecological receptor to reflect feeding habits, foraging range, habitat preferences, and life history. The exposure model assumed that each wildlife receptor spends 100% of its time within in the vicinity of the Belledune study area. Extensive literature searches were conducted and data collected to determine the appropriate model inputs. Each of these inputs is discussed briefly below.

J-2.1 Normalized Food Intake Rate (NFIR)

Data on food intake rate (FIR) are only available for a few species, primarily due to the difficulties in measuring intake for free-ranging wildlife. This assessment does not use measured food intake rates determined using captive animals, because captive animals do not expend energy foraging for food and water, avoiding predators, defending territories, *etc*. (Lamprey, 1964; Buechner and Golley, 1967; Koplin *et al.*, 1980; U.S. EPA, 1993). Thus, food intake rates for captive animals considerably underestimate the expected FIRs for free-ranging animals. In this assessment, allometric equations developed from measurements of free metabolic rate (FMR) in free-ranging animals were used to estimate food intake rate for each ecological receptor. The FMR is normalized to the body weight of the receptor. The normalized food intake rate (NFIR) is derived from the normalized FMR using the following equation:

$$NFIR_k = \frac{FE_k * NFMR}{ME_k}$$ Equation 2

where,

NFMR is the free metabolic rate normalized to body weight (kcal/kg bw/day),

ME_k is metabolizable free energy k^{th} food item (kcal/kg/bw), and

FE_k is free energy from each dietary item, and is calculated using this following equation:

$$FE_k = \frac{P_k * ME_k}{\sum_{k=1}^{m}(P_k * ME_k)}$$ Equation 3

where,

P_k is proportion of diet by mass.

The exposure model uses the allometric relationship of Nagy *et al.* (1999) to estimate the FMR for each ecological receptor. The general form of the model is:

$$\overline{\qquad\qquad}$$ Equation 4

The slope (*a*) and power (*b*) parameters were based on the data reported in Nagy *et al.* (1999). FMR is then divided by the BW of the species of interest to obtain the normalized FMR (*i.e.*, kcal/kg bw/day). The FMR equation for each ecological receptor is presented within the section describing each receptor in detail (Section J-3).

J-2.2 Body Weight (BW)

Body weight is not used in the wildlife exposure model directly, but is a required parameter in allometric models (*e.g.*, Nagy, 1987) to estimate food intake or free metabolic rates (*FMR*s). FMRs represent the total energy requirements for animals in the wild, including thermoregulation, feeding, reproduction and predator avoidance. Mean body weights for each of the wildlife receptors were obtained from the literature. For species where there was significant difference between male and female body weight (*e.g.*, northern saw-whet owl), the lower body weight was used in the exposure modeling to represent a more conservative selection in the context of the exposure assessment.

J-2.3 Proportions of Dietary Items (P_i)

Extensive literature searches were conducted to locate data and information on the dietary preferences of the ecological receptors assessed. Information in the literature on dietary preferences was evaluated to determine the relevance to the ecological receptors living in the Belledune study area. Some receptors have dietary preferences that can include a large number of prey items. Therefore, only dietary items that comprise at least 5% of the total diet of each species were included in the exposure model. In these cases, dietary items comprising >5% of the diet were adjusted resulting in the sum of all dietary components equalling 100%.

In cases where very little data or information was available on the dietary preferences of the selected wildlife receptors, conservative assumptions were used to evaluate their potential COPC exposure.

J-2.4 Inhalation Rate (IR)

Air inhalation rates for avian and mammalian receptors were based on allometric relationships developed by Lasiewski and Calder (1971). The inhalation rates for birds and mammals were derived using the following equations (US EPA, 1993):

(Birds) Equation 5

(Mammals) Equation 6

Where
IR = Inhalation rate (m^3/day)
BW = Body weight (kg)

The estimated inhalation rate was used to predict chemicals exposures from the air and dust inhalation pathway.

J-2.5 Soil Intake Rate (SIR)

U.S. EPA (1993; 1999; 2005) and Sample and Suter (1994) estimated soil consumption rates for a large number of wildlife species based on reviews of the literature. Where data were unavailable for a particular species, a soil intake rate equal to the intake rate of the most closely related species, as determined by faunal class, body weight and feeding behaviour was assumed. Where U.S. EPA (1993; 1999; 2005) and Sample and Suter (1994) recommended soil intake rates for a particular wildlife receptor, those values were used. Otherwise, soil intake rates were based on review of the literature. The SIR is expressed as a proportion of the rate of the overall FIR for each of the ecological receptors.

J-2.6 Water Intake Rate (WIR)

The water intake rate is based on an allometric relationship. The relationship relates avian or mammalian body weight to daily water flux rate. The daily water flux rate or turnover rate for birds and mammals was estimated as follows:

Equation 7

where *WIR* is the drinking rate (mL/day) and *BW* is the body weight (kg) (Calder and Braun, 1983). The slope (*a*) and power (*b*) parameters for birds are 0.059 and 0.67 (Calder and Braun, 1983). The slope (*a*) and power (*b*) parameters for mammals are 0.099 and 0.9, respectively (Calder and Braun, 1983). WIR is then normalized by dividing the average daily water flux by the BW of the species of interest (*i.e.*, L/kg bw/day).

The normalized intake rate for water assumes that the ecological receptors are in water equilibrium, such that water balance is maintained each day. Water contained in food as well as water produced metabolically will decrease the daily drinking water requirement. However, these additional sources of water are not considered in the above equation.

J-2.7 Assimilation Efficiency (AE) and Gross Energy (GE)

To calculate the food intake rate (*FIR*) for each wildlife receptor, gross energy (*GE*) and assimilation efficiency (*AE*) are required for each dietary item. Combined, these two parameters yield the metabolizable energy ($ME = GE \text{ x } AE$) of the dietary item. The gross energy content of a dietary item represents the total amount of energy that is available from a food item and is a function of the characteristics of the food. The assimilation efficiency represents the amount of energy an organism can obtain from a particular dietary item. The lowest reported assimilation efficiencies of all dietary items that at least one wildlife receptor will consume in the study area were obtained from the Wildlife Exposure Factors Handbook (U.S. EPA, 1993). Gross energy values for each dietary item were also obtained from the Wildlife Exposure Factors Handbook (U.S. EPA, 1993). Gross energy is easily measured and thus uncertainty is likely to be low for this input parameter.

J-3.0 ECOLOGICAL RECEPTOREXPOSURE PARAMETERS AND ASSUMPTIONS

The following sections provide a description of the life history, including habitat preferences, dietary habits and home range, for each of the ecological receptors assessed in the ERA. In addition, the exposure model parameters that were used for each ecological receptor are described, including:

- Body Weight (BW);
- Inhalation Rate (IR);
- Food Intake Rate (FIR);
- Soil Intake Rate (SIR);
- Water Intake Rate (WIR);
- Assimilation Efficiency (AE);
- Gross Energy (GE); and,
- Proportions of Dietary Items (P_i).

Parameter values used in the exposure assessment for each of the following ecological receptors are summarized in the following sections:

- Dark-Eyed Junco (Section J-3.1)
- Northern Saw-whet Owl (Section J-3.2)
- Ruffed Grouse (Section J-3.3)
- Masked Shrew (Section J-3.4)
- Snowshoe Hare (Section J-3.5)
- Ermine (Short-tailed weasel) (Section J-3.6)
- White-tailed Deer (Section J-3.7)

J-3.1 Dark-eyed Junco

The dark-eyed junco (*Junco hyemalis*) was selected as a representative species because it is a small passerine that is known to occur in New Brunswick and the Maritime provinces throughout the winter and breeding seasons (Nolan *et al.*, 2002). The junco's habitat consists of coniferous and deciduous forest, including the forest edge, clearings, bogs, and brushy areas adjacent to forest (AOU, 1983). Most importantly, the dark-eyed junco forages on the ground and consumes mainly seeds and invertebrates (NatureServe, 2008). Ground foraging species are expected to have higher exposure to metals in soils due to inadvertent soil intake than other bird species that forage elsewhere. Input parameters for the dark-eyed junco are provided in Table J-3-1.

J-3.1.1 Life History

The dark-eyed junco is one of the most common and familiar North American passerines. It is a small greyish sparrow belonging to the *Emberizidae* family. The dark-eyed junco occurs across the continent from northern Alaska south to northern Mexico. During the breeding season, home range size ranged from 1.43 to 3.89 ha (mean = 2.11 ± 0.22 SE) for males (Chandler *et al.*, 1997) and females had a median home range size of 2.22 ha (inter-quartile range = 1.87) (Neudorf *et al.*, 2002). Although most populations are migratory, some populations are nearly sedentary or are short-distance migrants (Nolan *et al.*, 2002). Their habitat consists of coniferous, deciduous, and mixed forest, forest edge, clearings, bogs, and open woodland throughout North America (NatureServe, 2008). They nest in depressions on the ground, concealed by vegetation or other material. Normally two clutches of four eggs are laid during the breeding season.

Pulliam and Enders (1971) reported that junco spend approximately 35% of their feeding time on the ground. The dark-eyed junco forages on the ground and in leaf litter (Holmes *et al.*, 1986; Medin, 1984) during the breeding and non-breeding seasons. Generally seeds and occasionally fruit and waste grain in agricultural fields are also dietary items (Nolan *et al.*, 2002). Most animal food consists of insects including spiders (*Arachnida*), beetles (*Coleoptera*), moths and butterflies (*Lepidoptera*) and their caterpillars, ants and wasps (*Hymenoptera*), and flies (*Diptera*). Seed species include chickweed (*Stellaria* spp.), rough pigweed (*Amaranthus* spp.), alfilaria (*Erodium* spp.), knotweed (*Polygonum* spp.) and sorrel (*Rumex* spp.). Other important groups include timothy (*Phleum*), ragweed (*Ambrosia*), knotweed, lamb's quarters (*Chenopodium*), pigweed, *Bouteloua aristoides*, and crabgrass (*Digitaria sanguinalis*) (Beal, 1907; Judd, 1901; Nolan *et al.*, 2002). Juncos drink from small streams, casual pools, moisture on vegetation and eat snow in the winter (Nolan *et al.*, 2002).

Table J.3-1 Input Parameters for Dark-eyed Junco Exposure Analyses

Input Parameter	*Distribution*	*Parameters*	*References*	*Notes*
BW (kg)	Point estimate	0.0188	Dunning, 1993	Average of female body weights.
Proportion of Soil in Diet	Point Estimate	0.093	Beyer *et al.* 1994	Wild turkey used as a surrogate due to similarity of diet
Assimilation Efficiency Seeds	Point estimate	0.75	Karasov, 1990	Value for passerines consuming seeds.
Assimilation Efficiency Terrestrial Invertebrates	Point estimate	0.72	Karasov, 1990; Ricklefs, 1974; Bryant and Bryant, 1988	Value for all birds consuming insects.
Gross Energy (kcal/kg dw) Terrestrial Invertebrates	Point estimate	5,600	Cummins and Wuycheck, 1971; Collopy, 1975; Bell, 1990	Estimated from measured values for grasshoppers, crickets, and beetles.
Gross Energy (kcal/kg dw) Seeds	Point estimate	5,100	Drozdz, 1968; Golley, 1961; Robel *et al.*, 1979	
Proportion in Diet Terrestrial Invertebrates	Point estimate	0.6	Martin *et al.*, 1951	
Proportion in Diet Seeds	Point estimate	0.4	Martin *et al.*, 1951	

J-3.1.2 Body Weight

Body weights of the subspecies *J. h. hyemalis* range from 14.3 to 26.7 g for males (mean 20.4 ± 1.21 g, *n* = 2819) and from 14.3 to 25.1 g for females (mean 18.8 ± 0.78 g, *n* = 1316) (Dunning, 1993). A mean adult body weight of 0.0188 kg (based on females) was used in the exposure analysis. The exposure modeling considered females because they are smaller than males, and thus represent a more conservative selection in the context of the exposure assessment (*i.e.*, lower body weights produce higher ingestion rates relative to body weight).

J-3.1.3 Inhalation Rate (IR)

The air inhalation rate of the dark-eyed junco was based on allometric modeling approach described in Section J-2.4. The resulting equation for the IR for the dark eyed junco is as follows:

Equation 8

The estimated inhalation rate was used to predict chemicals exposures from the air and dust inhalation pathway.

J-3.1.4 Food Intake Rate (FIR)

Food intake rate of the dark-eyed junco has been measured in studies of captive birds (Ramenofsky *et al.*, 1999; Thompson *et al.*, 2004). Because the birds were under captive conditions, the measured food intake rates likely underestimated actual food intake rates of free-living juncos (U.S. EPA, 1993). Therefore, the allometric modeling approach described in Section J-2.1 was used to estimate food intake rate for the dark-eyed junco. The slope (*a*) and power (*b*) parameters were based on data for passerines reported in Nagy *et al.* (1999). The resulting equation for FMR for the dark-eyed junco is:

Equation 9

In the exposure assessment, FMR was normalized to dark-eyed junco body weight:

Equation 10

The resulting estimated FMR for the dark-eyed junco was 971 kcal/kg bw/day.

J-3.1.5 Soil Intake Rate (SIR)

No data were available for dark-eyed junco soil ingestion rates. Therefore, for modeling purposes, the proportion of soil ingested by the dark eyed junco was estimated to be 0.093 (9.3%

of the diet), based on values reported in Beyer *et al.* (1994) using the wild turkey as a surrogate species.

J-3.1.6 Water Intake Rate (WIR)

The water intake rate for the dark-eyed junco was based on the allometric equation for birds reported in Nagy and Peterson (1988). The resulting equation for daily water flux rate for the dark-eyed junco is:

Equation 11

In the exposure assessment, WIR was normalized to dark-eyed junco body weight:

Equation 12

The resulting estimated WIR for the dark-eyed junco was 0.219 L/kg bw/day.

J-3.1.7 Assimilation Efficiency (AE)

The assimilation efficiencies of food items in the dark-eyed junco diet were used to calculate the FIR. Average assimilation efficiency for passerines consuming wild seeds is 0.75 (Karasov, 1990), and for birds consuming terrestrial insects, assimilation efficiency is 0.72 (Karasov, 1990; Ricklefs, 1974; Bryant and Bryant, 1988).

J-3.1.8 Gross Energy (GE)

The gross energy of food items in the dark-eyed junco diet was also used in the calculation of the FIR. The mean gross energies reported in the literature are as follows: terrestrial invertebrates (assumed from measured values for grasshoppers, crickets and beetles) contain 5,600 kcal/kg dw (Cummins and Wuycheck, 1971; Collopy, 1975; Bell, 1990); and, seeds (assumed from measured values for dicots) contain 5,100 kcal/kg dw (Drozdz, 1968; Golley, 1961; Dice, 1922; Robel *et al.*, 1979).

J-3.1.9 Proportions of Dietary Items (P_i)

The proportion of various dietary items in the dark-eyed junco diet is the final parameter used to calculate the NFIR. Available dietary studies show variation in the proportion of dietary items reported for the dark-eyed junco. In a seasonal analysis, Judd (1901) reported a summer diet of 49% animal and 51% plant, and a winter diet of 91% vegetable. Dietary proportions are similar to those reported in a season-specific analysis of stomach contents of 248 *J. hyemalis*, in which vegetable matter made up 76% of the diet in Nov-Mar, 40% in Apr-May, 93% in Jun-Aug, and 92% Sep-Oct (Martin *et al.*, 1951). Pulliam and Enders (1971) reported a similar trend where during the breeding and rearing months, the diet consists of larger quantities of terrestrial invertebrates (50 – 85%), while during the winter months, the diet is largely plant based (60 – 80%) (Pulliam and Enders, 1971). In the exposure model, it was assumed that terrestrial invertebrates and wild seeds constituted 60% and 40% of the dark-eyed junco diet, respectively.

J-3.2 Northern Saw-whet Owl

The northern saw-whet owl (*Aegolius acadicus*) was selected as a representative species because it is a small owl that is known to occur year-round in eastern North America (Mueller and Berger, 1967; Holroyd and Woods, 1975; Weir *et al.*, 1980; Duffy and Kerlinger, 1992; Whalen and Watts, 2002). Its habitat consists of dense coniferous and mixed forest, cedar groves, alder thickets, swamps, and tamarack bogs (NatureServe, 2008). The saw-whet owl preys almost entirely on small mammals such as rodents. Input parameters for the saw-whet owl are provided in Table J-3-2.

J-3.2.1 Life History

The northern saw-whet owl (hereafter saw-whet owl) is a small owl belonging to the *Strigidae* family and is one of the most common owls in forested habitats across southern Canada and the northern United States. Studies of a few birds yielded seasonal home range estimate of about 75 to 150 ha (Cannings, 1987). The saw-whet owl is found in a variety of forest types (Johnson and Anderson, 2003), with densities highest in coniferous forests at moderate elevation and latitude. Some are permanent residents, remaining on the breeding grounds through the winter, while others may migrate south in winter or move down from higher elevations (Cannings, 2008). The saw-whet owl is a hole-nesting species, nesting in old woodpecker holes and other tree cavities, as well as nest boxes (NatureServe, 2008).

The northern saw-whet owl is a carnivore, preying mainly on rodents and other small mammals (Rasmussen *et al.*, 2008). Deer mice and white-footed mice are the dominant prey (Catling, 1972; Barb, 1995; Hayward and Garton, 1988; Holt *et al.*, 1991; Dinsmore and Clark, 1991; Petit, 1995; Johnson, 1999) in some parts of the range, but shrews (*Sorex*, *Blarina*, *Cryptotis*) comprised more than half the diet in North Carolina (Cockerel, 1997). In Idaho, house mice (*Mus musculus*), harvest mice (*Reithrodontomys megalotis*) and montane voles (*Microtus montanus*) were taken in greater proportion than deer mice (Rains, 1998; Marks and Doremus, 1988). Beetles (*Coleoptera*) and grasshoppers (*Orthoptera*) can be consumed (*e.g.*, Boula, 1982; Swengel and Swengel, 1992), but little detailed information is available on the importance of invertebrates in the diet. The saw-whet owl uses a variety of microhabitats for foraging, generally hunting along forest edges and clearings (Cannings, 1993), hunting almost entirely at night from low perches. Prey items are swallowed piecemeal and are generally less than 40 g. The mean mass of mammalian prey taken in Connecticut was 24.7 g (n = 1,496; Petit, 1995) with 89% of all mammals weighing 20-25 g (range = 5.2-52.5 g). Prey items weighing more than 20 g are usually consumed as two meals at least four or five hours apart (Collins, 1963).

Table J.3-2 Input Parameters for Northern Saw-whet Owl Exposure Analyses

Input Parameter	*Distribution*	*Parameters*	*References*	*Notes*
BW (kg)	Point estimate	0.0688	Rasmussen *et al.*, 2008	Average of male body weights.
Proportion of Soil in Diet	90th Percentile	0.05	U.S. EPA, 2005	Conservatively-skewed value selected to represent majority of individuals within population without being over protective.
Assimilation Efficiency Small Mammals	Point estimate	0.78	Karasov, 1990; Stalmaster and Gessaman, 1982; Koplin *et al.*, 1980; Castro *et al.*, 1989	
Gross Energy (kcal/kg dw) Small Mammals	Point estimate	5,000	Górecki, 1975; Golley, 1960; Koplin *et al.*, 1980	Estimated from measured values for mice, voles, and rabbits.
Proportion in Diet Small Mammals	Point estimate	1	Catling, 1972; Barb, 1995; Hayward and Garton, 1988; Holt *et al.*, 1991; Dinsomore and Clark, 1991; Petit, 1995; Johnson, 1999; Cockerel, 1997; Rains, 1998; Marks and Doremus, 1988	

J-3.2.2 Body Weight (BW)

Northern saw-whet owls exhibit reverse sexual size dimorphism, the female being larger than the male. Mean body weight data from museum specimens were 68.8 g ± 11.68 SD (range = 47-97, n = 39) for males and 85.9 g ± 12.39 SD (range = 50-103, n = 30) for females (Rasmussen *et al.*, 2008). During the breeding season in Idaho, mean body mass of males was 76.3 g ± 3.8 SD (n = 11) and females was 121.1 g ± 9.2 SD (n = 14) (Rains, 1998). A mean adult body weight of 0.0688 kg was used in the exposure analysis. Considering males are smaller than females and museum specimens are typically biased towards emaciated birds, this body weight represents a conservative selection.

J-3.2.3 Inhalation Rate (IR)

The air inhalation rate of the northern saw-whet owl was based on allometric modeling approach described in Section J-2.4. The resulting equation for the IR for the northern saw-whet owl is as follows:

Equation 13

The estimated inhalation rate was used to predict chemicals exposures from the air and dust inhalation pathway.

J-3.2.4 Food Intake Rate (FIR)

Food intake rate of the saw-whet owl has been measured in studies of captive birds (Graber, 1962; Collins, 1963). In a study of food intake, a 96 g captive female saw-whet owl required 17.5 g/day of fresh tissue (69 kcal) to maintain its mass (Graber, 1962). Over a 12 day period, an

80 g male and a 108 g female ate 23.9 and 31.8 g/day of mouse tissue and gained 3.7% and 15.3% body mass, respectively (Collins, 1963). This represents a gross energy intake of 94.3 kcal/day for the male and 125.5 kcal/day for the female. However, because the birds were under captive conditions, the measured food intake rates likely underestimated actual food intake rates of free-living owls (U.S. EPA, 1993). Therefore, the allometric modeling approach described in Section J-2.1 was used to estimate food intake rate for the saw-whet owl. The slope (*a*) and power (*b*) parameters were based on data for all birds reported in Nagy *et al.* (1999). The resulting equation for FMR for the saw-whet owl is:

Equation 14

In the exposure assessment, FMR was normalized to saw-whet owl body weight:

Equation 15

The resulting estimated FMR for the saw-whet owl was 650 kcal/kg bw/day.

J-3.2.5 Soil Intake Rate (SIR)

U.S. EPA (2005) recommended a soil consumption rate for avian carnivores of 5% of their overall food intake rate (FIR). This value is based on data for the red-tailed hawk, under the assumption that its diet is made up of 100% small mammals (U.S. EPA 2005).

J-3.2.6 Water Intake Rate (WIR)

The water intake rate for the saw-whet owl was based on the allometric equation for birds reported in Nagy and Peterson (1988). The resulting equation for daily water flux rate for the saw-whet owl is:

Equation 16

In the exposure assessment, WIR was normalized to saw-whet owl body weight:

Equation 17

The resulting estimated WIR for the saw-whet owl was 0.143 L/kg bw/day.

J-3.2.7 Assimilation Efficiency (AE)

The assimilation efficiencies of food items in the saw-whet owl diet were used to calculate the FIR. Average assimilation efficiency for birds of prey consuming birds and small mammals is 0.78 (Karasov, 1990; Stalmaster and Gessaman, 1982; Koplin *et al.*, 1980; Castro *et al.*, 1989).

J-3.2.8 Gross Energy (GE)

The gross energy of food items in the saw-whet owl diet was also used in the calculation of the FIR. The mean gross energy for small mammals (assumed from measured values for mice, voles, and rabbits) is 5,000 kcal/kg dw (Górecki, 1975; Golley, 1960; Koplin *et al.*, 1980).

J-3.2.9 Proportions of Dietary Items (P_i)

The proportion of various dietary items in the saw-whet owl diet is the final parameter used to calculate the FIR. Although saw-whet owls can consume invertebrates, it was assumed that small mammals constituted 100% of the saw-whet owl diet in the exposure model.

J-3.3 Ruffed Grouse

The ruffed grouse (*Bonasa umbellus*) was selected as a representative species because it is a medium sized grouse occurring throughout North America in both deciduous and coniferous forests. The ruffed grouse is a non-migratory species with a relatively small home range. Most importantly, the ruffed grouse forages on the ground, thus it would have higher exposure to metals in soils than other bird species due to inadvertent soil ingestion. Input parameters for the ruffed grouse are provided in Table J-3-3.

J-3.3.1 Life History

Ruffed grouse are members of the *Phasianidae* family and are most abundant in early-successional forests dominated by aspens and poplars (*Populus* spp.) (Rusch *et al.*, 2000). The optimal habitat of the ruffed grouse consists of an interspersion of three different forest age classes (Cade and Sousa, 1985) including: regenerating aspens (1 to 2 years old), which provide optimal brood over; sapling aspens (13 to 25 years old), which provide optimal fall to spring cover (for male courtship displays, *i.e.*, drumming); and, mature aspens (>25 years old), which provide an essential winter food source and nesting habitat. The home range of the ruffed grouse varies significantly by region and by habitat type. Female grouse tend to have small home ranges when they have eggs or chicks, while males have been known to defend a territory of 4 to 12.2 ha in the breeding season (Csuti *et al*., 1997; Rusch *et al*., 2000). Banded and radio-marked males in Alberta and Wisconsin defended territories that averaged 2.1 ha ± 0.9 SD (*n* = 218) during the breeding season while females were not observed to be territorial. In spring, females in Minnesota and Wisconsin had overlapping home ranges (not defended) of 2 to 10 ha and some visited several male territories during a breeding season (Maxson, 1989). Males (*n* = 10) defended an average size territory of 2.3 ha ± 0.5 SD in Minnesota (Archibald, 1975).

The ruffed grouse diet is primarily comprised of leaves, buds, and fruits of deciduous-forest plants. Buds and catkins of aspen **(***Populus tremula*), willows (*Salix* spp.), and birches (*Betula* spp.) are important winter food in Canada (Rusch *et al*., 2000). To determine the dietary preferences of the ruffed grouse, a literature search was performed to identify field studies that had examined grouse dietary composition through scat and/or stomach content analysis. Based on the available studies, ruffed grouse feed primarily on vegetation including a wide variety of seeds, nuts, fruits, buds, leaves, and flowers. They also prey on terrestrial invertebrates (*e.g*., spiders, beetles, caterpillars), but to a lesser extent for adult ruffed grouse (<5% diet) (Mackie *et al*., 2005). Snakes, frogs, and salamanders also are consumed infrequently (Ruffed Grouse Society, 2003). Aspen leaves, mushrooms and other vegetation (*e.g.*, white birch) were found in ruffed grouse crops in a study conducted in northern Ontario (Rose and Parker, 1983).

Table J.3-3 Input Parameters for Ruffed Grouse Exposure Analyses

Input Parameter	*Distribution*	*Parameters*	*References*	*Notes*
BW (kg)	Point estimate	0.544	Bump *et al*., 1947; Stoll and McClain, 1988	Average female body weight.
Proportion of Soil in Diet	Point estimate	0.093	Beyer *et al*., 1994	Assumed wild turkey as surrogate.
Assimilation Efficiency Seeds [1]	Point estimate	0.59	Karasov, 1990	Value for non-passerines consuming seeds.
Assimilation Efficiency Fruit Pulp, Skin, Seeds[1]	Point estimate	0.51	Karasov, 1990	
Assimilation Efficiency Leaves[1]	Point estimate	0.47	Karasov, 1990	
Assimilation Efficiency Stems, Twigs, and Pine Needles[1]	Point estimate	0.34	Karasov, 1990	Value for grouse and ptarmigan consuming stems, twigs and needles.
Assimilation Efficiency Terrestrial Invertebrates	Point estimate	0.72	Karasov, 1990; Ricklefs, 1974; Bryant and Bryant, 1988	
Gross Energy (kcal/kg dw) Terrestrial Invertebrates	Point estimate	5,600	Cummins and Wuycheck, 1971; Collopy, 1975; Bell, 1990	Estimated from measured values for grasshoppers, crickets, and beetles.
Gross Energy (kcal/kg dw) Twigs, Buds, and Catkins[1]	Point estimate	4,300	Golley (1961)	Reference in EPA (1993); assumed equivalent to GE of stems and branches
Gross Energy (kcal/kg dw) Leaves[1]	Point estimate	4,200	Golley, 1961	
Gross Energy (kcal/kg dw) Seeds[1]	Point estimate	5,100	Drozdz, 1968; Golley, 1961; Dice, 1922; Robel *et al*., 1979	
Gross Energy (kcal/kg dw) Fruit Pulp, Skin, and Seeds[1]	Point estimate	2,200	Karasov, 1990	
Proportion in Diet Terrestrial Invertebrates	Point estimate	0.05	SARA, 2006	Value of 0.014 was rounded up to allow for 5% terrestrial invertebrate ingestion.

Input Parameter	*Distribution*	*Parameters*	*References*	*Notes*
Proportion in Diet Terrestrial Vegetation	Point estimate	0.95	SARA, 2006	Value of 0.986 was rounded down to 0.95 to allow for 5% terrestrial invertebrate ingestion. Vegetation includes leaves, seeds, twigs, buds, catkins, and soft fruits.

1 An average of assimilation efficiency for the various plant food items was used in the exposure modeling.
2 An average of gross energy for the various plant food items was used in the exposure modeling.

J-3.3.2 Body Weight (BW)

Adult female ruffed grouse generally weigh between 0.45 and 0.60 kg, while adult males generally weigh between 0.50 and 0.75 kg (Rusch *et al.*, 2000). For the exposure analysis, the mean adult weight of female ruffed grouse was estimated to be 0.544 kg based on measured body weights (Bump *et al.*, 1947; Stoll and McClain, 1988). The exposure modeling considered females because they are smaller than males, and thus represent a more conservative selection in the context of the exposure assessment.

J-3.3.3 Inhalation Rate (IR)

The air inhalation rate of the ruffed grouse was based on allometric modeling approach described in Section J-2.4. The resulting equation for the IR for the ruffed grouse is as follows:

Equation 18

The estimated inhalation rate was used to predict chemicals exposures from the air and dust inhalation pathway.

J-3.3.4 Food Intake Rate (FIR)

The daily energy requirements of the ruffed grouse vary depending primarily on environmental conditions. Ruffed grouse on average consumed 65.6 g of aspen buds (fresh weight) during the day during winter in Minnesota (Huempfner and Tester, 1988). Average bite size was 0.053 g/bite, feeding rate was 25.1 bites/min ± 0.7 SD, and food intake rates while actively foraging were reported as 1.33 g/min (Huempfner and Tester, 1988). Given the regional variation in the dietary preferences of the ruffed grouse, and the markedly different environmental conditions for this assessment from those reported in Huempfner and Tester (1988), FIR was estimated using the allometric equation described in Section J-2.1 rather than using the literature-reported value. The slope (*a*) and power (*b*) parameters were based on data for galliformes reported in Nagy *et al.* (1999). The resulting equation for FMR for the ruffed grouse is:

Equation 19

In the exposure assessment, FMR was normalized to ruffed grouse body weight:

Equation 20

The resulting estimated FMR for the ruffed grouse was 157 kcal/kg bw/day.

J-3.3.5 Soil Intake Rate (SIR)

No data were available for ruffed grouse soil ingestion rates. For modeling purposes, the proportion of soil ingested by the ruffed grouse was estimated to be 0.093 (9.3% of the diet), based on values reported in Beyer *et al.* (1994) using the wild turkey as a surrogate species.

J-3.3.6 Water Intake Rate (WIR)

The water intake rate for the ruffed grouse was based on the allometric equation for birds reported in Nagy and Peterson (1988). The resulting equation for daily water flux rate for the ruffed grouse is:

Equation 21

In the exposure assessment, WIR was normalized to ruffed grouse body weight:

Equation 22

The resulting estimated WIR for the ruffed grouse was 0.0721 L/kg bw/day.

J-3.3.7 Assimilation Efficiency (AE)

The assimilation efficiencies of food items in the ruffed grouse diet were used to calculate the FIR. Average assimilation efficiencies are 0.59 for non-passerines consuming wild seeds, 0.51 for birds consuming fruit pulp, skin and seeds, and 0.47 for birds consuming grasses and leaves (Karasov, 1990). Assimilation efficiency for grouse consuming stems, twigs, and pine needles is 0.34 (Karasov, 1990). For birds feeding on terrestrial insects, assimilation efficiency is 0.72 (Karasov, 1990; Ricklefs, 1974; Bryant and Bryant, 1988).

J-3.3.8 Gross Energy (GE)

The gross energy of food items in the ruffed grouse diet was also used in the calculation of the FIR. The mean gross energies of dietary items reported in the literature were as follows: terrestrial invertebrates (assumed from measured values for grasshoppers, crickets and beetles) contain 5,600 kcal/kg dw (Cummins and Wuycheck, 1971; Collopy, 1975; Bell, 1990); leaves (assumed from measured values for dicots) contain 4,200 kcal/kg dw (Golley, 1961); seeds (assumed from measured values for dicots) contain 5,100 kcal/kg dw (Drozdz, 1968; Golley, 1961; Dice, 1922; Robel *et al.*, 1979); and, fruit pulp, skin and seeds contain 2,200 kcal/kg dw (Karasov, 1990).

J-3.3.9 Proportions of Dietary Items (P_i)

There are numerous quantitative dietary studies for ruffed grouse (*e.g.*, Rusch *et al.*, 2000; Csuti *et al.*, 1997; Servello and Kirkpatrick, 1987; Stafford and Dimmick, 1979; Korschgen, 1966; Stollberg *et al.*, 1952; Kittams, 1943), however, diets for grouse are highly variable both temporally and spatially (Servello and Kirkpatrick, 1987). The diet of the ruffed grouse is primarily vegetation. They prefer leaves, buds, and flowers of grasses and forbs (Csuti *et al.*, 1997). During the summer, the proportion of terrestrial invertebrates in the diet may increase but vegetation remains the dominant source of nutrients. Based on the diets reported in these studies, the mean percentage of each prey item estimated in the ruffed grouse diet was estimated as: 98.6% (range 33 to 100%) terrestrial vegetation (leaves, seeds, twigs, buds, catkins, soft fruits); and 1.4% (range 0 to 4%) terrestrial invertebrates (SARA, 2006). For the purpose of the exposure modeling, terrestrial vegetation ingestion was rounded down to 95% and invertebrate ingestion was rounded up to 5% ingestion.

J-3.4 Masked Shrew

Several behavioural factors influence the extent of chemical exposure of the masked shrew (*Sorex cinereus*). This species was selected as a representative species because it has a high potential for exposure to chemicals within surface soils due to its burrowing behaviour and small home range. Shrews build underground nests and runways usually within the top 10 cm of soil (George *et al*., 1986) and have a limited home range (0.03 to 0.07 ha in areas of high prey density and 1 to 2.2 ha in low prey density areas in winter during non-breeding; Platt, 1976). As such, chemical exposures would originate from relatively small areas of land. This feature makes the masked shrew a good sentinel receptor for assessing chemical exposures from a specific environmental location. Input parameters for the masked shrew are provided in Table J-3-4.

J-3.4.1 Life History

The masked shrew is a small insectivorous rodent species belonging to the family *Soricidae*. This species inhabits moist forests of Canada, the northern United States, and Alaska (U.S. EPA, 1993) and is the most widely distributed shrew in North American. The masked shrew occupies a variety of habitats including coniferous, hardwood and mixed forest, meadows, river banks, lake shores, and forested and herbaceous wetland. The average lifespan of a masked shrew is 14 to 16 months (Banfield, 1974).

Shrews have high metabolic rates and consume large quantities of insects, worms, snails and other soil invertebrates on a daily basis (U.S. EPA, 1993). The diet of the masked shrew consists mostly of insects and other invertebrates (*i.e.*, mostly insects but also worms, possibly slugs and snails, a small portion of vertebrates, such as salamanders and young mice/voles) (JWL, Pers.

Comm.). Ants represent 50% of the food source for shrew in Michigan, whereas insect larvae are the dominant prey item in New Brunswick (Lee, 2001).

Table J.3-4 Input Parameters for Masked Shrew Exposure Analyses

Input Parameter	*Distribution*	*Parameters*	*References*	*Notes*
BW (kg)	Point estimate	0.005	NatureServe, 2008	
Proportion Soil in Diet	Point estimate	0.03	U.S. EPA, 2005	Value for short-tailed shrew as surrogate.
Assimilation Efficiency Terrestrial Invertebrates	Point estimate	0.87	Barrett and Stueck, 1976; Grodzinski and Wunder, 1975	
Gross Energy (kcal/kg dw) Terrestrial Invertebrates	Point estimate	5,600	Cummins and Wuycheck, 1971; Collopy, 1975; Bell, 1990	Estimated from measured values for grasshoppers, crickets, and beetles.
Proportion in Diet Terrestrial Invertebrates	Point estimate	1	Lee, 2001; NatureServe, 2008	

J-3.4.2 Body Weight (BW)

There is no significant sexual dimorphism in the masked shrew. Body weights of masked shrew range from 3 to 6 g (U.S. EPA, 1993). For the exposure analysis, a mean adult body weight of 0.005 kg was used (NatureServe, 2008).

J-3.4.3 Inhalation Rate (IR)

The air inhalation rate of the masked shrew was based on allometric modeling approach described in Section J-2.4. The resulting equation for the IR for the masked shrew is as follows:

Equation 23

The estimated inhalation rate was used to predict chemicals exposures from the air and dust inhalation pathway.

J-3.4.4 Food Intake Rate (FIR)

Food intake rate of shrews has been measured in laboratory animals (Kollars and Bäumler, 1994; Barrett, 1969). Because the animals were kept in a laboratory, the measured food intake rates likely underestimated actual food intake rates of free-living shrews (U.S. EPA, 1993). Therefore, the allometric modeling approach described in Section J-2.1 was used to estimate food intake rate for the masked shrew. The slope (*a*) and power (*b*) parameters were based on data for insectivores reported in Nagy *et al.* (1999). The resulting equation for FMR for the masked shrew is:

Equation 24

In the exposure assessment, FMR was normalized to masked shrew body weight:

Equation 25

The resulting estimated FMR for the masked shrew was 907 kcal/kg bw/day.

J-3.4.5 Soil Intake Rate (SIR)

No data were available for masked shrew soil ingestion rates. For modeling purposes, the proportion of soil ingested by the masked shrew was estimated to be 0.03 (3% of the diet), based on values reported by U.S. EPA (2005) using the short-tailed shrew as a surrogate species.

J-3.4.6 Water Intake Rate (WIR)

The water intake rate for the masked shrew was based on the allometric equation for mammals reported in Nagy and Peterson (1988). The resulting equation for daily water flux rate for the masked shrew is:

Equation 26

In the exposure assessment, WIR was normalized to masked shrew body weight:

Equation 27

The resulting estimated WIR for the masked shrew was 0.168 L/kg bw/day.

J-3.4.7 Assimilation Efficiency (AE)

The assimilation efficiencies of food items in the shrew diet were used to calculate the FIR. Average assimilation efficiency for mammals consuming terrestrial invertebrates is 0.87 (Barrett and Stueck, 1976; Grodzinski and Wunder, 1975).

J-3.4.8 Gross Energy (GE)

The gross energy of food items in the masked shrew diet was also used in the calculation of the FIR. The mean gross energies reported in the literature are as follows: terrestrial invertebrates (assumed from measured values for grasshoppers, crickets and beetles) contain 5,600 kcal/kg dw (Cummins and Wuycheck, 1971; Collopy, 1975; Bell, 1990).

J-3.4.9 Proportions of Dietary Items (P_i)

The proportion of various dietary items in the masked shrew diet is the final parameter used to calculate the FIR. It was assumed that terrestrial invertebrates constituted 100% of the masked shrew diet in the exposure model (Lee, 2001; NatureServe, 2008).

J-3.5 Snowshoe Hare

The snowshoe hare (*Lepus americanus*) was selected as a representative species because it is a medium-sized grazing herbivore that occurs in the Maritimes. Snowshoe hares occupy many forest types, preferring areas with a dense understory and have relatively small home ranges. The U.S. EPA (1993) reports a home range of about 4 ha. Receptor species with small home ranges may be at higher risk from exposure to metals because they would spend a higher proportion of time within the Study Area. Input parameters for the snowshoe hare are provided in Table J-3-5.

J-3.5.1 Life History

The snowshoe hare (*Lepus americanus*) is a member of the family *Leporidae* and is found throughout Canada, Alaska, and in the northernmost United States. Snowshoe hare occupy various habitats including boreal forest, aspen parkland, mixed deciduous forest, coniferous forest, commercial tree plantations, orchards, and shrub areas (Wolff, 1980; Pietz and Tester, 1983; Hodges, 2000). Their preferred habitat is coniferous forest containing deadfalls and low shrubs. Keith (1990) summarized data on hare home ranges and concluded that average year-round home range sizes were 5.2 and 6.7 ha for adult females and males, respectively. However, other studies have reported similar home ranges sizes between sexes (O'Farrell, 1965; Dolbeer and Clark, 1975) and male home ranges that were larger than those of females (Adams, 1959; Austin, 1960; Bider, 1961; Ferron and Ouellet, 1992; Rongstad and Tester, 1971). Common predators of the snowshoe hare include owls, lynx, foxes, and coyotes (Towers, 1980). Most snowshoe hare populations go through cyclic population fluctuations (Chevron *et al*., 1996). The life expectancy of snowshoe hare is relatively low, with hares rarely reaching the age of 5 years (Nostrand, 1971).

Hares are herbivorous, and rely mainly on leafy vegetation during summer and woody browse during winter (Hodges, 2000). During summer, hare diets include such foods as grasses (*Graminae*), sedges (*Cyperaceae*), ferns (*Polypodiaceae*), and forbs. Where available, clover (*Trifolium* spp.), lupine (*Lupinus latifolus*), dandelion (*Taraxacum* sp.), jewelweed (*Impatiens biflora*), marsh marigold (*Caltha palustris*), and the flowers of spotted cat's ear (*Hypochoeris radicata*) are among the species consumed during summer (Aldous, 1936; Grange, 1932; Dodds, 1960; Bider, 1961; Radwan and Campbell, 1968; Mozejko, 1971). In Nova Scotia and Newfoundland, winter diets included blueberry (*Vaccinium* spp.), maple (*Acer* spp.), balsam fir (*Abies balsamea*), spruce (*Picea* spp.), and birch (Dodds, 1960; Telfer, 1972; Dodds, 1987).

Table J.3-5 Input Parameters for Snowshoe Hare Exposure Analyses

Input Parameter	*Distribution*	*Parameters*	*References*	*Notes*
BW (kg)	Point estimate	1.3	Grange, 1932; Rowan and Keith, 1959	Average of male and female body weights.
Proportion Soil in Diet	Point estimate	0.063	Arthur and Gates, 1988	Value for jackrabbit as surrogate.
Assimilation Efficiency Woody Browse and Terrestrial Vegetation	Point estimate	0.73	Grodzinski and Wunder, 1975; Drozdz, 1968; Batzli and Cole, 1979; U.S. EPA, 1993	
Gross Energy (kcal/kg dw) Woody Browse and Terrestrial Vegetation	Point estimate	4,200	Cummins and Wuycheck, 1971; Davis and Golley, 1963; Golley, 1960; Kendeigh and West, 1965; Golley, 1961; Drozdz, 1968; U.S. EPA, 1993	
Proportion in Diet Woody Browse and Terrestrial Vegetation	Point estimate	1	NatureServe, 2008	

J-3.5.2 Body Weight (BW)

The snowshoe hare ranges in body weight from 0.9 to 1.8 kg (U.S. EPA, 1993). An average weight of 1.3 kg has been reported for adult snowshoe hares, with a range of 0.9 to 2.3 kg, however, populations fluctuate seasonally and annually (Grange, 1932; Rowan and Keith, 1959). Female snowshoe hares weigh about 10-25% more than males. A mean adult body weight of 1.3 kg was used in the exposure analysis.

J-3.5.3 Inhalation Rate (IR)

The air inhalation rate of the snowshoe hare was based on allometric modeling approach described in Section J-2.4. The resulting equation for the IR for the snowshoe hare is as follows:

Equation 28

The estimated inhalation rate was used to predict chemicals exposures from the air and dust inhalation pathway.

J-3.5.4 Food Intake Rate (FIR)

Among captive hares the daily energy requirement is about 300 g of browse per day, which for some species may correspond to a standing crop biomass of about 3000 g of plant material (Mautz *et al.*, 1976; Bookhout, 1965; Pease *et al.*, 1979). Dietary requirements of hares are about 6% of their body mass per day when fed *ad libidum* on a high-protein diet, which represents minimum daily needs of 110 kcal / BW (kg)$^{0.75}$ of energy of 2.6 g / BW (kg)$^{0.75}$ of digestible protein (Holter *et al.*, 1974). Because the animals were kept in captivity, the measured food intake rates likely underestimated actual food intake rates of free-living hares (U.S. EPA, 1993). Therefore, the allometric modeling approach described in Section 1.1.1 was used to estimate food intake rate for the snowshoe hare. The slope (*a*) and power (*b*) parameters were based on data for herbivores reported in Nagy *et al.* (1999). The resulting equation for FMR for the snowshoe hare is:

$$\text{FMR (kcal/day)} = \frac{7.94 \cdot 1300^{0.646}}{4.1875} = 195 \qquad \text{Equation 29}$$

In the exposure assessment, FMR was normalized to snowshoe hare weight:

Equation 30

The resulting estimated FMR for the snowshoe hare was 150 kcal/kg bw/day.

J-3.5.5 Soil Intake Rate (SIR)

No data were available for snowshoe hare soil ingestion rates. For modeling purposes, the proportion of soil ingested by the snowshoe hare was estimated to be 0.063 (6.3% of the diet), based on a value reported by Arthur and Gates (1988) for the jackrabbit.

J-3.5.6 Water Intake Rate (WIR)

The water intake rate for the snowshoe hare was based on the allometric equation for mammals reported in Nagy and Peterson (1988). The resulting equation for daily water flux rate for the snowshoe hare is:

Equation 31

In the exposure assessment, WIR was normalized to snowshoe hare body weight:

Equation 32

The resulting estimated WIR for the snowshoe hare was 0.0964 L/kg bw/day.

J-3.5.7 Assimilation Efficiency (AE)

The assimilation efficiencies of food items in the snowshoe hare diet were used to calculate the FIR. Average assimilation efficiency for mammals (*i.e.*, rabbits, voles and mice) consuming green forbs is 0.73 (Grodzinski and Wunder, 1975; Drozdz, 1968; Batzli and Cole, 1979). For mammals (*i.e.*, rabbits, voles and rats) consuming plants, assimilation efficiency is 0.76 (Grodzinski and Wunder, 1975; Drozdz, 1968; Drozdz *et al.*, 1971).

J-3.5.8 Gross Energy (GE)

The gross energy of food items in the snowshoe hare diet was also used in the calculation of the FIR. The mean gross energies of dietary items reported in the literature were as follows: young grasses (monocots) contain 4,200 kcal/kg dw (Davis and Golley, 1963; Drozdz, 1968); mature dry grasses (monocots) contain 4,300 kcal/kg dw (Cummins and Wuycheck, 1971; Davis and Golley, 1963; Golley, 1960; Kendeigh and West, 1965); leaves (dicots) contain 4,200 kcal/kg dw (Golley, 1961); and, stems and branches (dicots) contain 4,300 kcal/kg dw (Golley, 1961).

J-3.5.9 Proportions of Dietary Items (P_i)

The proportion of various dietary items in the snowshoe hare diet is the final parameter used to calculate the FIR. It was assumed that woody browse and terrestrial vegetation constituted 100% of the snowshoe hare diet in the exposure model (NatureServe, 2008).

J-3.6 Ermine

The ermine (*Mustela erminea*) (also known as the short-tailed weasel or stoat) was selected as a representative species because it is a small carnivorous mammal occurring in forested and forest edge habitats of New Brunswick. Most importantly, the elongated weasel body shape results in a higher surface-to-volume ratio than that of standard-shaped mammals of the same weight. The long, thin shape of the ermine and its small size considerably increase the cost of thermoregulation, resulting in a high metabolic rate. For this reason, ermines may be at greater risk than other mammals of the same weight. Input parameters for the ermine are provided in Table J-3-6.

J-3.6.1 Life History

The ermine is a member of the *Mustelidae* family. The ermine occurs throughout the northern temperate, subarctic and Arctic regions of Europe, Asia, and North America (King, 1983; Fagerstone, 1987). This species is a medium-sized to small weasel. In summer, the ermine's fur is medium to dark brown on the head and back, with white or cream on the underside. In the winter, this species turns entirely white. The total length is 22.5-34 cm in males and 19-29 cm in females (Svendsen, 2003). The local distribution of ermine is broadly related to that of small rodents and lagomorphs (*i.e.*, hares). Ermine tend to avoid dense forest, and settle in successional or forest-edge habitats, in scrub, alpine meadows, marshes, riparian woodlands, hedgerows, and riverbanks rich in small mammals (Svendsen, 2003). Based on snow tracking, Nyholm (1959) reported an average home range of 34 ha for males and 7.4 ha for females. Using radio-collared animals, Erlinge (1977) determined home ranges to be 2-3 ha for females and 8-13 ha for males in late autumn. In late summer, females used 4-10 ha and males 15 ha. Ermine are specialist predators of small, warm-blooded vertebrates, consuming mainly small mammals such as rodents (*e.g.*, mice, shrews, and voles), and occasionally other small vertebrates (*e.g.*, birds and fish) and insects (NatureServe, 2008).

Table J.3-6 Input Parameters for Ermine Exposure Analyses

Input Parameter	*Distribution*	*Parameters*	*References*	*Notes*
BW (kg)	Point estimate	0.043	Elsasser and Parker, 2008	Average female body weight.
Proportion Soil in Diet	Point estimate	0.04	U.S. EPA, 2005	Assumed long-tailed weasel as surrogate.
Assimilation Efficiency Small Mammals	Point estimate	0.84	Litvaitis and Mautz, 1976; Vogtsberger and Barrett, 1973; Grodzinski and Wunder, 1975	
Gross Energy (kcal/kg dw) Small Mammals	Point estimate	5,000	Górecki, 1975; Golley, 1960; Koplin *et al.*, 1980	Estimated from measured values for mice, voles, and rabbits.
Proportion in Diet Small Mammals	Point estimate	1.0	Svensen, 2003	

J-3.6.2 Body Weight (BW)

Sexual dimorphism is apparent in the ermine, male ermines being about 30% larger and heavier than females (Svendsen, 2003). Mean body weights of adult males in North America range from 56 to 206 g and are typically smaller in the south (King, 1983). Elsasser and Parker (2008) reported an average body weight of 104 g (*n* = 77-103) and 43 g (*n* = 2) for male and female ermines from western Quebec, respectively. A mean adult body weight of 0.043 kg was used in the exposure analysis (Elsasser and Parker, 2008). The exposure modeling considered females because they are smaller than males, and thus represent a more conservative selection in the context of the exposure assessment.

J-3.6.3 Inhalation Rate (IR)

The air inhalation rate of the ermine was based on allometric modeling approach described in Section J-2.4. The resulting equation for the IR for the ermine is as follows:

Equation 33

The estimated inhalation rate was used to predict chemicals exposures from the air and dust inhalation pathway.

J-3.6.4 Food Intake Rate (FIR)

Müller (1970) studied the daily food requirements of captive European ermines, in temperate conditions and fed on whole small mammals. Daily intake averaged 19 to 32% of body weight per day in males and 23 to 27% in females. Because the animals were kept in captivity, the measured food intake rates likely underestimated actual food intake rates of free-living ermines (U.S. EPA, 1993). Free-living ermines, unlike captive ermines, expend energy foraging for food, avoiding predators, *etc*. As a result, rather than the rates reported from the captive study, the allometric modeling approach described in Section J-2.1 was used to estimate food intake rate for the ermine. The slope (*a*) and power (*b*) parameters were based on data for carnivores reported in Nagy *et al*. (1999). The resulting equation for FMR for the ermine is:

Equation 34

In the exposure assessment, FMR was normalized to ermine body weight:

Equation 35

The resulting estimated FMR for the ermine was 303 kcal/kg bw/day.

J-3.6.5 Soil Intake Rate (SIR)

No data were available for ermine soil ingestion rates. For modeling purposes, the proportion of soil ingested by the ermine was estimated to be 0.04 (4% of the diet), based on values reported by U.S. EPA (2005) using the long-tailed weasel as a surrogate species.

J-3.6.6 Water Intake Rate (WIR)

The water intake rate for the ermine was based on the allometric equation for mammals reported in Nagy and Peterson (1988). The resulting equation for daily water flux rate for the ermine is:

Equation 36

In the exposure assessment, WIR was normalized to ermine body weight:

Equation 37

The resulting estimated WIR for the ermine was 0.136 L/kg bw/day.

J-3.6.7 Assimilation Efficiency (AE)

The assimilation efficiencies of food items in the ermine diet were used to calculate the FIR. Average assimilation efficiency for mammals consuming small birds and mammals is 0.84 kcal/kg dw (Litvaitis and Mautz, 1976; Vogtsberger and Barrett, 1973; Grodzinski and Wunder, 1975).

J-3.6.8 Gross Energy (GE)

The gross energy of food items in the ermine diet was also used in the calculation of the FIR. The mean gross energy for small mammals (assumed from measured values for mice, voles, and rabbits) is 5,000 kcal/kg dw (Górecki, 1975; Golley, 1960; Koplin *et al.*, 1980).

J-3.6.9 Proportions of Dietary Items (P_i)

The proportion of various dietary items in the ermine diet is the final parameter used to calculate the FIR. Between 50% and 80% of the yearly food intake of weasels consist of small mammals, mainly rodents. Other foods vary in proportion depending on the season, availability, and individual preferences. Small mammals were predominant as prey items of ermine in New York. Winter food items determined from stomach analysis in the Northwest Territories and Alberta, Canada, included 55% mammals, 13% fish, 7% amphibian, 4% birds, 4% insects, and 14% vegetation (Svensen, 2003). For the exposure analysis, it was assumed that small mammals constituted 100% of the ermine's diet in the exposure model.

J-3.7 White-tailed Deer

White-tailed deer (*Odocoileus virginianus*) were selected as a representative species because they are large browsing ruminants (*i.e.*, herbivores) and they are the most widely distributed North American mammal (CWS, 1990). They occur in eastern Canada and their preferred habitat is a combination of dense forest and edge environments (Dewey, 2003). Input parameters for the white tailed deer are provided in Table J-3-7.

J-3.7.1 Life History

White-tailed deer are members of the family *Cervidae* ranging from the southern-most reaches of the continent to northern boreal and coniferous forests. Across Canada, they range from south-central British Columbia to the Maritime Provinces (Passmore, 1990). Mating occurs between October and December and is most intense during the last three weeks of November (Passmore, 1990; Dewey, 2003). Gestation lasts for approximately six and a half months, with fawns typically born in the early spring (Passmore, 1990). The lifespan of a wild deer is approximately 10 years (Dewey, 2003). White-tailed deer can survive in a variety of habitats. Ideal conditions provide a combination of dense forest and edge environments (Dewey, 2003). During the winter, white-tailed deer will congregate in sheltered areas termed "deer yards". These areas provide deer with protection from adverse climatic conditions, such as severe cold and deep snow (Dewey, 2003; Passmore, 1990). White-tailed deer may travel many kilometers between winter and summer ranges (Passmore, 1990).

The diet of white-tailed deer varies seasonally with the availability of food items. In the spring and early summer, deer primarily consume shoots, leaves and twigs, shrubs, grasses, and forbs (Short, 1986). During the summer, and into the winter, fruits, seeds and nuts become important sources of food. Deciduous leaves are consumed until they die off in the fall, and coniferous leaves may be consumed all year (Short, 1986). Cool season herbages provide a highly digestible food source during the winter and early spring (Short, 1986).

While they may congregate in "deer yards" during the winter, white-tailed deer exhibit more solitary behaviour during the summer (Dewey, 2003). The home range of white-tailed deer is often less than one deer per km^2 (Dewey, 2003). A wide range of population densities are reported in the literature (LaRoe *et al.*, 1995; Dumont *et al.*, 2000). Data collected for the northeastern United States in 1992 reported an average deer density of 5.5 deer/km^2, ranging from 2.7 deer/km^2 in Rhode Island to 9.2 deer/km^2 in Pennsylvania (LaRoe *et al.*, 1995). Studies in Quebec have reported deer densities ranging from 8.4 to 20.8 deer/km^2 (Dumont *et al.*, 2000; Lesage *et al.*, 2001). Passmore (1990) reported an average density of three deer/km^2.

Table J.3-7 Input Parameters for White-tailed Deer Exposure Analyses

Input Parameter	*Distribution*	*Parameters*	*References*	*Notes*
BW (kg)	Point estimate	45	Lesage *et al.*, 2001; SARA, 2006	Average female body weight.
Proportion of Soil in Diet	Point estimate	0.02	Beyer *et al.*, 1994	
Assimilation Efficiency Twigs and Buds	Point estimate	0.46	Drozdz, 1968; Drozdz *et al.*, 1971; Grodzinski and Wunder, 1975; Gray and Servello, 1995; Ullrey *et al.*, 1972; Mautz *et al.*, 1976	
Gross Energy (kcal/kg dw) Forbs[1]	Point estimate	4,500	Golley, 1961	
Gross Energy (kcal/kg dw) Grasses[1]	Point estimate	4,300	Cummins and Wuycheck, 1971; Davis and Golley, 1963; Drozdz, 1968; Golley, 1960; Kendeigh and West, 1965	
Gross Energy (kcal/kg dw) Twigs and Buds[1]	Point estimate	5,000	Gray and Servello, 1995; Shipley and Spalinger ,1995; Mautz *et al.*, 1976	
Gross Energy (kcal/kg dw) Fruits, Nuts and Seeds[1]	Point estimate	3,650	Golley, 1961; Karasov, 1990; Dice, 1922; Robel *et al.*, 1979; Drozdz, 1968	
Proportion in Diet Forbs[2]	Point estimate	0.25	Brown and Doucet, 1991; Crawford, 1982; Whitaker, 1996; McMahan, 1964; SARA, 2006	
Proportion in Diet Grasses[2]	Point estimate	0.10	Brown and Doucet, 1991; Crawford, 1982; Whitaker, 1996; McMahan, 1964; SARA, 2006	
Proportion in Diet Twigs and Buds[2]	Point estimate	0.575	Brown and Doucet, 1991; Crawford, 1982; Whitaker, 1996; McMahan, 1964; SARA, 2006	
Proportion in Diet Fruits, Nuts and Seeds[2]	Point estimate	0.075	Brown and Doucet, 1991; Crawford, 1982; Whitaker, 1996; McMahan, 1964; SARA, 2006	

1 In the exposure modeling an average gross energy for forbs; grasses; twigs and buds; and fruits, nuts and seeds of 4363 kcal/kg-dw [*i.e.*, (4500 + 4300 + 5000 + 3650) / 4] was used .

2 In the exposure modeling browse was assumed to represent 100% of the diet.

J-3.7.2 Body Weight (BW)

A study performed in Quebec recorded the body weights of male and female white-tailed deer for different age groups in three separate populations (Lesage *et al.*, 2001). The populations were differentiated by their density and according to various climatic conditions. Body weights for adult male white-tailed deer (≥ 2.5 years) ranged from 53 to 116 kg. Body weights for adult female white-tailed deer (≥ 2.5 years) ranged from 39 to 52 kg. For the exposure analysis, the mean weight of females was estimated to be 45 kg (SARA, 2006). The study used to derive the value collected a large number of samples and considered the influence of environmental and demographic factors, thus there is low uncertainty associated with this variable.

J-3.7.3 Inhalation Rate (IR)

The air inhalation rate of the white-tailed deer was based on allometric modeling approach described in Section J-2.4. The resulting equation for the IR for the white-tailed deer is as follows:

Equation 38

The estimated inhalation rate was used to predict chemicals exposures from the air and dust inhalation pathway.

J-3.7.4 Food Intake Rate (FIR)

The daily energy requirements of white-tailed deer vary according to season and stage of the reproductive cycle. Fasting metabolic rates and metabolized energy intakes were calculated for five penned does between September and March (Worden and Pekins, 1995). The fasting metabolic rate represents the metabolic rate of an animal in a post-absorptive (>48 hr) and resting state. The highest metabolic rates were recorded in October, with a mean rate of 90.7 kcal/kg·BW$^{0.75}$/day (Worden and Pekins, 1995). Values recorded between November and March were similar, with a mean metabolic rate of 79.8 kcal/kg·BW$^{0.75}$/day (Worden and Pekins, 1995). Metabolizable energy intake (MEI) was greatest during September and October, with a mean intake rate of 170.3 kcal/kg·BW$^{0.75}$/day (Worden and Pekins, 1995). Between November and March the mean MEI was 85.5 kcal/kg·BW$^{0.75}$/day (Worden and Pekins, 1995). Because the animals were penned, the measured food intake rates likely underestimated actual food intake rates of free-living deer (U.S. EPA, 1993). For this assessment, FIR was estimated using the allometric equation described in Section 1.1.1 rather than using the literature-reported values for penned white-tailed deer. The slope (*a*) and power (*b*) parameters were based on data for mammals reported in Nagy *et al.* (1999). The resulting equation for FMR for the white-tailed deer is:

Equation 39

In the exposure assessment, FMR was normalized to white-tailed deer body weight:

Equation 40

The resulting estimated FMR for the white-tailed deer was 66.6 kcal/kg bw/day.

J-3.7.5 Soil Intake Rate (SIR)

White-tailed deer are likely to consume soil while foraging on forbs, seeds, nuts, grasses and other food items. A study using mule deer (*Odocoileus hemionus*) reported winter, spring, summer and fall soil intakes rates of 0.0183, 0.0296, 0.0077, and 0.0088 kg/day, respectively (Arthur and Alldredge, 1979). Arthur and Alldredge (1979) report that soil intake rates ranged from 0.6 to 2% of the mule deer food intake rate. This corresponds with a study on white-tailed deer that found that soil comprises <2 % of the total diet (Beyer *et al.*, 1994). For the exposure modeling, the proportion of soil ingested by the white-tailed deer was estimated to be 0.02.

J-3.7.6 Water Intake Rate (WIR)

The water intake rate for the white-tailed deer was based on the allometric equation for mammals reported in Nagy and Peterson (1988). The resulting equation for daily water flux rate for the white-tailed deer is:

Equation 41

In the exposure assessment, WIR was normalized to white-tailed deer body weight:

Equation 42

The resulting estimated WIR for the white-tailed deer was 0.0677 L/kg bw/day.

J-3.7.7 Assimilation Efficiency (AE)

The assimilative efficiencies of food items in the white-tailed deer diet were used to calculate the FIR. Average assimilation efficiency for white-tailed deer consuming twigs and buds is 0.46 (Drozdz, 1968; Drozdz *et al.*, 1971; Grodzinski and Wunder, 1975; Gray and Servello, 1995; Ullrey *et al.*, 1972; Mautz *et al.*, 1976).

For forbes the average assimilation efficiency is 0.760 (Drozdz,1968; Drozdz *et al.*, 1971; Grodzinski & Wunder, 1975). For grasses the assimilation efficiency is 0.410 (Batzli and Cole, 1979). For fruits, nuts, and seeds the average assimilation efficiency is 0.850 based on data in (Grodzinski & Wunder, 1975; Drozdz, 1968).

J-3.7.8 Gross Energy (GE)

The gross energy of food items in the white tailed deer diet was also used in the calculation of the FIR. The mean gross energies of dietary items reported in the literature were as follows: forbs contain 4,500 kcal/kg dw (Golley, 1961); grasses contain 4,300 kcal/kg dw (Cummins and Wuycheck, 1971; Davis and Golley, 1963; Drozdz, 1968; Golley, 1960; Kendeigh and West, 196**5);** twigs and buds contain 5,000 kcal/kg dw (Gray and Servello, 1995; Shipley and Spalinger ,1995; Mautz *et al*., 1976); and, fruits, nuts and seeds contain 3,650 kcal/kg dw (Golley, 1961; Karasov, 1990; Dice, 1922; Robel *et al*., 1979; Drozdz, 1968).

J-3.7.9 Proportions of Dietary Items (P_i)

The following studies were selected to characterize the proportion of different items in the white-tailed deer diet: Brown and Doucet (1991), Crawford (1982), Whitaker (1996), and McMahan (1964). Winter feeding habits were recorded over three years at a 34 km^2 study area in southwestern Quebec (Brown and Doucet, 1991). The study reported browsing pressure on different twig species and noted changes in forage selection over the course of the winter. Crawford (1982) recorded seasonal food selection habits of tame white-tailed deer in central Maine. Findings included white-tailed deer preference for hardwood leaves, forbs and other new growth during the spring and summer, and the importance of hemlock shoots during the winter (Crawford, 1982). Based on the diets reported in these studies, the mean percentage of each forage item estimated in the white-tailed deer diet was: 25% forbs; 10% grasses; 57.5% twigs and buds; and, 7.5% fruits, nuts and seeds (SARA, 2006).

J-3.12 Terrestrial Vegetation

Plants are important monitors of soil quality since their root systems are in constant contact with soil particles and associated chemicals. In addition to uptake of chemicals through the roots, a portion of the airborne chemicals which deposit on the shoots can be taken up by the plant.

Terrestrial vegetation was evaluated as a group in the ERA using a screening level approach (comparison of COPC concentrations in soil to soil quality benchmarks protective of terrestrial vegetation). Measured soil concentrations were assumed to represent exposure of the COPCs to terrestrial vegetation.

J-3.13 Soil Invertebrates and Soil Micro-organisms

Terrestrial soil invertebrates spend the majority (if not all) of their lifetime in contact with soils and are therefore appropriate indicators of soil quality through their high exposure potential. Earthworms and other soil dwelling invertebrates are important for the maintenance of soil quality, through their activities, which break down organic matter, release nutrients, and improve aeration, drainage and soil aggregation. In addition, earthworms are sources of food for a number of wildlife species. Earthworms are continually burrowing and ingesting significant quantities of soil and decaying organic matter (Will and Suter II, 1995).

Soil microorganisms are primary consumers of organic matter which convert soil nutrients into forms that are available for uptake by plants and higher trophic level organisms. As such, soil microorganisms are important to the natural nutrient cycling of soils (Will and Suter II, 1995).

Terrestrial soil invertebrates and soil microorganisms were evaluated as a group in the ERA using a screening level approach (comparison of COPC concentrations in soil to available soil quality benchmarks protective of soil invertebrates and soil microorganisms). Measured soil concentrations were assumed to represent exposure of the COPCs to soil invertebrates and soil microorganisms.

J-4.0 CONCENTRATIONS OF COPCS IN ENVIRONMENTAL MEDIA AND DIETARY ITEMS

Five scenarios were evaluated in this ERA including:

- Reference areas;
- 0 to 3 km radius from Study Area;
- 0 to 1 km radius from Study Area;
- 1 to 2 km radius from Study Area; and
- 2 to 3 km radius from Study Area.

The sources of data used in the exposure modelling for each scenario are identified in Table J.4-1. Data used to model these scenarios are provided in Attachment J-1 of this Appendix.

Table J.4-1 Sources of Data Used in the ERA

Media	Scenario		
	Reference Areas	**0 to 3 km Radius**	**0 to 1 km; 1 to 2 km and 2 to 3 km Radius**
Ambient Air	Measured ambient air data from rural National Air Pollution Surveillance (NAPS) Program stations at various locations in Canada	Measured SO_2, ambient air data in the vicinity of the facility (i.e., Chalmers and Boulay ambient air monitors)	Measured SO_2, ambient air data in the vicinity of the facility (i.e., Chalmers and Boulay ambient air monitors)
Freshwater surface water	Measured data from streams within the reference area and other streams in north eastern NB that are considered appropriate reference areas [1]	Measured data from streams within the study boundary (Hendry Brook and Unnamed Brook)	Measured data from streams within the study boundary (Hendry Brook and Unnamed Brook)
Soil	Measured reference surface soil concentrations (UCLM 95 and 95th percentile)	Measured study area surface soil concentrations (UCLM 95 and 95th percentile of 0 to 3 km soil concentrations)	Measured study area surface soil concentrations (UCLM 95 of 0 to 1 km, 1 to 2 km and 2 to 3 km soil concentrations)
Terrestrial vegetation (*e.g.*, leaves, fruits, nuts, seeds, vegetation, grasses, forbs) [2]	Predicted using trophic transfer models and measured soil concentrations in reference areas (UCLM 95 and 95th percentile)	Predicted using trophic transfer models and measured soil concentrations in study area (UCLM 95 and 95th percentile of 0 to 3 km soil concentrations)	Predicted using trophic transfer models and measured soil concentrations in study area (UCLM 95 of 0 to 1 km, 1 to 2 km and 2 to 3 km soil concentrations)
Terrestrial Prey[3]	Predicted using measured soil concentrations and trophic transfer models or bioconcentation factors (BCFs) (Sample *et al*., 1998; US EPA, 2005; See Section J-4.1)	Predicted using measured soil concentrations and trophic transfer models or BCFs (Sample *et al*., 1998; US EPA, 2005; See Section J-4.1)	Predicted using measured soil concentrations and trophic transfer models or BCFs (Sample *et al*., 1998; US EPA, 2005; See Section J-4.1)
Terrestrial Invertebrates	Predicted using trophic transfer models and measured soil concentrations in reference areas (UCLM 95 and 95th percentile)	Predicted using trophic transfer models and measured soil concentrations in the study area (UCLM 95 and 95th percentile of 0 to 3 km soil concentrations)	Predicted using trophic transfer models and measured soil concentrations in the study area (UCLM 95 of 0 to 1 km, 1 to 2 km and 2 to 3 km soil concentrations)

1 Reference area freshwater surface chemistry data were collected from a local reference brook (*i.e.*, Armstrong Brook). As the sample size from Armstrong Brook was limited (N=5), reference data from other locations in Northern NB

considered to be un-influenced were used as reference surface water concentrations (Pooled dataset N=62). For more information see Appendix H.

2 Terrestrial vegetation included leaves, fruits, nuts, seeds, vegetation, grasses and forbs.

3 Terrestrial prey included small mammals. Prey concentrations for antimony was based on BCF multiplied by average dietary (*i.e*., browse, berries & invertebrates) concentration (see Table J.4-7)

J-4.1 Estimation of Prey Tissue Concentrations

Prey concentrations were based on measured soil concentrations and trophic transfer models (Sample *et al*., 1998) or BCFs (US EPA, 2005). Prey concentrations were estimated to assess the exposure to species that eat prey such as small mammals (*i.e*., short-tailed weasel and saw whet owl).

Literature based regression models were derived for several COPCs for the purpose of predicting small mammal concentrations based on measured COPC concentrations in soil. The general form of the regression model equation is:

$$\ln [small\ \_\ mammal] = B_0 + B_1 \text{ x } \ln [soil] \text{ or } [small\ \_\ mammal] = e\ (^{B_0 + B_1 \text{ x } \ln [soil]})$$

where:
ln[small_mammal] = predicted small mammal concentration [mg/kg-DW]
B_0 = Y-intercept
B_1 = slope or change in Y relative to a change in X
Soil = measured soil concentration
(See Table J.4-7 for B0 and B1 inputs)

No regression equation was available for antimony. Therefore, a BCF approach was used based on the following equation (US EPA, 2005):

[Average in Diet]*BCF.

Table J.4-7 Literature Based Small Mammal Trophic Transfer Models

Chemical	Model	Value	B0	B1	Comment
Antimony	BCF	0.05			US EPA, 2005
Arsenic	REG		4.8471	0.8188	Sample *et al*. 1998
Lead	REG		0.0761	0.4422	Sample *et al*. 1998
Zinc	REG		4.47	0.0738	Sample *et al*. 1998

Notes:
BCF = bio-concentration factor (also referred to as uptake factor or UF); REG = regression; B0 = Y-intercept; B1 = slope or change in Y relative to change in X

Predicted prey tissue concentrations are provided in Attachment J-1.

J-4.2 Ambient Air Concentrations for Assessment of Vegetation

Ambient air concentrations in the Study boundary were based on ambient air quality data collected in the vicinity of the Glencore smelter (air data provided by Glencore). The Hi Vol TS ambient air metals data from the ambient air monitors based in Bouley and Chalmers for the years 2007-2009 (n=357) were used to derived ambient air input values. To ensure an appropriate comparison to the reference scenario (where metals data were obtained from PM2.5 as opposed to TSP), TSP COPC concentrations were divided by a factor of 2.7 (obtained from ratios of geomean TSP and PM2.5 metals concentrations for near-smelter monitoring stations in Sudbury, Ontario).

J-4.3 Concentrations in Aboveground Forage/Browse Consumed by Wildlife

Atmospheric deposition was only considered for plants whose edible portions are aboveground and where the chemical potentially exists in particulate form. The following series of equations was used to predict concentrations of browse and aboveground plants for consumption by wildlife as a result of deposition processes on a dry weight (DW) basis (US EPA 2005):

Where

D_d = dry deposition(mg/m²/yr)

C_a = Concentration in air (mg/m^3)

F_v = fraction that is volatile (Assumed 0%)

V_d = Dry deposition velocity (m/s; 0.03)

CF = 31536000 (seconds/year)

Where

D_w = wet deposition (mg/m²/yr)

C_a = Concentration in air (mg/m^3)

F_v = fraction that is volatile (Assumed 0%)

V_w = Wet deposition velocity (m/s; 0.0062)

CF = 31536000 (seconds/year)

$$Pd = \frac{\left[D_d + \left(D_w \times 0.6\right)\right] \times Rp \times \left[1.0 - \exp\left(-kp \times Tp\right)\right]}{Yp \times kp}$$

Where:

Pd = browse concentration as a result of direct deposition (mg/kg DW)

Rp = intercept fraction of edible portions of plant (0.5; unitless)

kp = plant surface loss coefficient (18 yr^{-1})

Tp = length of plant exposure to deposition (0.12 yr)

Yp = yield or productivity (0.24 kg DW/m²)

J-4.4 Concentrations in Invertebrates

Two trophic transfer models were considered for predicting terrestrial invertebrate concentrations based on soil concentrations. The ecological risk assessment selected the exponential regression model first and used the linear BCF model second. The selection process was based on recommendations by Sample *et al.* (1998). The following equations (*i.e.*, linear BCF model or exponential regression model) were used to predict chemical concentrations in terrestrial invertebrates:

$$C_{invert} = C_s \times BCF$$

Or

Where:

C_{invert} = chemical concentration in invertebrates (mg/kg DW)
C_s = chemical concentration in soil (mg/kg)
BCF = soil-to-soil invertebrate bioconcentration factor (kg soil/kg invertebrate DW)
M = slope of the regression model
C = constant of the regression model

J-5.0 REFERENCES

Adams, L. 1959. An analysis of a population of snowshoe hares in southwestern Montana. Ecological Monographs 29:141-170.

Aldous, C.M. 1936. Food habits of *Lepus americanus phaeonotus*. Journal of Mammology 17:175-176.

AOU (American Ornithologists' Union). 1983. Check-list of North American Birds, 6th edition. Allen Press, Inc., Lawrence, Kansas. 877 pp.

Archibald, H.L. 1975. Temporal patterns of spring space use by Ruffed Grouse. Journal of Wildlife Management 39:472-481.

Arthur, W.J. III, and R.J. Gates. 1988. Trace element intake via soil ingestion in pronghorns and black-tailed jackrabbits. Journal of Range Management 41:162-166.

Arthur, W.J., III. and A.W. Alldredge. 1979. Soil ingestion by mule deer in north central Colorado. Journal of range management. 32:67-70.

Austin, D. 1960. Some environmental relationships of the snowshoe hare, *Lepus americanus* Erxl., in Wellington County, Ontario. M.S. Thesis. Ontario Agricultural College, University of Toronto, Toronto, ON.

Banfield, A.W.F. 1974. The Mammals of Canada. Toronto: University of Toronto Press

Barb, M. 1995. Natural history of the Northern Saw-whet Owl (*Aegolius acadicus*) in southern Appalachian mountains. Ph.D. dissertation, Eastern Tennessee State University.

Barrett, G.W. 1969. Bioenergetics of a captive least shrew, *Cryptotis parva*. Journal of Mammalogy 50:629-630.

Barrett, G.W. and K.L. Stueck. 1976. Caloric ingestion rate and assimilation efficiency of the short-tailed shrew, *Blarina brevicaudz*. Ohio Journal of Science 76:25-26.

Batzli, G.O. and F.R. Cole. 1979. Nutritional ecology of microtine rodents: digestibility of forage. Journal of Mammalogy 60:740-750.

Beal, F.E.L. 1907. Birds of California in relation to the fruit industry, Pt. I. U.S. Department of Agriculture Biological Survey Bulletin 30.

Bell, G.P. 1990. Birds and mammals on an insect diet: a primer on diet composition analysis in relation to ecological energetics. Studies in Avian Biology 13:391-415.

Beyer, W.N., E.E. Connor, and S. Gerould. 1994. Estimates of soil ingestion by wildlife. The Journal of Wildlife Management 58:375-382.

Bider, J.R. 1961. An ecological study of the hare *Lepus americanus*. Canadian Journal of Zoology 39:81-103.

Bookhout, T.A. 1965. Feeding coactions between showhoe hares and white-tailed deer in northern Michigan. Transactions of the North American Wildlife and Natural Resources Conference 30:321-335.

Boula, K.M. 1982. Food habits and roost-sites of Northern Saw-whet Owls in northeastern Oregon. Murrelet 63:92-93.

Brown, D.T. and G.J. Doucet. 1991. Temporal changes in winter diet selection by white-tailed deer in a northern deer yard. Journal of Wildlife Management 55:361-376.

Bryant, D.M. and V.M. Bryant. 1988. Assimilation efficiency and growth of nestling insectivores. Ibis 130:268-274.

Buechner, H.K. and F.B. Golley. 1967. Preliminary estimation of energy flow in Uganda kob (*Adenota kob thomasi* Neumann). In: Petrusewicz, L. (Ed.), Secondary Productivity of Terrestrial Ecosystems. Warszawa-Krakow. pp. 243-254.

Bump, G., R.W. Darrow, F.C. Edminster, and W.F. Crissey. 1947. The Ruffed Grouse: life history, propagation, management. New York State Conservation Department, Albany, NY.

Cade, B.S. and P.J. Sousa. 1985. Habitat suitability index models: Ruffed Grouse. U.S. Fish and Wildlife Service Biological Report 82(10.86). 31 pp.

Calder, W.A. and E.J. Braun. 1983. Scaling of osmotic regulation in mammals and birds. American Journal of Physiology 224:R601-R606.

Cannings, R.J., J.L. Rasmussen, and S.G. Sealy. 2008. Northern Saw-whet Owl (Aegolius acadicus), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/042

Cannings, R.J. 1993. Northern Saw-whet Owl. Birds of North America 42:1-20.

Cannings, R.J. 1987. The breeding biology of Northern Saw-whet Owls in southern British Columbia. *In* Nero, R.W., R.J. Clark, R.J. Knapton, and H. Hamre (Eds.). Biology and Conservation of Northern Forest Owls. USDA Forest Service General Technical Report RM-142, USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. pp. 193-198.

Castro, G., N. Stoyan, and J.P. Myers. 1989. Assimilation efficiency in birds; a function of taxon or food type? Comparative Biochemistry and Physiology A-Comparative Physiology 92:271-278.

Catling, P.M. 1972. Food and pellet analysis studies of the Saw-whet Owl (*Aegolius acadicus*). Ontario Field Biologist 26:1-15.

Chandler, C.R., E.D. Ketterson, and V. Nolan, Jr. 1997. Effects of testosterone on use of space by male dark-eyed juncos when their mates are fertile. Animal Behaviour 54:543-549.

Chevron, Mobil, and Petro-Canada. 1996. Newfoundland Transshipment Terminal Project: Environmental Assessment. Volume 2, Main Report. Prepared for Chevron Canada Resources Limited, Mobil Oil Canada Properties, and Petro-Canada, St. John’s, NF.

Cockerel, B.J. 1997. Prey preferences of the Northern Saw-whet Owl (*Aegolius acadicus*) in the southern Appalachian mountains. Ph.D. dissertation, Appalachian State University.

Collins, C.T. 1963. Notes on the feeding behavior, metabolism, and weight of the Saw-whet Owl (*Aegolius acadicus*). Condor 65:528-530.

Collopy, M.W. 1975. Behavioral and predatory dynamics of kestrels wintering in the Arcata Bottoms. Master’s Thesis. Humboldt State University, Arcata, CA.

Crawford, H.S. 1982. Seasonal food selection and digestibility by tame white-tailed deer in central Maine. Journal of Wildlife Management 46:974-982.

Csuti, B., A.J. Kimerling, T.A. O’Neil, M.M. Shaughnessy, E.P. Gaines, and M.M.P. Huso. 1997. Atlas of Oregon wildlife: distribution, habitat, and natural history. Oregon State University Press, Corvallis, OR.

Cummins, K.W. and J.C. Wuycheck. 1971. Caloric equivalents for investigations in ecological energetic. International Association of Theoretical and Applied Limnology, Stuttgart, West Germany.

CWS. 1990. Hinterlands Who’s Who – White-tailed Deer. Environment Canada, Ottawa, Canada. Canadian Wildlife Service. http://www.cws scf.ec.gc.ca/index_e.cfm

Davis, D.E. F.B. and Golley. 1963. Principles in Mammalogy. Van Nostrand Rheinhold, New York, NY.

Dewey, T. 2003. Odocoileus virginianus. Animal Diversity Web. University of Michigan Museum of Zoology, Ann Arbor, MI. http://animaldiversity.ummz.umich.edu/site/accounts/information/Odocoileus_virginianus.html.

Dice, L.R. 1922. Some factors affecting the distribution of the prairie vole, forest deer mouse, and prairie deer mouse. Ecology 3:29-47.

Dinsmore, S.J. and W.R. Clark. 1991. Food habits of the Northern Saw-whet Owl in central Iowa: effects of roost location. Journal of the Iowa Academy of Science 98:167-169.

Dodds, D.G. 1960. Food competition and range relationships of moose and snowshoe hare in Newfoundland. Journal of Wildlife Management 24:52-60.

Dodds, D.G. 1987. Nova Scotia's snowshoe hare: Life history and management. Department of Lands and Forests, Halifax, NS.

Dolbeer, R.A. and W.R. Clark. 1975. Population ecology of snowshoe hares in the central Rocky Mountains. Journal of Wildlife Management 39:535-549.

Drozdz, A. 1968. Digestibility and assimilation of natural foods in small rodents. Acta Theriologica 13:367-389.

Drozdz, A., A. Górecki, and W. Grodzinski. 1971. Bioenergetics of water voles (*Arvicola terrestris* L.) from southern Moravia. Annales Zoologici Fennici 8:97-103.

Duffy, K. and P. Kerlinger. 1992. Autumn owl migration at Cape May Point, New Jersey. Wilson Bulletin 104:312-320.

Dunning Jr., J.B. 1993. CRC Handbook of Avian Body Masses. CRC Press, Inc., Boca Raton, FL.

Dumont, A., M. Crête, J.P. Ouellet, J.M. Huot, and J. Lamoureux. 2000. Population dynamics of northern white-tailed deer during mild winters: Evidence of regulation by food competition. Canadian Journal of Zoology 78:764-776.

Elsasser, S.C. and G.H. Parker. 2008. Morphometric criteria for distinguishing species and age-cohorts of ermine (*Mustela ermine*) and long-tailed weasel (*M. frenata*). Acta Zoologica Academiae Scientiarum Hungaricae 54:75-88.

Erlinge, S. 1977. Home range utilization and movements of the stoat, *Mustela ermine*. *In* Proceedings of the 13th Congress of Game Biologists. pp. 31-42.

Fagerstone, K. 1987. Black-footed ferret, long-tailed weasel, short-tailed weasel, and least weasel. *In* Novak, M., J.A. Baker, M.E. Obbard, and B. Malloch (Eds.), Wild Furbearer Management and Conservation in North America. Ontario Ministry of Natural Resources, Ontario, Canada. pp. 555-561.

Ferron, J. and J.-P. Ouellette. 1992. Daily partitioning of summer habitat and use of space by the snowshoe hare in southern boreal forest. Canadian Journal of Zoology 70:2178-2183.

George, S.B., J.R. Choate, and H.H. Genoways. 1986. *Blarina brevicauda*. American Society of Mammalogists; Mammalian Species 261. Cited In: U.S. EPA, 1993.

Golley, F.B. 1960. Energy dynamics of a food chain of an old-field community. Ecological Monographs 30:187-206.

Golley, F.B. 1961. Energy values of ecological materials. Ecology 42:581-584.

Górecki, A. 1975. Calorimetry in ecological studies. *In* Grodzinski, W., R.Z. Klekowski, and A. Duncan (Eds.), Blackwell Scientific Publications, Oxford, London, Edinburgh, Melbourne. IPB Handbook No. 24. pp.275-281.

Graber, R.R. 1962. Food and oxygen consumption in three species of owls (Strigidae). Condor 64:473-487.

Grange, W.G. 1932. Observations of the snowshoe hare, *Lepus americanus phaenotus*, Allen. Journal of Mammalogy 13:1-19.

Gray, P.B. and F.A. Servello. 1995. Energy intake relationships for white-tailed deer on winter browse diets. Journal of Wildlife Management 59:147-152.

Grodzinski, W. and B.A. Wunder. 1975. Ecological energetics of small mammals. *In* Golley, F.B., K. Petrusewicz, and L. Ryszkowski (Eds.), Small Mammals: Their productivity and population dynamics. Cambridge University Press, Cambridge, MA.

Hayward, G.D. and E.O. Garton. 1988. Resource partitioning among forest owls in the River of No Return wilderness, Idaho. Oecologia 75:253-265.

Hodges, K.E. 2000. Ecology of snowshoe hares in southern boreal and montane forests. *In* Ruggiero, L.F., K.B. Aubry, S.W. Buskirk, G.M. Koehler, C.J. Krebs, K.S. McKelvey, and J.R. Squires (Eds.), Ecology and Conservation of Lynx in the United States. University of Colorado and U.S. Department of Agriculture, Rocky Mountain Research Station, Denver, CO. pp. 136-206.

Holmes, R.T., T.W. Sherry, and F.W. Sturges. 1986. Bird community dynamics in a temperate deciduous forest: long-term trends at Hubbard Brook. Ecological Monographs 56:201-220.

Holroyd, G.L. and J.G. Woods. 1975. Migration of Saw-whet owl in eastern North America. Bird-Banding 46:101-105.

Holt, DW, E. Andrews, and N. Claflin. 1991. Nonbreeding season diet of Northern Saw-whet Owls, *Aegolius acadicus*, on Nantucket Island, Massachusetts. Canadian Field-Naturalist 105:382-385.

Holter, J.B., G. Tyler, and T. Walski. 1974. Nutrition of the snowshoe hare (*Lepus americanus*). Canadian Journal of Zoology 52:1553-1558.

Huempfner, R.A. and J.R. Tester. 1988. Winter arboreal feeding behaviour of Ruffed Grouse in east-central Minnesota. *In* Bergerud, A.T. and M.W. Gratson (Eds.), Adaptive strategies and population ecology of northern grouse. University of Minnesota Press, Minneapolis, MN. pp. 122-157.

Johnson, J. 1999. Abundance and distribution of Saw-whet owls (*Aegolius acadicus*) on Santa Cruz Island. Ph.D. dissertation, California State University.

Johnson, A. and S.H. Anderson. 2003. Conservation assessment for the northern saw-whet owl in the black hills national forest, South Dakota and Wyoming. University of Wyoming.

Judd, S.D. 1901. The relation of sparrows to agriculture. U.S. Department of Agriculture Bulletin No. 15.

Karasov, W.H. 1990. Digestion in birds: chemical and physiological determinants and ecological implications. Studies in Avian Biology 13:391-415.

Keith, L.B. 1990. Dynamics of snowshoe hare populations. *In* Genoways, H.H. (Ed.), Current Mammalogy. Plenum Press, New York, NY. pp. 119-195.

Kendeigh, S.C. and G.C. West. 1965. Caloric values of plant seeds eaten by birds. Ecology 46:553-555.

King, C.M. 1983. *Mustela erminea*. Mammalian Species 195:1-8.

Kittams. 1943. October foods of ruffed grouse in Maine. Journal of Wildlife Management 7:231-233.

Kollars, T.M., Jr. and W. Bäumler. 1994. An artificial diet for shrews (Soricidae). Journal of Pest Science 67:179.

Koplin, J.R., M.W. Collopy, A.R. Bammann, and H. Levenson. 1980. Energetics of two wintering raptors. Auk 97:795-806.

Korschgen, L.J. 1966. Foods and nutrition of ruffed grouse in Missouri. Journal of Wildlife Management 30:86-100.

Lamprey, H.F. 1964. Estimation of the large mammal densities, biomass and energy exchange in the Tarangire Game Reserve and the Masai Steppe in Tanganyika, East African Wildlife Journal 2:1-46.

LaRoe, E.T., Farris, G.S., Puckett, C.E., Doran, P.D., and Mac, M.J. (Eds.). 1995. Our Living Resources: A Report to the Nation on the Distribution, Abundance, and Health of U.S. Plants, Animals, and Ecosystems. U.S. Department of the Interior, National Biological Service, Washington, DC. http://biology.usgs.gov/s+t/index.htm

Lasiewski, R. C.; Calder, W. A. (1971) A preliminary allometric analysis of respiratory variables in resting birds. Resp. Phys. 11: 152-166. Cited in U.S. EPA 1993

Lee, W. 2001. *Sorex cinereus*, Animal Diversity Web. Available at http://animaldiversity.ummz.umich.edu/site/accounts/information/Sorex_cinereus.html.

Lesage, L., M. Crête, J. Huot, and J.P. Ouellet. 2001. Evidence for a trade-off between growth and body reserves in northern white-tailed deer. Oecologia 126:30-41.

Litvaitis, J.A. and W.W. Mautz. 1976. Energy utilization of three diets fed to a captive red fox. Journal of Wildlife Management 40:365-368.

Mackie, R.J., R.F. Batchelor, M.E. Majerus, J.P. Weigand, and V.P. Sundberg. 2005. Habitat management suggestions for selected wildlife species: Ruffed Grouse. Animal & Range Sciences, Montana State University. Available at http://animalrangeextension.montana.edu/Articles/Forage/Animals/Wildlife-enhancement.htm

Marks, J.S. and J.H. Doremus. 1988. Breeding-season diet of northern saw-whet owls in southwestern Idaho. Wilson Bulletin 100:690-694.

Martin, A.C., H.S. Zim, and A.L. Nelson. 1951. American Wildlife and Plants. Dover Publications, New York, NY.

Mautz, W.M., H. Silver, J.B. Holter, H.H. Hayes, and W.E. Urban. 1976. Digestibility and related nutritional data for seven northern deer browse species. Journal of Wildlife Management 40:630-638.

Maxson, S.J. 1989. Patterns of activity and home range of hens. *In* Atwater, S. and J. Schnell (Eds.), Ruffed Grouse. Stackpole Books, Harrisburg, PA. pp. 118-129.

McMahan, C.A. 1964. Comparative food habits of deer and three classes of livestock. Journal of Wildlife Management 28:798-808.

Medin, D.E. 1984. Breeding birds of an ancient bristlecone pine stand in east central Nevada. Great Basin Naturalist 44:272–276.

Moore, D.R.J. and P.Y. Caux. 1997. Estimating low toxic effects. Environmental Toxicology and Chemistry 16:794-801.

Moore, D.R.J., B.E. Sample, G.W. Suter, B.R. Parkhurst, and R.S. Teed. 1999. A probabilistic risk assessment of the effects of methylmercury and PCBs on mink and kingfishers along East Fork Poplar Creek, Oak Ridge, Tennessee, USA. Environmental Toxicology and Chemistry 18:2941-2953.

Mozejko, A.T. 1971. A food habits study of the snowshoe hare, *Lepus americanus washingtonii* Baird, in western Oregon. Ph.D. Dissertation, Oregon State University, Corvallis, OR.

Mueller, H.C. and D.D. Berger. 1967. Observations on migrating saw-whet owls. Bird-Banding 38:120.

Müller, H. 1970. Observation on the biology of ermines, *Mustela ermine* Linné 1758. Säugetierk Mitt. 18:293-380.

Nagy, K.A. 1987. Field metabolic rate and food requirement scaling in mammals and birds. Ecological Monographs 57:11-128.

Nagy, K.A., I.A. Girard, and T.K. Brown. 1999. Energetics of free-ranging mammals, reptiles, and birds. Annual Review of Nutrition 19:247-277.

Nagy, K. and C. Peterson. 1988. Scaling of Water Flux Rate in Animals. University of California Press, Berkeley, CA. 172 pp.

NatureServe. 2008. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, Virginia. Available at http://www.natureserve.org/explorer

Neudorf, D.L., D.J. Ziolkowski Jr., V. Nolan Jr., and E.D. Ketterson. 2002. Testosterone manipulation of male attractiveness has no detectable effect on female home-range size and behaviour during the fertile period. Ethology 108:713-726.

Nolan Jr., V., E.D. Ketterson, D.A. Cristol, C.M. Rogers, E.D. Clotfelter, R.C. Titus, S.J. Schoech, and E. Snajdr. 2002. Dark-eyed Junco (*Junco hyemalis*). *In* Poole, A. (Ed.), The Birds of North America Online. Ithaca: Cornell Lab of Ornithology. Available at http://bna.birds.cornell.edu/bna/species/716

Nostrand, N.V. 1971. Snowshoe Hare in Nova Scotia. Prepared for Nova Scotia Department of Land and Forests. Truro.

Nyholm, E.S. 1959. About the ermine and the weasel and their winter territory. Suomen Riista 13:106-116.

O'Farrell, T.P. 1965. Home range and ecology of snowshoe hares in interior Alaska. Journal of Mammology 46:406-418.

Passmore, R.C. 1990. Mammal Fact Sheet – White-tailed Deer. Hinterland's Who's Who. Environment Canada. CW69-4/7- 1990E. http://www.hww.ca/hww2p.asp?id=106&cid=0

Pease, J.L., R.H. Vowles, and L.B. Keith. 1979. Interaction of snowshoe hares and woody vegetation. Journal of Wildlife Management 43:43-60.

Petit, K. 1995. Winter diet and habitat selection by the northern saw-whet owl in Connecticut. Ph.D. dissertation, Southern Connecticut State University.

Pietz, P.J. and J.R. Tester. 1983. Habitat selection by snowshoe hares in north central Minnesota. Journal of Wildlife Management 47:686-696.

Radwan, M.A. and D.L. Campbell. 1968. Snowshoe hare preference for spotted catsear flowers in western Washington. Journal of Wildlife Management 32:104-108.

Rains, C. 1998. Niche overlap, and nearest neighbor distances of northern saw-whet owls (A*egolius acadicus*) and western screech-owls (O*tus kennicottii*) in southern idaho. Ph.D. dissertation, Boise State University.

Ramenofsky, M., R. Savard, and M.R.C. Greenwood. 1999. Seasonal and diet transitions in physiology and behavior in the migratory dark-eyed junco. Comparative Biochemistry and Physiology – Part A: Molecular & Integrative Physiology 122:385-397.

Rasmussen, J.L., S.G. Sealy, and R.J. Cannings. 2008. Northern Saw-whet Owl (*Aegolius acadicus*), The Birds of North America Online. *In* Poole A. (Ed.), The Birds of North America Online. Ithaca: Cornell Lab of Ornithology. Available at: http://bna.birds.cornell.edu/bna/species/042

Ricklefs, R.E. 1974. Energetics of reproduction in birds. *In* Paynter, R.A. (Ed.), Avian Energetics. Nuttall Ornithological Club, Cambridge, MA.

Robel, R.J., A.R. Bisset, A.D. Dayton, and K.E. Kemp. 1979. Comparative energetic of bobwhites on six different foods. Journal of Wildlife Management 43:987-992.

Rongstad, O.J. and J.R. Tester. 1971. Behavior and maternal relations of young snowshoe hares. Journal of Wildlife Management 35:338-346.

Rose, G.A, and G.H. Parker. 1983. Metal content of body tissues, diet items, and dung of ruffed grouse near the copper-nickel smelters at Sudbury, Ont. Canadian Journal of Zoology 61:505-511.

Rowan, W. and L.B. Keith. 1956. Reproductive potential and sex ratios of snowshoe hares in northern Alberta. Canadian Journal of Zoology 34:273-281.

Ruffed Grouse Society. 2003. Ruffed Grouse Facts. Available at http://www.ruffedgrousesociety.org/ruffedfaccts.asp

Rusch, D.H., S. DeStefano, M.C. Reynolds, and D. Lauten. 2000. Ruffed Grouse (*Bonasa umbellus*). *In* Poole, A. and F. Gill (Eds.), The Birds of North America, No. 515. The Birds of North America, Inc., Philadelphia, PA.

Sample, B.E. and G.W. Suter II. 1994. Estimating exposure of terrestrial wildlife to contaminants. Oak Ridge National Laboratory. Environmental Sciences Division. ES/ER/TM-125.

Sample, B.E., Beauchamp, J.J., Efroymson, R.A., Suter, G.W. II, Ashwood, T.L. 1998. Development and validation of bioaccumulation models for earthworms. Prepared for the US Department of Energy, Office of Environmental Management. ES/ER/TM-220.

Sample *et al*. 1998 Development and Validation of Bioaccumulation Models for Small Mammals. Prepared for the U.S. Department of Energy, Office of Environmental Management. February 1998. ES/ER/TM-219.

SARA (Sudbury Area Risk Assessment). 2006. Sudbury Soils Study - Volume III: Ecological Risk Assessment. Prepared by the SARA Group.

Servello, F.A. and R.L. Kirkpatrick. 1987. Regional variation in the nutritional ecology of ruffed grouse. Journal of Wildlife Management 51:749-770.

Shipley, L.A. and D.E. Spalinger. 1995. Influence of size and density of browse patches on intake rates in foraging decisions of young moose and white-tailed deer. Oecologia 104:112-121.

Short, H.L. 1986. Habitat Suitability Index Models: White-Tailed Deer in the Gulf of Mexico and South Atlantic Coastal Plains. National Ecology Research Center, Fort Collins, CO. 47 p. Report no. A819223.

Stafford, S.K. and R.W. Dimmick. 1979. Autumn and winter foods of ruffed grouse in the Southern Appalachians. Journal of Wildlife Management 43:121-127.

Stalmaster, M.V. and J.A. Gessaman. 1982. Food consumption and energy requirements of captive bald eagles. Journal of Wildlife Management 46:646-654.

Stoll, R.J., Jr. and M.W. McClain. 1988. Body weights of Ohio Ruffed Grouse (*Bonasa umbellus*). Ohio Journal of Science 88:126-131.

Stollberg, B.P., R.L. Hine, and B. James. 1952. Food habit studies of ruffed grouse, pheasant, quail, and mink in Wisconsin. Technical Bulletin, Wisconsin Department of Natural Resources. 22 pp.

Svendsen, G.E. 2003. Weasels and black-footed ferret – *Mustela* species. *In* Feldhamer, G.A., B.C. Thompson, and J.A. Chapman (Eds.), Wild Mammals of North America: Biology, Management, and Conservation. Johns Hopkins University Press, Baltimore, MD. pp. 650-661.

Swengel, S.R. and A.B. Swengel. 1992. Diet of Northern Saw-whet Owls in southern Wisconsin. Condor 94:707-711.

Telfer, E.S. 1972. Browse selection by deer and hare. Journal of Wildlife Management 36:1344-1349.

Thompson, D.B., D.F. Tomback, M.A. Cunningham, and M.C. Baker. 2004. Seed selection by dark-eyed juncos (*Junco hyemalis*): optimal foraging with nutrient constraints? Oecologia 74:106-111.

Towers, J. 1980. Wildlife of Nova Scotia. Nova Scotia Department of Natural Resources. pp. 124.

US EPA (United States Environmental Protection Agency). 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/630/R-93/18a7

U.S. EPA (United States Environmental Protection Agency). 1999. Data Collection for the Hazard Waste Identification Rule. Section 12.0: Ecological Exposure Factors. U.S. Environmental Protection Agency, Office of Solid Waste, Washington, DC.

U.S. EPA (United States Environmental Protection Agency). 2005. Guidance for Developing Ecological Soil Screening Levels. Office of Solid Waste and Emergency Response. 1200 Pennsylvania Avenue, N.W. Washington, DC 20460. OSWER Directive 9285.7-55 November 2003 (Revised February 2005).

U.S. EPA OSW. 2005. Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities. Final. United States Environmental Protection Agency Region 6. Multimedia Plannign and Permitting Dvision. Center for Combustion Science and Engineering. Office of Solid Waste. EPA530-R-05-006.

Ullrey, D.E., W.G. Youatt, H.E. Johnson, A.B. Cowan, R.L. Covert, and W.T. Magee. 1972. Digestibility and estimated metabolizability of aspen browse for white-tailed deer. Journal of Wildlife Management 36:885-891.

Vogtsberger, L.M. and G.W. Barrett. 1973. Bioenergetics of captive red foxes. Journal of Wildlife Management 37:495-500.

Weir, R.D., F. Cooke, M.H. Edwards, and R.B. Stewart. 1980. Fall migration of Saw-whet Owls at Prince Edward Point, Ontario. Wilson Bulletin 92:475-488.

Whalen, D.M. and B.D. Watts. 2002. Annual migration density and stopover patterns of Northern Saw-whet owls (*Aegolius acadicus*). Auk 119:1154-1161.

Whitaker, J.O. 1996. National Audubon Society Field Guide to North American Mammals. Alfred A. Knopf, New York, NY.

Will, M.E. and G.W. Suter II. 1995. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process. Prepared by the Environmental Restoration Risk Assessment Program for the U.S. Department of Energy. ES/ER/TM-126/R1.

Wolff, J.O. 1980. The role of habitat patchiness in the population dynamics of snowshoe hares. Ecological Monographs 50:111-129.

Worden, K.A., and Pekins, P.J. 1995. Seasonal change in feed intake, body composition, and metabolic rate of white-tailed deer. Canadian Journal of Zoology 73:452-457.

Table 1 Portion of Exposure Derived from Exposure Areas

Receptor	0-3km	Total
Dark-eyed_junco	100%	100%
Masked_shrew	100%	100%
Northern_saw-whet_owl	100%	100%
Ermine	100%	100%
Ruffed_grouse	100%	100%
Snowshoe_hare	100%	100%
White-tailed_deer	100%	100%

Table 2. Summary of Hazard Quotient Values Based on NOAEL

		95UCLM			90th Percentile			95th Percentile		
Receptor	Chemical	0-3km	Total	Reference	0-3km	Total	Reference	0-3km	Total	Reference
Dark-eyed_junco	Antimony	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Dark-eyed_junco	Arsenic	5.6E-01	5.6E-01	1.2E-01	8.0E-01	8.0E-01	1.2E-01	8.7E-01	8.7E-01	2.1E-01
Dark-eyed_junco	Lead	1.4E+01	1.4E+01	2.3E+00	1.7E+01	1.7E+01	3.3E+00	2.2E+01	2.2E+01	3.5E+00
Dark-eyed_junco	Zinc	1.9E+00	1.9E+00	8.6E-01	1.7E+00	1.7E+00	8.7E-01	2.4E+00	2.4E+00	9.8E-01
Ermine	Antimony	6.8E-01	6.8E-01	1.6E-01	4.6E-01	4.6E-01	1.6E-01	7.1E-01	7.1E-01	1.6E-01
Ermine	Arsenic	1.1E-01	1.1E-01	1.8E-02	1.6E-01	1.6E-01	1.8E-02	1.7E-01	1.7E-01	3.4E-02
Ermine	Lead	4.6E-01	4.6E-01	1.2E-01	5.6E-01	5.6E-01	1.5E-01	7.0E-01	7.0E-01	1.6E-01
Ermine	Zinc	1.5E-01	1.5E-01	1.2E-01	1.5E-01	1.5E-01	1.2E-01	1.8E-01	1.8E-01	1.2E-01
Masked_shrew	Antimony	2.9E+01	2.9E+01	6.5E+00	1.9E+01	1.9E+01	6.5E+00	2.9E+01	2.9E+01	6.5E+00
Masked_shrew	Arsenic	6.5E-01	6.5E-01	1.6E-01	9.0E-01	9.0E-01	1.6E-01	9.5E-01	9.5E-01	2.7E-01
Masked_shrew	Lead	3.9E+00	3.9E+00	7.4E-01	4.8E+00	4.8E+00	1.0E+00	6.0E+00	6.0E+00	1.1E+00
Masked_shrew	Zinc	1.7E+00	1.7E+00	8.6E-01	1.5E+00	1.5E+00	8.6E-01	2.0E+00	2.0E+00	9.7E-01
Northern_saw-whet_owl	Antimony	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Northern_saw-whet_owl	Arsenic	1.2E-01	1.2E-01	2.1E-02	1.8E-01	1.8E-01	2.2E-02	2.0E-01	2.0E-01	4.2E-02
Northern_saw-whet_owl	Lead	3.2E+00	3.2E+00	8.2E-01	3.9E+00	3.9E+00	1.1E+00	4.8E+00	4.8E+00	1.1E+00
Northern_saw-whet_owl	Zinc	4.2E-01	4.2E-01	3.1E-01	3.9E-01	3.9E-01	3.1E-01	4.8E-01	4.8E-01	3.2E-01

Table 2. Summary of Hazard Quotient Values Based on NOAEL

		95UCLM			90th Percentile			95th Percentile		
Receptor	Chemical	0-3km	Total	Reference	0-3km	Total	Reference	0-3km	Total	Reference
Ruffed_grouse	Antimony	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Ruffed_grouse	Arsenic	1.7E-01	1.7E-01	3.1E-02	2.4E-01	2.4E-01	3.2E-02	2.7E-01	2.7E-01	5.4E-02
Ruffed_grouse	Lead	2.5E+00	2.5E+00	3.5E-01	3.4E+00	3.4E+00	4.9E-01	4.7E+00	4.7E+00	5.3E-01
Ruffed_grouse	Zinc	2.7E-01	2.7E-01	8.3E-02	2.3E-01	2.3E-01	8.3E-02	3.9E-01	3.9E-01	1.0E-01
Snowshoe_hare	Antimony	8.1E-01	8.1E-01	2.1E-01	6.3E-01	6.3E-01	2.1E-01	9.8E-01	9.8E-01	2.2E-01
Snowshoe_hare	Arsenic	1.8E-01	1.8E-01	3.5E-02	2.6E-01	2.6E-01	3.5E-02	3.0E-01	3.0E-01	5.8E-02
Snowshoe_hare	Lead	4.1E-01	4.1E-01	5.7E-02	5.8E-01	5.8E-01	7.9E-02	8.1E-01	8.1E-01	8.5E-02
Snowshoe_hare	Zinc	1.2E-01	1.2E-01	3.8E-02	1.1E-01	1.1E-01	3.8E-02	1.8E-01	1.8E-01	4.7E-02
White-tailed_deer	Antimony	3.3E-01	3.3E-01	9.4E-02	2.9E-01	2.9E-01	9.4E-02	4.4E-01	4.4E-01	1.0E-01
White-tailed_deer	Arsenic	8.0E-02	8.0E-02	1.7E-02	1.1E-01	1.1E-01	1.7E-02	1.4E-01	1.4E-01	2.6E-02
White-tailed_deer	Lead	1.7E-01	1.7E-01	2.5E-02	2.6E-01	2.6E-01	3.3E-02	3.8E-01	3.8E-01	3.5E-02
White-tailed_deer	Zinc	7.4E-02	7.4E-02	2.4E-02	6.5E-02	6.5E-02	2.5E-02	1.1E-01	1.1E-01	3.0E-02

Notes:

HQ > 1

HQ > 10

Value of zero indicates that exposure not estimated due to missing information or TRV unavailable

Table 3. Summary of Hazard Quotient Values Based on LOAEL - 0 to 3 km

		95UCLM			90th Percentile			95th Percentile		
Receptor	Chemical	0-3km	Total	Reference	0-3km	Total	Reference	0-3km	Total	Reference
Dark-eyed_junco	Antimony	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Dark-eyed_junco	Arsenic	9.0E-02	9.0E-02	1.9E-02	1.3E-01	1.3E-01	1.9E-02	1.4E-01	1.4E-01	3.3E-02
Dark-eyed_junco	Lead	2.2E+00	2.2E+00	3.8E-01	2.8E+00	2.8E+00	5.4E-01	3.6E+00	3.6E+00	5.8E-01
Dark-eyed_junco	Zinc	1.6E+00	1.6E+00	7.4E-01	1.4E+00	1.4E+00	7.4E-01	2.0E+00	2.0E+00	8.4E-01
Ermine	Antimony	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Ermine	Arsenic	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Ermine	Lead	6.2E-02	6.2E-02	1.6E-02	7.5E-02	7.5E-02	2.0E-02	9.3E-02	9.3E-02	2.2E-02
Ermine	Zinc	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Masked_shrew	Antimony	2.9E+00	2.9E+00	6.5E-01	1.9E+00	1.9E+00	6.5E-01	2.9E+00	2.9E+00	6.5E-01
Masked_shrew	Arsenic	2.1E-01	2.1E-01	5.1E-02	2.8E-01	2.8E-01	5.2E-02	3.0E-01	3.0E-01	8.7E-02
Masked_shrew	Lead	5.3E-01	5.3E-01	9.9E-02	6.4E-01	6.4E-01	1.4E-01	8.0E-01	8.0E-01	1.5E-01
Masked_shrew	Zinc	1.3E+00	1.3E+00	6.9E-01	1.2E+00	1.2E+00	6.9E-01	1.6E+00	1.6E+00	7.7E-01
Northern_saw-whet_owl	Antimony	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Northern_saw-whet_owl	Arsenic	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Northern_saw-whet_owl	Lead	5.3E-01	5.3E-01	1.4E-01	6.4E-01	6.4E-01	1.8E-01	7.9E-01	7.9E-01	1.8E-01
Northern_saw-whet_owl	Zinc	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

Table 3. Summary of Hazard Quotient Values Based on LOAEL - 0 to 3 km

		95UCLM			90th Percentile			95th Percentile		
Receptor	Chemical	0-3km	Total	Reference	0-3km	Total	Reference	0-3km	Total	Reference
Ruffed_grouse	Antimony	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Ruffed_grouse	Arsenic	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Ruffed_grouse	Lead	4.0E-01	4.0E-01	5.7E-02	5.6E-01	5.6E-01	8.1E-02	7.7E-01	7.7E-01	8.7E-02
Ruffed_grouse	Zinc	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Snowshoe_hare	Antimony	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Snowshoe_hare	Arsenic	5.7E-02	5.7E-02	1.1E-02	8.1E-02	8.1E-02	1.1E-02	9.4E-02	9.4E-02	1.8E-02
Snowshoe_hare	Lead	5.5E-02	5.5E-02	7.6E-03	7.8E-02	7.8E-02	1.1E-02	1.1E-01	1.1E-01	1.1E-02
Snowshoe_hare	Zinc	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
White-tailed_deer	Antimony	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
White-tailed_deer	Arsenic	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
White-tailed_deer	Lead	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
White-tailed_deer	Zinc	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

Notes:

HQ > 1

HQ > 10

Value of zero indicates that exposure not estimated due to missing information or TRV unavailable

Table 4. Summary of Exposures [mg/kg/day]

		95UCLM		90th Percentile		95th Percentile	
Receptor	Chemical	0-3km	Reference	0-3km	Reference	0-3km	Reference
Dark-eyed_junco	Antimony	1.5E+00	3.5E-01	9.9E-01	3.5E-01	1.5E+00	3.5E-01
Dark-eyed_junco	Arsenic	1.3E+00	2.6E-01	1.8E+00	2.7E-01	1.9E+00	4.6E-01
Dark-eyed_junco	Lead	2.2E+01	3.8E+00	2.8E+01	5.4E+00	3.6E+01	5.8E+00
Dark-eyed_junco	Zinc	1.2E+02	5.7E+01	1.1E+02	5.7E+01	1.6E+02	6.5E+01
Ermine	Antimony	4.0E-02	9.4E-03	2.7E-02	9.4E-03	4.2E-02	9.6E-03
Ermine	Arsenic	1.1E-01	1.8E-02	1.6E-01	1.9E-02	1.8E-01	3.6E-02
Ermine	Lead	2.2E+00	5.6E-01	2.6E+00	7.2E-01	3.3E+00	7.5E-01
Ermine	Zinc	1.2E+01	8.9E+00	1.1E+01	8.9E+00	1.3E+01	9.2E+00
Masked_shrew	Antimony	1.7E+00	3.9E-01	1.1E+00	3.9E-01	1.7E+00	3.9E-01
Masked_shrew	Arsenic	6.8E-01	1.7E-01	9.3E-01	1.7E-01	9.8E-01	2.9E-01
Masked_shrew	Lead	1.9E+01	3.5E+00	2.2E+01	4.9E+00	2.8E+01	5.2E+00
Masked_shrew	Zinc	1.3E+02	6.5E+01	1.1E+02	6.5E+01	1.5E+02	7.3E+01
Northern_saw-whet_owl	Antimony	1.0E-01	2.4E-02	6.7E-02	2.4E-02	1.0E-01	2.4E-02
Northern_saw-whet_owl	Arsenic	2.8E-01	4.7E-02	4.1E-01	4.9E-02	4.4E-01	9.3E-02
Northern_saw-whet_owl	Lead	5.3E+00	1.3E+00	6.3E+00	1.7E+00	7.8E+00	1.8E+00
Northern_saw-whet_owl	Zinc	2.7E+01	2.1E+01	2.6E+01	2.1E+01	3.2E+01	2.1E+01
Ruffed_grouse	Antimony	1.1E-01	2.8E-02	8.4E-02	2.8E-02	1.3E-01	2.9E-02
Ruffed_grouse	Arsenic	3.7E-01	7.0E-02	5.3E-01	7.1E-02	6.1E-01	1.2E-01
Ruffed_grouse	Lead	4.0E+00	5.6E-01	5.5E+00	8.0E-01	7.6E+00	8.6E-01
Ruffed_grouse	Zinc	1.8E+01	5.5E+00	1.5E+01	5.5E+00	2.6E+01	6.7E+00
Snowshoe_hare	Antimony	4.8E-02	1.3E-02	3.7E-02	1.3E-02	5.8E-02	1.3E-02
Snowshoe_hare	Arsenic	1.9E-01	3.6E-02	2.7E-01	3.7E-02	3.1E-01	6.0E-02
Snowshoe_hare	Lead	1.9E+00	2.7E-01	2.7E+00	3.7E-01	3.8E+00	4.0E-01
Snowshoe_hare	Zinc	9.3E+00	2.9E+00	8.1E+00	2.9E+00	1.4E+01	3.5E+00
White-tailed_deer	Antimony	1.9E-02	5.6E-03	1.7E-02	5.6E-03	2.6E-02	6.0E-03
White-tailed_deer	Arsenic	8.3E-02	1.7E-02	1.2E-01	1.8E-02	1.4E-01	2.7E-02
White-tailed_deer	Lead	8.0E-01	1.2E-01	1.2E+00	1.5E-01	1.8E+00	1.7E-01
White-tailed_deer	Zinc	5.6E+00	1.8E+00	4.9E+00	1.8E+00	8.0E+00	2.2E+00

Table 5. Predicted Exposure & Hazard Quotient Values

Scenario	Site	Chemical	Receptor	Soil mg/day	Water mg/day	Inhalation mg/day	Browse mg/day	Invert mg/day	Prey mg/day	Fish mg/day	Total mg/day	Total (BA Adjusted) mg/day	Dose mg/kg/day	HQ(NOAEL) Unitless
90th Percentile	0-3km	Antimony	Dark-eyed_junco	2.45E-03	4.12E-06	5.51E-05	7.06E-04	1.55E-02	0.00E+00	0.00E+00	1.87E-02	1.87E-02	9.95E-01	#VALUE!
90th Percentile	0-3km	Arsenic	Dark-eyed_junco	1.90E-02	6.42E-06	4.25E-04	4.67E-03	9.51E-03	0.00E+00	0.00E+00	3.36E-02	3.36E-02	1.79E+00	7.97E-01
90th Percentile	0-3km	Lead	Dark-eyed_junco	1.82E-01	8.93E-06	5.11E-03	5.07E-02	2.88E-01	0.00E+00	0.00E+00	5.25E-01	5.25E-01	2.79E+01	1.71E+01
90th Percentile	0-3km	Zinc	Dark-eyed_junco	1.67E-01	6.26E-05	3.10E-03	2.67E-01	1.64E+00	0.00E+00	0.00E+00	2.08E+00	2.08E+00	1.11E+02	1.67E+00
90th Percentile	Reference	Antimony	Dark-eyed_junco	8.60E-04	4.12E-06	1.68E-05	2.27E-04	5.43E-03	0.00E+00	0.00E+00	6.54E-03	6.54E-03	3.48E-01	#VALUE!
90th Percentile	Reference	Arsenic	Dark-eyed_junco	2.15E-03	1.56E-05	3.52E-05	7.76E-04	2.04E-03	0.00E+00	0.00E+00	5.02E-03	5.02E-03	2.67E-01	1.19E-01
90th Percentile	Reference	Lead	Dark-eyed_junco	2.91E-02	6.71E-06	3.75E-04	5.97E-03	6.55E-02	0.00E+00	0.00E+00	1.01E-01	1.01E-01	5.37E+00	3.29E+00
90th Percentile	Reference	Zinc	Dark-eyed_junco	3.08E-02	1.37E-04	7.12E-04	1.03E-01	9.43E-01	0.00E+00	0.00E+00	1.08E+00	1.08E+00	5.73E+01	8.68E-01
95th Percentile	0-3km	Antimony	Dark-eyed_junco	3.78E-03	4.12E-06	8.69E-05	1.10E-03	2.39E-02	0.00E+00	0.00E+00	2.89E-02	2.89E-02	1.54E+00	#VALUE!
95th Percentile	0-3km	Arsenic	Dark-eyed_junco	2.01E-02	6.92E-06	5.41E-04	5.94E-03	9.91E-03	0.00E+00	0.00E+00	3.65E-02	3.65E-02	1.94E+00	8.67E-01
95th Percentile	0-3km	Lead	Dark-eyed_junco	2.37E-01	1.41E-05	7.61E-03	7.49E-02	3.56E-01	0.00E+00	0.00E+00	6.76E-01	6.76E-01	3.60E+01	2.21E+01
95th Percentile	0-3km	Zinc	Dark-eyed_junco	3.83E-01	1.01E-04	6.05E-03	4.20E-01	2.16E+00	0.00E+00	0.00E+00	2.97E+00	2.97E+00	1.58E+02	2.39E+00
95th Percentile	Reference	Antimony	Dark-eyed_junco	8.60E-04	4.12E-06	1.88E-05	2.51E-04	5.43E-03	0.00E+00	0.00E+00	6.57E-03	6.57E-03	3.49E-01	#VALUE!
95th Percentile	Reference	Arsenic	Dark-eyed_junco	4.21E-03	1.98E-05	6.04E-05	1.10E-03	3.29E-03	0.00E+00	0.00E+00	8.68E-03	8.68E-03	4.62E-01	2.06E-01
95th Percentile	Reference	Lead	Dark-eyed_junco	3.16E-02	1.16E-05	4.16E-04	6.38E-03	7.00E-02	0.00E+00	0.00E+00	1.08E-01	1.08E-01	5.76E+00	3.54E+00
95th Percentile	Reference	Zinc	Dark-eyed_junco	4.30E-02	1.70E-04	9.54E-04	1.24E-01	1.05E+00	0.00E+00	0.00E+00	1.22E+00	1.22E+00	6.50E+01	9.83E-01
95UCLM	0-3km	Antimony	Dark-eyed_junco	3.78E-03	4.12E-06	5.60E-05	7.39E-04	2.39E-02	0.00E+00	0.00E+00	2.85E-02	2.85E-02	1.52E+00	#VALUE!
95UCLM	0-3km	Arsenic	Dark-eyed_junco	1.27E-02	5.68E-06	2.88E-04	3.45E-03	7.16E-03	0.00E+00	0.00E+00	2.36E-02	2.36E-02	1.25E+00	5.60E-01
95UCLM	0-3km	Lead	Dark-eyed_junco	1.45E-01	9.39E-06	3.15E-03	3.10E-02	2.39E-01	0.00E+00	0.00E+00	4.18E-01	4.18E-01	2.22E+01	1.36E+01
95UCLM	0-3km	Zinc	Dark-eyed_junco	2.18E-01	9.51E-05	3.11E-03	3.01E-01	1.79E+00	0.00E+00	0.00E+00	2.32E+00	2.32E+00	1.23E+02	1.86E+00
95UCLM	Reference	Antimony	Dark-eyed_junco	8.60E-04	4.12E-06	1.68E-05	2.27E-04	5.43E-03	0.00E+00	0.00E+00	6.54E-03	6.54E-03	3.48E-01	#VALUE!
95UCLM	Reference	Arsenic	Dark-eyed_junco	2.11E-03	1.06E-05	3.47E-05	7.68E-04	2.02E-03	0.00E+00	0.00E+00	4.94E-03	4.94E-03	2.63E-01	1.17E-01
95UCLM	Reference	Lead	Dark-eyed_junco	1.90E-02	6.79E-06	2.64E-04	4.84E-03	4.66E-02	0.00E+00	0.00E+00	7.07E-02	7.07E-02	3.76E+00	2.31E+00
95UCLM	Reference	Zinc	Dark-eyed_junco	3.05E-02	9.92E-05	7.09E-04	1.03E-01	9.41E-01	0.00E+00	0.00E+00	1.07E+00	1.07E+00	5.72E+01	8.65E-01
90th Percentile	0-3km	Antimony	Ermine	7.07E-04	5.83E-06	1.27E-04	0.00E+00	0.00E+00	3.23E-04	0.00E+00	1.16E-03	1.16E-03	2.70E-02	4.58E-01
90th Percentile	0-3km	Arsenic	Ermine	5.47E-03	9.10E-06	9.75E-04	0.00E+00	0.00E+00	5.41E-04	0.00E+00	7.00E-03	7.00E-03	1.63E-01	1.56E-01
90th Percentile	0-3km	Lead	Ermine	5.25E-02	1.27E-05	1.17E-02	0.00E+00	0.00E+00	4.85E-02	0.00E+00	1.13E-01	1.13E-01	2.62E+00	5.58E-01
90th Percentile	0-3km	Zinc	Ermine	4.81E-02	8.86E-05	7.12E-03	0.00E+00	0.00E+00	4.21E-01	0.00E+00	4.77E-01	4.77E-01	1.11E+01	1.47E-01
90th Percentile	Reference	Antimony	Ermine	2.48E-04	5.83E-06	3.85E-05	0.00E+00	0.00E+00	1.13E-04	0.00E+00	4.05E-04	4.05E-04	9.42E-03	1.60E-01
90th Percentile	Reference	Arsenic	Ermine	6.20E-04	2.22E-05	8.09E-05	0.00E+00	0.00E+00	9.09E-05	0.00E+00	8.14E-04	8.14E-04	1.89E-02	1.82E-02
90th Percentile	Reference	Lead	Ermine	8.39E-03	9.50E-06	8.62E-04	0.00E+00	0.00E+00	2.16E-02	0.00E+00	3.08E-02	3.08E-02	7.17E-01	1.53E-01
90th Percentile	Reference	Zinc	Ermine	8.88E-03	1.94E-04	1.64E-03	0.00E+00	0.00E+00	3.72E-01	0.00E+00	3.83E-01	3.83E-01	8.90E+00	1.18E-01
95th Percentile	0-3km	Antimony	Ermine	1.09E-03	5.83E-06	2.00E-04	0.00E+00	0.00E+00	4.99E-04	0.00E+00	1.80E-03	1.80E-03	4.18E-02	7.08E-01
95th Percentile	0-3km	Arsenic	Ermine	5.80E-03	9.80E-06	1.24E-03	0.00E+00	0.00E+00	5.67E-04	0.00E+00	7.62E-03	7.62E-03	1.77E-01	1.70E-01
95th Percentile	0-3km	Lead	Ermine	6.84E-02	1.99E-05	1.75E-02	0.00E+00	0.00E+00	5.46E-02	0.00E+00	1.40E-01	1.40E-01	3.27E+00	6.95E-01
95th Percentile	0-3km	Zinc	Ermine	1.10E-01	1.43E-04	1.39E-02	0.00E+00	0.00E+00	4.48E-01	0.00E+00	5.72E-01	5.72E-01	1.33E+01	1.76E-01
95th Percentile	Reference	Antimony	Ermine	2.48E-04	5.83E-06	4.33E-05	0.00E+00	0.00E+00	1.13E-04	0.00E+00	4.11E-04	4.11E-04	9.55E-03	1.62E-01
95th Percentile	Reference	Arsenic	Ermine	1.22E-03	2.80E-05	1.39E-04	0.00E+00	0.00E+00	1.58E-04	0.00E+00	1.54E-03	1.54E-03	3.58E-02	3.44E-02
95th Percentile	Reference	Lead	Ermine	9.11E-03	1.65E-05	9.56E-04	0.00E+00	0.00E+00	2.24E-02	0.00E+00	3.24E-02	3.24E-02	7.55E-01	1.61E-01
95th Percentile	Reference	Zinc	Ermine	1.24E-02	2.40E-04	2.19E-03	0.00E+00	0.00E+00	3.81E-01	0.00E+00	3.96E-01	3.96E-01	9.21E+00	1.22E-01
95UCLM	0-3km	Antimony	Ermine	1.09E-03	5.83E-06	1.29E-04	0.00E+00	0.00E+00	4.89E-04	0.00E+00	1.72E-03	1.72E-03	3.99E-02	6.76E-01
95UCLM	0-3km	Arsenic	Ermine	3.66E-03	8.05E-06	6.62E-04	0.00E+00	0.00E+00	3.89E-04	0.00E+00	4.72E-03	4.72E-03	1.10E-01	1.06E-01
95UCLM	0-3km	Lead	Ermine	4.17E-02	1.33E-05	7.24E-03	0.00E+00	0.00E+00	4.38E-02	0.00E+00	9.28E-02	9.28E-02	2.16E+00	4.59E-01
95UCLM	0-3km	Zinc	Ermine	6.30E-02	1.35E-04	7.15E-03	0.00E+00	0.00E+00	4.30E-01	0.00E+00	5.00E-01	5.00E-01	1.16E+01	1.54E-01
95UCLM	Reference	Antimony	Ermine	2.48E-04	5.83E-06	3.85E-05	0.00E+00	0.00E+00	1.13E-04	0.00E+00	4.05E-04	4.05E-04	9.42E-03	1.60E-01
95UCLM	Reference	Arsenic	Ermine	6.08E-04	1.50E-05	7.97E-05	0.00E+00	0.00E+00	8.95E-05	0.00E+00	7.92E-04	7.92E-04	1.84E-02	1.77E-02

Table 5. Predicted Exposure & Hazard Quotient Values

Scenario	Site	Chemical	Receptor	Soil mg/day	Water mg/day	Inhalation mg/day	Browse mg/day	Invert mg/day	Prey mg/day	Fish mg/day	Total mg/day	Total (BA Adjusted) mg/day	Dose mg/kg/day	HQ(NOAEL) Unitless
95UCLM	Reference	Lead	Ermine	5.50E-03	9.62E-06	6.06E-04	0.00E+00	0.00E+00	1.79E-02	0.00E+00	2.40E-02	2.40E-02	5.58E-01	1.19E-01
95UCLM	Reference	Zinc	Ermine	8.81E-03	1.41E-04	1.63E-03	0.00E+00	0.00E+00	3.72E-01	0.00E+00	3.82E-01	3.82E-01	8.89E+00	1.18E-01
90th Percentile	0-3km	Antimony	Masked_shrew	1.59E-04	8.41E-07	2.26E-05	0.00E+00	5.31E-03	0.00E+00	0.00E+00	5.49E-03	5.49E-03	1.10E+00	18.6081422
90th Percentile	0-3km	Antimony	Masked_shrew	1.59E-04	8.41E-07	2.26E-05	0.00E+00	5.31E-03	0.00E+00	0.00E+00	5.49E-03	5.49E-03	1.10E+00	1.86E+01
90th Percentile	0-3km	Arsenic	Masked_shrew	1.23E-03	1.31E-06	1.74E-04	0.00E+00	3.26E-03	0.00E+00	0.00E+00	4.66E-03	4.66E-03	9.33E-01	8.97E-01
90th Percentile	0-3km	Arsenic	Masked_shrew	1.23E-03	1.31E-06	1.74E-04	0.00E+00	3.26E-03	0.00E+00	0.00E+00	4.66E-03	4.66E-03	9.33E-01	8.97E-01
90th Percentile	0-3km	Lead	Masked_shrew	1.18E-02	1.82E-06	2.10E-03	0.00E+00	9.86E-02	0.00E+00	0.00E+00	1.12E-01	1.12E-01	2.25E+01	4.79E+00
90th Percentile	0-3km	Lead	Masked_shrew	1.18E-02	1.82E-06	2.10E-03	0.00E+00	9.86E-02	0.00E+00	0.00E+00	1.12E-01	1.12E-01	2.25E+01	4.79E+00
90th Percentile	0-3km	Zinc	Masked_shrew	1.08E-02	1.28E-05	1.27E-03	0.00E+00	5.63E-01	0.00E+00	0.00E+00	5.75E-01	5.75E-01	1.15E+02	1.52E+00
90th Percentile	0-3km	Zinc	Masked_shrew	1.08E-02	1.28E-05	1.27E-03	0.00E+00	5.63E-01	0.00E+00	0.00E+00	5.75E-01	5.75E-01	1.15E+02	1.52E+00
90th Percentile	Reference	Antimony	Masked_shrew	5.59E-05	8.41E-07	6.88E-06	0.00E+00	1.86E-03	0.00E+00	0.00E+00	1.93E-03	1.93E-03	3.85E-01	6.52744444
90th Percentile	Reference	Antimony	Masked_shrew	5.59E-05	8.41E-07	6.88E-06	0.00E+00	1.86E-03	0.00E+00	0.00E+00	1.93E-03	1.93E-03	3.85E-01	6.53E+00
90th Percentile	Reference	Arsenic	Masked_shrew	1.40E-04	3.20E-06	1.45E-05	0.00E+00	7.00E-04	0.00E+00	0.00E+00	8.58E-04	8.58E-04	1.72E-01	1.65E-01
90th Percentile	Reference	Arsenic	Masked_shrew	1.40E-04	3.20E-06	1.45E-05	0.00E+00	7.00E-04	0.00E+00	0.00E+00	8.58E-04	8.58E-04	1.72E-01	1.65E-01
90th Percentile	Reference	Lead	Masked_shrew	1.89E-03	1.37E-06	1.54E-04	0.00E+00	2.24E-02	0.00E+00	0.00E+00	2.45E-02	2.45E-02	4.90E+00	1.04E+00
90th Percentile	Reference	Lead	Masked_shrew	1.89E-03	1.37E-06	1.54E-04	0.00E+00	2.24E-02	0.00E+00	0.00E+00	2.45E-02	2.45E-02	4.90E+00	1.04E+00
90th Percentile	Reference	Zinc	Masked_shrew	2.00E-03	2.79E-05	2.92E-04	0.00E+00	3.23E-01	0.00E+00	0.00E+00	3.26E-01	3.26E-01	6.51E+01	8.64E-01
90th Percentile	Reference	Zinc	Masked_shrew	2.00E-03	2.79E-05	2.92E-04	0.00E+00	3.23E-01	0.00E+00	0.00E+00	3.26E-01	3.26E-01	6.51E+01	8.64E-01
95th Percentile	0-3km	Antimony	Masked_shrew	2.46E-04	8.41E-07	3.57E-05	0.00E+00	8.19E-03	0.00E+00	0.00E+00	8.48E-03	8.48E-03	1.70E+00	28.7293691
95th Percentile	0-3km	Antimony	Masked_shrew	2.46E-04	8.41E-07	3.57E-05	0.00E+00	8.19E-03	0.00E+00	0.00E+00	8.48E-03	8.48E-03	1.70E+00	2.87E+01
95th Percentile	0-3km	Arsenic	Masked_shrew	1.31E-03	1.41E-06	2.22E-04	0.00E+00	3.39E-03	0.00E+00	0.00E+00	4.92E-03	4.92E-03	9.85E-01	9.47E-01
95th Percentile	0-3km	Arsenic	Masked_shrew	1.31E-03	1.41E-06	2.22E-04	0.00E+00	3.39E-03	0.00E+00	0.00E+00	4.92E-03	4.92E-03	9.85E-01	9.47E-01
95th Percentile	0-3km	Lead	Masked_shrew	1.54E-02	2.88E-06	3.13E-03	0.00E+00	1.22E-01	0.00E+00	0.00E+00	1.41E-01	1.41E-01	2.81E+01	5.98E+00
95th Percentile	0-3km	Lead	Masked_shrew	1.54E-02	2.88E-06	3.13E-03	0.00E+00	1.22E-01	0.00E+00	0.00E+00	1.41E-01	1.41E-01	2.81E+01	5.98E+00
95th Percentile	0-3km	Zinc	Masked_shrew	2.49E-02	2.06E-05	2.48E-03	0.00E+00	7.39E-01	0.00E+00	0.00E+00	7.66E-01	7.66E-01	1.53E+02	2.03E+00
95th Percentile	0-3km	Zinc	Masked_shrew	2.49E-02	2.06E-05	2.48E-03	0.00E+00	7.39E-01	0.00E+00	0.00E+00	7.66E-01	7.66E-01	1.53E+02	2.03E+00
95th Percentile	Reference	Antimony	Masked_shrew	5.59E-05	8.41E-07	7.74E-06	0.00E+00	1.86E-03	0.00E+00	0.00E+00	1.93E-03	1.93E-03	3.85E-01	6.53035391
95th Percentile	Reference	Antimony	Masked_shrew	5.59E-05	8.41E-07	7.74E-06	0.00E+00	1.86E-03	0.00E+00	0.00E+00	1.93E-03	1.93E-03	3.85E-01	6.53E+00
95th Percentile	Reference	Arsenic	Masked_shrew	2.74E-04	4.04E-06	2.48E-05	0.00E+00	1.13E-03	0.00E+00	0.00E+00	1.43E-03	1.43E-03	2.86E-01	2.75E-01
95th Percentile	Reference	Arsenic	Masked_shrew	2.74E-04	4.04E-06	2.48E-05	0.00E+00	1.13E-03	0.00E+00	0.00E+00	1.43E-03	1.43E-03	2.86E-01	2.75E-01
95th Percentile	Reference	Lead	Masked_shrew	2.05E-03	2.38E-06	1.71E-04	0.00E+00	2.40E-02	0.00E+00	0.00E+00	2.62E-02	2.62E-02	5.24E+00	1.12E+00
95th Percentile	Reference	Lead	Masked_shrew	2.05E-03	2.38E-06	1.71E-04	0.00E+00	2.40E-02	0.00E+00	0.00E+00	2.62E-02	2.62E-02	5.24E+00	1.12E+00
95th Percentile	Reference	Zinc	Masked_shrew	2.79E-03	3.46E-05	3.92E-04	0.00E+00	3.61E-01	0.00E+00	0.00E+00	3.64E-01	3.64E-01	7.28E+01	9.65E-01
95th Percentile	Reference	Zinc	Masked_shrew	2.79E-03	3.46E-05	3.92E-04	0.00E+00	3.61E-01	0.00E+00	0.00E+00	3.64E-01	3.64E-01	7.28E+01	9.65E-01
95UCLM	0-3km	Antimony	Masked_shrew	2.46E-04	8.41E-07	2.30E-05	0.00E+00	8.19E-03	0.00E+00	0.00E+00	8.46E-03	8.46E-03	1.69E+00	2.87E+01
95UCLM	0-3km	Antimony	Masked_shrew	2.46E-04	8.41E-07	2.30E-05	0.00E+00	8.19E-03	0.00E+00	0.00E+00	8.46E-03	8.46E-03	1.69E+00	2.87E+01
95UCLM	0-3km	Arsenic	Masked_shrew	8.24E-04	1.16E-06	1.18E-04	0.00E+00	2.45E-03	0.00E+00	0.00E+00	3.40E-03	3.40E-03	6.79E-01	6.53E-01
95UCLM	0-3km	Arsenic	Masked_shrew	8.24E-04	1.16E-06	1.18E-04	0.00E+00	2.45E-03	0.00E+00	0.00E+00	3.40E-03	3.40E-03	6.79E-01	6.53E-01
95UCLM	0-3km	Lead	Masked_shrew	9.39E-03	1.92E-06	1.29E-03	0.00E+00	8.19E-02	0.00E+00	0.00E+00	9.26E-02	9.26E-02	1.85E+01	3.94E+00
95UCLM	0-3km	Lead	Masked_shrew	9.39E-03	1.92E-06	1.29E-03	0.00E+00	8.19E-02	0.00E+00	0.00E+00	9.26E-02	9.26E-02	1.85E+01	3.94E+00
95UCLM	0-3km	Zinc	Masked_shrew	1.42E-02	1.94E-05	1.28E-03	0.00E+00	6.15E-01	0.00E+00	0.00E+00	6.30E-01	6.30E-01	1.26E+02	1.67E+00
95UCLM	0-3km	Zinc	Masked_shrew	1.42E-02	1.94E-05	1.28E-03	0.00E+00	6.15E-01	0.00E+00	0.00E+00	6.30E-01	6.30E-01	1.26E+02	1.67E+00
95UCLM	Reference	Antimony	Masked_shrew	5.59E-05	8.41E-07	6.88E-06	0.00E+00	1.86E-03	0.00E+00	0.00E+00	1.93E-03	1.93E-03	3.85E-01	6.53E+00
95UCLM	Reference	Antimony	Masked_shrew	5.59E-05	8.41E-07	6.88E-06	0.00E+00	1.86E-03	0.00E+00	0.00E+00	1.93E-03	1.93E-03	3.85E-01	6.53E+00
95UCLM	Reference	Arsenic	Masked_shrew	1.37E-04	2.17E-06	1.43E-05	0.00E+00	6.90E-04	0.00E+00	0.00E+00	8.44E-04	8.44E-04	1.69E-01	1.62E-01
95UCLM	Reference	Arsenic	Masked_shrew	1.37E-04	2.17E-06	1.43E-05	0.00E+00	6.90E-04	0.00E+00	0.00E+00	8.44E-04	8.44E-04	1.69E-01	1.62E-01
95UCLM	Reference	Lead	Masked_shrew	1.24E-03	1.39E-06	1.08E-04	0.00E+00	1.60E-02	0.00E+00	0.00E+00	1.73E-02	1.73E-02	3.46E+00	7.36E-01
95UCLM	Reference	Lead	Masked_shrew	1.24E-03	1.39E-06	1.08E-04	0.00E+00	1.60E-02	0.00E+00	0.00E+00	1.73E-02	1.73E-02	3.46E+00	7.36E-01

Table 5. Predicted Exposure & Hazard Quotient Values

Scenario	Site	Chemical	Receptor	Soil mg/day	Water mg/day	Inhalation mg/day	Browse mg/day	Invert mg/day	Prey mg/day	Fish mg/day	Total mg/day	Total (BA Adjusted) mg/day	Dose mg/kg/day	HQ(NOAEL) Unitless
95UCLM	Reference	Zinc	Masked_shrew	1.98E-03	2.03E-05	2.91E-04	0.00E+00	3.22E-01	0.00E+00	0.00E+00	3.25E-01	3.25E-01	6.49E+01	8.61E-01
95UCLM	Reference	Zinc	Masked_shrew	1.98E-03	2.03E-05	2.91E-04	0.00E+00	3.22E-01	0.00E+00	0.00E+00	3.25E-01	3.25E-01	6.49E+01	8.61E-01
90th Percentile	0-3km	Antimony	Northern_saw-whet_owl	3.27E-03	9.82E-06	1.50E-04	0.00E+00	0.00E+00	1.20E-03	0.00E+00	4.62E-03	4.62E-03	6.72E-02	#VALUE!
90th Percentile	0-3km	Arsenic	Northern_saw-whet_owl	2.53E-02	1.53E-05	1.15E-03	0.00E+00	0.00E+00	2.00E-03	0.00E+00	2.85E-02	2.85E-02	4.14E-01	1.85E-01
90th Percentile	0-3km	Lead	Northern_saw-whet_owl	2.43E-01	2.13E-05	1.39E-02	0.00E+00	0.00E+00	1.79E-01	0.00E+00	4.36E-01	4.36E-01	6.34E+00	3.89E+00
90th Percentile	0-3km	Zinc	Northern_saw-whet_owl	2.23E-01	1.49E-04	8.41E-03	0.00E+00	0.00E+00	1.56E+00	0.00E+00	1.79E+00	1.79E+00	2.60E+01	3.93E-01
90th Percentile	Reference	Antimony	Northern_saw-whet_owl	1.15E-03	9.82E-06	4.55E-05	0.00E+00	0.00E+00	4.17E-04	0.00E+00	1.62E-03	1.62E-03	2.35E-02	#VALUE!
90th Percentile	Reference	Arsenic	Northern_saw-whet_owl	2.87E-03	3.73E-05	9.56E-05	0.00E+00	0.00E+00	3.36E-04	0.00E+00	3.34E-03	3.34E-03	4.85E-02	2.17E-02
90th Percentile	Reference	Lead	Northern_saw-whet_owl	3.88E-02	1.60E-05	1.02E-03	0.00E+00	0.00E+00	7.98E-02	0.00E+00	1.20E-01	1.20E-01	1.74E+00	1.07E+00
90th Percentile	Reference	Zinc	Northern_saw-whet_owl	4.11E-02	3.26E-04	1.93E-03	0.00E+00	0.00E+00	1.38E+00	0.00E+00	1.42E+00	1.42E+00	2.06E+01	3.12E-01
95th Percentile	0-3km	Antimony	Northern_saw-whet_owl	5.05E-03	9.82E-06	2.36E-04	0.00E+00	0.00E+00	1.85E-03	0.00E+00	7.14E-03	7.14E-03	1.04E-01	#VALUE!
95th Percentile	0-3km	Arsenic	Northern_saw-whet_owl	2.68E-02	1.65E-05	1.47E-03	0.00E+00	0.00E+00	2.10E-03	0.00E+00	3.04E-02	3.04E-02	4.42E-01	1.97E-01
95th Percentile	0-3km	Lead	Northern_saw-whet_owl	3.16E-01	3.36E-05	2.07E-02	0.00E+00	0.00E+00	2.02E-01	0.00E+00	5.39E-01	5.39E-01	7.83E+00	4.80E+00
95th Percentile	0-3km	Zinc	Northern_saw-whet_owl	5.10E-01	2.41E-04	1.64E-02	0.00E+00	0.00E+00	1.66E+00	0.00E+00	2.18E+00	2.18E+00	3.17E+01	4.80E-01
95th Percentile	Reference	Antimony	Northern_saw-whet_owl	1.15E-03	9.82E-06	5.12E-05	0.00E+00	0.00E+00	4.20E-04	0.00E+00	1.63E-03	1.63E-03	2.37E-02	#VALUE!
95th Percentile	Reference	Arsenic	Northern_saw-whet_owl	5.62E-03	4.71E-05	1.64E-04	0.00E+00	0.00E+00	5.84E-04	0.00E+00	6.42E-03	6.42E-03	9.32E-02	4.16E-02
95th Percentile	Reference	Lead	Northern_saw-whet_owl	4.21E-02	2.78E-05	1.13E-03	0.00E+00	0.00E+00	8.27E-02	0.00E+00	1.26E-01	1.26E-01	1.83E+00	1.12E+00
95th Percentile	Reference	Zinc	Northern_saw-whet_owl	5.74E-02	4.05E-04	2.59E-03	0.00E+00	0.00E+00	1.41E+00	0.00E+00	1.47E+00	1.47E+00	2.14E+01	3.23E-01
95UCLM	0-3km	Antimony	Northern_saw-whet_owl	5.05E-03	9.82E-06	1.52E-04	0.00E+00	0.00E+00	1.81E-03	0.00E+00	7.02E-03	7.02E-03	1.02E-01	#VALUE!
95UCLM	0-3km	Arsenic	Northern_saw-whet_owl	1.69E-02	1.35E-05	7.82E-04	0.00E+00	0.00E+00	1.44E-03	0.00E+00	1.92E-02	1.92E-02	2.78E-01	1.24E-01
95UCLM	0-3km	Lead	Northern_saw-whet_owl	1.93E-01	2.24E-05	8.56E-03	0.00E+00	0.00E+00	1.62E-01	0.00E+00	3.64E-01	3.64E-01	5.28E+00	3.24E+00
95UCLM	0-3km	Zinc	Northern_saw-whet_owl	2.91E-01	2.27E-04	8.46E-03	0.00E+00	0.00E+00	1.59E+00	0.00E+00	1.89E+00	1.89E+00	2.75E+01	4.15E-01
95UCLM	Reference	Antimony	Northern_saw-whet_owl	1.15E-03	9.82E-06	4.55E-05	0.00E+00	0.00E+00	4.17E-04	0.00E+00	1.62E-03	1.62E-03	2.35E-02	#VALUE!
95UCLM	Reference	Arsenic	Northern_saw-whet_owl	2.81E-03	2.53E-05	9.43E-05	0.00E+00	0.00E+00	3.31E-04	0.00E+00	3.26E-03	3.26E-03	4.74E-02	2.12E-02
95UCLM	Reference	Lead	Northern_saw-whet_owl	2.54E-02	1.62E-05	7.16E-04	0.00E+00	0.00E+00	6.62E-02	0.00E+00	9.23E-02	9.23E-02	1.34E+00	8.23E-01
95UCLM	Reference	Zinc	Northern_saw-whet_owl	4.07E-02	2.37E-04	1.93E-03	0.00E+00	0.00E+00	1.37E+00	0.00E+00	1.42E+00	1.42E+00	2.06E+01	3.12E-01
90th Percentile	0-3km	Antimony	Ruffed_grouse	2.27E-02	3.92E-05	7.35E-04	1.59E-02	6.04E-03	0.00E+00	0.00E+00	4.54E-02	4.54E-02	8.35E-02	#VALUE!
90th Percentile	0-3km	Arsenic	Ruffed_grouse	1.76E-01	6.12E-05	5.67E-03	1.05E-01	3.70E-03	0.00E+00	0.00E+00	2.90E-01	2.90E-01	5.34E-01	2.38E-01
90th Percentile	0-3km	Lead	Ruffed_grouse	1.69E+00	8.51E-05	6.82E-02	1.14E+00	1.12E-01	0.00E+00	0.00E+00	3.01E+00	3.01E+00	5.53E+00	3.39E+00
90th Percentile	0-3km	Zinc	Ruffed_grouse	1.55E+00	5.96E-04	4.13E-02	6.00E+00	6.40E-01	0.00E+00	0.00E+00	8.23E+00	8.23E+00	1.51E+01	2.29E-01
90th Percentile	Reference	Antimony	Ruffed_grouse	7.97E-03	3.92E-05	2.24E-04	5.12E-03	2.12E-03	0.00E+00	0.00E+00	1.55E-02	1.55E-02	2.84E-02	#VALUE!
90th Percentile	Reference	Arsenic	Ruffed_grouse	1.99E-02	1.49E-04	4.70E-04	1.75E-02	7.97E-04	0.00E+00	0.00E+00	3.88E-02	3.88E-02	7.13E-02	3.18E-02
90th Percentile	Reference	Lead	Ruffed_grouse	2.69E-01	6.40E-05	5.01E-03	1.35E-01	2.55E-02	0.00E+00	0.00E+00	4.34E-01	4.34E-01	7.99E-01	4.90E-01
90th Percentile	Reference	Zinc	Ruffed_grouse	2.85E-01	1.30E-03	9.50E-03	2.32E+00	3.68E-01	0.00E+00	0.00E+00	2.98E+00	2.98E+00	5.48E+00	8.30E-02
95th Percentile	0-3km	Antimony	Ruffed_grouse	3.51E-02	3.92E-05	1.16E-03	2.47E-02	9.32E-03	0.00E+00	0.00E+00	7.03E-02	7.03E-02	1.29E-01	#VALUE!
95th Percentile	0-3km	Arsenic	Ruffed_grouse	1.86E-01	6.59E-05	7.22E-03	1.34E-01	3.86E-03	0.00E+00	0.00E+00	3.31E-01	3.31E-01	6.09E-01	2.72E-01
95th Percentile	0-3km	Lead	Ruffed_grouse	2.20E+00	1.34E-04	1.02E-01	1.69E+00	1.39E-01	0.00E+00	0.00E+00	4.12E+00	4.12E+00	7.58E+00	4.65E+00
95th Percentile	0-3km	Zinc	Ruffed_grouse	3.55E+00	9.61E-04	8.07E-02	9.47E+00	8.40E-01	0.00E+00	0.00E+00	1.39E+01	1.39E+01	2.56E+01	3.88E-01
95th Percentile	Reference	Antimony	Ruffed_grouse	7.97E-03	3.92E-05	2.52E-04	5.66E-03	2.12E-03	0.00E+00	0.00E+00	1.60E-02	1.60E-02	2.95E-02	#VALUE!
95th Percentile	Reference	Arsenic	Ruffed_grouse	3.90E-02	1.88E-04	8.06E-04	2.48E-02	1.28E-03	0.00E+00	0.00E+00	6.61E-02	6.61E-02	1.21E-01	5.42E-02
95th Percentile	Reference	Lead	Ruffed_grouse	2.92E-01	1.11E-04	5.56E-03	1.44E-01	2.73E-02	0.00E+00	0.00E+00	4.69E-01	4.69E-01	8.62E-01	5.29E-01
95th Percentile	Reference	Zinc	Ruffed_grouse	3.98E-01	1.62E-03	1.27E-02	2.80E+00	4.10E-01	0.00E+00	0.00E+00	3.62E+00	3.62E+00	6.66E+00	1.01E-01
95UCLM	0-3km	Antimony	Ruffed_grouse	3.51E-02	3.92E-05	7.48E-04	1.66E-02	9.32E-03	0.00E+00	0.00E+00	6.18E-02	6.18E-02	1.14E-01	#VALUE!
95UCLM	0-3km	Arsenic	Ruffed_grouse	1.18E-01	5.41E-05	3.84E-03	7.78E-02	2.79E-03	0.00E+00	0.00E+00	2.02E-01	2.02E-01	3.71E-01	1.66E-01
95UCLM	0-3km	Lead	Ruffed_grouse	1.34E+00	8.95E-05	4.20E-02	6.99E-01	9.32E-02	0.00E+00	0.00E+00	2.17E+00	2.17E+00	4.00E+00	2.45E+00
95UCLM	0-3km	Zinc	Ruffed_grouse	2.02E+00	9.06E-04	4.16E-02	6.77E+00	6.99E-01	0.00E+00	0.00E+00	9.54E+00	9.54E+00	1.75E+01	2.65E-01
95UCLM	Reference	Antimony	Ruffed_grouse	7.97E-03	3.92E-05	2.24E-04	5.12E-03	2.12E-03	0.00E+00	0.00E+00	1.55E-02	1.55E-02	2.84E-02	#VALUE!
95UCLM	Reference	Arsenic	Ruffed_grouse	1.95E-02	1.01E-04	4.63E-04	1.73E-02	7.85E-04	0.00E+00	0.00E+00	3.82E-02	3.82E-02	7.02E-02	3.13E-02

Table 5. Predicted Exposure & Hazard Quotient Values

Scenario	Site	Chemical	Receptor	Soil mg/day	Water mg/day	Inhalation mg/day	Browse mg/day	Invert mg/day	Prey mg/day	Fish mg/day	Total mg/day	Total (BA Adjusted) mg/day	Dose mg/kg/day	HQ(NOAEL) Unitless
95UCLM	Reference	Lead	Ruffed_grouse	1.76E-01	6.47E-05	3.52E-03	1.09E-01	1.81E-02	0.00E+00	0.00E+00	3.07E-01	3.07E-01	5.65E-01	3.46E-01
95UCLM	Reference	Zinc	Ruffed_grouse	2.83E-01	9.46E-04	9.46E-03	2.31E+00	3.67E-01	0.00E+00	0.00E+00	2.97E+00	2.97E+00	5.46E+00	8.26E-02
90th Percentile	0-3km	Antimony	Snowshoe_hare	2.28E-02	1.25E-04	1.93E-03	2.35E-02	0.00E+00	0.00E+00	0.00E+00	4.84E-02	4.84E-02	3.72E-02	6.31E-01
90th Percentile	0-3km	Arsenic	Snowshoe_hare	1.76E-01	1.96E-04	1.49E-02	1.55E-01	0.00E+00	0.00E+00	0.00E+00	3.47E-01	3.47E-01	2.67E-01	2.57E-01
90th Percentile	0-3km	Lead	Snowshoe_hare	1.69E+00	2.72E-04	1.80E-01	1.69E+00	0.00E+00	0.00E+00	0.00E+00	3.56E+00	3.56E+00	2.74E+00	5.83E-01
90th Percentile	0-3km	Zinc	Snowshoe_hare	1.55E+00	1.91E-03	1.09E-01	8.87E+00	0.00E+00	0.00E+00	0.00E+00	1.05E+01	1.05E+01	8.10E+00	1.07E-01
90th Percentile	Reference	Antimony	Snowshoe_hare	8.00E-03	1.25E-04	5.88E-04	7.56E-03	0.00E+00	0.00E+00	0.00E+00	1.63E-02	1.63E-02	1.25E-02	2.12E-01
90th Percentile	Reference	Arsenic	Snowshoe_hare	2.00E-02	4.76E-04	1.24E-03	2.58E-02	0.00E+00	0.00E+00	0.00E+00	4.75E-02	4.75E-02	3.66E-02	3.51E-02
90th Percentile	Reference	Lead	Snowshoe_hare	2.71E-01	2.04E-04	1.32E-02	1.99E-01	0.00E+00	0.00E+00	0.00E+00	4.83E-01	4.83E-01	3.71E-01	7.90E-02
90th Percentile	Reference	Zinc	Snowshoe_hare	2.87E-01	4.16E-03	2.50E-02	3.43E+00	0.00E+00	0.00E+00	0.00E+00	3.74E+00	3.74E+00	2.88E+00	3.82E-02
95th Percentile	0-3km	Antimony	Snowshoe_hare	3.52E-02	1.25E-04	3.05E-03	3.65E-02	0.00E+00	0.00E+00	0.00E+00	7.48E-02	7.48E-02	5.76E-02	9.76E-01
95th Percentile	0-3km	Arsenic	Snowshoe_hare	1.87E-01	2.11E-04	1.90E-02	1.98E-01	0.00E+00	0.00E+00	0.00E+00	4.04E-01	4.04E-01	3.11E-01	2.99E-01
95th Percentile	0-3km	Lead	Snowshoe_hare	2.21E+00	4.29E-04	2.67E-01	2.49E+00	0.00E+00	0.00E+00	0.00E+00	4.97E+00	4.97E+00	3.82E+00	8.13E-01
95th Percentile	0-3km	Zinc	Snowshoe_hare	3.56E+00	3.07E-03	2.12E-01	1.40E+01	0.00E+00	0.00E+00	0.00E+00	1.78E+01	1.78E+01	1.37E+01	1.81E-01
95th Percentile	Reference	Antimony	Snowshoe_hare	8.00E-03	1.25E-04	6.62E-04	8.36E-03	0.00E+00	0.00E+00	0.00E+00	1.72E-02	1.72E-02	1.32E-02	2.24E-01
95th Percentile	Reference	Arsenic	Snowshoe_hare	3.92E-02	6.02E-04	2.12E-03	3.66E-02	0.00E+00	0.00E+00	0.00E+00	7.85E-02	7.85E-02	6.04E-02	5.81E-02
95th Percentile	Reference	Lead	Snowshoe_hare	2.94E-01	3.55E-04	1.46E-02	2.12E-01	0.00E+00	0.00E+00	0.00E+00	5.21E-01	5.21E-01	4.01E-01	8.53E-02
95th Percentile	Reference	Zinc	Snowshoe_hare	4.00E-01	5.17E-03	3.35E-02	4.14E+00	0.00E+00	0.00E+00	0.00E+00	4.57E+00	4.57E+00	3.52E+00	4.67E-02
95UCLM	0-3km	Antimony	Snowshoe_hare	3.52E-02	1.25E-04	1.97E-03	2.46E-02	0.00E+00	0.00E+00	0.00E+00	6.19E-02	6.19E-02	4.76E-02	8.07E-01
95UCLM	0-3km	Arsenic	Snowshoe_hare	1.18E-01	1.73E-04	1.01E-02	1.15E-01	0.00E+00	0.00E+00	0.00E+00	2.43E-01	2.43E-01	1.87E-01	1.80E-01
95UCLM	0-3km	Lead	Snowshoe_hare	1.35E+00	2.86E-04	1.11E-01	1.03E+00	0.00E+00	0.00E+00	0.00E+00	2.49E+00	2.49E+00	1.91E+00	4.07E-01
95UCLM	0-3km	Zinc	Snowshoe_hare	2.03E+00	2.90E-03	1.09E-01	1.00E+01	0.00E+00	0.00E+00	0.00E+00	1.21E+01	1.21E+01	9.35E+00	1.24E-01
95UCLM	Reference	Antimony	Snowshoe_hare	8.00E-03	1.25E-04	5.88E-04	7.56E-03	0.00E+00	0.00E+00	0.00E+00	1.63E-02	1.63E-02	1.25E-02	2.12E-01
95UCLM	Reference	Arsenic	Snowshoe_hare	1.96E-02	3.23E-04	1.22E-03	2.56E-02	0.00E+00	0.00E+00	0.00E+00	4.67E-02	4.67E-02	3.59E-02	3.45E-02
95UCLM	Reference	Lead	Snowshoe_hare	1.77E-01	2.07E-04	9.26E-03	1.61E-01	0.00E+00	0.00E+00	0.00E+00	3.48E-01	3.48E-01	2.67E-01	5.69E-02
95UCLM	Reference	Zinc	Snowshoe_hare	2.84E-01	3.02E-03	2.49E-02	3.41E+00	0.00E+00	0.00E+00	0.00E+00	3.72E+00	3.72E+00	2.86E+00	3.80E-02
90th Percentile	0-3km	Antimony	White-tailed_deer	1.70E-01	3.04E-03	3.30E-02	5.52E-01	0.00E+00	0.00E+00	0.00E+00	7.58E-01	7.58E-01	1.69E-02	2.86E-01
90th Percentile	0-3km	Arsenic	White-tailed_deer	1.32E+00	4.75E-03	2.54E-01	3.65E+00	0.00E+00	0.00E+00	0.00E+00	5.23E+00	5.23E+00	1.16E-01	1.12E-01
90th Percentile	0-3km	Lead	White-tailed_deer	1.26E+01	6.61E-03	3.06E+00	3.96E+01	0.00E+00	0.00E+00	0.00E+00	5.53E+01	5.53E+01	1.23E+00	2.62E-01
90th Percentile	0-3km	Zinc	White-tailed_deer	1.16E+01	4.63E-02	1.85E+00	2.08E+02	0.00E+00	0.00E+00	0.00E+00	2.22E+02	2.22E+02	4.93E+00	6.54E-02
90th Percentile	Reference	Antimony	White-tailed_deer	5.97E-02	3.04E-03	1.00E-02	1.78E-01	0.00E+00	0.00E+00	0.00E+00	2.50E-01	2.50E-01	5.56E-03	9.43E-02
90th Percentile	Reference	Arsenic	White-tailed_deer	1.49E-01	1.16E-02	2.11E-02	6.06E-01	0.00E+00	0.00E+00	0.00E+00	7.88E-01	7.88E-01	1.75E-02	1.68E-02
90th Percentile	Reference	Lead	White-tailed_deer	2.02E+00	4.96E-03	2.25E-01	4.67E+00	0.00E+00	0.00E+00	0.00E+00	6.92E+00	6.92E+00	1.54E-01	3.27E-02
90th Percentile	Reference	Zinc	White-tailed_deer	2.14E+00	1.01E-01	4.26E-01	8.05E+01	0.00E+00	0.00E+00	0.00E+00	8.32E+01	8.32E+01	1.85E+00	2.45E-02
95th Percentile	0-3km	Antimony	White-tailed_deer	2.63E-01	3.04E-03	5.20E-02	8.57E-01	0.00E+00	0.00E+00	0.00E+00	1.17E+00	1.17E+00	2.61E-02	4.42E-01
95th Percentile	0-3km	Arsenic	White-tailed_deer	1.40E+00	5.11E-03	3.24E-01	4.64E+00	0.00E+00	0.00E+00	0.00E+00	6.37E+00	6.37E+00	1.42E-01	1.36E-01
95th Percentile	0-3km	Lead	White-tailed_deer	1.65E+01	1.04E-02	4.55E+00	5.85E+01	0.00E+00	0.00E+00	0.00E+00	7.96E+01	7.96E+01	1.77E+00	3.76E-01
95th Percentile	0-3km	Zinc	White-tailed_deer	2.66E+01	7.46E-02	3.62E+00	3.29E+02	0.00E+00	0.00E+00	0.00E+00	3.59E+02	3.59E+02	7.98E+00	1.06E-01
95th Percentile	Reference	Antimony	White-tailed_deer	5.97E-02	3.04E-03	1.13E-02	1.97E-01	0.00E+00	0.00E+00	0.00E+00	2.71E-01	2.71E-01	6.01E-03	1.02E-01
95th Percentile	Reference	Arsenic	White-tailed_deer	2.93E-01	1.46E-02	3.61E-02	8.59E-01	0.00E+00	0.00E+00	0.00E+00	1.20E+00	1.20E+00	2.67E-02	2.57E-02
95th Percentile	Reference	Lead	White-tailed_deer	2.19E+00	8.62E-03	2.49E-01	4.99E+00	0.00E+00	0.00E+00	0.00E+00	7.44E+00	7.44E+00	1.65E-01	3.52E-02
95th Percentile	Reference	Zinc	White-tailed_deer	2.99E+00	1.25E-01	5.71E-01	9.72E+01	0.00E+00	0.00E+00	0.00E+00	1.01E+02	1.01E+02	2.24E+00	2.97E-02
95UCLM	0-3km	Antimony	White-tailed_deer	2.63E-01	3.04E-03	3.35E-02	5.78E-01	0.00E+00	0.00E+00	0.00E+00	8.77E-01	8.77E-01	1.95E-02	3.30E-01
95UCLM	0-3km	Arsenic	White-tailed_deer	8.81E-01	4.20E-03	1.72E-01	2.70E+00	0.00E+00	0.00E+00	0.00E+00	3.76E+00	3.76E+00	8.35E-02	8.03E-02
95UCLM	0-3km	Lead	White-tailed_deer	1.00E+01	6.94E-03	1.89E+00	2.43E+01	0.00E+00	0.00E+00	0.00E+00	3.62E+01	3.62E+01	8.04E-01	1.71E-01
95UCLM	0-3km	Zinc	White-tailed_deer	1.52E+01	7.03E-02	1.86E+00	2.35E+02	0.00E+00	0.00E+00	0.00E+00	2.52E+02	2.52E+02	5.61E+00	7.43E-02
95UCLM	Reference	Antimony	White-tailed_deer	5.97E-02	3.04E-03	1.00E-02	1.78E-01	0.00E+00	0.00E+00	0.00E+00	2.50E-01	2.50E-01	5.56E-03	9.43E-02
95UCLM	Reference	Arsenic	White-tailed_deer	1.46E-01	7.85E-03	2.08E-02	6.01E-01	0.00E+00	0.00E+00	0.00E+00	7.76E-01	7.76E-01	1.72E-02	1.66E-02

Table 5. Predicted Exposure & Hazard Quotient Values

Scenario	Site	Chemical	Receptor	Soil mg/day	Water mg/day	Inhalation mg/day	Browse mg/day	Invert mg/day	Prey mg/day	Fish mg/day	Total mg/day	Total (BA Adjusted) mg/day	Dose mg/kg/day	HQ(NOAEL) Unitless
95UCLM	Reference	Lead	White-tailed_deer	1.32E+00	5.02E-03	1.58E-01	3.78E+00	0.00E+00	0.00E+00	0.00E+00	5.27E+00	5.27E+00	1.17E-01	2.49E-02
95UCLM	Reference	Zinc	White-tailed_deer	2.12E+00	7.34E-02	4.24E-01	8.02E+01	0.00E+00	0.00E+00	0.00E+00	8.28E+01	8.28E+01	1.84E+00	2.44E-02

Table 6. Summary of Predicted Exposure Point Concentration Values

																Percent Air/Soil Contribution	
				Soil	Water	Air	Dust	Predicted Deposition	Browse Deposition	Browse Soil	Browse Total	Berries Soil	Invert Soil	Prey Soil	Fish	Browse Deposition	Browse Soil
Scenario	Site	Chemical	Abbreviation	mg/kg	mg/L	µg/m^3	µg/m^3	mg/m^2/year	mg/kg-dw	mg/kg-dw	mg/kg-dw	mg/kg-dw	mg/kg-dw	mg/kg-dw	mg/kg-dw	%	%
90th Percentile	0-3km	Antimony	90th Percentile_0-3km_Antimony	5.70E+00	1.00E-03	1.45E-03	1.42E-03	1.65E+00	1.68E-01	2.02E-01	3.70E-01	1.82E-01	5.70E+00	1.04E-01	5.00E-01	45%	55%
90th Percentile	0-3km	Arsenic	90th Percentile_0-3km_Arsenic	4.41E+01	1.56E-03	1.11E-02	1.10E-02	1.27E+01	1.29E+00	1.15E+00	2.45E+00	2.79E-01	3.50E+00	1.74E-01	2.00E+00	53%	47%
90th Percentile	0-3km	Lead	90th Percentile_0-3km_Lead	4.23E+02	2.17E-03	1.61E-01	1.06E-01	1.83E+02	1.87E+01	7.88E+00	2.66E+01	5.75E+00	1.06E+02	1.56E+01	5.00E-01	70%	30%
90th Percentile	0-3km	Zinc	90th Percentile_0-3km_Zinc	3.88E+02	1.52E-02	6.46E-02	9.70E-02	7.36E+01	7.50E+00	1.32E+02	1.40E+02	3.76E+01	6.04E+02	1.36E+02	5.00E+00	5%	95%
90th Percentile	Reference	Antimony	90th Percentile_Reference_Antimony	2.00E+00	1.00E-03	3.74E-04	5.00E-04	4.26E-01	4.34E-02	7.56E-02	1.19E-01	6.38E-02	2.00E+00	3.64E-02	0.00E+00	36%	64%
90th Percentile	Reference	Arsenic	90th Percentile_Reference_Arsenic	5.00E+00	3.80E-03	5.86E-04	1.25E-03	6.68E-01	6.80E-02	3.38E-01	4.06E-01	3.16E-02	7.52E-01	2.93E-02	0.00E+00	17%	83%
90th Percentile	Reference	Lead	90th Percentile_Reference_Lead	6.76E+01	1.63E-03	2.68E-03	1.69E-02	3.06E+00	3.11E-01	2.82E+00	3.13E+00	9.19E-01	2.41E+01	6.95E+00	0.00E+00	10%	90%
90th Percentile	Reference	Zinc	90th Percentile_Reference_Zinc	7.16E+01	3.32E-02	1.92E-02	1.79E-02	2.19E+01	2.23E+00	5.17E+01	5.39E+01	6.95E+00	3.47E+02	1.20E+02	0.00E+00	4%	96%
95th Percentile	0-3km	Antimony	95th Percentile_0-3km_Antimony	8.80E+00	1.00E-03	2.33E-03	2.20E-03	2.66E+00	2.71E-01	3.03E-01	5.74E-01	2.81E-01	8.80E+00	1.61E-01	5.00E-01	47%	53%
95th Percentile	0-3km	Arsenic	95th Percentile_0-3km_Arsenic	4.68E+01	1.68E-03	1.65E-02	1.17E-02	1.88E+01	1.92E+00	1.19E+00	3.11E+00	2.96E-01	3.65E+00	1.83E-01	2.00E+00	62%	38%
95th Percentile	0-3km	Lead	95th Percentile_0-3km_Lead	5.52E+02	3.42E-03	2.59E-01	1.38E-01	2.95E+02	3.01E+01	9.15E+00	3.92E+01	7.50E+00	1.31E+02	1.76E+01	5.00E-01	77%	23%
95th Percentile	0-3km	Zinc	95th Percentile_0-3km_Zinc	8.90E+02	2.45E-02	9.30E-02	2.22E-01	1.06E+02	1.08E+01	2.09E+02	2.20E+02	8.63E+01	7.94E+02	1.44E+02	5.00E+00	5%	95%
95th Percentile	Reference	Antimony	95th Percentile_Reference_Antimony	2.00E+00	1.00E-03	4.83E-04	5.00E-04	5.51E-01	5.61E-02	7.56E-02	1.32E-01	6.38E-02	2.00E+00	3.66E-02	0.00E+00	43%	57%
95th Percentile	Reference	Arsenic	95th Percentile_Reference_Arsenic	9.80E+00	4.80E-03	7.00E-04	2.45E-03	7.98E-01	8.12E-02	4.94E-01	5.75E-01	6.20E-02	1.21E+00	5.09E-02	0.00E+00	14%	86%
95th Percentile	Reference	Lead	95th Percentile_Reference_Lead	7.34E+01	2.83E-03	3.36E-03	1.83E-02	3.83E+00	3.90E-01	2.95E+00	3.34E+00	9.98E-01	2.58E+01	7.21E+00	0.00E+00	12%	88%
95th Percentile	Reference	Zinc	95th Percentile_Reference_Zinc	1.00E+02	4.12E-02	2.48E-02	2.50E-02	2.83E+01	2.88E+00	6.22E+01	6.51E+01	9.70E+00	3.87E+02	1.23E+02	0.00E+00	4%	96%
95UCLM	0-3km	Antimony	95UCLM_0-3km_Antimony	8.80E+00	1.00E-03	7.22E-04	2.20E-03	8.23E-01	8.38E-02	3.03E-01	3.87E-01	2.81E-01	8.80E+00	1.58E-01	5.00E-01	22%	78%
95UCLM	0-3km	Arsenic	95UCLM_0-3km_Arsenic	2.95E+01	1.38E-03	7.65E-03	7.38E-03	8.72E+00	8.88E-01	9.20E-01	1.81E+00	1.87E-01	2.63E+00	1.25E-01	2.00E+00	49%	51%
95UCLM	0-3km	Lead	95UCLM_0-3km_Lead	3.36E+02	2.28E-03	8.03E-02	8.41E-02	9.15E+01	9.32E+00	6.93E+00	1.62E+01	4.57E+00	8.80E+01	1.41E+01	5.00E-01	57%	43%
95UCLM	0-3km	Zinc	95UCLM_0-3km_Zinc	5.08E+02	2.31E-02	3.54E-02	1.27E-01	4.04E+01	4.11E+00	1.53E+02	1.58E+02	4.93E+01	6.60E+02	1.39E+02	5.00E+00	3%	97%
95UCLM	Reference	Antimony	95UCLM_Reference_Antimony	2.00E+00	1.00E-03	3.74E-04	5.00E-04	4.26E-01	4.34E-02	7.56E-02	1.19E-01	6.38E-02	2.00E+00	3.64E-02	0.00E+00	36%	64%
95UCLM	Reference	Arsenic	95UCLM_Reference_Arsenic	4.90E+00	2.58E-03	5.86E-04	1.23E-03	6.68E-01	6.80E-02	3.34E-01	4.02E-01	3.10E-02	7.42E-01	2.88E-02	0.00E+00	17%	83%
95UCLM	Reference	Lead	95UCLM_Reference_Lead	4.43E+01	1.65E-03	2.68E-03	1.11E-02	3.06E+00	3.11E-01	2.22E+00	2.53E+00	6.02E-01	1.71E+01	5.77E+00	0.00E+00	12%	88%
95UCLM	Reference	Zinc	95UCLM_Reference_Zinc	7.10E+01	2.41E-02	1.92E-02	1.78E-02	2.19E+01	2.23E+00	5.15E+01	5.37E+01	6.89E+00	3.46E+02	1.20E+02	0.00E+00	4%	96%

Table 7. Wildlife Oral Toxicity Reference Values (TRVs) [mg/kg/day]

Wildlife Receptor	Chemical	Abbreviation	NOAEL	LOAEL	Comment for NOAEL	Reference
Dark-eyed_junco	Antimony	Dark-eyed_junco_Antimony	na	na	TRV not available	See Section 7.2, Main Report
Ermine	Antimony	Ermine_Antimony	0.059	na	Highest bounded NOAEL below the lowest bounded LOAEL	See Section 7.2, Main Report
Masked_shrew	Antimony	Masked_shrew_Antimony	0.059	0.59	Highest bounded NOAEL below the lowest bounded LOAEL	See Section 7.2, Main Report
Northern_saw-whet_owl	Antimony	Northern_saw-whet_owl_Antimony	na	na	TRV not available	See Section 7.2, Main Report
Ruffed_grouse	Antimony	Ruffed_grouse_Antimony	na	na	TRV not available	See Section 7.2, Main Report
Snowshoe_hare	Antimony	Snowshoe_hare_Antimony	0.059	na	Highest bounded NOAEL below the lowest bounded LOAEL	See Section 7.2, Main Report
White-tailed_deer	Antimony	White-tailed_deer_Antimony	0.059	na	Highest bounded NOAEL below the lowest bounded LOAEL	See Section 7.2, Main Report
Dark-eyed_junco	Arsenic	Dark-eyed_junco_Arsenic	2.24	14	Lowest NOAEL for reproduction, growth or survival	See Section 7.2, Main Report
Ermine	Arsenic	Ermine_Arsenic	1.04	na	Highest bounded NOAEL below the lowest bounded LOAEL	See Section 7.2, Main Report
Masked_shrew	Arsenic	Masked_shrew_Arsenic	1.04	3.3	Highest bounded NOAEL below the lowest bounded LOAEL	See Section 7.2, Main Report
Northern_saw-whet_owl	Arsenic	Northern_saw-whet_owl_Arsenic	2.24	na	Lowest NOAEL for reproduction, growth or survival	See Section 7.2, Main Report
Ruffed_grouse	Arsenic	Ruffed_grouse_Arsenic	2.24	na	Lowest NOAEL for reproduction, growth or survival	See Section 7.2, Main Report
Snowshoe_hare	Arsenic	Snowshoe_hare_Arsenic	1.04	3.3	Highest bounded NOAEL below the lowest bounded LOAEL	See Section 7.2, Main Report
White-tailed_deer	Arsenic	White-tailed_deer_Arsenic	1.04	na	Highest bounded NOAEL below the lowest bounded LOAEL	See Section 7.2, Main Report
Dark-eyed_junco	Lead	Dark-eyed_junco_Lead	1.63	9.9	Highest bounded NOAEL below the lowest bounded LOAEL for reproduction, growth, or survival	See Section 7.2, Main Report
Ermine	Lead	Ermine_Lead	4.7	35	Highest bounded NOAEL below the lowest bounded LOAEL for reproduction, growth, or survival	See Section 7.2, Main Report
Masked_shrew	Lead	Masked_shrew_Lead	4.7	35	Highest bounded NOAEL below the lowest bounded LOAEL for reproduction, growth, or survival	See Section 7.2, Main Report
Northern_saw-whet_owl	Lead	Northern_saw-whet_owl_Lead	1.63	9.9	Highest bounded NOAEL below the lowest bounded LOAEL for reproduction, growth, or survival	See Section 7.2, Main Report
Ruffed_grouse	Lead	Ruffed_grouse_Lead	1.63	9.9	Highest bounded NOAEL below the lowest bounded LOAEL for reproduction, growth, or survival	See Section 7.2, Main Report
Snowshoe_hare	Lead	Snowshoe_hare_Lead	4.7	35	Highest bounded NOAEL below the lowest bounded LOAEL for reproduction, growth, or survival	See Section 7.2, Main Report
White-tailed_deer	Lead	White-tailed_deer_Lead	4.7	na	Highest bounded NOAEL below the lowest bounded LOAEL for reproduction, growth, or survival	See Section 7.2, Main Report
Dark-eyed_junco	Zinc	Dark-eyed_junco_Zinc	66.1	77	Geometric mean of NOAELs for reproduction and growth	See Section 7.2, Main Report
Ermine	Zinc	Ermine_Zinc	75.4	na	Geometric mean of NOAELs for reproduction and growth	See Section 7.2, Main Report
Masked_shrew	Zinc	Masked_shrew_Zinc	75.4	94.2	Geometric mean of NOAELs for reproduction and growth	See Section 7.2, Main Report
Northern_saw-whet_owl	Zinc	Northern_saw-whet_owl_Zinc	66.1	na	Geometric mean of NOAELs for reproduction and growth	See Section 7.2, Main Report
Ruffed_grouse	Zinc	Ruffed_grouse_Zinc	66.1	na	Geometric mean of NOAELs for reproduction and growth	See Section 7.2, Main Report
Snowshoe_hare	Zinc	Snowshoe_hare_Zinc	75.4	na	Geometric mean of NOAELs for reproduction and growth	See Section 7.2, Main Report
White-tailed_deer	Zinc	White-tailed_deer_Zinc	75.4	na	Geometric mean of NOAELs for reproduction and growth	See Section 7.2, Main Report

Table 8. Soil Ingestion Rate [kg/day]	
Receptor	Value
Dark-eyed_junco	4.30E-04
Ermine	1.24E-04
Masked_shrew	2.79E-05
Northern_saw-whet_ow	5.74E-04
Ruffed_grouse	3.98E-03
Snowshoe_hare	4.00E-03
White-tailed_deer	2.99E-02

Receptor	**Percent Soil in Diet**
Dark-eyed_junco	9.3%

NFMR

9.71E+02	kcal/kg/day
1.83E+01	kcal/day

BW

1.88E-02	kg

Estimation of Average Metabolizable Energy

Diet	Portion	GE [kcal/kg-DW]	AE [%]	MEavg kcal/kg-DW
Browse	40%	5100	75%	1.53E+03
Fish	0%	4900	79%	0.00E+00
Invert	60%	5600	72%	2.42E+03
Prey	0%	5000	78%	0.00E+00
	100%		**Sum**	**3.95E+03**

Estimation of Total Ingestion Rate [kg-food / day]	4.62E-03
Soil Ingestion Rate [kg-soil / day]	4.30E-04
Estimation of Total Ingestion Rate [kg-food / kg-BW day]	2.46E-01

Table 8. Soil Ingestion Rate [kg/day]

Receptor				**Percent Soil in Diet**
Ermine			4.0%	
NFMR				
3.03E+02	kcal/kg/day			
1.30E+01	kcal/day			
BW				
4.30E-02	kg			
Estimation of Average Metabolizable Energy				
		GE	AE	MEavg
Diet	Portion	[kcal/kg-DW]	[%]	kcal/kg-DW
Browse	0%	4200	46%	0.00E+00
Fish	0%	4900	79%	0.00E+00
Invert	0%	5600	87%	0.00E+00
Prey	100%	5000	84%	4.20E+03
	100%		**Sum**	**4.20E+03**
Estimation of Total Ingestion Rate [kg-food / day]				3.10E-03
Soil Ingestion Rate [kg-soil / day]				1.24E-04
Estimation of Total Ingestion Rate [kg-food / kg-BW day]				7.21E-02

Receptor				**Percent Soil in Diet**
Masked_shrew			3.0%	
NFMR				
9.07E+02	kcal/kg/day			
4.54E+00	kcal/day			
BW				
5.00E-03	kg			
Estimation of Average Metabolizable Energy				
		GE	AE	MEavg
Diet	Portion	[kcal/kg-DW]	[%]	kcal/kg-DW
Browse	0%	4200	46%	0.00E+00
Fish	0%	4900	79%	0.00E+00
Invert	100%	5600	87%	4.87E+03
Prey	0%	5000	84%	0.00E+00
	100%		**Sum**	**4.87E+03**
Estimation of Total Ingestion Rate [kg-food / day]				9.31E-04
Soil Ingestion Rate [kg-soil / day]				2.79E-05
Estimation of Total Ingestion Rate [kg-food / kg-BW day]				1.86E-01

Table 8. Soil Ingestion Rate [kg/day]				
Receptor			**Percent Soil in Diet**	
Northern_saw-whet_owl			5.0%	
NFMR				
6.50E+02	kcal/kg/day			
4.47E+01	kcal/day			
BW				
6.88E-02	kg			
	Estimation of Average Metabolizable Energy			
		GE	AE	MEavg
Diet	Portion	[kcal/kg-DW]	[%]	kcal/kg-DW
Browse	0%	5100	75%	0.00E+00
Fish	0%	4900	79%	0.00E+00
Invert	0%	5600	72%	0.00E+00
Prey	100%	5000	78%	3.90E+03
	100%		**Sum**	**3.90E+03**
			Estimation of Total Ingestion Rate [kg-food / day]	1.15E-02
			Soil Ingestion Rate [kg-soil / day]	5.74E-04
			Estimation of Total Ingestion Rate [kg-food / kg-BW day]	1.67E-01
Receptor			**Percent Soil in Diet**	
Ruffed_grouse			9.3%	
NFMR				
1.57E+02	kcal/kg/day			
8.54E+01	kcal/day			
BW				
5.44E-01	kg			
	Estimation of Average Metabolizable Energy			
		GE	AE	MEavg
Diet	Portion	[kcal/kg-DW]	[%]	kcal/kg-DW
Browse	95%	3950	48%	1.79E+03
Fish	0%	4900	79%	0.00E+00
Invert	5%	5600	72%	2.02E+02
Prey	0%	5000	78%	0.00E+00
	100%		**Sum**	**1.99E+03**
			Estimation of Total Ingestion Rate [kg-food / day]	4.28E-02
			Soil Ingestion Rate [kg-soil / day]	3.98E-03
			Estimation of Total Ingestion Rate [kg-food / kg-BW day]	7.87E-02

Table 8. Soil Ingestion Rate [kg/day]

Receptor	**Percent Soil in Diet**
Snowshoe_hare	6.3%

NFMR

1.50E+02	kcal/kg/day
1.95E+02	kcal/day

BW

1.30E+00	kg

Estimation of Average Metabolizable Energy

Diet	Portion	GE [kcal/kg-DW]	AE [%]	MEavg kcal/kg-DW
Browse	100%	4200	73%	3.07E+03
Fish	0%	4900	79%	0.00E+00
Invert	0%	5600	87%	0.00E+00
Prey	0%	5000	84%	0.00E+00
	100%		**Sum**	**3.07E+03**

Estimation of Total Ingestion Rate [kg-food / day]	6.35E-02
Soil Ingestion Rate [kg-soil / day]	4.00E-03
Estimation of Total Ingestion Rate [kg-food / kg-BW day]	4.89E-02

Receptor	**Percent Soil in Diet**
White-tailed_deer	2.0%

NFMR

6.66E+01	kcal/kg/day
3.00E+03	kcal/day

BW

4.50E+01	kg

Estimation of Average Metabolizable Energy

Diet	Portion	GE [kcal/kg-DW]	AE [%]	MEavg kcal/kg-DW
Browse	100%	4363	46%	2.01E+03
Fish	0%	4900	79%	0.00E+00
Invert	0%	5600	87%	0.00E+00
Prey	0%	5000	84%	0.00E+00
	100%		**Sum**	**2.01E+03**

Estimation of Total Ingestion Rate [kg-food / day]	1.49E+00
Soil Ingestion Rate [kg-soil / day]	2.99E-02
Estimation of Total Ingestion Rate [kg-food / kg-BW day]	3.32E-02

Table 9. Receptor Exposure Variables

Receptor	Variable	Abbreviation	Value	Units	Reference/Comments
Dark-eyed_junco	BW	BW_Dark-eyed_junco	1.88E-02	kg-WW	See Appendix J for details
Dark-eyed_junco	IR	IR_Dark-eyed_junco	1.92E-02	m^3/day	See Appendix J for details
Dark-eyed_junco	SIR	SIR_Dark-eyed_junco	4.3E-04	kg/day	See Appendix J for details
Dark-eyed_junco	SIR_Per	SIR_Per_Dark-eyed_junco	9.3%	% of Diet	See Appendix J for details
Dark-eyed_junco	WIR	WIR_Dark-eyed_junco	4.12E-03	L/day	See Appendix J for details
Ermine	BW	BW_Ermine	4.30E-02	kg-WW	See Appendix J for details
Ermine	IR	IR_Ermine	4.40E-02	m^3/day	See Appendix J for details
Ermine	SIR	SIR_Ermine	1.2E-04	kg/day	See Appendix J for details
Ermine	SIR_Per	SIR_Per_Ermine	4.0%	% of Diet	See Appendix J for details
Ermine	WIR	WIR_Ermine	5.83E-03	L/day	See Appendix J for details
Masked_shrew	BW	BW_Masked_shrew	5.00E-03	kg-WW	See Appendix J for details
Masked_shrew	IR	IR_Masked_shrew	7.87E-03	m^3/day	See Appendix J for details
Masked_shrew	SIR	SIR_Masked_shrew	2.8E-05	kg/day	See Appendix J for details
Masked_shrew	SIR_Per	SIR_Per_Masked_shrew	3.0%	% of Diet	See Appendix J for details
Masked_shrew	WIR	WIR_Masked_shrew	8.41E-04	L/day	See Appendix J for details
Northern_saw-whet_owl	BW	BW_Northern_saw-whet_owl	6.88E-02	kg-WW	See Appendix J for details
Northern_saw-whet_owl	IR	IR_Northern_saw-whet_owl	5.21E-02	m^3/day	See Appendix J for details
Northern_saw-whet_owl	SIR	SIR_Northern_saw-whet_owl	5.7E-04	kg/day	See Appendix J for details
Northern_saw-whet_owl	SIR_Per	SIR_Per_Northern_saw-whet_owl	5.0%	% of Diet	See Appendix J for details
Northern_saw-whet_owl	WIR	WIR_Northern_saw-whet_owl	9.82E-03	L/day	See Appendix J for details
Ruffed_grouse	BW	BW_Ruffed_grouse	5.44E-01	kg-WW	See Appendix J for details
Ruffed_grouse	IR	IR_Ruffed_grouse	2.56E-01	m^3/day	See Appendix J for details
Ruffed_grouse	SIR	SIR_Ruffed_grouse	4.0E-03	kg/day	See Appendix J for details
Ruffed_grouse	SIR_Per	SIR_Per_Ruffed_grouse	9.3%	% of Diet	See Appendix J for details
Ruffed_grouse	WIR	WIR_Ruffed_grouse	3.92E-02	L/day	See Appendix J for details
Snowshoe_hare	BW	BW_Snowshoe_hare	1.30E+00	kg-WW	See Appendix J for details
Snowshoe_hare	IR	IR_Snowshoe_hare	6.73E-01	m^3/day	See Appendix J for details
Snowshoe_hare	SIR	SIR_Snowshoe_hare	4.0E-03	kg/day	See Appendix J for details
Snowshoe_hare	SIR_Per	SIR_Per_Snowshoe_hare	6.3%	% of Diet	See Appendix J for details
Snowshoe_hare	WIR	WIR_Snowshoe_hare	1.25E-01	L/day	See Appendix J for details
White-tailed_deer	BW	BW_White-tailed_deer	4.50E+01	kg-WW	See Appendix J for details
White-tailed_deer	IR	IR_White-tailed_deer	1.15E+01	m^3/day	See Appendix J for details
White-tailed_deer	SIR	SIR_White-tailed_deer	3.0E-02	kg/day	See Appendix J for details
White-tailed_deer	SIR_Per	SIR_Per_White-tailed_deer	2.0%	% of Diet	See Appendix J for details
White-tailed_deer	WIR	WIR_White-tailed_deer	3.04E+00	L/day	See Appendix J for details

Table 10. Normalized to Body Weight Free-living (Field) Metabolic Rate (NFMR)

Receptor	NFMR [kcal/kg bw/day] A	FMR [kcal/day] B	Body Weight [grams]	Slope	Power	Reference/Comments
Dark-eyed_junco	9.71E+02	1.83E+01	1.88E+01	1.04E+01	6.80E-01	Nagy et al. 1999; Passerines
Masked_shrew	9.07E+02	4.54E+00	5.00E+00	6.98E+00	6.22E-01	See Appendix J for details
Northern_saw-whet_owl	6.50E+02	4.47E+01	6.88E+01	1.05E+01	6.81E-01	See Appendix J for details
Ermine	3.03E+02	1.30E+01	4.30E+01	2.23E+00	8.50E-01	See Appendix J for details
Ruffed_grouse	1.57E+02	8.54E+01	5.44E+02	8.51E-01	9.59E-01	See Appendix J for details
Snowshoe_hare	1.50E+02	1.95E+02	1.30E+03	7.94E+00	6.46E-01	See Appendix J for details
White-tailed_deer	6.66E+01	3.00E+03	4.50E+04	4.82E+00	7.34E-01	See Appendix J for details

A) NFMR = Normalized Free Metabolic Rate = FMR / BW; Where BW is in kg

B) FMR = Free Metabolic Rate = [Slope x BW^{Power}] / 4.1875 Kj/calorie; Where BW is in grams

Table 11. Receptor Dietary Composition [Media % of Diet]

Receptor	Media	Value	Comment
Dark-eyed_junco	Browse	40.0%	See Appendix J for details
Dark-eyed_junco	Fish	0.0%	See Appendix J for details
Dark-eyed_junco	Invert	60.0%	See Appendix J for details
Dark-eyed_junco	Prey	0.0%	See Appendix J for details
Ermine	Browse	0.0%	See Appendix J for details
Ermine	Fish	0.0%	See Appendix J for details
Ermine	Invert	0.0%	See Appendix J for details
Ermine	Prey	100.0%	See Appendix J for details
Masked_shrew	Browse	0.0%	See Appendix J for details
Masked_shrew	Fish	0.0%	See Appendix J for details
Masked_shrew	Invert	100.0%	See Appendix J for details
Masked_shrew	Prey	0.0%	See Appendix J for details
Northern_saw-whet_owl	Browse	0.0%	See Appendix J for details
Northern_saw-whet_owl	Fish	0.0%	See Appendix J for details
Northern_saw-whet_owl	Invert	0.0%	See Appendix J for details
Northern_saw-whet_owl	Prey	100.0%	See Appendix J for details
Ruffed_grouse	Browse	95.0%	See Appendix J for details
Ruffed_grouse	Fish	0.0%	See Appendix J for details
Ruffed_grouse	Invert	5.0%	See Appendix J for details
Ruffed_grouse	Prey	0.0%	See Appendix J for details
Snowshoe_hare	Browse	100.0%	See Appendix J for details
Snowshoe_hare	Fish	0.0%	See Appendix J for details
Snowshoe_hare	Invert	0.0%	See Appendix J for details
Snowshoe_hare	Prey	0.0%	See Appendix J for details
White-tailed_deer	Browse	100.0%	See Appendix J for details
White-tailed_deer	Fish	0.0%	See Appendix J for details
White-tailed_deer	Invert	0.0%	See Appendix J for details
White-tailed_deer	Prey	0.0%	See Appendix J for details

Table 12. Metabolizable Energy (ME) of Dietary Items [kcal/kg] [A]

Receptor	Dietary Item	Abbreviation	Value
Dark-eyed_junco	Browse	Dark-eyed_junco_Browse	3825
Dark-eyed_junco	Fish	Dark-eyed_junco_Fish	3871
Dark-eyed_junco	Invert	Dark-eyed_junco_Invert	4032
Dark-eyed_junco	Prey	Dark-eyed_junco_Prey	3900
Ermine	Browse	Ermine_Browse	1932
Ermine	Fish	Ermine_Fish	3871
Ermine	Invert	Ermine_Invert	4872
Ermine	Prey	Ermine_Prey	4200
Masked_shrew	Browse	Masked_shrew_Browse	1932
Masked_shrew	Fish	Masked_shrew_Fish	3871
Masked_shrew	Invert	Masked_shrew_Invert	4872
Masked_shrew	Prey	Masked_shrew_Prey	4200
Northern_saw-whet_owl	Browse	Northern_saw-whet_owl_Browse	3825
Northern_saw-whet_owl	Fish	Northern_saw-whet_owl_Fish	3871
Northern_saw-whet_owl	Invert	Northern_saw-whet_owl_Invert	4032
Northern_saw-whet_owl	Prey	Northern_saw-whet_owl_Prey	3900
Ruffed_grouse	Browse	Ruffed_grouse_Browse	1886
Ruffed_grouse	Fish	Ruffed_grouse_Fish	3871
Ruffed_grouse	Invert	Ruffed_grouse_Invert	4032
Ruffed_grouse	Prey	Ruffed_grouse_Prey	3900
Snowshoe_hare	Browse	Snowshoe_hare_Browse	3066
Snowshoe_hare	Fish	Snowshoe_hare_Fish	3871
Snowshoe_hare	Invert	Snowshoe_hare_Invert	4872
Snowshoe_hare	Prey	Snowshoe_hare_Prey	4200
White-tailed_deer	Browse	White-tailed_deer_Browse	2007
White-tailed_deer	Fish	White-tailed_deer_Fish	3871
White-tailed_deer	Invert	White-tailed_deer_Invert	4872
White-tailed_deer	Prey	White-tailed_deer_Prey	4200

A) US EPA 1993; Equation 4-17; ME = GE x AE

Table 13. Gross Energy (GE) of Dietary Items [kcal/kg dw] [A]

Receptor	Dietary Item	Value	Reference/Comments	**Diet %**
Dark-eyed_junco	Browse	5100		40%
Dark-eyed_junco	Fish	4900	bony fishes	0%
Dark-eyed_junco	Invert	5600		60%
Dark-eyed_junco	Prey	5000		0%
Ermine	Browse	4200		0%
Ermine	Fish	4900	bony fishes	0%
Ermine	Invert	5600		0%
Ermine	Prey	5000		100%
Masked_shrew	Browse	4200		0%
Masked_shrew	Fish	4900	bony fishes	0%
Masked_shrew	Invert	5600		100%
Masked_shrew	Prey	5000		0%
Northern_saw-whet_owl	Browse	5100		0%
Northern_saw-whet_owl	Fish	4900	bony fishes	0%
Northern_saw-whet_owl	Invert	5600		0%
Northern_saw-whet_owl	Prey	5000		100%
Ruffed_grouse	Browse	3950	Average of browse diet	95%
Ruffed_grouse	Fish	4900	bony fishes	0%
Ruffed_grouse	Invert	5600		5%
Ruffed_grouse	Prey	5000		0%
Snowshoe_hare	Browse	4200		100%
Snowshoe_hare	Fish	4900	bony fishes	0%
Snowshoe_hare	Invert	5600		0%
Snowshoe_hare	Prey	5000		0%
White-tailed_deer	Browse	4363	Average of browse diet	100%
White-tailed_deer	Fish	4900	bony fishes	0%
White-tailed_deer	Invert	5600		0%
White-tailed_deer	Prey	5000		0%

A) US EPA 1993; Tables 4-1 & 4-2

Table 14. Assimilation Efficiency (AE) of Dietary Items [Percent% Efficiency] [A]

Receptor	Dietary Item	Value	Reference/Comments
Dark-eyed_junco	Browse	75%	
Dark-eyed_junco	Fish	79%	
Dark-eyed_junco	Invert	72%	
Dark-eyed_junco	Prey	78%	
Ermine	Browse	46%	
Ermine	Fish	79%	
Ermine	Invert	87%	
Ermine	Prey	84%	
Masked_shrew	Browse	46%	
Masked_shrew	Fish	79%	
Masked_shrew	Invert	87%	
Masked_shrew	Prey	84%	
Northern_saw-whet_owl	Browse	75%	
Northern_saw-whet_owl	Fish	79%	
Northern_saw-whet_owl	Invert	72%	
Northern_saw-whet_owl	Prey	78%	
Ruffed_grouse	Browse	48%	Average of browse diet
Ruffed_grouse	Fish	79%	
Ruffed_grouse	Invert	72%	
Ruffed_grouse	Prey	78%	
Snowshoe_hare	Browse	73%	
Snowshoe_hare	Fish	79%	
Snowshoe_hare	Invert	87%	
Snowshoe_hare	Prey	84%	
White-tailed_deer	Browse	46%	
White-tailed_deer	Fish	79%	
White-tailed_deer	Invert	87%	
White-tailed_deer	Prey	84%	

A) US EPA 1993; Table 4-3

Table 15. BioAccessibility [%]

Media	Chemical	Abbreviation	Value
Soil	Antimony	Soil_Antimony	100%
Soil	Arsenic	Soil_Arsenic	100%
Soil	Lead	Soil_Lead	100%
Soil	Zinc	Soil_Zinc	100%

Table 16. Literature and Site-specific Derived Regression Models and Bio-Concentration Factors [Dry Weight Basis]

		Regression Variables		BCF		
		Constant	Coeff#1			
Media	Chemical	Average	Average	Value	Model	Reference
Browse	Antimony	-3.23E+00	9.38E-01		Ln_Normal	U.S. EPA 2005
Browse	Arsenic	-1.99E+00	5.64E-01		Ln_Normal	BJC 1998
Browse	Lead	-1.33E+00	5.61E-01		Ln_Normal	BJC 1998
Browse	Zinc	1.58E+00	5.55E-01		Ln_Normal	BJC 1998
Berries	Antimony			3.19E-02	BCF	U.S. EPA 2005
Berries	Arsenic			6.33E-03	BCF	U.S. EPA 2005
Berries	Lead			1.36E-02	BCF	U.S. EPA 2005
Berries	Zinc			9.70E-02	BCF	U.S. EPA 2005
Invert	Antimony			1.00E+00	BCF	U.S. EPA 2005
Invert	Arsenic	-1.42E+00	7.06E-01		Ln_Normal	Sample et al. 1998b
Invert	Lead	-2.18E-01	8.07E-01		Ln_Normal	Sample et al. 1998b
Invert	Zinc	4.45E+00	3.28E-01		Ln_Normal	Sample et al. 1998b
Prey	Antimony			5.00E-02	[Diet]*BCF	US EPA 2005
Prey	Arsenic	-4.85E+00	8.19E-01		Ln_Normal	Sample et al. 1998a
Prey	Lead	7.61E-02	4.42E-01		Ln_Normal	Sample et al. 1998a
Prey	Zinc	4.47E+00	7.38E-02		Ln_Normal	Sample et al. 1998a

Table 17. Measured and Predicted Exposure Point Concentrations for the Ecological Risk Assessment

Scenario	Site	Chemical	Media	Abbreviation	Value	Units	Reference/Comment
90th Percentile	0-3km	Antimony	Air	90th Percentile_0-3km_Antimony_Air	1.45E-03	µg/m³	Based on Bouley + Chalmers 2007-2009 (n=357) Hivol TSP metals data; data provided by Xstrata Zinc; to ensure an appropriate comparison to TNBR scenario, TSP COPC concentrations were divided by a factor of 2.7 (obtained from ratios of geomean TSP and PM2.5 metals concentrations for near-smelter monitoring stations in Sudbury, ON).
90th Percentile	0-3km	Arsenic	Air	90th Percentile_0-3km_Arsenic_Air	1.11E-02	µg/m³	Based on Bouley + Chalmers 2007-2009 (n=357) divided by 2.7
90th Percentile	0-3km	Lead	Air	90th Percentile_0-3km_Lead_Air	1.61E-01	µg/m³	Based on Bouley + Chalmers 2007-2009 (n=357) divided by 2.7
90th Percentile	0-3km	Zinc	Air	90th Percentile_0-3km_Zinc_Air	6.46E-02	µg/m³	Based on Bouley + Chalmers 2007-2009 (n=357) divided by 2.7
95th Percentile	0-3km	Antimony	Air	95th Percentile_0-3km_Antimony_Air	2.33E-03	µg/m³	Based on Bouley + Chalmers 2007-2009 (n=357) divided by 2.7
95th Percentile	0-3km	Arsenic	Air	95th Percentile_0-3km_Arsenic_Air	1.65E-02	µg/m³	Based on Bouley + Chalmers 2007-2009 (n=357) divided by 2.7
95th Percentile	0-3km	Lead	Air	95th Percentile_0-3km_Lead_Air	2.59E-01	µg/m³	Based on Bouley + Chalmers 2007-2009 (n=357) divided by 2.7
95th Percentile	0-3km	Zinc	Air	95th Percentile_0-3km_Zinc_Air	9.30E-02	µg/m³	Based on Bouley + Chalmers 2007-2009 (n=357) divided by 2.7
95UCLM	0-3km	Antimony	Air	95UCLM_0-3km_Antimony_Air	7.22E-04	µg/m³	Based on Bouley + Chalmers 2007-2009 (n=357) divided by 2.7
95UCLM	0-3km	Arsenic	Air	95UCLM_0-3km_Arsenic_Air	7.65E-03	µg/m³	Based on Bouley + Chalmers 2007-2009 (n=357) divided by 2.7
95UCLM	0-3km	Lead	Air	95UCLM_0-3km_Lead_Air	8.03E-02	µg/m³	Based on Bouley + Chalmers 2007-2009 (n=357) divided by 2.7
95UCLM	0-3km	Zinc	Air	95UCLM_0-3km_Zinc_Air	3.54E-02	µg/m³	Based on Bouley + Chalmers 2007-2009 (n=357) divided by 2.7
90th Percentile	Reference	Antimony	Air	90th Percentile_Reference_Antimony_Air	3.74E-04	µg/m³	Average of 90th percentile data for rural air stations - 2005 to 2010 - data provided by Tom Dann
90th Percentile	Reference	Arsenic	Air	90th Percentile_Reference_Arsenic_Air	5.86E-04	µg/m³	Average of 90th percentile data for rural air stations - 2005 to 2010 - data provided by Tom Dann
90th Percentile	Reference	Lead	Air	90th Percentile_Reference_Lead_Air	2.68E-03	µg/m³	Average of 90th percentile data for rural air stations - 2005 to 2010 - data provided by Tom Dann
90th Percentile	Reference	Zinc	Air	90th Percentile_Reference_Zinc_Air	1.92E-02	µg/m³	Average of 90th percentile data for rural air stations - 2005 to 2010 - data provided by Tom Dann
95th Percentile	Reference	Antimony	Air	95th Percentile_Reference_Antimony_Air	4.83E-04	µg/m³	Average of 95th percentile data for rural air stations - 2005 to 2010 - data provided by Tom Dann
95th Percentile	Reference	Arsenic	Air	95th Percentile_Reference_Arsenic_Air	7.00E-04	µg/m³	Average of 95th percentile data for rural air stations - 2005 to 2010 - data provided by Tom Dann
95th Percentile	Reference	Lead	Air	95th Percentile_Reference_Lead_Air	3.36E-03	µg/m³	Average of 95th percentile data for rural air stations - 2005 to 2010 - data provided by Tom Dann
95th Percentile	Reference	Zinc	Air	95th Percentile_Reference_Zinc_Air	2.48E-02	µg/m³	Average of 95th percentile data for rural air stations - 2005 to 2010 - data provided by Tom Dann
95UCLM	Reference	Antimony	Air	95UCLM_Reference_Antimony_Air	3.74E-04	µg/m³	Could not calculate a UCLM - therefore used the average of 90th percentile data for rural air stations - 2005 to 2010 - data provided by Tom Dann
95UCLM	Reference	Arsenic	Air	95UCLM_Reference_Arsenic_Air	5.86E-04	µg/m³	Could not calculate a UCLM - therefore used the average of 90th percentile data for rural air stations - 2005 to 2010 - data provided by Tom Dann
95UCLM	Reference	Lead	Air	95UCLM_Reference_Lead_Air	2.68E-03	µg/m³	Could not calculate a UCLM - therefore used the average of 90th percentile data for rural air stations - 2005 to 2010 - data provided by Tom Dann
95UCLM	Reference	Zinc	Air	95UCLM_Reference_Zinc_Air	1.92E-02	µg/m³	Could not calculate a UCLM - therefore used the average of 90th percentile data for rural air stations - 2005 to 2010 - data provided by Tom Dann
90th Percentile	0-3km	Antimony	Soil	90th Percentile_0-3km_Antimony_Soil	5.70E+00	mg/kg	
90th Percentile	0-3km	Arsenic	Soil	90th Percentile_0-3km_Arsenic_Soil	4.41E+01	mg/kg	
90th Percentile	0-3km	Lead	Soil	90th Percentile_0-3km_Lead_Soil	4.23E+02	mg/kg	
90th Percentile	0-3km	Zinc	Soil	90th Percentile_0-3km_Zinc_Soil	3.88E+02	mg/kg	
95th Percentile	0-3km	Antimony	Soil	95th Percentile_0-3km_Antimony_Soil	8.80E+00	mg/kg	
95th Percentile	0-3km	Arsenic	Soil	95th Percentile_0-3km_Arsenic_Soil	4.68E+01	mg/kg	
95th Percentile	0-3km	Lead	Soil	95th Percentile_0-3km_Lead_Soil	5.52E+02	mg/kg	
95th Percentile	0-3km	Zinc	Soil	95th Percentile_0-3km_Zinc_Soil	8.90E+02	mg/kg	
95UCLM	0-3km	Antimony	Soil	95UCLM_0-3km_Antimony_Soil	8.80E+00	mg/kg	not calculated (few sampled detected – DL = <2); used 95th percentile
95UCLM	0-3km	Arsenic	Soil	95UCLM_0-3km_Arsenic_Soil	2.95E+01	mg/kg	
95UCLM	0-3km	Lead	Soil	95UCLM_0-3km_Lead_Soil	3.36E+02	mg/kg	
95UCLM	0-3km	Zinc	Soil	95UCLM_0-3km_Zinc_Soil	5.08E+02	mg/kg	
90th Percentile	Reference	Antimony	Soil	90th Percentile_Reference_Antimony_Soil	2.00E+00	mg/kg	Using the detection limit

Table 17. Measured and Predicted Exposure Point Concentrations for the Ecological Risk Assessment

Scenario	Site	Chemical	Media	Abbreviation	Value	Units	Reference/Comment
90th Percentile	Reference	Arsenic	Soil	90th Percentile_Reference_Arsenic_Soil	5.00E+00	mg/kg	Belledune Off-Site ERA Reference Data (n=23)
90th Percentile	Reference	Lead	Soil	90th Percentile_Reference_Lead_Soil	6.76E+01	mg/kg	Belledune Off-Site ERA Reference Data (n=23)
90th Percentile	Reference	Zinc	Soil	90th Percentile_Reference_Zinc_Soil	7.16E+01	mg/kg	Belledune Off-Site ERA Reference Data (n=23)
95th Percentile	Reference	Antimony	Soil	95th Percentile_Reference_Antimony_Soil	2.00E+00	mg/kg	Using the detection limit
95th Percentile	Reference	Arsenic	Soil	95th Percentile_Reference_Arsenic_Soil	9.80E+00	mg/kg	Belledune Off-Site ERA Reference Data (n=23)
95th Percentile	Reference	Lead	Soil	95th Percentile_Reference_Lead_Soil	7.34E+01	mg/kg	Belledune Off-Site ERA Reference Data (n=23)
95th Percentile	Reference	Zinc	Soil	95th Percentile_Reference_Zinc_Soil	1.00E+02	mg/kg	Belledune Off-Site ERA Reference Data (n=23)
95UCLM	Reference	Antimony	Soil	95UCLM_Reference_Antimony_Soil	2.00E+00	mg/kg	Using the detection limit
95UCLM	Reference	Arsenic	Soil	95UCLM_Reference_Arsenic_Soil	4.90E+00	mg/kg	Belledune Off-Site ERA Reference Data (n=23)
95UCLM	Reference	Lead	Soil	95UCLM_Reference_Lead_Soil	4.43E+01	mg/kg	Belledune Off-Site ERA Reference Data (n=23)
95UCLM	Reference	Zinc	Soil	95UCLM_Reference_Zinc_Soil	7.10E+01	mg/kg	Belledune Off-Site ERA Reference Data (n=23)
90th Percentile	0-3km	Antimony	Fish	90th Percentile_0-3km_Antimony_Fish	5.00E-01	mg/kg	Used detection limit
90th Percentile	0-3km	Arsenic	Fish	90th Percentile_0-3km_Arsenic_Fish	2.00E+00	mg/kg	Used detection limit
90th Percentile	0-3km	Lead	Fish	90th Percentile_0-3km_Lead_Fish	5.00E-01	mg/kg	Used detection limit
90th Percentile	0-3km	Zinc	Fish	90th Percentile_0-3km_Zinc_Fish	5.00E+00	mg/kg	Used detection limit
95th Percentile	0-3km	Antimony	Fish	95th Percentile_0-3km_Antimony_Fish	5.00E-01	mg/kg	Used detection limit
95th Percentile	0-3km	Arsenic	Fish	95th Percentile_0-3km_Arsenic_Fish	2.00E+00	mg/kg	Used detection limit
95th Percentile	0-3km	Lead	Fish	95th Percentile_0-3km_Lead_Fish	5.00E-01	mg/kg	Used detection limit
95th Percentile	0-3km	Zinc	Fish	95th Percentile_0-3km_Zinc_Fish	5.00E+00	mg/kg	Used detection limit
95UCLM	0-3km	Antimony	Fish	95UCLM_0-3km_Antimony_Fish	5.00E-01	mg/kg	Used detection limit
95UCLM	0-3km	Arsenic	Fish	95UCLM_0-3km_Arsenic_Fish	2.00E+00	mg/kg	Used detection limit
95UCLM	0-3km	Lead	Fish	95UCLM_0-3km_Lead_Fish	5.00E-01	mg/kg	Used detection limit
95UCLM	0-3km	Zinc	Fish	95UCLM_0-3km_Zinc_Fish	5.00E+00	mg/kg	Used detection limit
90th Percentile	Reference	Antimony	Fish	90th Percentile_Reference_Antimony_Fish		mg/kg	
90th Percentile	Reference	Arsenic	Fish	90th Percentile_Reference_Arsenic_Fish		mg/kg	
90th Percentile	Reference	Lead	Fish	90th Percentile_Reference_Lead_Fish		mg/kg	
90th Percentile	Reference	Zinc	Fish	90th Percentile_Reference_Zinc_Fish		mg/kg	
95th Percentile	Reference	Antimony	Fish	95th Percentile_Reference_Antimony_Fish		mg/kg	
95th Percentile	Reference	Arsenic	Fish	95th Percentile_Reference_Arsenic_Fish		mg/kg	
95th Percentile	Reference	Lead	Fish	95th Percentile_Reference_Lead_Fish		mg/kg	
95th Percentile	Reference	Zinc	Fish	95th Percentile_Reference_Zinc_Fish		mg/kg	
95UCLM	Reference	Antimony	Fish	95UCLM_Reference_Antimony_Fish		mg/kg	
95UCLM	Reference	Arsenic	Fish	95UCLM_Reference_Arsenic_Fish		mg/kg	
95UCLM	Reference	Lead	Fish	95UCLM_Reference_Lead_Fish		mg/kg	
95UCLM	Reference	Zinc	Fish	95UCLM_Reference_Zinc_Fish		mg/kg	
90th Percentile	0-3km	Antimony	Water	90th Percentile_0-3km_Antimony_Water	1.00E-03	mg/L	Not detected in all 9 samples - used detection limit
90th Percentile	0-3km	Arsenic	Water	90th Percentile_0-3km_Arsenic_Water	1.56E-03	mg/L	90th percentile of freshwater data from Belledune
90th Percentile	0-3km	Lead	Water	90th Percentile_0-3km_Lead_Water	2.17E-03	mg/L	90th percentile of freshwater data from Belledune
90th Percentile	0-3km	Zinc	Water	90th Percentile_0-3km_Zinc_Water	1.52E-02	mg/L	90th percentile of freshwater data from Belledune
95th Percentile	0-3km	Antimony	Water	95th Percentile_0-3km_Antimony_Water	1.00E-03	mg/L	Not detected in all 9 samples - used detection limit
95th Percentile	0-3km	Arsenic	Water	95th Percentile_0-3km_Arsenic_Water	1.68E-03	mg/L	95th percentile of freshwater data from Belledune
95th Percentile	0-3km	Lead	Water	95th Percentile_0-3km_Lead_Water	3.42E-03	mg/L	95th percentile of freshwater data from Belledune
95th Percentile	0-3km	Zinc	Water	95th Percentile_0-3km_Zinc_Water	2.45E-02	mg/L	95th percentile of freshwater data from Belledune
95UCLM	0-3km	Antimony	Water	95UCLM_0-3km_Antimony_Water	1.00E-03	mg/L	Not detected in all 9 samples - used detection limit
95UCLM	0-3km	Arsenic	Water	95UCLM_0-3km_Arsenic_Water	1.38E-03	mg/L	UCLM95 of freshwater data from Belledune
95UCLM	0-3km	Lead	Water	95UCLM_0-3km_Lead_Water	2.28E-03	mg/L	UCLM95 of freshwater data from Belledune
95UCLM	0-3km	Zinc	Water	95UCLM_0-3km_Zinc_Water	2.31E-02	mg/L	UCLM95 of freshwater data from Belledune
90th Percentile	Reference	Antimony	Water	90th Percentile_Reference_Antimony_Water	1.00E-03	mg/L	detection limit (lowest used - 0.001, 0.002 and 0.020 were RDLs reported) - freshwater pooled dataset - pooled data set (n=62)
90th Percentile	Reference	Arsenic	Water	90th Percentile_Reference_Arsenic_Water	3.80E-03	mg/L	freshwater data from pooled dataset (N=62)
90th Percentile	Reference	Lead	Water	90th Percentile_Reference_Lead_Water	1.63E-03	mg/L	freshwater data from pooled dataset (N=62)
90th Percentile	Reference	Zinc	Water	90th Percentile_Reference_Zinc_Water	3.32E-02	mg/L	freshwater data from pooled dataset (N=62)

Table 17. Measured and Predicted Exposure Point Concentrations for the Ecological Risk Assessment

Scenario	Site	Chemical	Media	Abbreviation	Value	Units	Reference/Comment
95th Percentile	Reference	Antimony	Water	95th Percentile_Reference_Antimony_Water	1.00E-03	mg/L	detection limit (lowest used - 0.001, 0.002 and 0.020 were RDLs reported) - freshwater pooled dataset - pooled data set (n=62)
95th Percentile	Reference	Arsenic	Water	95th Percentile_Reference_Arsenic_Water	4.80E-03	mg/L	freshwater data from pooled dataset (N=62)
95th Percentile	Reference	Lead	Water	95th Percentile_Reference_Lead_Water	2.83E-03	mg/L	freshwater data from pooled dataset (N=62)
95th Percentile	Reference	Zinc	Water	95th Percentile_Reference_Zinc_Water	4.12E-02	mg/L	freshwater data from pooled dataset (N=62)
95UCLM	Reference	Antimony	Water	95UCLM_Reference_Antimony_Water	1.00E-03	mg/L	detection limit (lowest used - 0.001, 0.002 and 0.020 were RDLs reported) - freshwater pooled dataset - pooled data set (n=62)
95UCLM	Reference	Arsenic	Water	95UCLM_Reference_Arsenic_Water	2.58E-03	mg/L	freshwater data from pooled dataset (N=62)
95UCLM	Reference	Lead	Water	95UCLM_Reference_Lead_Water	1.65E-03	mg/L	freshwater data from pooled dataset (N=62)
95UCLM	Reference	Zinc	Water	95UCLM_Reference_Zinc_Water	2.41E-02	mg/L	freshwater data from pooled dataset (N=62)

References

Baes et al. 1984	Baes, C.F. (III), Sharp, R., Sjoreen, A., and Shor, R. 1984. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radio-Nuclides Through Agriculture. Department of Energy, US (DOE), Washington, DC.
Sample et al.1998a	Development and Validation of Bioaccumulation Models for Small Mammals. Prepared for the U.S. Department of Energy, Office of Environmental Management. February 1998. ES/ER/TM-219
Sample et al.1998b	Development and Validation of Bioaccumulation Models for Earthworms. Prepared for the U.S. Department of Energy, Office of Environmental Management. February 1998. ES/ER/TM-220
BJC 1998	Bechtel Jacobs Company. Empirical Models for the Uptake of Inorganic Chemicals from Soil by Plants. Prepared for the U.S. Department of Energy. September 1998.
U.S. EPA 1999	USEPA OSW. 1999. Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities, Volume I Peer Review Draft. (US) United States Environmental Protection Agency Region 6. Multimedia Planning and Permitting Division. Center for Combustion Science and Engineering. Office of Solid Waste
U.S. EPA 2005	Ecological Soil Screening Levels (Eco-SSL). Guidance Documents and SOPs. Ecological Soil Screening levels for Antimony. Interim Final. February 2005.
USEPA. 1993b.	Wildlife Exposure Factors Handbook. Volumes I and II. Office of Research and Development. ORD. EPA-600-R-93-187. December 1993.

Table 1 Portion of Exposure Derived from Exposure Areas

Receptor	0-3km	Total
Dark-eyed_junco	100%	100%
Masked_shrew	100%	100%
Northern_saw-whet_owl	100%	100%
Ermine	100%	100%
Ruffed_grouse	100%	100%
Snowshoe_hare	100%	100%
White-tailed_deer	100%	100%

Table 2. Summary of Hazard Quotient Values Based on NOAEL 0 to 3 km CADMIUM AND THALLIUM ONLY

		95UCLM			90th Percentile			95th Percentile		
Receptor	Chemical	0-3km	Total	Reference	0-3km	Total	Reference	0-3km	Total	Reference
Dark-eyed_junco	Cadmium	3.3E+00	3.3E+00	1.2E+00	4.4E+00	4.4E+00	1.2E+00	5.0E+00	5.0E+00	1.3E+00
Dark-eyed_junco	Thallium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Ermine	Cadmium	1.6E-01	1.6E-01	8.2E-02	2.0E-01	2.0E-01	8.1E-02	2.2E-01	2.2E-01	8.3E-02
Ermine	Thallium	3.0E+00	3.0E+00	3.3E-01	3.7E+00	3.7E+00	2.9E-01	7.0E+00	7.0E+00	2.9E-01
Masked_shrew	Cadmium	7.6E+00	7.6E+00	2.8E+00	1.0E+01	1.0E+01	2.8E+00	1.2E+01	1.2E+01	2.9E+00
Masked_shrew	Thallium	8.0E+00	8.0E+00	1.1E+00	8.7E+00	8.7E+00	9.4E-01	1.7E+01	1.7E+01	9.4E-01
Northern_saw-whet_owl	Cadmium	2.0E-01	2.0E-01	1.0E-01	2.4E-01	2.4E-01	9.9E-02	2.7E-01	2.7E-01	1.0E-01
Northern_saw-whet_owl	Thallium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Ruffed_grouse	Cadmium	1.6E-01	1.6E-01	6.7E-02	2.1E-01	2.1E-01	6.6E-02	2.5E-01	2.5E-01	6.9E-02
Ruffed_grouse	Thallium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Snowshoe_hare	Cadmium	1.3E-01	1.3E-01	5.8E-02	1.7E-01	1.7E-01	5.7E-02	2.0E-01	2.0E-01	6.0E-02
Snowshoe_hare	Thallium	1.2E+00	1.2E+00	9.0E-02	1.7E+00	1.7E+00	8.1E-02	3.1E+00	3.1E+00	8.1E-02
White-tailed_deer	Cadmium	8.1E-02	8.1E-02	3.6E-02	1.0E-01	1.0E-01	3.6E-02	1.2E-01	1.2E-01	3.7E-02
White-tailed_deer	Thallium	5.5E-01	5.5E-01	2.8E-02	8.6E-01	8.6E-01	2.6E-02	1.5E+00	1.5E+00	2.6E-02

Notes:

HQ > 1

HQ > 10

Value of zero indicates that exposure not estimated due to missing information or TRV unavailable

Table 3. Summary of Hazard Quotient Values Based on LOAEL 0 to 3 km CADMIUM AND THALLIUM ONLY

		95UCLM			90th Percentile			95th Percentile		
Receptor	Chemical	0-3km	Total	Reference	0-3km	Total	Reference	0-3km	Total	Reference
Dark-eyed_junco	Cadmium	2.0E+00	2.0E+00	7.6E-01	2.7E+00	2.7E+00	7.5E-01	3.1E+00	3.1E+00	7.9E-01
Dark-eyed_junco	Thallium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Ermine	Cadmium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Ermine	Thallium	6.0E-01	6.0E-01	6.6E-02	7.3E-01	7.3E-01	5.9E-02	1.4E+00	1.4E+00	5.9E-02
Masked_shrew	Cadmium	2.6E+00	2.6E+00	9.6E-01	3.4E+00	3.4E+00	9.4E-01	3.9E+00	3.9E+00	9.9E-01
Masked_shrew	Thallium	1.6E+00	1.6E+00	2.1E-01	1.7E+00	1.7E+00	1.9E-01	3.5E+00	3.5E+00	1.9E-01
Northern_saw-whet_owl	Cadmium	1.2E-01	1.2E-01	6.2E-02	1.5E-01	1.5E-01	6.1E-02	1.7E-01	1.7E-01	6.3E-02
Northern_saw-whet_owl	Thallium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Ruffed_grouse	Cadmium	1.0E-01	1.0E-01	4.1E-02	1.3E-01	1.3E-01	4.1E-02	1.5E-01	1.5E-01	4.3E-02
Ruffed_grouse	Thallium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Snowshoe_hare	Cadmium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Snowshoe_hare	Thallium	2.4E-01	2.4E-01	1.8E-02	3.4E-01	3.4E-01	1.6E-02	6.1E-01	6.1E-01	1.6E-02
White-tailed_deer	Cadmium	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
White-tailed_deer	Thallium	1.1E-01	1.1E-01	5.7E-03	1.7E-01	1.7E-01	5.2E-03	3.1E-01	3.1E-01	5.2E-03

Notes:

HQ > 1

HQ > 10

Value of zero indicates that exposure not estimated due to missing information or TRV unavailable

Table 4. Summary of Exposures [mg/kg/day]

Receptor	Chemical	95UCLM 0-3km	95UCLM Reference	90th Percentile 0-3km	90th Percentile Reference	95th Percentile 0-3km	95th Percentile Reference
Dark-eyed_junco	Cadmium	4.8E+00	1.8E+00	6.5E+00	1.8E+00	7.4E+00	1.9E+00
Dark-eyed_junco	Thallium	1.6E-01	1.9E-02	1.8E-01	1.7E-02	3.6E-01	1.7E-02
Ermine	Cadmium	1.2E-01	6.3E-02	1.5E-01	6.2E-02	1.7E-01	6.4E-02
Ermine	Thallium	4.5E-02	5.0E-03	5.5E-02	4.4E-03	1.0E-01	4.4E-03
Masked_shrew	Cadmium	5.8E+00	2.2E+00	7.9E+00	2.1E+00	9.0E+00	2.3E+00
Masked_shrew	Thallium	1.2E-01	1.6E-02	1.3E-01	1.4E-02	2.6E-01	1.4E-02
Northern_saw-whet_owl	Cadmium	2.9E-01	1.5E-01	3.6E-01	1.4E-01	4.0E-01	1.5E-01
Northern_saw-whet_owl	Thallium	1.0E-01	1.2E-02	1.3E-01	1.0E-02	2.4E-01	1.0E-02
Ruffed_grouse	Cadmium	2.4E-01	9.8E-02	3.1E-01	9.6E-02	3.6E-01	1.0E-01
Ruffed_grouse	Thallium	3.5E-02	3.1E-03	4.7E-02	2.8E-03	8.7E-02	2.8E-03
Snowshoe_hare	Cadmium	1.0E-01	4.4E-02	1.3E-01	4.4E-02	1.6E-01	4.6E-02
Snowshoe_hare	Thallium	1.8E-02	1.4E-03	2.5E-02	1.2E-03	4.6E-02	1.2E-03
White-tailed_deer	Cadmium	6.2E-02	2.8E-02	7.8E-02	2.8E-02	9.2E-02	2.9E-02
White-tailed_deer	Thallium	8.2E-03	4.3E-04	1.3E-02	3.9E-04	2.3E-02	3.9E-04

Table 5. Predicted Exposure & Hazard Quotient Values

Scenario	Site	Chemical	Receptor	Soil mg/day	Water mg/day	Inhalation mg/day	Browse mg/day	Invert mg/day	Prey mg/day	Fish mg/day	Total mg/day	Total (BA Adjusted) mg/day	Dose mg/kg/day	HQ(NOAEL) Unitless
90th Percentile	0-3km	Cadmium	Dark-eyed_junco	3.31E-03	2.73E-07	8.28E-05	4.15E-03	1.14E-01	0.00E+00	0.00E+00	1.22E-01	1.22E-01	6.47E+00	4.3987631
90th Percentile	0-3km	Thallium	Dark-eyed_junco	1.16E-03	4.12E-07	6.27E-05	5.95E-04	1.61E-03	0.00E+00	0.00E+00	3.43E-03	3.43E-03	1.83E-01	#VALUE!
90th Percentile	Reference	Cadmium	Dark-eyed_junco	6.45E-04	2.06E-07	1.04E-05	1.52E-03	3.11E-02	0.00E+00	0.00E+00	3.32E-02	3.32E-02	1.77E+00	1.20261793
90th Percentile	Reference	Thallium	Dark-eyed_junco	1.29E-04	4.12E-07	2.01E-06	8.94E-06	1.79E-04	0.00E+00	0.00E+00	3.20E-04	3.20E-04	1.70E-02	#VALUE!
95th Percentile	0-3km	Cadmium	Dark-eyed_junco	3.91E-03	3.32E-07	1.22E-04	4.86E-03	1.30E-01	0.00E+00	0.00E+00	1.39E-01	1.39E-01	7.40E+00	5.03394656
95th Percentile	0-3km	Thallium	Dark-eyed_junco	2.32E-03	4.12E-07	1.11E-04	1.03E-03	3.23E-03	0.00E+00	0.00E+00	6.69E-03	6.69E-03	3.56E-01	#VALUE!
95th Percentile	Reference	Cadmium	Dark-eyed_junco	6.88E-04	2.63E-07	1.23E-05	1.59E-03	3.27E-02	0.00E+00	0.00E+00	3.50E-02	3.50E-02	1.86E+00	1.265898
95th Percentile	Reference	Thallium	Dark-eyed_junco	1.29E-04	6.15E-07	2.01E-06	8.94E-06	1.79E-04	0.00E+00	0.00E+00	3.20E-04	3.20E-04	1.70E-02	#VALUE!
95UCLM	0-3km	Cadmium	Dark-eyed_junco	2.27E-03	2.51E-07	5.92E-05	3.34E-03	8.46E-02	0.00E+00	0.00E+00	9.03E-02	9.03E-02	4.80E+00	3.27E+00
95UCLM	0-3km	Thallium	Dark-eyed_junco	1.08E-03	4.12E-07	4.03E-05	3.46E-04	1.51E-03	0.00E+00	0.00E+00	2.98E-03	2.98E-03	1.58E-01	#VALUE!
95UCLM	Reference	Cadmium	Dark-eyed_junco	6.62E-04	6.21E-07	1.06E-05	1.54E-03	3.17E-02	0.00E+00	0.00E+00	3.39E-02	3.39E-02	1.80E+00	1.23E+00
95UCLM	Reference	Thallium	Dark-eyed_junco	1.46E-04	6.15E-07	2.21E-06	9.25E-06	2.03E-04	0.00E+00	0.00E+00	3.62E-04	3.62E-04	1.92E-02	#VALUE!
90th Percentile	0-3km	Cadmium	Ermine	9.55E-04	3.86E-07	1.90E-04	0.00E+00	0.00E+00	5.44E-03	0.00E+00	6.59E-03	6.59E-03	1.53E-01	1.99E-01
90th Percentile	0-3km	Thallium	Ermine	3.35E-04	5.83E-07	1.44E-04	0.00E+00	0.00E+00	1.88E-03	0.00E+00	2.36E-03	2.36E-03	5.48E-02	3.65E+00
90th Percentile	Reference	Cadmium	Ermine	1.86E-04	2.92E-07	2.40E-05	0.00E+00	0.00E+00	2.46E-03	0.00E+00	2.67E-03	2.67E-03	6.20E-02	8.05E-02
90th Percentile	Reference	Thallium	Ermine	3.72E-05	5.83E-07	4.62E-06	0.00E+00	0.00E+00	1.47E-04	0.00E+00	1.89E-04	1.89E-04	4.40E-03	2.93E-01
95th Percentile	0-3km	Cadmium	Ermine	1.13E-03	4.70E-07	2.80E-04	0.00E+00	0.00E+00	5.90E-03	0.00E+00	7.31E-03	7.31E-03	1.70E-01	2.21E-01
95th Percentile	0-3km	Thallium	Ermine	6.70E-04	5.83E-07	2.55E-04	0.00E+00	0.00E+00	3.58E-03	0.00E+00	4.50E-03	4.50E-03	1.05E-01	6.98E+00
95th Percentile	Reference	Cadmium	Ermine	1.98E-04	3.73E-07	2.82E-05	0.00E+00	0.00E+00	2.53E-03	0.00E+00	2.76E-03	2.76E-03	6.42E-02	8.34E-02
95th Percentile	Reference	Thallium	Ermine	3.72E-05	8.72E-07	4.62E-06	0.00E+00	0.00E+00	1.47E-04	0.00E+00	1.89E-04	1.89E-04	4.40E-03	2.94E-01
95UCLM	0-3km	Cadmium	Ermine	6.56E-04	3.56E-07	1.36E-04	0.00E+00	0.00E+00	4.53E-03	0.00E+00	5.33E-03	5.33E-03	1.24E-01	1.61E-01
95UCLM	0-3km	Thallium	Ermine	3.13E-04	5.83E-07	9.27E-05	0.00E+00	0.00E+00	1.53E-03	0.00E+00	1.93E-03	1.93E-03	4.49E-02	2.99E+00
95UCLM	Reference	Cadmium	Ermine	1.91E-04	8.79E-07	2.44E-05	0.00E+00	0.00E+00	2.49E-03	0.00E+00	2.70E-03	2.70E-03	6.29E-02	8.17E-02
95UCLM	Reference	Thallium	Ermine	4.22E-05	8.72E-07	5.06E-06	0.00E+00	0.00E+00	1.65E-04	0.00E+00	2.13E-04	2.13E-04	4.96E-03	3.31E-01
90th Percentile	0-3km	Cadmium	Masked_shrew	2.15E-04	5.57E-08	3.40E-05	0.00E+00	3.91E-02	0.00E+00	0.00E+00	3.93E-02	3.93E-02	7.86E+00	1.02E+01
90th Percentile	0-3km	Thallium	Masked_shrew	7.54E-05	8.41E-08	2.57E-05	0.00E+00	5.53E-04	0.00E+00	0.00E+00	6.54E-04	6.54E-04	1.31E-01	8.72E+00
90th Percentile	Reference	Cadmium	Masked_shrew	4.19E-05	4.20E-08	4.29E-06	0.00E+00	1.06E-02	0.00E+00	0.00E+00	1.07E-02	1.07E-02	2.14E+00	2.78E+00
90th Percentile	Reference	Thallium	Masked_shrew	8.38E-06	8.41E-08	8.27E-07	0.00E+00	6.14E-05	0.00E+00	0.00E+00	7.07E-05	7.07E-05	1.41E-02	9.43E-01
95th Percentile	0-3km	Cadmium	Masked_shrew	2.54E-04	6.78E-08	5.00E-05	0.00E+00	4.46E-02	0.00E+00	0.00E+00	4.49E-02	4.49E-02	8.98E+00	1.17E+01
95th Percentile	0-3km	Thallium	Masked_shrew	1.51E-04	8.41E-08	4.56E-05	0.00E+00	1.11E-03	0.00E+00	0.00E+00	1.30E-03	1.30E-03	2.61E-01	1.74E+01
95th Percentile	Reference	Cadmium	Masked_shrew	4.47E-05	5.38E-08	5.04E-06	0.00E+00	1.12E-02	0.00E+00	0.00E+00	1.13E-02	1.13E-02	2.25E+00	2.92E+00
95th Percentile	Reference	Thallium	Masked_shrew	8.38E-06	1.26E-07	8.27E-07	0.00E+00	6.14E-05	0.00E+00	0.00E+00	7.08E-05	7.08E-05	1.42E-02	9.44E-01
95UCLM	0-3km	Cadmium	Masked_shrew	1.48E-04	5.13E-08	2.43E-05	0.00E+00	2.90E-02	0.00E+00	0.00E+00	2.92E-02	2.92E-02	5.83E+00	7.57E+00
95UCLM	0-3km	Thallium	Masked_shrew	7.04E-05	8.41E-08	1.66E-05	0.00E+00	5.16E-04	0.00E+00	0.00E+00	6.03E-04	6.03E-04	1.21E-01	8.04E+00
95UCLM	Reference	Cadmium	Masked_shrew	4.30E-05	1.27E-07	4.37E-06	0.00E+00	1.09E-02	0.00E+00	0.00E+00	1.09E-02	1.09E-02	2.18E+00	2.84E+00
95UCLM	Reference	Thallium	Masked_shrew	9.50E-06	1.26E-07	9.06E-07	0.00E+00	6.96E-05	0.00E+00	0.00E+00	8.02E-05	8.02E-05	1.60E-02	1.07E+00
90th Percentile	0-3km	Cadmium	Northern_saw-whet_owl	4.42E-03	6.50E-07	2.25E-04	0.00E+00	0.00E+00	2.01E-02	0.00E+00	2.48E-02	2.48E-02	3.60E-01	2.45E-01
90th Percentile	0-3km	Thallium	Northern_saw-whet_owl	1.55E-03	9.82E-07	1.70E-04	0.00E+00	0.00E+00	6.94E-03	0.00E+00	8.66E-03	8.66E-03	1.26E-01	#VALUE!
90th Percentile	Reference	Cadmium	Northern_saw-whet_owl	8.60E-04	4.91E-07	2.84E-05	0.00E+00	0.00E+00	9.08E-03	0.00E+00	9.97E-03	9.97E-03	1.45E-01	9.86E-02
90th Percentile	Reference	Thallium	Northern_saw-whet_owl	1.72E-04	9.82E-07	5.47E-06	0.00E+00	0.00E+00	5.42E-04	0.00E+00	7.21E-04	7.21E-04	1.05E-02	#VALUE!
95th Percentile	0-3km	Cadmium	Northern_saw-whet_owl	5.22E-03	7.91E-07	3.31E-04	0.00E+00	0.00E+00	2.18E-02	0.00E+00	2.74E-02	2.74E-02	3.98E-01	2.71E-01
95th Percentile	0-3km	Thallium	Northern_saw-whet_owl	3.10E-03	9.82E-07	3.02E-04	0.00E+00	0.00E+00	1.32E-02	0.00E+00	1.66E-02	1.66E-02	2.42E-01	#VALUE!
95th Percentile	Reference	Cadmium	Northern_saw-whet_owl	9.18E-04	6.28E-07	3.33E-05	0.00E+00	0.00E+00	9.37E-03	0.00E+00	1.03E-02	1.03E-02	1.50E-01	1.02E-01
95th Percentile	Reference	Thallium	Northern_saw-whet_owl	1.72E-04	1.47E-06	5.47E-06	0.00E+00	0.00E+00	5.42E-04	0.00E+00	7.21E-04	7.21E-04	1.05E-02	#VALUE!
95UCLM	0-3km	Cadmium	Northern_saw-whet_owl	3.03E-03	5.99E-07	1.61E-04	0.00E+00	0.00E+00	1.68E-02	0.00E+00	2.00E-02	2.00E-02	2.90E-01	1.97E-01
95UCLM	0-3km	Thallium	Northern_saw-whet_owl	1.45E-03	9.82E-07	1.10E-04	0.00E+00	0.00E+00	5.64E-03	0.00E+00	7.20E-03	7.20E-03	1.05E-01	#VALUE!
95UCLM	Reference	Cadmium	Northern_saw-whet_owl	8.83E-04	1.48E-06	2.89E-05	0.00E+00	0.00E+00	9.20E-03	0.00E+00	1.01E-02	1.01E-02	1.47E-01	1.00E-01
95UCLM	Reference	Thallium	Northern_saw-whet_owl	1.95E-04	1.47E-06	5.99E-06	0.00E+00	0.00E+00	6.11E-04	0.00E+00	8.14E-04	8.14E-04	1.18E-02	#VALUE!

Table 5. Predicted Exposure & Hazard Quotient Values

Scenario	Site	Chemical	Receptor	Soil mg/day	Water mg/day	Inhalation mg/day	Browse mg/day	Invert mg/day	Prey mg/day	Fish mg/day	Total mg/day	Total (BA Adjusted) mg/day	Dose mg/kg/day	HQ(NOAEL) Unitless
90th Percentile	0-3km	Cadmium	Ruffed_grouse	3.07E-02	2.60E-06	1.10E-03	9.34E-02	4.44E-02	0.00E+00	0.00E+00	1.70E-01	1.70E-01	3.12E-01	2.12E-01
90th Percentile	0-3km	Thallium	Ruffed_grouse	1.08E-02	3.92E-06	8.36E-04	1.34E-02	6.29E-04	0.00E+00	0.00E+00	2.56E-02	2.56E-02	4.71E-02	#VALUE!
90th Percentile	Reference	Cadmium	Ruffed_grouse	5.98E-03	1.96E-06	1.39E-04	3.42E-02	1.21E-02	0.00E+00	0.00E+00	5.24E-02	5.24E-02	9.63E-02	6.55E-02
90th Percentile	Reference	Thallium	Ruffed_grouse	1.20E-03	3.92E-06	2.69E-05	2.01E-04	6.99E-05	0.00E+00	0.00E+00	1.50E-03	1.50E-03	2.75E-03	#VALUE!
95th Percentile	0-3km	Cadmium	Ruffed_grouse	3.63E-02	3.16E-06	1.62E-03	1.10E-01	5.07E-02	0.00E+00	0.00E+00	1.98E-01	1.98E-01	3.64E-01	2.48E-01
95th Percentile	0-3km	Thallium	Ruffed_grouse	2.15E-02	3.92E-06	1.48E-03	2.31E-02	1.26E-03	0.00E+00	0.00E+00	4.74E-02	4.74E-02	8.71E-02	#VALUE!
95th Percentile	Reference	Cadmium	Ruffed_grouse	6.37E-03	2.51E-06	1.64E-04	3.57E-02	1.27E-02	0.00E+00	0.00E+00	5.50E-02	5.50E-02	1.01E-01	6.88E-02
95th Percentile	Reference	Thallium	Ruffed_grouse	1.20E-03	5.87E-06	2.69E-05	2.01E-04	6.99E-05	0.00E+00	0.00E+00	1.50E-03	1.50E-03	2.76E-03	#VALUE!
95UCLM	0-3km	Cadmium	Ruffed_grouse	2.11E-02	2.39E-06	7.90E-04	7.52E-02	3.30E-02	0.00E+00	0.00E+00	1.30E-01	1.30E-01	2.39E-01	1.63E-01
95UCLM	0-3km	Thallium	Ruffed_grouse	1.00E-02	3.92E-06	5.38E-04	7.79E-03	5.87E-04	0.00E+00	0.00E+00	1.90E-02	1.90E-02	3.49E-02	#VALUE!
95UCLM	Reference	Cadmium	Ruffed_grouse	6.14E-03	5.92E-06	1.42E-04	3.47E-02	1.24E-02	0.00E+00	0.00E+00	5.33E-02	5.33E-02	9.80E-02	6.67E-02
95UCLM	Reference	Thallium	Ruffed_grouse	1.35E-03	5.87E-06	2.94E-05	2.08E-04	7.92E-05	0.00E+00	0.00E+00	1.68E-03	1.68E-03	3.08E-03	#VALUE!
90th Percentile	0-3km	Cadmium	Snowshoe_hare	3.08E-02	8.30E-06	2.91E-03	1.38E-01	0.00E+00	0.00E+00	0.00E+00	1.72E-01	1.72E-01	1.32E-01	1.71E-01
90th Percentile	0-3km	Thallium	Snowshoe_hare	1.08E-02	1.25E-05	2.20E-03	1.98E-02	0.00E+00	0.00E+00	0.00E+00	3.28E-02	3.28E-02	2.52E-02	1.68E+00
90th Percentile	Reference	Cadmium	Snowshoe_hare	6.00E-03	6.27E-06	3.67E-04	5.05E-02	0.00E+00	0.00E+00	0.00E+00	5.69E-02	5.69E-02	4.37E-02	5.68E-02
90th Percentile	Reference	Thallium	Snowshoe_hare	1.20E-03	1.25E-05	7.07E-05	2.97E-04	0.00E+00	0.00E+00	0.00E+00	1.58E-03	1.58E-03	1.22E-03	8.11E-02
95th Percentile	0-3km	Cadmium	Snowshoe_hare	3.64E-02	1.01E-05	4.27E-03	1.62E-01	0.00E+00	0.00E+00	0.00E+00	2.03E-01	2.03E-01	1.56E-01	2.02E-01
95th Percentile	0-3km	Thallium	Snowshoe_hare	2.16E-02	1.25E-05	3.90E-03	3.41E-02	0.00E+00	0.00E+00	0.00E+00	5.97E-02	5.97E-02	4.59E-02	3.06E+00
95th Percentile	Reference	Cadmium	Snowshoe_hare	6.40E-03	8.02E-06	4.31E-04	5.28E-02	0.00E+00	0.00E+00	0.00E+00	5.96E-02	5.96E-02	4.59E-02	5.96E-02
95th Percentile	Reference	Thallium	Snowshoe_hare	1.20E-03	1.87E-05	7.07E-05	2.97E-04	0.00E+00	0.00E+00	0.00E+00	1.59E-03	1.59E-03	1.22E-03	8.14E-02
95UCLM	0-3km	Cadmium	Snowshoe_hare	2.12E-02	7.65E-06	2.08E-03	1.11E-01	0.00E+00	0.00E+00	0.00E+00	1.34E-01	1.34E-01	1.03E-01	1.34E-01
95UCLM	0-3km	Thallium	Snowshoe_hare	1.01E-02	1.25E-05	1.42E-03	1.15E-02	0.00E+00	0.00E+00	0.00E+00	2.30E-02	2.30E-02	1.77E-02	1.18E+00
95UCLM	Reference	Cadmium	Snowshoe_hare	6.16E-03	1.89E-05	3.74E-04	5.12E-02	0.00E+00	0.00E+00	0.00E+00	5.78E-02	5.78E-02	4.44E-02	5.77E-02
95UCLM	Reference	Thallium	Snowshoe_hare	1.36E-03	1.87E-05	7.74E-05	3.08E-04	0.00E+00	0.00E+00	0.00E+00	1.76E-03	1.76E-03	1.36E-03	9.05E-02
90th Percentile	0-3km	Cadmium	White-tailed_deer	2.30E-01	2.02E-04	4.95E-02	3.24E+00	0.00E+00	0.00E+00	0.00E+00	3.52E+00	3.52E+00	7.83E-02	1.02E-01
90th Percentile	0-3km	Thallium	White-tailed_deer	8.06E-02	3.04E-04	3.75E-02	4.65E-01	0.00E+00	0.00E+00	0.00E+00	5.84E-01	5.84E-01	1.30E-02	8.65E-01
90th Percentile	Reference	Cadmium	White-tailed_deer	4.48E-02	1.52E-04	6.25E-03	1.19E+00	0.00E+00	0.00E+00	0.00E+00	1.24E+00	1.24E+00	2.75E-02	3.57E-02
90th Percentile	Reference	Thallium	White-tailed_deer	8.96E-03	3.04E-04	1.20E-03	6.99E-03	0.00E+00	0.00E+00	0.00E+00	1.75E-02	1.75E-02	3.88E-04	2.59E-02
95th Percentile	0-3km	Cadmium	White-tailed_deer	2.72E-01	2.45E-04	7.28E-02	3.80E+00	0.00E+00	0.00E+00	0.00E+00	4.15E+00	4.15E+00	9.22E-02	1.20E-01
95th Percentile	0-3km	Thallium	White-tailed_deer	1.61E-01	3.04E-04	6.65E-02	8.02E-01	0.00E+00	0.00E+00	0.00E+00	1.03E+00	1.03E+00	2.29E-02	1.53E+00
95th Percentile	Reference	Cadmium	White-tailed_deer	4.78E-02	1.95E-04	7.34E-03	1.24E+00	0.00E+00	0.00E+00	0.00E+00	1.30E+00	1.30E+00	2.88E-02	3.74E-02
95th Percentile	Reference	Thallium	White-tailed_deer	8.96E-03	4.55E-04	1.20E-03	6.99E-03	0.00E+00	0.00E+00	0.00E+00	1.76E-02	1.76E-02	3.91E-04	2.61E-02
95UCLM	0-3km	Cadmium	White-tailed_deer	1.58E-01	1.86E-04	3.54E-02	2.61E+00	0.00E+00	0.00E+00	0.00E+00	2.80E+00	2.80E+00	6.23E-02	8.09E-02
95UCLM	0-3km	Thallium	White-tailed_deer	7.52E-02	3.04E-04	2.41E-02	2.70E-01	0.00E+00	0.00E+00	0.00E+00	3.70E-01	3.70E-01	8.23E-03	5.48E-01
95UCLM	Reference	Cadmium	White-tailed_deer	4.60E-02	4.59E-04	6.37E-03	1.20E+00	0.00E+00	0.00E+00	0.00E+00	1.26E+00	1.26E+00	2.79E-02	3.63E-02
95UCLM	Reference	Thallium	White-tailed_deer	1.02E-02	4.55E-04	1.32E-03	7.23E-03	0.00E+00	0.00E+00	0.00E+00	1.92E-02	1.92E-02	4.26E-04	2.84E-02

Table 6. Summary of Predicted Exposure Point Concentration Values

																Percent Air/Soil Contribution	
				Soil	Water	Air	Dust	Predicted Deposition	Browse Deposition	Browse Soil	Browse Total	Berries Soil	Invert Soil	Prey Soil	Fish	Browse Deposition	Browse Soil
Scenario	Site	Chemical	Abbreviation	mg/kg	mg/L	µg/m^3	µg/m^3	mg/m^2/year	mg/kg-dw	mg/kg-dw	mg/kg-dw	mg/kg-dw	mg/kg-dw	mg/kg-dw	mg/kg-dw	%	%
90th Percentile	0-3km	Cadmium	90th Percentile_0-3km_Cadmium	7.70E+00	6.62E-05	2.39E-03	1.92E-03	2.73E+00	2.78E-01	1.89E+00	2.17E+00	9.62E-01	4.20E+01	1.75E+00	3.00E-01	13%	87%
90th Percentile	0-3km	Thallium	90th Percentile_0-3km_Thallium	2.70E+00	1.00E-04	2.59E-03	6.75E-04	2.96E+00	3.01E-01	1.08E-02	3.12E-01	2.32E-03	5.94E-01	6.05E-01	1.00E-01	97%	3%
90th Percentile	Reference	Cadmium	90th Percentile_Reference_Cadmium	1.50E+00	5.00E-05	1.70E-04	3.75E-04	1.94E-01	1.97E-02	7.75E-01	7.95E-01	1.88E-01	1.14E+01	7.92E-01	0.00E+00	2%	98%
90th Percentile	Reference	Thallium	90th Percentile_Reference_Thallium	3.00E-01	1.00E-04	3.00E-05	7.50E-05	3.42E-02	3.48E-03	1.20E-03	4.68E-03	2.57E-04	6.60E-02	4.73E-02	0.00E+00	74%	26%
95th Percentile	0-3km	Cadmium	95th Percentile_0-3km_Cadmium	9.10E+00	8.06E-05	4.07E-03	2.28E-03	4.64E+00	4.73E-01	2.07E+00	2.55E+00	1.14E+00	4.79E+01	1.90E+00	3.00E-01	19%	81%
95th Percentile	0-3km	Thallium	95th Percentile_0-3km_Thallium	5.40E+00	1.00E-04	4.44E-03	1.35E-03	5.07E+00	5.16E-01	2.16E-02	5.37E-01	4.63E-03	1.19E+00	1.15E+00	1.00E-01	96%	4%
95th Percentile	Reference	Cadmium	95th Percentile_Reference_Cadmium	1.60E+00	6.40E-05	2.40E-04	4.00E-04	2.74E-01	2.79E-02	8.03E-01	8.31E-01	2.00E-01	1.20E+01	8.17E-01	0.00E+00	3%	97%
95th Percentile	Reference	Thallium	95th Percentile_Reference_Thallium	3.00E-01	1.50E-04	3.00E-05	7.50E-05	3.42E-02	3.48E-03	1.20E-03	4.68E-03	2.57E-04	6.60E-02	4.73E-02	0.00E+00	74%	26%
95UCLM	0-3km	Cadmium	95UCLM_0-3km_Cadmium	5.29E+00	6.10E-05	1.77E-03	1.32E-03	2.01E+00	2.05E-01	1.54E+00	1.75E+00	6.61E-01	3.11E+01	1.46E+00	3.00E-01	12%	88%
95UCLM	0-3km	Thallium	95UCLM_0-3km_Thallium	2.52E+00	1.00E-04	1.47E-03	6.30E-04	1.68E+00	1.71E-01	1.01E-02	1.81E-01	2.16E-03	5.54E-01	4.92E-01	1.00E-01	94%	6%
95UCLM	Reference	Cadmium	95UCLM_Reference_Cadmium	1.54E+00	1.51E-04	1.70E-04	3.85E-04	1.94E-01	1.97E-02	7.86E-01	8.06E-01	1.92E-01	1.17E+01	8.02E-01	0.00E+00	2%	98%
95UCLM	Reference	Thallium	95UCLM_Reference_Thallium	3.40E-01	1.50E-04	3.00E-05	8.50E-05	3.42E-02	3.48E-03	1.36E-03	4.84E-03	2.92E-04	7.48E-02	5.33E-02	0.00E+00	72%	28%

Notes:

Entered maximum measured values

Table 7. Wildlife Oral Toxicity Reference Values (TRVs) [mg/kg/day]

Wildlife Receptor	Chemical	Abbreviation	NOAEL	LOAEL	Comment for NOAEL	Reference
Dark-eyed_junco	Cadmium	Dark-eyed_junco_Cadmium	1.47	2.37	Geometric mean of NOAELs for reproduction and growth	See Appendix J
Ermine	Cadmium	Ermine_Cadmium	0.77	na	Highest bounded NOAEL below the lowest bounded LOAEL	See Appendix J
Masked_shrew	Cadmium	Masked_shrew_Cadmium	0.77	2.28	Highest bounded NOAEL below the lowest bounded LOAEL	See Appendix J
Northern_saw-whet_owl	Cadmium	Northern_saw-whet_owl_Cadmium	1.47	2.37	Geometric mean of NOAELs for reproduction and growth	See Appendix J
Ruffed_grouse	Cadmium	Ruffed_grouse_Cadmium	1.47	2.37	Geometric mean of NOAELs for reproduction and growth	See Appendix J
Snowshoe_hare	Cadmium	Snowshoe_hare_Cadmium	0.77	na	Highest bounded NOAEL below the lowest bounded LOAEL	See Appendix J
White-tailed_deer	Cadmium	White-tailed_deer_Cadmium	0.77	na	Highest bounded NOAEL below the lowest bounded LOAEL	See Appendix J
Dark-eyed_junco	Thallium	Dark-eyed_junco_Thallium	na	na	TRV not available	See Appendix J
Ermine	Thallium	Ermine_Thallium	0.015	0.075		See Appendix J
Masked_shrew	Thallium	Masked_shrew_Thallium	0.015	0.075		See Appendix J
Northern_saw-whet_owl	Thallium	Northern_saw-whet_owl_Thallium	na	na	TRV not available	See Appendix J
Ruffed_grouse	Thallium	Ruffed_grouse_Thallium	na	na	TRV not available	See Appendix J
Snowshoe_hare	Thallium	Snowshoe_hare_Thallium	0.015	0.075		See Appendix J
White-tailed_deer	Thallium	White-tailed_deer_Thallium	0.015	0.075		See Appendix J

Table 8. Soil Ingestion Rate [kg/day]

Receptor	Value
Dark-eyed_junco	4.30E-04
Ermine	1.24E-04
Masked_shrew	2.79E-05
Northern_saw-whet_owl	5.74E-04
Ruffed_grouse	3.98E-03
Snowshoe_hare	4.00E-03
White-tailed_deer	2.99E-02

Receptor	**Percent Soil in Diet**
Dark-eyed_junco	9.3%

NFMR

9.71E+02	kcal/kg/day
1.83E+01	kcal/day

BW

1.88E-02	kg

Estimation of Average Metabolizable Energy

Diet	Portion	GE [kcal/kg-DW]	AE [%]	MEavg kcal/kg-DW
Browse	40%	5100	75%	1.53E+03
Fish	0%	4900	79%	0.00E+00
Invert	60%	5600	72%	2.42E+03
Prey	0%	5000	78%	0.00E+00
	100%		**Sum**	**3.95E+03**

Estimation of Total Ingestion Rate [kg-food / day]	4.62E-03
Soil Ingestion Rate [kg-soil / day]	4.30E-04
Estimation of Total Ingestion Rate [kg-food / kg-BW day]	2.46E-01

Table 8. Soil Ingestion Rate [kg/day]

Receptor	**Percent Soil in Diet**
Ermine	4.0%

NFMR

3.03E+02	kcal/kg/day
1.30E+01	kcal/day

BW

4.30E-02	kg

Estimation of Average Metabolizable Energy

Diet	Portion	GE [kcal/kg-DW]	AE [%]	MEavg kcal/kg-DW
Browse	0%	4200	46%	0.00E+00
Fish	0%	4900	79%	0.00E+00
Invert	0%	5600	87%	0.00E+00
Prey	100%	5000	84%	4.20E+03
	100%		**Sum**	**4.20E+03**

Estimation of Total Ingestion Rate [kg-food / day]	3.10E-03
Soil Ingestion Rate [kg-soil / day]	1.24E-04
Estimation of Total Ingestion Rate [kg-food / kg-BW day]	7.21E-02

Receptor	**Percent Soil in Diet**
Masked_shrew	3.0%

NFMR

9.07E+02	kcal/kg/day
4.54E+00	kcal/day

BW

5.00E-03	kg

Estimation of Average Metabolizable Energy

Diet	Portion	GE [kcal/kg-DW]	AE [%]	MEavg kcal/kg-DW
Browse	0%	4200	46%	0.00E+00
Fish	0%	4900	79%	0.00E+00
Invert	100%	5600	87%	4.87E+03
Prey	0%	5000	84%	0.00E+00
	100%		**Sum**	**4.87E+03**

Estimation of Total Ingestion Rate [kg-food / day]	9.31E-04
Soil Ingestion Rate [kg-soil / day]	2.79E-05
Estimation of Total Ingestion Rate [kg-food / kg-BW day]	1.86E-01

Table 8. Soil Ingestion Rate [kg/day]

Receptor				**Percent Soil in Diet**
Northern_saw-whet_owl			5.0%	
NFMR				
6.50E+02	kcal/kg/day			
4.47E+01	kcal/day			
BW				
6.88E-02	kg			
Estimation of Average Metabolizable Energy				
		GE	AE	MEavg
Diet	Portion	[kcal/kg-DW]	[%]	kcal/kg-DW
Browse	0%	5100	75%	0.00E+00
Fish	0%	4900	79%	0.00E+00
Invert	0%	5600	72%	0.00E+00
Prey	100%	5000	78%	3.90E+03
	100%		**Sum**	**3.90E+03**
Estimation of Total Ingestion Rate [kg-food / day]				1.15E-02
Soil Ingestion Rate [kg-soil / day]				5.74E-04
Estimation of Total Ingestion Rate [kg-food / kg-BW day]				1.67E-01

Receptor				**Percent Soil in Diet**
Ruffed_grouse			9.3%	
NFMR				
1.57E+02	kcal/kg/day			
8.54E+01	kcal/day			
BW				
5.44E-01	kg			
Estimation of Average Metabolizable Energy				
		GE	AE	MEavg
Diet	Portion	[kcal/kg-DW]	[%]	kcal/kg-DW
Browse	95%	3950	48%	1.79E+03
Fish	0%	4900	79%	0.00E+00
Invert	5%	5600	72%	2.02E+02
Prey	0%	5000	78%	0.00E+00
	100%		**Sum**	**1.99E+03**
Estimation of Total Ingestion Rate [kg-food / day]				4.28E-02
Soil Ingestion Rate [kg-soil / day]				3.98E-03
Estimation of Total Ingestion Rate [kg-food / kg-BW day]				7.87E-02

Table 8. Soil Ingestion Rate [kg/day]

Receptor	**Percent Soil in Diet**
Snowshoe_hare	6.3%

NFMR

1.50E+02 kcal/kg/day
1.95E+02 kcal/day

BW

1.30E+00 kg

Estimation of Average Metabolizable Energy

Diet	Portion	GE [kcal/kg-DW]	AE [%]	MEavg kcal/kg-DW
Browse	100%	4200	73%	3.07E+03
Fish	0%	4900	79%	0.00E+00
Invert	0%	5600	87%	0.00E+00
Prey	0%	5000	84%	0.00E+00
	100%		**Sum**	**3.07E+03**

Estimation of Total Ingestion Rate [kg-food / day]	6.35E-02
Soil Ingestion Rate [kg-soil / day]	4.00E-03
Estimation of Total Ingestion Rate [kg-food / kg-BW day]	4.89E-02

Receptor	**Percent Soil in Diet**
White-tailed_deer	2.0%

NFMR

6.66E+01 kcal/kg/day
3.00E+03 kcal/day

BW

4.50E+01 kg

Estimation of Average Metabolizable Energy

Diet	Portion	GE [kcal/kg-DW]	AE [%]	MEavg kcal/kg-DW
Browse	100%	4363	46%	2.01E+03
Fish	0%	4900	79%	0.00E+00
Invert	0%	5600	87%	0.00E+00
Prey	0%	5000	84%	0.00E+00
	100%		**Sum**	**2.01E+03**

Estimation of Total Ingestion Rate [kg-food / day]	1.49E+00
Soil Ingestion Rate [kg-soil / day]	2.99E-02
Estimation of Total Ingestion Rate [kg-food / kg-BW day]	3.32E-02

Table 9. Receptor Exposure Variables

Receptor	Variable	Abbreviation	Value	Units	Reference/Comments
Dark-eyed_junco	BW	BW_Dark-eyed_junco	1.88E-02	kg-WW	See Appendix J
Dark-eyed_junco	IR	IR_Dark-eyed_junco	1.92E-02	m^3/day	See Appendix J
Dark-eyed_junco	SIR	SIR_Dark-eyed_junco	4.3E-04	kg/day	See Appendix J
Dark-eyed_junco	SIR_Per	SIR_Per_Dark-eyed_junco	9.3%	% of Diet	See Appendix J
Dark-eyed_junco	WIR	WIR_Dark-eyed_junco	4.12E-03	L/day	See Appendix J
Ermine	BW	BW_Ermine	4.30E-02	kg-WW	See Appendix J
Ermine	IR	IR_Ermine	4.40E-02	m^3/day	See Appendix J
Ermine	SIR	SIR_Ermine	1.2E-04	kg/day	See Appendix J
Ermine	SIR_Per	SIR_Per_Ermine	4.0%	% of Diet	See Appendix J
Ermine	WIR	WIR_Ermine	5.83E-03	L/day	See Appendix J
Masked_shrew	BW	BW_Masked_shrew	5.00E-03	kg-WW	See Appendix J
Masked_shrew	IR	IR_Masked_shrew	7.87E-03	m^3/day	See Appendix J
Masked_shrew	SIR	SIR_Masked_shrew	2.8E-05	kg/day	See Appendix J
Masked_shrew	SIR_Per	SIR_Per_Masked_shrew	3.0%	% of Diet	See Appendix J
Masked_shrew	WIR	WIR_Masked_shrew	8.41E-04	L/day	See Appendix J
Northern_saw-whet_owl	BW	BW_Northern_saw-whet_owl	6.88E-02	kg-WW	See Appendix J
Northern_saw-whet_owl	IR	IR_Northern_saw-whet_owl	5.21E-02	m^3/day	See Appendix J
Northern_saw-whet_owl	SIR	SIR_Northern_saw-whet_owl	5.7E-04	kg/day	See Appendix J
Northern_saw-whet_owl	SIR_Per	SIR_Per_Northern_saw-whet_owl	5.0%	% of Diet	See Appendix J
Northern_saw-whet_owl	WIR	WIR_Northern_saw-whet_owl	9.82E-03	L/day	See Appendix J
Ruffed_grouse	BW	BW_Ruffed_grouse	5.44E-01	kg-WW	See Appendix J
Ruffed_grouse	IR	IR_Ruffed_grouse	2.56E-01	m^3/day	See Appendix J
Ruffed_grouse	SIR	SIR_Ruffed_grouse	4.0E-03	kg/day	See Appendix J
Ruffed_grouse	SIR_Per	SIR_Per_Ruffed_grouse	9.3%	% of Diet	See Appendix J
Ruffed_grouse	WIR	WIR_Ruffed_grouse	3.92E-02	L/day	See Appendix J
Snowshoe_hare	BW	BW_Snowshoe_hare	1.30E+00	kg-WW	See Appendix J
Snowshoe_hare	IR	IR_Snowshoe_hare	6.73E-01	m^3/day	See Appendix J
Snowshoe_hare	SIR	SIR_Snowshoe_hare	4.0E-03	kg/day	See Appendix J
Snowshoe_hare	SIR_Per	SIR_Per_Snowshoe_hare	6.3%	% of Diet	See Appendix J
Snowshoe_hare	WIR	WIR_Snowshoe_hare	1.25E-01	L/day	See Appendix J
White-tailed_deer	BW	BW_White-tailed_deer	4.50E+01	kg-WW	See Appendix J
White-tailed_deer	IR	IR_White-tailed_deer	1.15E+01	m^3/day	See Appendix J
White-tailed_deer	SIR	SIR_White-tailed_deer	3.0E-02	kg/day	See Appendix J
White-tailed_deer	SIR_Per	SIR_Per_White-tailed_deer	2.0%	% of Diet	See Appendix J
White-tailed_deer	WIR	WIR_White-tailed_deer	3.04E+00	L/day	See Appendix J

Table 10. Normalized to Body Weight Free-living (Field) Metabolic Rate (NFMR)

Receptor	NFMR [kcal/kg bw/day] [A]	FMR [kcal/day] [B]	Body Weight [grams]	Slope	Power	Reference/Comments
Dark-eyed_junco	9.71E+02	1.83E+01	1.88E+01	1.04E+01	6.80E-01	Nagy et al. 1999; Passerines
Masked_shrew	9.07E+02	4.54E+00	5.00E+00	6.98E+00	6.22E-01	See Appendix J
Northern_saw-whet_owl	6.50E+02	4.47E+01	6.88E+01	1.05E+01	6.81E-01	See Appendix J
Ermine	3.03E+02	1.30E+01	4.30E+01	2.23E+00	8.50E-01	See Appendix J
Ruffed_grouse	1.57E+02	8.54E+01	5.44E+02	8.51E-01	9.59E-01	See Appendix J
Snowshoe_hare	1.50E+02	1.95E+02	1.30E+03	7.94E+00	6.46E-01	See Appendix J
White-tailed_deer	6.66E+01	3.00E+03	4.50E+04	4.82E+00	7.34E-01	See Appendix J

A) NFMR = Normalized Free Metabolic Rate = FMR / BW; Where BW is in kg

B) FMR = Free Metabolic Rate = [Slope x BW^{Power}] / 4.1875 Kj/calorie; Where BW is in grams

Table 11. Receptor Dietary Composition [Media % of Diet]

Receptor	Media	Value	Comment
Dark-eyed_junco	Browse	40.0%	See Appendix J for details
Dark-eyed_junco	Fish	0.0%	See Appendix J for details
Dark-eyed_junco	Invert	60.0%	See Appendix J for details
Dark-eyed_junco	Prey	0.0%	See Appendix J for details
Ermine	Browse	0.0%	See Appendix J for details
Ermine	Fish	0.0%	See Appendix J for details
Ermine	Invert	0.0%	See Appendix J for details
Ermine	Prey	100.0%	See Appendix J for details
Masked_shrew	Browse	0.0%	See Appendix J for details
Masked_shrew	Fish	0.0%	See Appendix J for details
Masked_shrew	Invert	100.0%	See Appendix J for details
Masked_shrew	Prey	0.0%	See Appendix J for details
Northern_saw-whet_owl	Browse	0.0%	See Appendix J for details
Northern_saw-whet_owl	Fish	0.0%	See Appendix J for details
Northern_saw-whet_owl	Invert	0.0%	See Appendix J for details
Northern_saw-whet_owl	Prey	100.0%	See Appendix J for details
Ruffed_grouse	Browse	95.0%	See Appendix J for details
Ruffed_grouse	Fish	0.0%	See Appendix J for details
Ruffed_grouse	Invert	5.0%	See Appendix J for details
Ruffed_grouse	Prey	0.0%	See Appendix J for details
Snowshoe_hare	Browse	100.0%	See Appendix J for details
Snowshoe_hare	Fish	0.0%	See Appendix J for details
Snowshoe_hare	Invert	0.0%	See Appendix J for details
Snowshoe_hare	Prey	0.0%	See Appendix J for details
White-tailed_deer	Browse	100.0%	See Appendix J for details
White-tailed_deer	Fish	0.0%	See Appendix J for details
White-tailed_deer	Invert	0.0%	See Appendix J for details
White-tailed_deer	Prey	0.0%	See Appendix J for details

Table 12. Metabolizable Energy (ME) of Dietary Items [kcal/kg] [A]

Receptor	Dietary Item	Abbreviation	Value
Dark-eyed_junco	Browse	Dark-eyed_junco_Browse	3825
Dark-eyed_junco	Fish	Dark-eyed_junco_Fish	3871
Dark-eyed_junco	Invert	Dark-eyed_junco_Invert	4032
Dark-eyed_junco	Prey	Dark-eyed_junco_Prey	3900
Ermine	Browse	Ermine_Browse	1932
Ermine	Fish	Ermine_Fish	3871
Ermine	Invert	Ermine_Invert	4872
Ermine	Prey	Ermine_Prey	4200
Masked_shrew	Browse	Masked_shrew_Browse	1932
Masked_shrew	Fish	Masked_shrew_Fish	3871
Masked_shrew	Invert	Masked_shrew_Invert	4872
Masked_shrew	Prey	Masked_shrew_Prey	4200
Northern_saw-whet_owl	Browse	Northern_saw-whet_owl_Browse	3825
Northern_saw-whet_owl	Fish	Northern_saw-whet_owl_Fish	3871
Northern_saw-whet_owl	Invert	Northern_saw-whet_owl_Invert	4032
Northern_saw-whet_owl	Prey	Northern_saw-whet_owl_Prey	3900
Ruffed_grouse	Browse	Ruffed_grouse_Browse	1886
Ruffed_grouse	Fish	Ruffed_grouse_Fish	3871
Ruffed_grouse	Invert	Ruffed_grouse_Invert	4032
Ruffed_grouse	Prey	Ruffed_grouse_Prey	3900
Snowshoe_hare	Browse	Snowshoe_hare_Browse	3066
Snowshoe_hare	Fish	Snowshoe_hare_Fish	3871
Snowshoe_hare	Invert	Snowshoe_hare_Invert	4872
Snowshoe_hare	Prey	Snowshoe_hare_Prey	4200
White-tailed_deer	Browse	White-tailed_deer_Browse	2007
White-tailed_deer	Fish	White-tailed_deer_Fish	3871
White-tailed_deer	Invert	White-tailed_deer_Invert	4872
White-tailed_deer	Prey	White-tailed_deer_Prey	4200

A) US EPA 1993; Equation 4-17; ME = GE x AE

Table 13. Gross Energy (GE) of Dietary Items [kcal/kg dw] [A]

Receptor	Dietary Item	Value	Reference/Comments
Dark-eyed_junco	Browse	5100	
Dark-eyed_junco	Fish	4900	bony fishes
Dark-eyed_junco	Invert	5600	
Dark-eyed_junco	Prey	5000	
Ermine	Browse	4200	
Ermine	Fish	4900	bony fishes
Ermine	Invert	5600	
Ermine	Prey	5000	
Masked_shrew	Browse	4200	
Masked_shrew	Fish	4900	bony fishes
Masked_shrew	Invert	5600	
Masked_shrew	Prey	5000	
Northern_saw-whet_owl	Browse	5100	
Northern_saw-whet_owl	Fish	4900	bony fishes
Northern_saw-whet_owl	Invert	5600	
Northern_saw-whet_owl	Prey	5000	
Ruffed_grouse	Browse	3950	Average of browse diet
Ruffed_grouse	Fish	4900	bony fishes
Ruffed_grouse	Invert	5600	
Ruffed_grouse	Prey	5000	
Snowshoe_hare	Browse	4200	
Snowshoe_hare	Fish	4900	bony fishes
Snowshoe_hare	Invert	5600	
Snowshoe_hare	Prey	5000	
White-tailed_deer	Browse	4363	Average of browse diet
White-tailed_deer	Fish	4900	bony fishes
White-tailed_deer	Invert	5600	
White-tailed_deer	Prey	5000	

A) US EPA 1993; Tables 4-1 & 4-2

Table 14. Assimilation Efficiency (AE) of Dietary Items [Percent% Efficiency] [A]

Receptor	Dietary Item	Value	Reference/Comments
Dark-eyed_junco	Browse	75%	
Dark-eyed_junco	Fish	79%	
Dark-eyed_junco	Invert	72%	
Dark-eyed_junco	Prey	78%	
Ermine	Browse	46%	
Ermine	Fish	79%	
Ermine	Invert	87%	
Ermine	Prey	84%	
Masked_shrew	Browse	46%	
Masked_shrew	Fish	79%	
Masked_shrew	Invert	87%	
Masked_shrew	Prey	84%	
Northern_saw-whet_owl	Browse	75%	
Northern_saw-whet_owl	Fish	79%	
Northern_saw-whet_owl	Invert	72%	
Northern_saw-whet_owl	Prey	78%	
Ruffed_grouse	Browse	48%	Average of browse diet
Ruffed_grouse	Fish	79%	
Ruffed_grouse	Invert	72%	
Ruffed_grouse	Prey	78%	
Snowshoe_hare	Browse	73%	
Snowshoe_hare	Fish	79%	
Snowshoe_hare	Invert	87%	
Snowshoe_hare	Prey	84%	
White-tailed_deer	Browse	46%	
White-tailed_deer	Fish	79%	
White-tailed_deer	Invert	87%	
White-tailed_deer	Prey	84%	

A) US EPA 1993; Table 4-3

Table 15. BioAccessibility [%]

Media	Chemical	Abbreviation	Value
Soil	Cadmium	Soil_Cadmium	100%
Soil	Thallium	Soil_Thallium	100%

Table 16. Literature and Site-specific Derived Regression Models and Bio-Concentration Factors [Dry Weight Basis]

		Regression Variables		BCF		
		Constant	Coeff#1			
Media	Chemical	Average	Average	Value	Model	Reference
Browse	Cadmium	-4.76E-01	5.46E-01		Ln_Normal	BJC 1998
Browse	Thallium			4.00E-03	BCF	Baes et al. 1984
Berries	Cadmium			1.25E-01	BCF	U.S. EPA 2005
Berries	Thallium			8.58E-04	BCF	U.S. EPA 2005
Invert	Cadmium	2.11E+00	7.95E-01		Ln_Normal	Sample et al. 1998b
Invert	Thallium			2.20E-01	BCF	U.S. EPA 1999
Prey	Cadmium	-4.31E-01	4.87E-01		Ln_Normal	Sample et al. 1998a
Prey	Thallium			2.00E+00	[Diet]*BCF	Extrapolated; US EPA 2005

Table 17. Measured and Predicted Exposure Point Concentrations for the Ecological Risk Assessment - ONLY CD AND TL DATA FOR 0 to 3 KM

Scenario	Site	Chemical	Media	Abbreviation	Value	Units	Reference/Comment
90th Percentile	0-3km	Cadmium	Air	90th Percentile_0-3km_Cadmium_Air	2.39E-03	µg/m^3	Based on Bouley + Chalmers 2007-2009 (n=357) divided by 2.7
90th Percentile	0-3km	Thallium	Air	90th Percentile_0-3km_Thallium_Air	2.59E-03	µg/m^3	Based on Bouley + Chalmers 2007-2009 (n=357) divided by 2.7
95th Percentile	0-3km	Cadmium	Air	95th Percentile_0-3km_Cadmium_Air	4.07E-03	µg/m^3	Based on Bouley + Chalmers 2007-2009 (n=357) divided by 2.7
95th Percentile	0-3km	Thallium	Air	95th Percentile_0-3km_Thallium_Air	4.44E-03	µg/m^3	Based on Bouley + Chalmers 2007-2009 (n=357) divided by 2.7
95UCLM	0-3km	Cadmium	Air	95UCLM_0-3km_Cadmium_Air	1.77E-03	µg/m^3	Based on Bouley + Chalmers 2007-2009 (n=357) divided by 2.7
95UCLM	0-3km	Thallium	Air	95UCLM_0-3km_Thallium_Air	1.47E-03	µg/m^3	Based on Bouley + Chalmers 2007-2009 (n=357) divided by 2.7
90th Percentile	Reference	Cadmium	Air	90th Percentile_Reference_Cadmium_Air	1.70E-04	µg/m^3	Average of 90th percentile data for rural air stations - 2005 to 2010 - data provided by Tom Dann
90th Percentile	Reference	Thallium	Air	90th Percentile_Reference_Thallium_Air	3.00E-05	µg/m^3	Average of 90th percentile data for rural air stations - 2005 to 2010 - data provided by Tom Dann
95th Percentile	Reference	Cadmium	Air	95th Percentile_Reference_Cadmium_Air	2.40E-04	µg/m^3	Average of 95th percentile data for rural air stations - 2005 to 2010 - data provided by Tom Dann
95th Percentile	Reference	Thallium	Air	95th Percentile_Reference_Thallium_Air	3.00E-05	µg/m^3	Average of 95th percentile data for rural air stations - 2005 to 2010 - data provided by Tom Dann
95UCLM	Reference	Cadmium	Air	95UCLM_Reference_Cadmium_Air	1.70E-04	µg/m^3	Could not calculate a UCLM - therefore used the average of 90th percentile data for rural air stations - 2005 to 2010 - data provided by Tom Dann
95UCLM	Reference	Thallium	Air	95UCLM_Reference_Thallium_Air	3.00E-05	µg/m^3	Could not calculate a UCLM - therefore used the average of 90th percentile data for rural air stations - 2005 to 2010 - data provided by Tom Dann
90th Percentile	0-3km	Cadmium	Soil	90th Percentile_0-3km_Cadmium_Soil	7.70E+00	mg/kg	
90th Percentile	0-3km	Thallium	Soil	90th Percentile_0-3km_Thallium_Soil	2.70E+00	mg/kg	
95th Percentile	0-3km	Cadmium	Soil	95th Percentile_0-3km_Cadmium_Soil	9.10E+00	mg/kg	
95th Percentile	0-3km	Thallium	Soil	95th Percentile_0-3km_Thallium_Soil	5.40E+00	mg/kg	
95UCLM	0-3km	Cadmium	Soil	95UCLM_0-3km_Cadmium_Soil	5.29E+00	mg/kg	
95UCLM	0-3km	Thallium	Soil	95UCLM_0-3km_Thallium_Soil	2.52E+00	mg/kg	
90th Percentile	Reference	Cadmium	Soil	90th Percentile_Reference_Cadmium_Soil	1.50E+00	mg/kg	Belledune Off-Site ERA Reference Data (n=23)
90th Percentile	Reference	Thallium	Soil	90th Percentile_Reference_Thallium_Soil	3.00E-01	mg/kg	Belledune Off-Site ERA Reference Data (n=23)
95th Percentile	Reference	Cadmium	Soil	95th Percentile_Reference_Cadmium_Soil	1.60E+00	mg/kg	Belledune Off-Site ERA Reference Data (n=23)
95th Percentile	Reference	Thallium	Soil	95th Percentile_Reference_Thallium_Soil	3.00E-01	mg/kg	Belledune Off-Site ERA Reference Data (n=23)
95UCLM	Reference	Cadmium	Soil	95UCLM_Reference_Cadmium_Soil	1.54E+00	mg/kg	Belledune Off-Site ERA Reference Data (n=23)
95UCLM	Reference	Thallium	Soil	95UCLM_Reference_Thallium_Soil	3.40E-01	mg/kg	Belledune Off-Site ERA Reference Data (n=23)
90th Percentile	0-3km	Cadmium	Fish	90th Percentile_0-3km_Cadmium_Fish	3.00E-01	mg/kg	Used detection limit
90th Percentile	0-3km	Thallium	Fish	90th Percentile_0-3km_Thallium_Fish	1.00E-01	mg/kg	Used detection limit
95th Percentile	0-3km	Cadmium	Fish	95th Percentile_0-3km_Cadmium_Fish	3.00E-01	mg/kg	Used detection limit
95th Percentile	0-3km	Thallium	Fish	95th Percentile_0-3km_Thallium_Fish	1.00E-01	mg/kg	Used detection limit
95UCLM	0-3km	Cadmium	Fish	95UCLM_0-3km_Cadmium_Fish	3.00E-01	mg/kg	Used detection limit
95UCLM	0-3km	Thallium	Fish	95UCLM_0-3km_Thallium_Fish	1.00E-01	mg/kg	Used detection limit
90th Percentile	Reference	Cadmium	Fish	90th Percentile_Reference_Cadmium_Fish		mg/kg	
90th Percentile	Reference	Thallium	Fish	90th Percentile_Reference_Thallium_Fish		mg/kg	
95th Percentile	Reference	Cadmium	Fish	95th Percentile_Reference_Cadmium_Fish		mg/kg	
95th Percentile	Reference	Thallium	Fish	95th Percentile_Reference_Thallium_Fish		mg/kg	
95UCLM	Reference	Cadmium	Fish	95UCLM_Reference_Cadmium_Fish		mg/kg	
95UCLM	Reference	Thallium	Fish	95UCLM_Reference_Thallium_Fish		mg/kg	
90th Percentile	0-3km	Cadmium	Water	90th Percentile_0-3km_Cadmium_Water	6.62E-05	mg/L	90th percentile of freshwater data from Belledune
90th Percentile	0-3km	Thallium	Water	90th Percentile_0-3km_Thallium_Water	1.00E-04	mg/L	Not detected in 8 of 9 samples at det limit of 0.0001; one sample detected at 0.00011; used detection limit since detected value was so close to det limit
95th Percentile	0-3km	Cadmium	Water	95th Percentile_0-3km_Cadmium_Water	8.06E-05	mg/L	95th percentile of freshwater data from Belledune
95th Percentile	0-3km	Thallium	Water	95th Percentile_0-3km_Thallium_Water	1.00E-04	mg/L	Not detected in 8 of 9 samples at det limit of 0.0001; one sample detected at 0.00011; used detection limit since detected value was so close to det limit
95UCLM	0-3km	Cadmium	Water	95UCLM_0-3km_Cadmium_Water	6.10E-05	mg/L	UCLM95 of freshwater data from Belledune

Table 17. Measured and Predicted Exposure Point Concentrations for the Ecological Risk Assessment - ONLY CD AND TL DATA FOR 0 to 3 KM

Scenario	Site	Chemical	Media	Abbreviation	Value	Units	Reference/Comment
95UCLM	0-3km	Thallium	Water	95UCLM_0-3km_Thallium_Water	1.00E-04	mg/L	Not detected in 8 of 9 samples at det limit of 0.0001; one sample detected at 0.00011; used detection limit since detected value was so close to det limit
90th Percentile	Reference	Cadmium	Water	90th Percentile_Reference_Cadmium_Water	5.00E-05	mg/L	freshwater data from pooled dataset (N=62)
90th Percentile	Reference	Thallium	Water	90th Percentile_Reference_Thallium_Water	1.00E-04	mg/L	freshwater data from pooled dataset (N=62)
95th Percentile	Reference	Cadmium	Water	95th Percentile_Reference_Cadmium_Water	6.40E-05	mg/L	freshwater data from pooled dataset (N=62)
95th Percentile	Reference	Thallium	Water	95th Percentile_Reference_Thallium_Water	1.50E-04	mg/L	freshwater data from pooled dataset (N=62)
95UCLM	Reference	Cadmium	Water	95UCLM_Reference_Cadmium_Water	1.51E-04	mg/L	95th percentile used due to number of RDLs- freshwater data from pooled dataset N=62
95UCLM	Reference	Thallium	Water	95UCLM_Reference_Thallium_Water	1.50E-04	mg/L	95th percentile used due to number of RDLs- freshwater data from pooled dataset N=62

References

Baes et al. 1984	Baes, C.F. (III), Sharp, R., Sjoreen, A., and Shor, R. 1984. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radio-Nuclides Through Agriculture. Department of Energy, US (DOE), Washington, DC.
Sample et al.1998a	Development and Validation of Bioaccumulation Models for Small Mammals. Prepared for the U.S. Department of Energy, Office of Environmental Management. February 1998. ES/ER/TM-219
Sample et al.1998b	Development and Validation of Bioaccumulation Models for Earthworms. Prepared for the U.S. Department of Energy, Office of Environmental Management. February 1998. ES/ER/TM-220
BJC 1998	Bechtel Jacobs Company. Empirical Models for the Uptake of Inorganic Chemicals from Soil by Plants. Prepared for the U.S. Department of Energy. September 1998.
U.S. EPA 1999	USEPA OSW. 1999. Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities, Volume I Peer Review Draft. (US) United States Environmental Protection Agency Region 6. Multimedia Planning and Permitting Division. Center for Combustion Science and Engineering. Office of Solid Waste
U.S. EPA 2005	Ecological Soil Screening Levels (Eco-SSL). Guidance Documents and SOPs. Ecological Soil Screening levels for Antimony. Interim Final. February 2005.
USEPA. 1993b.	Wildlife Exposure Factors Handbook. Volumes I and II. Office of Research and Development. ORD. EPA-600-R-93-187. December 1993.

APPENDIX K

VEGETATION COMMUNITY ASSESSMENT

Vegetation Health Study Report

XSTRATA LEAD BELLEDUNE SMELTER

for:

INTRINSIK INC.

by:

LGL Limited
environmental research associates

MAY 2012

LGL FILE TA4803

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XSTRATA LEAD BELLEDUNE SMELTER

VEGETATION HEALTH STUDY

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MAY 2012

LGL PROJECT TA4803

TABLE OF CONTENTS

1.0 INTRODUCTION

LGL Limited was retained by Intrinsik Inc. to provide biological input in the assessment of vegetation health in the area surrounding the Belledune lead smelter. Environmental studies conducted for Xstrata during 2009 revealed that soil at some sites in the vicinity of the smelter had elevated concentrations of metals, some of which exceed vegetation health guidelines. This new information prompted the need for field observations to confirm vegetation response and health in the area.

1.1 BACKGROUND

1.1.1 Purpose of the Study

This study collected vegetation community information at sampling sites established within 2 km of the smelter (south, south east and south west) and at reference locations. Observations of vegetation health were recorded to facilitate correlation with existing soil quality data. Vegetation health was examined through comparisons of habitat characteristics between reference and smelter locations as well as general observations of plant stress.

2.0 METHODOLOGY

2.1 FIELD SURVEY

The vegetation survey was based on a combination of transect and plot methods. Five transects were established radiating from a single point close to the smelter and extending for a distance of up to 2 km. The transect locations were determined by Intrinsik, and were based on soil data collected in the summer of 2009. A total of 17 transect stations were established. The transects each contained up to 4 sampling stations that were established approximately 0.5 km apart. Transects 1, 2, and 3 each contained 4 sampling stations, whereas transect 4 and 5 contained 3 and 2 respectively (**Figure 1**), due to the proximity of privately owned lands. The sampling stations were located only on Xstrata-owned or Crown lands.

Four reference stations were located approximately 21 km upwind of prevailing wind direction to reduce possible influence on soil quality from the smelter emissions (**Figure 2**). Stations were established to provide reference vegetation composition similar to those of the transect stations. Stations were also chosen based on proximity to former soil sampling stations where possible. Where necessary, stations were established in remaining vegetation communities in proximity to old soil sampling locations, as some of these coordinates were located within logged areas and no longer contained vegetation.

LEGEND

● Sampling Station Location

Belledune Smelter

Sampling Station Locations

LGL LIMITED
environmental research associates

Project	TA4803	**Figure**	1
Date	May, 2012	**Prepared By:**	KC
Scale	1:13,000	**Verified By:**	JCN

LEGEND

● Reference Sampling Location

Belledune Smelter

Reference Sampling Locations

LGL LIMITED
environmental research associates

Project	TA4803	**Figure**	2
Date	May, 2012	**Prepared By:**	KC
Scale	1:10,000	**Verified By:**	JCN

Sampling stations consisted of a 10 x 10 m plot where detailed vegetation parameters were collected. Vegetation assessment consisted of species abundance and diversity within the canopy and subcanopy, canopy closure at each cardinal point, stand characteristics (size class abundance), standing snags and dead fall densities, ground cover richness and any signs of vegetation stress if present.

General site observations of community characteristics and vegetation health were recorded while walking along transects between stations. However, not all of the transects were walked in their entirety. Stations along transects 3 and 4 were instead accessed from the adjacent road.

3.0 RESULTS

A total of 124 plant species were recorded within the study area. Fifty species were recorded at the reference stations and 113 species were found along the transects within the exposed area south of the smelter. A list of plant species recorded within the study area is provided in **Appendix A.** A summary of habitat characteristics is presented in **Table 1**.

3.1 REFERENCE LOCATIONS

Reference location 1 is a cultural meadow which contains limited, scattered, woody vegetation. Vegetation consists of white birch (*Betula papyrifera*), red osier dogwood (*Cornus stolonifera*), field horsetail (*Equisetum arvensis*), fireweed (Eupatorium angustifolia), red top (*Agostis gigantea*), ox-eye daisy (*Leucanthemum vulgare*), scarlet strawberry (*Fragaria virginiana*), field hawkweed (*Hieracium caespitosum*), Kentucky bluegrass (*Poa pratensis ssp. pratensis*), and red clover (*Trifolium pratense*). The soil is very compact and composed of gravel with limited to no visible organic matter. The site resembles a staging area for logging operations (Photo 1). Among the reference stations, it was the one that contained species similar to the meadows observed within exposed locations of the study area.

Photo 1. Reference sampling station 1.

Reference locations 2, 3, and 4 occur within deciduous and mixed forest communities. Vegetation consists of balsam fir (*Abies balsamae*), trembling aspen (*Populus tremuloides*), white birch, red maple (*Acer rubrum*), eastern white cedar (*Thuja occidentalis*), bracken-fern (*Pteridium aquilinum* var. *latiusculus*), wild lily-of-the-valley (*Maianthemum canadense*), and red baneberry (*Actaea rubra*). These forested units are surrounded by clear–cut areas. The soils are rocky with well-developed organic and litter layers. These stands had a mixture of size classes with trees up to 36 cm diameter at breast height (DBH).

Photo 2. Reference sampling station 2.

Photo 3. Reference sampling station 3.

Table 1: Summary of Habitat Characteristics

Station ID	Species Diversity	Canopy Diversity	Vegetation Community	Tree Size Class Abundance (cm)					Canopy Closure	Comment
				Seedlings	<10	10-24	25-36	37-49		
Reference Locations										
1	21	0	Meadow	0	0	0	0	0	0	• Very compact soils • Lots of bare areas • No sign of stress
2	17	4	Deciduous Forest	5	1	3	1	0	77	• No sign of stress • On slope
3	15	4	Mixed Forest	5	2	3	1	0	77	• Dieback in poplars • Site on slope 20 m from clearing • Surrounded by clear cut • No sign of stress
4	22	5	Mixed Forest	6	5	3	0	0	78	• No sign of stress
Smelter Transects										
1-1	11	2	Dogwood Thicket	0	2	1	0	0	16	• No sign of stress • Site previously cleared and disturbed • Next to fill piles
1-2	21	0	Meadow/ fallow field	0	0	0	0	0	0	• Old fallow field • Vegetation growing over plough ruts • Limited woody species present • Manure smell when collecting soil samples • Surrounding area planted with white spruce saplings • No sign of stress
1-3	18	0	Meadow/ fallow field	0	0	0	0	0	0	• Old fallow field • Limited woody species present • No sign of stress
1-4	33	1	Dogwood Thicket	0	0	1	0	0	7	• No sign of stress • Area previously cleared
2-1	35	6	Mixed Forest	3	6	2	0	0	77	• No sign of stress
2-2	18	3	Mixed Forest	2	2	3	0	0	79	• No sign of stress • Located in opening in canopy
2-3	17	5	Mixed Forest	3	3	5	1	0	81	• No sign of stress
2-4	28	4	Mixed Forest	2	3	4	1	0	77	• Presence of introduced species • No sign of stress • Plot close to a fallow field
3-1	15	2	Mixed Forest	1	1	2	2	0	77	• No sign of stress
3-2	16	5	Deciduous Forest	5	4	3	0	0	83	• No sign of stress

Station ID	Species Diversity	Canopy Diversity	Vegetation Community	Tree Size Class Abundance (cm)					Canopy Closure	Comment
				Seedlings	<10	10-24	25-36	37-49		
3-3	21	5	Deciduous Forest	2	4	2	0	0	76	• No sign of stress
3-4	22	6	Mixed Forest	1	6	4	0	0	79	• No sign of stress
4-1	15	5	Mixed Forest	0	3	3	1	0	77	• No sign of stress • No seedling found since canopy is dense with conifers
4-2	22	4	Mixed Forest	0	1	3	0	0	77	• No sign of stress
4-3	19	5	Mixed Forest	2	5	3	0	0	77	• No sign of stress • Regeneration is occurring, abundance of species < 10 cm in size
5-1	16	2	Cultural Thicket	3	1	0	0	0	1	• Stunted growth (pin cherry, rough leaved goldenrod, star-flowered Solomon's seal) • Major twig dieback in pin cherry • Chlorosis • Areas of exposed soil • Highly disturbed site
5-2	17	2	Deciduous Forest	2	2	2	0	0	81	• Odd growth form of maples and aspen • Trees are small • Maples have multi-stem growth • Aspens have cankers along stem

Legend
Species Diversity: number of species found within each sampling station
Canopy Diversity: number of tree species found within the canopy of each sampling station
Vegetation Community: description of community present within the sampling station.
Size Class Abundance: number of woody species by size
Canopy closure: the amount of light obscured by the canopy

3.2 SMELTER

Qualitative observations south of the smelter revealed that the area contains a variety of vegetation communities which can be generally categorized as:

- Disturbed – cultural meadow;
- Disturbed – cultural thicket;
- Deciduous forest; and,
- Mixed forests.

The near-field area and along Transect 1 exhibited varying degrees of disturbance among the vegetation communities. This appeared to be the result of past clearing of land for the old airfield and for agricultural purposes. Far-field vegetation consists of mid-aged mixed and deciduous forest.

3.2.1 Transect 1

Vegetation communities along Transect 1 are mainly fallow lands from abandoned agricultural fields. A small depression, adjacent to several fill piles is dominated by a dense thicket of red osier dogwood in plot 1-1. The agricultural field was challenging to traverse, as the field had been ploughed and the furrows were left to naturalize. Mounds and depressions left from the plough were hidden by the colonization of old field vegetation. No shrubs or other woody vegetation were observed within 1-2 and 1-3. Plot 1-4 contained some woody species as this plot was located adjacent to a cultural plantation of pines, spruces and tamarack. Species diversity along this transect ranged from 11 to 33 vascular plant species. Dominant species along the transect include: fireweed, red osier dogwood, ox-eye daisy, wild carrot (*Daucus carota*), quack grass (*Elymus repens*), strawberry, shining bedstraw (*Galium concinnum*), field hawkweed, timothy (*Phleum pratense*), white spruce (*Picea glauca*), choke cherry (*Prunus virginiana* var. *virginiana*), red clover, and tufted vetch (*Vicia cracca*).

Photo 4. Fallow agricultural field in plots 1-2 and 2-3.

Photo 5. Woody species surrounding plot 1-4

3.2.2 Transect 2

This transect does not contain plots with any disturbed vegetation communities, although disturbed vegetation communities such as the cultural meadow, thicket and old airfield were observed in the near-field area while traversing to plot 2-1. Plots 1 through 4 were located within young to mid-aged mixed forest. This forest has regenerated since it was harvested approximately 40 years ago (ADITI Consultants Ltd 2006). Species diversity within the plots ranged from 17 to 35 species with canopy closure values between 77 to 81%. Dominant species within the canopy consisted of early successional species such as balsam fir, white birch, trembling aspen and red maple. Other species found in the ground cover and understorey included: mountain maple (*Acer spicatum*), red baneberry (*Actaea rubra*), wild sarsaparilla (*Aralia nudicaulis*), bluebead-lily (*Clintonia borealis*), bunch berry (*Cornus canadensis*), and wild lily of the valley (*Maianthemum canadense*). Gaps along the transect and near the plots represented rock outcrops or dead-fall. There were no signs of vegetation stress within the plots or along transects. Some balsam fir patches along the transect had signs of chlorosis, however none of the other surrounding species exhibited signs of yellowing or stress. The firs with signs of chlorosis were often found in clearings or in outcrops, and may have been stressed by environmental exposure or soil conditions in those locations. Introduced species such as common dandelion (*Taraxacum officinale*), hawkweed (*Hieracium* sp.), and helleborine (*Epipactis helleborine*) were observed in 2-4. This is an indication of disturbance or the plot is in close proximity to a disturbed area. Air photo analysis revealed an agricultural field less than 50 m from the sampling plot, which is likely to be the source of the introduction of these species into the forest.

Photo 6. Mixed forest along transect 2.

Photo 7. Mixed forest along transect 2 with limited ground cover.

3.2.4 Transect 3

Transect 3 also does not contain plots within any disturbed vegetation communities. Disturbed vegetation communities were restricted to the area near the road and within the slag pile between plots 3-2 and 3-3. The entire length of the transect was not walked as there was access to the sampling plot from the adjacent road. Vegetation communities along the transect consisted of mixed and deciduous forest. Plot 3-1 was dominated by eastern white cedar and large- toothed aspen (*Populus grandidentata*). Plots 3-2 and 3-4 are dominated by trembling aspen with red and sugar maple, white birch and balsam fir in the understorey and ground cover. Red and mountain maple are successfully regenerating as indicated by an observed abundance of seedlings. Species diversity within the plots ranged from 17 to 22 with canopy closure values between 77 and 83%. These young forests had a variety of age classes and species, and were comprised mainly of trees less than 25 cm DBH, with only a few isolated larger trees. There were no signs of vegetation stress within any of the plots.

Photo 8. Mixed forest of plot 3-1.

Photo 9. Deciduous forest of plot 3-2.

3.2.5 Transect 4

Transect 4 was shorter, and contained 3 sampling plots because of the proximity of privately owned land in that area. The plots were limited to Xstrata and Crown lands. The entire length of the transect was not walked, as access to the sampling plots could be achieved by road. Disturbed communities were restricted to those areas immediately adjacent to the roads and near plot 4-2. Community composition of the plots is similar as they are dominated by a mixed forest made up of balsam fir, red maple, white birch and trembling aspen. Ground cover and regeneration varies from limited (5%) to abundant (70%) with similar canopy closure values (77% for all plots). Species diversity ranged from 15 to 22 with canopy trees reaching a size of up to 25 cm DBH with the exception of a few isolated aspen trees reaching 35 cm. There were no signs of vegetation stress within the plots.

3.2.6 Transect 5

Transect 5 contained 2 sampling plots because of the proximity of privately owned land in that area. The plots were limited to Xstrata and Crown lands. Soils are very rocky with a very thin organic layer. Communities along Transect 5 are highly disturbed and consist of cultural thicket and deciduous forest. The cultural thicket (5-1) and areas between plots contained several areas of exposed mineral soil, scattered trees up to 5 m in height, as well as piles of charcoal left over from burning piles of wood. Pin cherry and other woody species seem to be exhibiting stunted growth and a considerable amount of twig dieback. Rough-leaved goldenrod and star-flowered Solomon's seal have obvious reduced growth forms (Photo 10 to 13). Canopy closure varies between the two sites as 5-1 contains low lying woody species less than 8 m tall (1%), where as the deciduous forest is a small treed pocket that has trees >10cm DBH and which have more developed canopies (81%). Trees found within the deciduous forest however have an odd growth form where all the trunks form a "J" pattern (Photo 14) about 50 cm above the ground indicating that the trees were all impacted by the same event, such as an ice storm, heavy snowfall or effects of ocean spray. The trembling aspens have canker along the stem. Species diversity is similar in both sampling plots with 15-16 species however composition of each is very different. Plot 1 contained open meadow, with a mix of early successional and non-native species such as English hawthorn (*Crataegus monogyna*), rough-leaved goldenrod (*Solidago rugosa ssp. rugosa*), Canada thistle (*Cirsium arvense*), sour dock (*Rumex acetosa* ssp. *thyrsiflorus*), swamp rose (*Rosa carolina*), and star-flowered Solomon seal. Species such as star-flower (*Trientalis borealis* ssp. *borealis*), wild sarsaparilla (*Aralia nudicaulis*), helleborine, goldthread (*Coptis trifolia*), bracken fern, and spinulose wood fern observed in plot 2 are more shade-loving species that are typical of forested areas.

Photo 10. Normal growth form for star-flowered Solomon' seal. Photos taken from plot 3-3.

Photo 11. Stunted growth of star-flowered Solomon's seal from plot 5-1. Leaves are more appressed to the stalk.

Photo 12. Rough-leaved goldenrod within the reference location. This mature specimen is approximately 50 cm tall with leaves evenly spaced along the stem.

Photo 13. Rough-leaved goldenrod within plot 5-1. Leaves are short and wide. This mature specimen is only approximately 20 cm tall.

Photo 14. Deformed trunk of the trembling aspen trees within plot 5-2.

Photo 15. Charcoal heap remains of burned wood piles.

4.0 DISCUSSION

Examining vegetation communities and vegetation health at sampling stations located on a gradient of soil metals concentrations extending in the direction of prevailing winds from the Belledune smelter is a key objective of Intrinsik's Ecological Risk Assessment. This study focused on a comparison of forest habitat characteristics between representative reference stations considered to be located beyond direct influence of the smelter, and the exposed area south of the smelter. This information, along with general site observations, was used to determine if vegetation community characteristics and vegetation health were affected by the Belledune Smelter.

4.1 NEAR FIELD

Reference station 1 is situated in a disturbed area with limited woody species and ground cover, and dominated by early successional and non-native species. Stations closest to the smelter and along Highway 134 were determined to occupy lands that were previously cleared and disturbed to varying degrees, consisting of open areas with limited woody species, with the exception of plots 1-1 and 5-2. Near-field exposed stations contained more herbaceous ground cover than those of the reference sites however species assemblages were similar.

Plots along Transect 1 were disturbed, however the vegetation did not show any signs of stress and appeared to be healthy and similar in condition to the reference station plants. Disturbance to this area appeared to be recent ploughing after which the area was abandoned. Woody vegetation has yet to colonize large portions of this area due to the ploughing.

Plots along transect 5 show signs of stress and reduced vegetation health. Species such as star-flowered Solomon seal, rough-leaved goldenrod and pin cherry on Transect 5 exhibited dramatic departures from their natural form, as observed elsewhere within the study area and as described in reference manuals. Stunted growth, twig dieback and chlorosis were particularly evident in plot 5-1. Twig dieback is caused by damage to living bud tissue along the branches, and can be caused by a range of environmental factors. Chlorosis can be caused by lack of nutrients, metal toxicity or can be due to a lack of water. Stunted growth habits of some plants can be the result of lack of water or essential nutrients used for the building of tissue (Raven et al. 1992). Plot 5-1 is located approximately 500 m southwest of the smelter smoke stack and is in close proximity to the road and ocean. Confirmation of previous use of this area may also provide more insight into what is observed on site, such as whether this area may have been previously used as a temporary staging or stockpile area.

All other vegetation plots within the near field area of the smelter (plots 2-1, 3-1 and 4-1) are located within young to mid-aged forested communities which have been regenerating since harvesting for the past 35 to 45 years. These communities have well-defined canopy structure, and species diversity similar to the mixed forests identified within the reference location. Community structure, composition, stand size and diversity and canopy closure are similar to reference stations. These stations showed no signs of stress or reduced vegetation health.

4.2 FAR FIELD

The far-field plots of Transects 2, 3 and 4 were situated within mixed and deciduous forests. These forests are young and contain species that typically colonize after disturbance, such as the timber harvesting which occurred in the area some time ago. No obvious signs of vegetation stress were observed within the forested communities, even in close proximity to the smelter site. These plots exhibited community characteristics and vegetation health similar to conditions within reference plots 2 through 4. They contained a diversity of species, and had similar canopy densities and species composition. They do not seem to be affected by the Belledune Smelter.

5.0 CONCLUSION

The vegetation health study did not demonstrate a gradient of vegetation effects in the vicinity of the Belledune Smelter. Rather, only localized differences were observed in vegetation community characteristics and signs of health near the Belledune smelter. These observations were limited to Transects 1 and 5, which are located close to the highway. These areas are typically cleared (or were formerly cleared) near the road/sea frontage of the narrow rural properties that characterize the local area and occurred on the smelter site prior to its construction and operation.

In the near field, including all plots on Transects 1 and 5 and the nearest plots on Transects 2, 3 and 4 (i.e., 2-1, 3-1 and 4-1), only the Transect 1 and 5 plots differed in terms of vegetation community characteristics from the reference plots. The proximal plots on Transects 2, 3 and 4 were located within wooded vegetation communities that were similar to the reference plot communities and showed no overt signs of vegetation stress. Transect 1 plots showed no sign of stress, but the vegetation differed from reference conditions because Transect 1 extends across the cultural meadows of the cleared ends of a number of narrow former agricultural properties. Transect 5 similarly occupies the frontage of several former agricultural properties that appear to have been cleared in the past. However, the signs of vegetative stress along Transect 5 indicated other potential contributing factors may be differentially affecting plant health in that area, such as:

- General site disturbance and/or possible former use of the area as a stockpile for concentrate, slag or other materials;

- Dust and emissions deposition migration southward across the highway from the smelter site;
- Dust deposition from the transport road and slag disposal area;
- Seasonal drought-induced stress due to artificial drainage of the site;
- Salt spray from the highway;
- Soil nutrient deficiencies; and,
- Emissions from the upwind coal-fired power plant.

Confirmation of the existence, relevance and magnitude of these possible stressors was beyond the scope of the vegetation health study and would need to be addressed separately. Any, all or a combination of these factors could contribute to physical and chemical conditions leading to the observed signs of vegetative stress.

All of the far field plots, on Transects 2, 3 and 4, revealed vegetation community characteristics similar to reference plots and without sign of vegetative stress. As stated above, the study did not reveal a gradient of effect on vegetation radiating from the smelter. Only the observations of plant stress along Transect 5 were indicative of vegetation health effects, but a number of site-specific factors could be involved.

6.0 REFERENCES

ADITI Consultants LTD., 2006. Forest Management Recommendations WMR-06-NSH-261. New Brunswick.

Hinds, H.R. 2000. Flora of New Brunswick. Second Edition. University of New Brunswick, Fredericton, New Brunswick. 459pp.

Newcomb, L. 1977. *Newcomb's Wildflower Guide*. Little, Brown and Company. Boston, Massachusetts. 490 pp.

APPENDIX A
VASCULAR PLANT CHECKLIST

Scientific Name	Common Name	Nom Commun Français
Abies balsamea	balsam fir	Sapin baumier
Acer pensylvanicum	striped maple	Érable de Pennsylvanie
Acer rubrum	red maple	Érable rouge
Acer saccharum var. saccharum	sugar maple	Érable à sucre
Acer spicatum	mountain maple	Érable à épis
Actaea rubra	red baneberry	Actée rouge
Agrostis gigantea	red-top	Agrostide blanche
Agrostis stolonifera	redtop	Agrostide stolonifère
Amelanchier laevis	smooth juneberry	Amélanchier glabre
Amelanchier sp.	juneberry	Amélanchier
Amelanchier sanguinea	roundleaf juneberry	Amélanchier sanguin
Apocynum androsaemifolium ssp. androsaemifolium	spreading dogbane	Apocyn à feuilles d'Androsème
Aralia nudicaulis	wild sarsaparilla	Aralie à tige nue
Aralia racemosa ssp. racemosa	spikenard	Aralie à grappes
Artemisia vulgaris	common mugwort	Armoise vulgaire
Symphyotrichum cordifolium	heart-leaved aster	Aster à feuilles cordées
Aster laevis var. laevis	smooth blue aster	Aster lisse
Aster umbellatus var. umbellatus	flat-top white aster	Aster à ombelles
Betula papyrifera	white birch	Bouleau de Sandberg
Bromus inermis ssp. inermis	awnless brome	Brome inerme
Carex sp.	sedge	Carex
Centaurea nigra	black knapweed	Centaurée noire
Leucanthemum vulgare	ox-eye daisy	Marguerite blanche
Cirsium arvense	Canada thistle	Chardron du Canada
Clintonia borealis	bluebead-lily	Clintonie boréale
Convolvulus arvensis	field bindweed	Liseron des champs
Coptis trifolia	goldthread	Coptide trifoliolée
Cornus canadensis	bunchberry	Cornouiller du Canada
Corylus cornuta ssp. cornuta	beaked hazel	Noisetier à long bec
Cornus sericea ssp. sericea	red-osier dogwood	Cornouiller stolonifère
Crataegus monogyna	English hawthorn	Aubépine mongyne
Daucus carota	wild carrot	Carotte potagère
Diervilla lonicera	bush honeysuckle	Dièrville chèvrefeuille
Lycopodium digitatum	southern running-pine	Lycopode à massue
Dryopteris carthusiana	spinulose wood fern	Dryoptère spinuleuse
Dryopteris intermedia	evergreen wood fern	Dryoptère intermédiare
Elymus repens	quack grass	Chiendent rampante
Epipactis helleborine	common helleborine	Épipactus petit-helléborine
Equisetum arvense	field horsetail	Prêle littorale
Equisetum pratense	meadow horsetail	Prêle des prés
Erigeron annuus	daisy fleabane	Vergette rude
Euthamia graminifolia	flat-topped bushy goldenrod	Verge d'or
Chamerion angustifolium ssp. angustifolium	fireweed	Épilobe à feuille étroites
Fragaria virginiana ssp. virginiana	scarlet strawberry	Fraisier
Galium boreale	northern bedstraw	Gaillet boréal
Galium concinnum	shining bedstraw	Gaillet
Galium triflorum	sweet-scented bedstraw	Gaillet à trois fleurs
	Grass sp.	
Galeopsis tetrahit	common hemp-nettle	Galéopside à tige carée
Hieracium caespitosum	field hawkweed	Épervière des prés

Scientific Name	Common Name	Nom Commun Français
Hieracium sp.	hawkweed	Épervière
Hieracium lachenalii	Lachenal's hawkweed	Épervière de Lachenal
Hypericum perforatum	common St. John's-wort	Millepertuis perforé
Larix laricina	tamarack	Mélèze laricin
Linnaea borealis ssp. longiflora	twinflower	Linnée boreale
Linaria vulgaris	butter-and-eggs	Linaire vulgaire
Lonicera canadensis	american fly honeysuckle	Chevrefeuille du Canada
Lycopodium clavatum	running club-moss	Lycopode
Lycopodium dendroideum	prickly tree club-moss	Lycopode foncé
Maianthemum canadense	wild lily-of-the-valley	Maïanthème du Canada
Maianthemum stellatum	star-flowered Solomon's seal	Smilacine étoilée
Malus pumila	common apple	Pommier nain
Melilotus alba	white sweet-clover	Mélilot blanc
Medicago sativa ssp. falcata	alfalfa	Luzerne rustique
Mitella nuda	naked mitrewort	Mitrelle nue
Monotropa uniflora	Indian-pipe	Monotrope uniflore
Nemopanthus mucronatus	mountain-holly	Mitrelle nue
Oenothera biennis	common evening-primrose	Onagre
	orchid sp.	
Osmunda cinnamomea	cinnamon fern	Osmonde cannelle
Panicum sp.	panic grass sp.	Panic
Pastinaca sativa	wild parsnip	Panais sauvage
Phleum pratense	timothy	Phléole des prés
Picea glauca	white spruce	Épinette blanche
Picea rubens	red spruce	Épinette rouge
Pimpinella saxifraga	burnet saxifrage	Boucage petite
Chimaphila umbellata ssp. cisatlantica	common pipsissewa	Chimaphhille à ombelles
Platanthera hyperborea	tall leafy green orchis	Habénaire hyperboréale
Plantago major	common plantain	Plantain majeur
Poa compressa	Canada blue grass	Pâturin comprimé
Poa pratensis ssp. pratensis	Kentucky bluegrass	Pâturin des prés
Populus balsamifera ssp. balsamifera	balsam poplar	Peuplier baumier
Populus grandidentata	large-tooth aspen	Peuplier à grandes dents
Populus tremuloides	trembling aspen	Peuplier faux-tremble
Potentilla recta	rough-fruited cinquefoil	Potentille dressée
Prenanthes sp.	rattlesnake-root	Prenanthe
Prunus pensylvanica	pin cherry	Cerisier de Pennsylvanie
Prunus virginiana var. virginiana	choke cherry	Cerisier de Virginie
Prunella vulgaris ssp. lanceolata	heal-all	Prunelle vulgaire
Pteridium aquilinum var. latiusculum	eastern bracken-fern	Fougère d'aigle commune
Pyrola asarifolia	pink pyrola	Pyrole à feuilles d'asaret
Pyrola sp.	pyrola	Pyrole
Orthilia secunda	one-sided shinleaf	Pyrole unilatérale
Raphanus raphanistrum	wild radish	Radis sauvage
Ribes lacustre	swamp black currant	Gadellier lacustre
Ribes triste	wild red currant	Gadellier amer
Rosa carolina	swamp rose	Rosier de Caroline
Rubus idaeus ssp. strigosus	wild red raspberry	Framboisier
Rubus occidentalis	thimble-berry	Mûrier
Rubus pubescens	dwarf raspberry	Ronce pubescente
Rumex acetosa ssp. thyrsiflorus	sour dock	Rumex perit-oseille

Scientific Name	**Common Name**	**Nom Commun Français**
Salix bebbiana	long-beaked willow	Saule d Beschel
Sambucus racemosa var. racemosa	red-berried elderberry	Sureau rouge
Solidago canadensis	canada goldenrod	Verge d'or du Canada
Solidago flexicaulis	zig-zag goldenrod	Verge d'or zigzag
Solidago rugosa ssp. rugosa	rough goldenrod	Verge d'or de Beaudry
Sambucus canadensis	common elderberry	Sureau blanc
Sorbus americana	American mountain-ash	Sorbier d'Amérique
Sorbus decora	showy mountain-ash	Sorbier décoratif
Stachys tenuifolia	rough-hedge nettle	Épiaire à feuilles minces
Stellaria graminea	grass-leaved stitchwort	Stellaire à feuilles de graminées
Streptopus amplexifolius	clasping-leaved twisted-stalk	Streptope amplexicaule
Symphoricarpos albus	snowberry	Symphorine blanche
Taraxacum officinale	common dandelion	Pissenlit officinal
Thuja occidentalis	eastern white cedar	Cedre
Trientalis borealis ssp. borealis	star-flower	Trientale boréale
Trillium cernuum	nodding trillium	Trille penché
Trifolium pratense	red clover	Trèfle rouge
Tussilago farfara	coltsfoot	Tussilage pas d'âne
Uvularia grandiflora	large-flowered bellwort	Uvulaire grandiflore
Vaccinium myrtilloides	velvet-leaf blueberry	Airelle fausse-myrtille
Viburnum nudum var. cassinoides	northern wild raisin	Viorne cassinoïde
Vicia cracca	tufted vetch	Vesce jargeau
Viola sp.	violet	Viollette

APPENDIX L

BREEDING BIRD SURVEY

BELLEDUNE SMELTER BREEDING BIRD STUDY

BELLEDUNE, NEW BRUNSWICK

prepared for

INTRINSIK ENVIRONMENTAL SCIENCES

on behalf of

XSTRATA

by

LGL LIMITED
environmental research associates

JANUARY 2012
LGL PROJECT TA8048

BELLEDUNE SMELTER BREEDING BIRD STUDY

BELLEDUNE, NEW BRUNSWICK

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JANUARY 2012
LGL PROJECT TA8048

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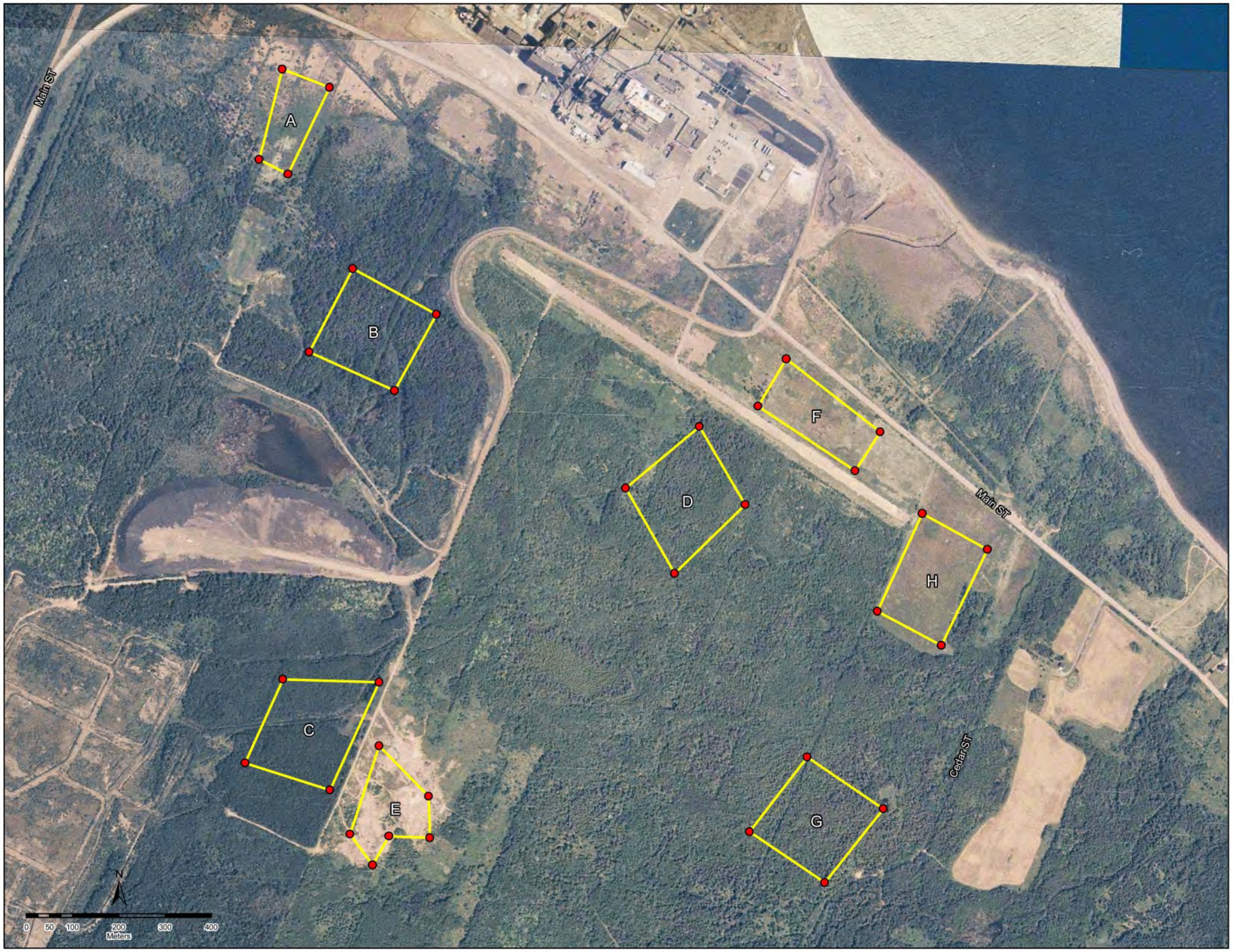
1.0 INTRODUCTION

LGL Limited (LGL) was retained by Intrinsik Environmental Sciences Inc. (Intrinsik) to qualitatively compare metrics of breeding success between the Belledune Smelter property, where soil concentrations of some metals are greater than Canadian Council of Ministers of the Environment ecological guidelines, to appropriately matched control areas. A companion ecological risk assessment study which is underway by Intrinsik had predicted that avifauna with high soil ingestion rates and/or soil-based insectivorous diets had an elevated exposure potential, and hence increased risk levels associated with lead and zinc within the study area. This breeding bird study was therefore commissioned to provide some supplemental biological data related to abundance and diversity, as well as fledgling evidence, of avifauna (particularly soil insectivores) within the study area relative to control areas.

The Belledune Smelter is located on the Bay of Chaleur (Baie du Chaleur) north of Bathurst, New Brunswick. The property extends south of the smelter and contains many naturalized areas including both meadow and forest habitats. Surveys were conducted on the south side of the property in areas that were identified in previous studies (see Intrinsik, 2012) as having either high or medium soil metal concentrations (hereafter referred to as high and medium exposure areas) and in a control area near Benjamin River, 25 kilometres to the west of the smelter, and without any known smelter-related influence.

2.0 METHODS

Survey plots were selected near the smelter in areas of potential medium (4 plots) and high exposure (4 plots) relative to a control area (6 plots) 25 km distant from the smelter. Areas of high and medium exposure were identified by Intrinsik. Each plot was approximately 200 m by 200 m although the dimensions varied somewhat to fit the plots into the available habitat. The average plot size was 3.6 hectares (ha), but areas ranged from 1.8 ha to 4.5 ha. Plots in all three exposure areas (i.e., medium, high, control) were established in two habitats: forest (7 plots) and meadow (7 plots). Plots on the Belledune Smelter property and at the control area near Benjamin River are shown on Figure 1 and Figure 2, respectively. Plots K and O are both meadow sites but appear on the image to be forested since both areas have only been cleared since the aerial photograph was taken.



LEGEND

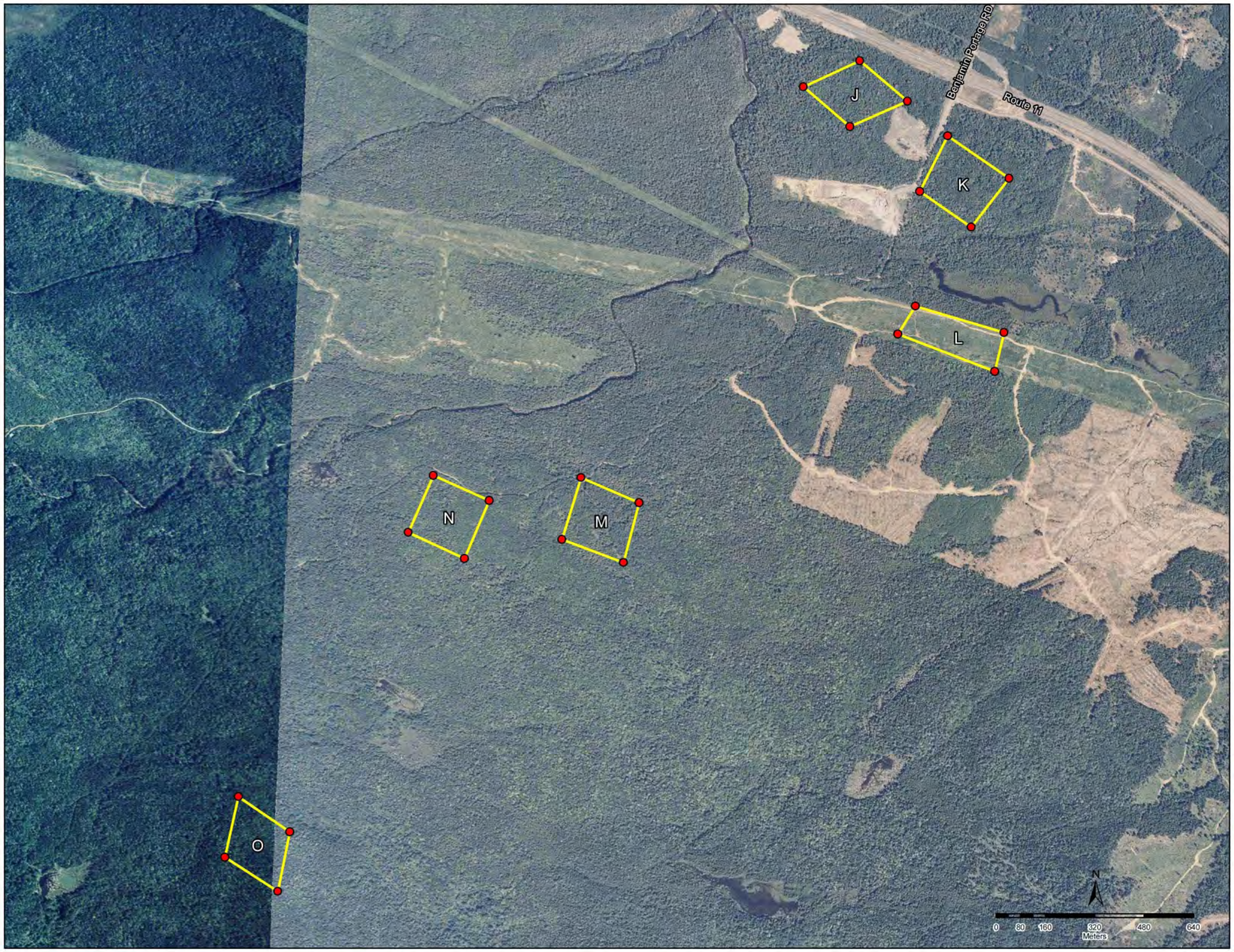
▨	Sample Plot
●	GPS Waypoints

Plot	Area (ha)	Habitat	Exposure
A	1.819	Meadow	High
B	3.981	Forest	High
C	4.358	Forest	Medium
D	4.185	Forest	High
E	2.407	Meadow	Medium
F	2.777	Meadow	High
G	4.009	Forest	Medium
H	3.664	Meadow	Medium

Belledune Smelter
Sample Plots

LGL LIMITED
environmental research associates

Project	TA8048	**Figure**	1
Date	November, 2011	**Prepared By:**	KC
Scale	1:8,000	**Verified By:**	ARD



LEGEND

🟨 Sample Plot
● GPS Waypoints

Plot	Area (ha)	Habitat	Exposure
J	3.672	Forest	Control
K	4.456	Meadow	Control
L	3.700	Meadow	Control
M	4.266	Forest	Control
N	4.053	Forest	Control
O	3.760	Meadow	Control

Belledune Smelter
Sample Plots (Control Sites)

LGL LIMITED
environmental research associates

Project	TA8048	**Figure**	2
Date	November, 2011	**Prepared By:**	KC
Scale	1:12,000	**Verified By:**	ARD

Breeding bird surveys were conducted during June 27 to 30, 2011. Each plot was surveyed within five hours of sunrise (which occurred at 5:27 a.m. on the survey dates). One observer (Andrew Davis, LGL) conducted wandering transects through the plot with the goal of covering the entire area of the plot and recorded all species observed and any evidence of breeding. Each plot survey took approximately 1.5 hours to complete (see Appendix C for survey times and weather conditions).

Breeding evidence was recorded using the protocols outlined in Bird Studies Canada's (2006) Breeding Bird Atlas. This protocol recognizes three levels of breeding evidence: possible, probable and confirmed. Species are considered to be possible breeders if they are observed in the correct habitat in the correct season, or if they are observed singing. Species are considered probable breeders if they are observed displaying behaviours that might indicate territoriality. These include the presence of a male / female pair, courtship displays (including copulation) and agitated behaviour or alarm calls in suitable nesting habitat. Species are considered to be confirmed breeders with nesting evidence, specifically: adults seen entering a nest, building a nest, carrying food to young, a nest found containing eggs or young or which was used in that season, observations of recently fledged young, or an adult engaged in a distraction display (Bird Studies Canada 2006).

Surveys specifically designed for confirmed breeders were conducted from July 20 to 25, 2011, where nests, nestlings and fledglings were the target of observers. The surveys to confirm breeding were done later in the season because nests are easier to find once there are young to feed in them and to ensure that later breeders were covered. Three of the original plots for which breeding birds surveys were conducted (Site E, medium exposure meadow; Site L, control meadow; and Site N control forest) were removed from this component of the study to allow more time to intensively survey the remaining sites for nests and fledglings. These plots were chosen for removal because they were most dissimilar in habitat to the other plots in their categories.

Nest searching methods included visual surveys, stick taps, rope drags, and nest pole inspections. In the stick-tap method, surveyors moved quietly and gently tap the outside of low, dense potential nest shrubs with a stick to temporarily flush incubating birds from their nests. Rope dragging is a method commonly used in open grassy habitat to flush birds while they are incubating eggs. Two observers walked with a rope between 15 to 20 m long stretched out between them, lightly dragging it across the tops of grassy vegetation. When done properly, this method safely and temporarily flushes incubating birds from nests that would otherwise have not been detectable, due to the incubating bird (usually the female) remaining motionless for long periods of time. A nest pole (a mirror attached to a telescoping rod) permitted the surveyors to examine the inside of nests in shrubs and trees within reach of the pole at full extension to determine if a nest found was currently active (had eggs or young) or potentially active earlier in the year.

Visual searches consisted of wandering transects through the plots, alertly scanning areas for nests or for nesting behaviour. Searching for nests consists of inspecting trees, shrubs, fallen woody debris or other potential nest habitat for nests of species observed in the area at the time of the survey, or earlier in the year during the breeding bird surveys. Knowing which species were present assists the surveyor to form a search image to narrow the search to a particular species' ideal nesting habitat. Surveyors also used behavioural cues to help locate nests, including birds taking repeated long flights to or from an area after foraging; birds carrying food or faecal sacs; and bird reluctance to leave an area upon surveyor approach. Finding nests using visual surveys is easiest during the nestling stage, due to the increased activity of both males and females, and often the loud begging calls of the young. Rope-drag and stick-tap methods are more effective at nest finding during the incubation stage. The nests of species known to use tree cavities to raise their young, such as woodpeckers, chickadees, wrens or nuthatches, were far less likely to be located as the survey took place later in the nesting season.

The location of each active nest found, or a nest whose level of wear or materials found within the nest suggested activity, was recorded by GPS and photographed. The number of eggs or young, the approximate above-ground height, the plant species the nest was found in, and (when possible) the bird species that constructed the nest, were recorded. After a nest is no longer actively holding young, it is often possible to determine the species that constructed and occupied it by examining the nest size and location, and the materials comprising the base, cup, and lining.

3.0 RESULTS

Seven plots were established in meadow habitats: two in areas of high metals exposure (Plots A and F), two in areas with medium exposure (Plots E and H) and three in control areas (Plots K, L and O). The meadow habitats were varied and included grassy fields, shrubby fields, a hydro corridor and two regenerating clear-cuts. Seven plots were also established in forest habitats: 2 in high metals exposure (Plots B and D), 2 in medium exposure (Plots C and G) and 3 control sites (Plots J, M and N). These plots were generally less varied in their habitats than the meadow plots, have similar structure and in most cases similar vegetation community species composition. Habitat descriptions for each plot can be found in Appendix A. The area surveyed was 51.1 hectares overall covering 28.5 h of forest and 22.6 h of meadow habitats (Table 1).

Table 1. Number of survey plots and total areas (in hectares) by habitat type and exposure level.

	Forest		**Meadow**		**Total**	
Control	3 plots	12.0 ha	3 plots	11.9 ha	6 plots	23.9 ha
Medium Exposure	2 plots	8.4 ha	2 plots	6.1 ha	4 plots	14.4 ha
High Exposure	2 plots	8.2 ha	2 plots	4.6 ha	4 plots	12.8 ha
Total	7 plots	28.5 ha	7 plots	22.6 ha	14 plots	51.1 ha

3.1 SPECIES RICHNESS

The June breeding bird surveys recorded 44 species. Species richness was higher in forest habitats (33 species) than in meadow habitats (23 species). The average number of species per plot was 12.7 for forest habitats compared to 8.4 for meadow habitats. For forested habitats, species richness tended to be somewhat higher on control plots than plots with high or medium exposure to metals (average of 14.3 species/control plot compared to 11.0 species/medium exposure plot and 12.0 species/high exposure plot). There was no clear trend for meadow habitats (average of 9.0 species/control plot compared to 6.5 species/medium exposure plot and 9.5 species/high exposure plot). The meadow plots ranged from 5 species to 15 species but two plots were obvious outliers. These two plots, Site A (high exposure) and Site K (control) were both unusually shrubby compared to the other meadow sites and had 13 and 15 species, respectively.

3.2 SPECIES COMPOSITION

A total of 46 species were recorded during the surveys within the Study Area and control areas (Table 2). There were 14 species found in the control areas that were not found in the exposure areas. Three of these, Wilson’s Snipe, Mourning Warbler and Dark-eyed Junco were found only in the control meadow plots. The remaining eleven species (Yellow-bellied Sapsucker, Northern Flicker, Red-breasted Nuthatch, Winter Wren, Golden-crowned Kinglet, Brown Creeper, Hermit Thrush, Northern Parula, Blackburnian Warbler, Black-throated Green Warbler and Yellow-rumped Warbler) were only found in control forest plots. Eight species reported in the Study Area plots were not found in the control plots: Least Flycatcher, American Crow, Yellow Warbler, Canada Warbler, Northern Waterthrush, Rose-breasted Grosbeak, Chipping Sparrow and Savannah Sparrow. Canada Warbler was the only species at risk was observed in this study (ranked Threatened by COSEWIC, SARA Schedule 1), it was found in a medium exposure forest site.

Table 2. Number of territories and level of breeding evidence found for each species by habitat and exposure level.

Common Name	**Scientific Name**	**Meadow (# of territories, level of breeding evidence)**			**Forest (# of territories, level of breeding evidence)**		
		High n=2	**Medium n=2**	**Control n=3**	**High n=2**	**Medium n=2**	**Control n=3**
Ruffed Grouse	*Bonasa umbellus*				1, Possible		1, Confirmed
Wilson's Snipe	*Limnodromus griseus*			1, Possible			
Yellow-bellied Sapsucker	*Sphyrapicus varius*						2, Possible
Northern Flicker	*Colaptes auratus*						1, Possible
Yellow-bellied Flycatcher	*Empidonax flaviventris*					1, Possible	1, Possible
Alder Flycatcher	*Empidonax alnorum*	1, Possible	1, Possible	3, Possible			
Least Flycatcher	*Empidonax minimus*		1, Possible			3, Confirmed	
Red-eyed Vireo	*Vireo olivaceus*	1, Possible	1, Possible	1, Possible	7, Confirmed	5, Probable	7, Possible
American Crow	*Corvus brachyrhynchos*	1, Possible					
Black-capped Chickadee	*Poecile atricapillus*	1, Possible		1, Possible	1, Possible	1, Possible	1, Possible
Red-breasted Nuthatch	*Sitta canadensis*						2, Possible
Winter Wren	*Troglodytes troglodytes*						1, Possible
Golden-crowned Kinglet	*Regulus satrapa*						3, Possible
Brown Creeper	*Certhia americana*						1, Possible
Cedar Waxwing	*Bombycilla cedrorum*	3, Possible		2, Possible	1, Possible	2, Possible	
Swainson's Thrush	*Catharus ustulatus*				3, Confirmed	3, Probable	2, Confirmed
Hermit Thrush	*Catharus guttatus*						4, Possible
Veery	*Catharus fuscescens*	1, Possible		3, Possible	1, Possible	2, Possible	1, Confirmed
American Robin	*Turdus migratorius*	2, Possible	2, Possible	1, Possible	1, Confirmed	5, Confirmed	2, Probable
Tennessee Warbler	*Vermivora peregrina*	1, Possible		1, Possible	1, Possible	1, Possible	
Nashville Warbler	*Vermivora ruficapilla*		1, Possible	1, Possible	2, Possible	3, Possible	1, Possible
Northern Parula	*Parula americana*						4, Possible
Yellow Warbler	*Dendroica petechia*	1, Possible					
Blackburnian Warbler	*Dendroica fusca*						2, Possible
Chestnut-sided Warbler	*Dendroica pensylvanica*	1, Possible		6, Possible	1, Possible		2, Possible
Magnolia Warbler	*Dendroica magnolia*	1, Possible		2, Possible	3, Possible		5, Confirmed
Bay-breasted Warbler	*Dendroica castanea*				1, Possible	1, Possible	1, Confirmed
Black-throated Blue Warbler	*Dendroica caerulescens*				1, Confirmed	1, Possible	2, Possible
Black-throated Green Warbler	*Dendroica virens*						3, Possible
Yellow-rumped Warbler	*Dendroica coronata*						1, Possible
Black-and-White Warbler	*Mniotilta varia*			1, Possible	1, Possible		

Common Name	**Scientific Name**	**Meadow (# of territories, level of breeding evidence)**			**Forest (# of territories, level of breeding evidence)**		
		High n=2	**Medium n=2**	**Control n=3**	**High n=2**	**Medium n=2**	**Control n=3**
American Redstart	*Setophaga ruticilla*	1, Possible	1, Possible	2, Possible	6, Possible	1, Possible	2, Possible
Canada Warbler	*Wilsonia canadensis*					1, Possible	
Mourning Warbler	*Oporornis philadelphia*		1, Confirmed				
Ovenbird	*Seiurus aurocapillus*				3, Possible	4, Confirmed	11, Confirmed
Northern Waterthrush	*Seiurus noveboracensis*				1, Possible		
Common Yellowthroat	*Geothlyphis trichas*	1, Confirmed	1, Possible	4, Confirmed			
Rose-breasted Grosbeak	*Pheucticus ludovicianus*					2, Confirmed	
Lincoln's Sparrow	*Melospiza lincolnii*		2, Probable	2, Confirmed			
Song Sparrow	*Melospiza melodia*	4, Possible	5, Possible	1, Possible			
Chipping Sparrow	*Spizella passerina*		1, Possible				
Savannah Sparrow	*Passerculus sandwichensis*	1, Probable	2, Confirmed				
White-throated Sparrow	*Zonotrichia albicollis*	7, Confirmed		10, Confirmed	5, Probable	4, Confirmed	1, Possible
Dark-eyed Junco	*Junco hyemalis*			2, Possible			
Purple Finch	*Carpodacus purpureus*					1, Possible	1, Possible
American Goldfinch	*Carduelis tristis*		1, Probable	2, Probable			
Species		**16**	**13**	**19**	**18**	**18**	**27**
Territories		**28**	**20**	**46**	**40**	**41**	**65**

Notes:
High = high exposure area; Medium = medium exposure area; Control = low exposure area

Twelve of the species recorded feed primarily on terrestrial invertebrates during the breeding season. These species are Ruffed Grouse, Wilson's Snipe, Winter Wren, Ovenbird, Northern Waterthrush, Common Yellowthroat, Lincoln's Sparrow, Song Sparrow, Chipping Sparrow, White-throated Sparrow and Dark-eyed Junco. Wilson's Snipe, Winter Wren and Dark-eyed Junco were found only in the Control Area, while Northern Waterthrush, Chipping Sparrow and Savannah Sparrow were not found in the Control Area. The remaining six species were found both in the high and medium exposure plots and in the control plots. See Appendix B for a complete list of species observed along with a description of their feeding and nesting requirements.

3.3 BREEDING ACTIVITY

Breeding activity was surveyed in June and is quantified by the number of presumed breeding territories held in each plot and the level of breeding evidence observed. Across all 14 plots a total of 240 presumed breeding territories were recorded, an average of 17.1 territories per plot. The average number of territories found in each of the exposure levels was close to the overall average; 18.7 in the control plots, 15.0 in the medium exposure level plots and 17.0 in the high exposure level plots (Table 3). There was little difference between exposure levels in the forest habitats. The medium exposure plots in the meadow habitat had a lower average number of territories than the high exposure and the control plots: this is partly due to Plot A (high exposure) and Plot K (control) that had a different habitat structure and a higher number of territories than the other plot in their exposure level category.

Table 3. Average of number of presumed breeding territories per plot, by habitat and exposure level.

	Forest	Meadow	Total
Control	21.7	15.7	18.7
Medium Exposure	20.5	9.5	15.0
High Exposure	20.0	14.0	17.0
Average	20.6	13.3	17.1

The level of breeding evidence is based on observations from both the June and July surveys. The number of confirmed and probable breeding species was similar across the exposure levels for each habitat type (Table 4). There were more possible breeding species found in the control forests than in the medium or high exposure forests and there were fewer possible breeders found in the medium exposure meadows than in control or high exposure meadows.

Table 4. Number of species for which confirmed, probable or possible breeding evidence was observed, by habitat and exposure level.

	Forest			**Meadow**		
	Confirmed	**Probable**	**Possible**	**Confirmed**	**Probable**	**Possible**
Control	5	2	20	3	1	15
Medium Exposure	5	2	11	2	2	9
High Exposure	4	1	13	2	1	13

3.4 BREEDING SUCCESS

Surveys for breeding success were conducted in July when there was a greater chance of discovering fledged young. Evidence of breeding success included recently occupied nests, nests containing eggs, nests with nestlings and fledged young (Table 5).

Table 5. Number of recently occupied nests, nests with eggs, nestlings and fledglings found in forest and meadow habitats, by exposure level.

	Forest				**Meadow**			
	Nests	**Eggs**	**Nestlings**	**Fledglings**	**Nests**	**Eggs**	**Nestlings**	**Fledglings**
Control	4	1	0	4	0	0	2	5
Medium Exposure	6	10	0	4	0	0	5	0
High Exposure	5	0	0	3	0	4	0	5
Total	15	11	0	11	0	4	7	10

Recently occupied nests were found only in forest habitats. This was to be expected as nests are typically easier to find in forest habitats than in meadows. Where possible the nest building species was identified based on features of the nest such as size, shape, materials and positioning. Three of the nests were identified as American Robin nests, three were Red-eyed Vireo nests and there was one each of Swainson`s Thrush, Least Flycatcher, American Redstart, Magnolia Warbler and Black-throated Green Warbler. The remaining four nests were unidentified but were likely warblers.

Eggs were found in five nests, with a total of 15 eggs and an average of three per nest. One White-throated Sparrow nest containing four eggs was found in a high exposure meadow habitat and another containing four eggs was found in a medium exposure forest. An American Robin nest and a Least Flycatcher nest, each containing three eggs were found in a medium exposure forest. A Swainson`s Thrush nest containing one egg was found in a control forest site. There was a pair of Swainson`s Thrushes with a fledged young near this nest so it may be that the one egg in the nest was one that did not hatch and was no longer being incubated.

Seven nestlings were found in two nests, both in meadow habitats. One White-throated Sparrow nest containing two nestlings was found in the O plot (control meadow) and one Savannah Sparrow nest containing five nestlings was found in the H plot (medium exposure meadow).

Fledglings were found as often in forests (11 fledglings) as in meadows (10 fledglings). There was little difference in the number of fledglings between habitat types and exposure levels, with the exception of medium exposure meadows in which no fledglings were found. The fledglings of 13 species were observed (American Robin, Hermit Thrush, Swainson's Thrush, Northern Parula, Black-throated Blue Warbler, Chestnut-sided Warbler, Bay-breasted Warbler, Magnolia Warbler, American Redstart, Ovenbird, Common Yellowthroat, Song Sparrow and White-throated Sparrow). These species are primarily insectivores in the breeding season, though the American Robin and the two thrushes have a variable diet that includes many seeds and fruits as well. The most commonly found species (three individuals of each) were American Robin, Common Yellowthroat and White-throated Sparrow.

4.0 DISCUSSION

Overall, there was very little difference in metrics of breeding success observed between the Belledune Smelter property, including the high and medium metal exposure areas, and the control area. Evidence of successful breeding was observed throughout the control and exposure areas. The average number of presumed breeding territories per plot was similar for all exposure levels. In meadow habitats two plots that were dissimilar to the others selected (higher shrub cover) may have biased the data, resulting in higher numbers of territories in control and high exposure plots than in medium exposure plots. The number of confirmed, probable and possible breeding species was consistent across the exposure levels for each habitat type.

Surveys for eggs, nestlings and fledglings were conducted to determine whether species breeding in areas of high or medium exposure were able to successfully raise young. The survey effort and sample size was too low to calculate any quantitative measure of nesting success but the results did confirm that birds are able to fledge young in all exposure levels. In the forest habitat, there was no clear difference in the number of fledglings between the control and the medium and high exposure areas. Fledglings were observed in control and high exposure plots in the meadow category.

The ability of this study to discern differences between control and exposure areas was limited by two primary factors.

- Level of effort
    - A minimum of two site visits during June would have improved the ability to identify breeding territories.
    - More effort searching for nests and fledglings over a longer period would have increased the number of nests found.
- Habitat differences
    - The meadow plots were quite varied in habitat. Two of the plots in the control meadows and one of the plots in the high exposure area had greater shrub cover than many of the other meadow plots. This makes it difficult to discern whether observed differences are due to exposure or habitat
    - Structural differences in the vegetation could also impact the success of nest searching

Although this level of effort may be too low to provide conclusive quantitative evidence and habitat differences make interpretation a challenge, the study was able to provide strong qualitative and limited quantitative evidence of breeding throughout the study area.

Ground-feeding insectivores were a component of the Intrinsik ERA, and quantitative modelling results in the ERA suggested that these species may be at a level of unacceptable risk from exposure to metals at the Belledune site. Insectivorous ground feeders found in the Study Area included Ovenbird, Lincoln’s Sparrow, Song Sparrow, Savannah Sparrow, White-throated Sparrow and Dark-eyed Junco. Dark-eyed Junco, the surrogate receptor species that was used in the risk assessment to represent this feeding guild, was found on only one of the plots, a control meadow. Juncos prefer open-forest habitats or cut-over areas and many of the forest and meadow plots may have been either too dense or too open for them (Rising and Beadle 1996). Ovenbirds were found in high and medium exposure forests but were more abundant in the control plots. Lincoln’s, Song and Savannah Sparrows were found in similar numbers at all exposure levels. Fledgling White-throated Sparrows were found in a high exposure meadow and in a medium exposure forest and nestling Savannah Sparrows were found in a medium exposure meadow indicating that the ground feeding species are capable of producing young in these exposure areas.

5.0 CONCLUSION

The results of this study indicate that birds are establishing breeding territories in areas near the Belledune smelter with medium and high soil metals concentrations at similar density to unaffected (*i.e.*, control) areas. The elevated soil metals concentrations near the smelter compared to control areas are a source of potentially elevated exposure for the birds nesting in those areas. Nevertheless, based on observations made during the 2011 breeding season, birds near the Belledune smelter were successful in nesting, egg-laying and fledging young in numbers similar to those recorded in distant control areas. While there are some uncertainties in the findings of this study, related to habitat differences and observation duration periods, the data collected to date do not suggest the presence of significant concerns for breeding avifauna in areas near the smelter.

6.0 ACKNOWLEDGEMENTS

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7.0 REFERENCES

Bird Studies Canada. 2006. Maritimes Breeding Bird Atlas Guide for Atlassers. Maritimes Breeding Bird Atlas, Sackville, NB. 41 p. Online at: http://www.mba-aom.ca/english/mbbaguide.pdf

Intrinsik 2012. Ecological Risk Assessment of Off-Site Terrestrial and Freshwater Aquatic areas near the Xstrata Zinc lead smelter in Belledune NB. Final Report, in progress.

Rising, J.D. and D. D. Beadle. 1996. A Guide to the Identification and Natural History of the Sparrows of the United States and Canada. Academic Press. San Diego, USA. 362p.

APPENDIX A
HABITAT AND AREA OF EACH SURVEY PLOT

Appendix A. Habitat and area of each survey plot

Plot	Exposure	Area (Hectares)	Habitat Description
A	High	1.819	**Meadow** – open shrubby field, mostly very thick dogwood (*Cornus* sp.), 1.5 m tall; interspersed with grassy areas
B	High	3.981	**Forest** – dense forest; stands of cedar, birch / red maple, creek running through west side.
C	Medium	4.358	**Forest** – birch/poplar/maple with open sub-canopy; lots of elderberry in understory
D	High	4.185	**Forest** – very dense spruce forest with no understory or ground cover, mixed with some areas of birch and maple with moderate understory
E	Medium	2.407	**Meadow** – old gravel pit, some patches of shrubs, some areas with little cover.
F	High	2.777	**Meadow** – open grassy field with a few small shrubs and 4 rows of planted jack pine.
G	Medium	4.009	**Forest** – fairly open and uniform cedar swamp, some areas with much understory and ground cover
H	Medium	3.664	**Meadow** – open field with scattered dogwood shrubs; ground cover mostly bedstraw (*Galium* sp.)
J	Control	3.672	**Forest** – dense canopy predominantly of fir and cedar, little understory or ground cover; some wet depressions
K	Control	4.458	**Meadow** – regenerating clearcuts, dense shrubs and small trees throughout site.
L	Control	3.700	**Meadow** – powerline cut therefore very open site; ground cover bracken and blueberry, some grassy patches, small area of alder swamp at east end.
M	Control	4.268	**Forest** – high canopy of fir and poplar, well developed sub-canopy and understory. Wet forest along east and south sides.
N	Control	4.053	**Forest** – fairly open; fir and red maple, some birch; little sub-canopy, moderate ground cover.
O	Control	3.760	**Meadow** – regenerating clearcuts, low shrubs dominate, lots of slash present

APPENDIX B
SPECIES RECORDED

Appendix B: Species recorded in the Belledune Breeding Bird Surveys, with notes on nesting habitat and feeding habits.

Common Name	Scientific Name	Breeding Evidence	Nesting Habitat	Feeding Habits	Reference
Ruffed Grouse	*Bonansa umbellus*	Confirmed	Ground nester, prefers open hardwood stands	Primarily plants, esp. aspen buds, some invertebrates	Rusch et al. (2000)
Wilson's Snipe	*Gallinago delicata*	Possible	Open habitats, nest in wet areas very close to water	Plants and insect larvae, feeds by probing soil	Mueller (1999)
Yellow-bellied Sapsucker	*Sphyrapicus varius*	Confirmed	Cavity nester, early-successional species	Creates small holes in trees to drink sap from and to feed on insects that come to the sap	Walters et al. (2002)
Northern Flicker	*Colaptes auratus*	Possible	Cavity nester, prefers aspen. Open forest.	Primarily a ground feeder. Eats insects, mostly ants.	Wiebe and Moore (2008)
Yellow-bellied Flycatcher	*Empidonax flaviventris*	Possible	Prefers cool, heavily vegetated forests, nest on or near ground	Primarily aerial forager. Flying insects	Gross and Lowther (2001)
Alder Flycatcher	*Empidonax alnorum*	Probable	Shrubby wetlands or thickets. Nests in low bushes.	Catches flying insects or gleans from trees	Lowther (1999)
Least Flycatcher	*Empidonax minimus*	Confirmed	Nest in crook of small tree or sapling, deciduous	Aerial forager for flying insects.	Tarof and Briskie (2008)
Red-eyed Vireo	*Vireo olivaceus*	Probable	Nest in deciduous trees or shrubs	Insects esp. caterpillars, feeds high in trees	Cimprich et al. (2000)
American Crow	*Corvus brachyrhynchos*	Possible	Nests in trees, usually near trunk	Extremely variable, opportunistic	Verbeek and Caffery (2002)
Black-capped Chickadee	*Poecile atricapilla*	Probable	Cavity nester, typically dead snags	Seeds and invertebrates	Smith (1993)
Red-breasted Nuthatch	*Sitta canadensis*	Probable	Excavates cavity, usually in aspen or conifers	Arboreal insects. Forages primarily on trunks and branches of conifers	Ghalambor and Martin (1999)

Common Name	**Scientific Name**	**Breeding Evidence**	**Nesting Habitat**	**Feeding Habits**	**Reference**
Brown Creeper	*Certhia americana*	Possible	Prefers dense forest, nest made behind loose bark on trunk	Arboreal insects. Forages on trunks of live trees	Hejl et al. (2002)
Winter Wren	*Troglodytes troglodytes*	Probable	Variable nest sites, cavities or domed structure, conifers	Invertebrates. Feeds on or near ground, and in understory	Hejl et al. (2002)
Golden-crowned Kinglet	*Regulus satrapa*	Probable	Nests high in conifers.	Small invertebrates gleaned from conifers	Ingold and Galati (1997)
Veery	*Catharus fuscescens*	Possible	Typically in wet deciduous woods. Nests on or near ground	Feeds primarily on ground, sometimes in understory	Bevier et al. (2005)
Swainson's Thrush	*Catharus ustulatus*	Probable	Forests, predominantly conifer with closed canopies	Variable. Feed on ground and in understory.	Mack and Yong (2000)
Hermit Thrush	*Catharus guttatus*	Confirmed	Ground nester, under conifer or in thickets	Variable. Feeds on ground and in understory.	Jones and Donovan (1996)
American Robin	*Turdus migratorius*	Probable	Variable nest site, usually in trees	Earthworms, insects, and fruits. Ground and trees.	Sallabanks and James (1999)
Cedar Waxwing	*Bombycilla cedrorum*	Possible	Trees, edge of wooded areas	Fleshy fruits, some insects	Witmer et al. (1997)
Tennessee Warbler	*Vermivora peregrina*	Possible	Ground nester, in sphagnum or base of shrub	Insects, primarily lepidoptera larva, also spruce budworm	Rimmer and Mcfarland (1998)
Nashville Warbler	*Vermivora ruficapilla*	Confirmed	Nests on ground, under bushes, grasses or logs	Insects, feeds at tips of branches, hardwoods	Williams (1996)
Northern Parula	*Parula americana*	Probable	Nests in hanging epiphytes, usually *Usnea* spp. lichens	Insects and spiders. Mid to upper canopy, tips of branches	Moldenhauer and Regelski (1996)
Chestnut-sided Warbler	*Dendroica pensylvanica*	Possible	Shrubby understory, close to ground	Insects, feeds on under-sides of leaves, second-growth deciduous habitat	Richardson and Brauning (1995)

Common Name	**Scientific Name**	**Breeding Evidence**	**Nesting Habitat**	**Feeding Habits**	**Reference**
Magnolia Warbler	*Dendroica magnolia*	Confirmed	Nest in low trees, dense coniferous vegetation	Insects, mostly caterpillars. Mid-canopy gleaning	Dunn and Hall (2010)
Black-throated Blue Warbler	*Dendroica caerulescens*	Probable	Large tracts of undisturbed hardwood or mixed forest, nest in shrubs	Insects, esp. lepidoptera and diptera. Feeds in lower to mid levels.	Holmes et al. (2005)
Blackburnian Warbler	*Dendroica fusca*	Possible	Nests primarily in conifers, variable height	Insects, gleans high in trees, conifer or deciduous	Morse (2004)
Yellow-rumped Warbler	*Dendroica coronata*	Confirmed	Nests in conifers, variable heights	Mostly insects, forages in conifers, also aerial sallies	Hunt and Flaspohler (1998)
Black-throated Green Warbler	*Dendroica virens*	Possible	Predominantly deciduous forest, tree nesters	Insects, especially caterpillars	Morse and Poole (2005)
Bay-breasted Warbler	*Dendroica castenea*	Possible	Nest typically in dense spruce, near trunk	Insects, feeds in mid-level of conifers	Williams (1996)
Black-and-White Warbler	*Mniotilta varia*	Probable	Ground nester, deciduous or mixed woods	Mostly caterpillars, other insects, feeds along trunk and branches	Kricher (1995)
American Redstart	*Setophaga ruticilla*	Probable	Deciduous trees or shrubs, near trunk	Mostly insects, variable foraging	Sherry and Holmes (1997)
Ovenbird	*Seiurus aurocapillus*	Probable	Domed oven-shaped nest built on ground	Forest invertebrates taken from leaf litter	Van Horn and Donovan (1994)
Northern Waterthrush	*Seiurus novaboracensis*	Probable	Nests in cavities of roots systems or along stream banks	Insects picked from ground or shallow pools	Eaton (1995)
Mourning Warbler	*Oporornis philadelphia*	Possible	Clearings, on or near ground in dense cover	Insects, gleans from branches of shrubs	Pitocchelli (1993)
Common Yellowthroat	*Geothlypis trichas*	Confirmed	Nests on or near ground in dense vegetation	Insects, feeds on ground or in low vegetation	Guzy and Ritchison (1999)

Common Name	**Scientific Name**	**Breeding Evidence**	**Nesting Habitat**	**Feeding Habits**	**Reference**
Canada Warbler	*Wilsonia canadensis*	Possible	Nest on or near ground, usually cool, mixed woods with complex understory	Mostly takes flying insects, also some spiders and larva	Reitsma et al. (2010)
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	Possible	Variable nest sites, usually deciduous trees or shrubs	Invertebrates, fruits and seeds. Canopy of hardwood forests	Wyatt and Francis (2002)
Chipping Sparrow	*Spizella passerina*	Possible	Nests in trees or shrubs, prefers conifers	Ground feeder, mostly seeds, some insects	Middleton (1998)
Song Sparrow	*Melospiza melodia*	Possible	Nest on or near ground, various habitats	Feeds in vegetation and on ground. Insects, some seeds	Acrese et al. (2002)
Savannah Sparrow	*Passerculus sandwichensis*	Confirmed	Nests on ground, grassy and densely vegetated habitats	Feeds on ground and short vegetation, mostly insects in breeding season.	Wheelright and Rising (2008)
Lincoln's Sparrow	*Melospiza lincolnii*	Probable	Nests on ground, wet areas with dense sedges	Ground feeder, mostly insects, some seeds	Ammon (1995)
White-throated Sparrow	*Zonotrichia albicollis*	Confirmed	Nests on or just above ground, forest edges	Primarily ground feeder but also on vegetation	Falls and Kopachena (2010)
Dark-eyed Junco	*Junco hyemalis*	Confirmed	Nest on ground, cavity under roots or bank	Ground feeder, seeds and insects.	Nolan et al. (2002)
Purple Finch	*Carpodacus purpureus*	Probable	Branch of conifer	Buds, seeds, flower nectar	Wootton (1996)
American Goldfinch	*Carduelis tristis*	Confirmed	Prefers early successional growth, avoids mature forest	Seeds of herbs, especially Compositeae and various trees	McGraw and Middleton (2009)

References

Arcese, Peter, Mark K. Sogge, Amy B. Marr and Michael A. Patten. 2002. Song Sparrow (Melospiza melodia), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/704 doi:10.2173/bna.704

Ammon, Elisabeth M. 1995. Lincoln's Sparrow (Melospiza lincolnii), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/191 doi:10.2173/bna.191

Bevier, Louis R., Alan F. Poole and William Moskoff. 2005. Veery (Catharus fuscescens), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/142 doi:10.2173/bna.142

Cimprich, David A., Frank R. Moore and Michael P. Guilfoyle. 2000. Red-eyed Vireo (Vireo olivaceus), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/527 doi:10.2173/bna.527

Dunn, Erica and George A. Hall. 2010. Magnolia Warbler (Dendroica magnolia), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/136 doi:10.2173/bna.136

Eaton, Stephen W. 1995. Northern Waterthrush (Seiurus noveboracensis), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/182 doi:10.2173/bna.182

Ghalambor, Cameron K. and Thomas E. Martin. 1999. Red-breasted Nuthatch (Sitta canadensis), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/459 doi:10.2173/bna.459

Gross, Douglas A. and Peter E. Lowther. 2001. Yellow-bellied Flycatcher (Empidonax flaviventris), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/566 doi:10.2173/bna.566

Guzy, Michael J. and Gary Ritchison. 1999. Common Yellowthroat (Geothlypis trichas), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/448 doi:10.2173/bna.448

Hejl, Sallie J., Jennifer A. Holmes and Donald E. Kroodsma. 2002. Winter Wren (Troglodytes troglodytes), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/623 doi:10.2173/bna.623

Hejl, S. J., K. R. Newlon, M. E. Mcfadzen, J. S. Young and C. K. Ghalambor. 2002. Brown Creeper (Certhia americana), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/669 doi:10.2173/bna.669

Holmes, Richard T., N. L. Rodenhouse and T. S. Sillett. 2005. Black-throated Blue Warbler (Dendroica caerulescens), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/087 doi:10.2173/bna.87

Hunt, P. D. and David J. Flaspohler. 1998. Yellow-rumped Warbler (Dendroica coronata), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/376 doi:10.2173/bna.376

Ingold, James L. and Robert Galati. 1997. Golden-crowned Kinglet (Regulus satrapa), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/301 doi:10.2173/bna.301

Jones, Peter W. and Therese M. Donovan. 1996. Hermit Thrush (Catharus guttatus), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/261 doi:10.2173/bna.261

Kricher, John C. 1995. Black-and-white Warbler (Mniotilta varia), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/158 doi:10.2173/bna.158

Lowther, Peter E. 1999. Alder Flycatcher (Empidonax alnorum), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/446 doi:10.2173/bna.446

McGraw, Kevin J. and Alex L. Middleton. 2009. American Goldfinch (Carduelis tristis), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/080 doi:10.2173/bna.80

Mack, Diane Evans and Wang Yong. 2000. Swainson's Thrush (Catharus ustulatus), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/540 doi:10.2173/bna.540

Moldenhauer, Ralph R. and Daniel J. Regelski. 1996. Northern Parula (Parula americana), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/215 doi:10.2173/bna.215

Morse, Douglass H. and Alan F. Poole. 2005. Black-throated Green Warbler (Dendroica virens), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/055 doi:10.2173/bna.55

Mueller, Helmut. 1999. Wilson's Snipe (Gallinago delicata), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/417 doi:10.2173/bna.417

Pitocchelli, Jay. 1993. Mourning Warbler (Oporornis philadelphia), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/072 doi:10.2173/bna.72

Richardson, Michael and Daniel W. Brauning. 1995. Chestnut-sided Warbler (Dendroica pensylvanica), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/190 doi:10.2173/bna.190

Rimmer, Christopher C. and Kent P. Mcfarland. 1998. Tennessee Warbler (Vermivora peregrina), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/350 doi:10.2173/bna.350

Reitsma, Len, Marissa Goodnow, Michael T. Hallworth and Courtney J. Conway. 2010. Canada Warbler (Wilsonia canadensis), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/421 doi:10.2173/bna.421

Rusch, Donald H., Stephen Destefano, Michael C. Reynolds and David Lauten. 2000. Ruffed Grouse (Bonasa umbellus), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/515 doi:10.2173/bna.515

Sallabanks, Rex and Frances C. James. 1999. American Robin (Turdus migratorius), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/462 doi:10.2173/bna.462

Sherry, Thomas W. and Richard T. Holmes. 1997. American Redstart (Setophaga ruticilla), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/277 doi:10.2173/bna.277

Smith, Susan M. 1993. Black-capped Chickadee (Poecile atricapillus), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/039 doi:10.2173/bna.39

Tarof, Scott and James V. Briskie. 2008. Least Flycatcher (Empidonax minimus), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/099 doi:10.2173/bna.99

Tarvin, Keith A. and Glen E. Woolfenden. 1999. Blue Jay (Cyanocitta cristata), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/469 doi:10.2173/bna.469

Van Horn, M. A. and T.M. Donovan. 1994. Ovenbird (Seiurus aurocapilla), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/088 doi:10.2173/bna.88

Verbeek, N. A. and C. Caffrey. 2002. American Crow (Corvus brachyrhynchos), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/647 doi:10.2173/bna.647

Walters, Eric L., Edward H. Miller and Peter E. Lowther. 2002. Yellow-bellied Sapsucker (Sphyrapicus varius), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/662 doi:10.2173/bna.662

Wheelwright, N. T. and J. D. Rising. 2008. Savannah Sparrow (Passerculus sandwichensis), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/045 doi:10.2173/bna.45

Wiebe, Karen L. and William S. Moore. 2008. Northern Flicker (Colaptes auratus), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/166a doi:10.2173/bna.166

Williams, Janet Mci. 1996. Bay-breasted Warbler (Dendroica castanea), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/206 doi:10.2173/bna.206

Williams, Janet Mci. 1996. Nashville Warbler (Vermivora ruficapilla), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/205 doi:10.2173/bna.205

Witmer, M. C., D. J. Mountjoy and L. Elliot. 1997. Cedar Waxwing (Bombycilla cedrorum), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/309 doi:10.2173/bna.309

Wootton, J. Timothy. 1996. Purple Finch (Carpodacus purpureus), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/208 doi:10.2173/bna.208

Wyatt, Valerie E. and Charles M. Francis. 2002. Rose-breasted Grosbeak (Pheucticus ludovicianus), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/692 doi:10.2173/bna.692

APPENDIX C
BREEDING BIRD SURVEY TIMES AND CONDITIONS

Appendix C: Breeding Bird Survey Times and Weather Conditions

Plot	**Date & Time**	**Wind**	**Cloud**	**Temperature**	**Precipitation**
A	June 27, 2011 5:10-6:25	nil	overcast	14 ºC	Rained before survey started
B	June 27, 2011 6:40-8:00	nil	overcast	15 ºC	Rained overnight
C	June 29, 2011 9:30-11:25	Beaufort 3-5	100% overcast	14 ºC	None
D	June 27, 2011 8:10-9:40	Beaufort 2	50% overcast	16 ºC	Rained overnight
E	June 29, 2011 8:35-9:20	Beaufort 3-4	100% overcast	14 ºC	None
F	June 27, 2011 9:45-11:00	Beaufort 4	sunny, clear	18 ºC	None
G	June 29, 2011 6:40-8:10	Beaufort 2	100% overcast	15 ºC	None
H	June 29, 2011 4:55-5:55	Beaufort 3-4	100% overcast	14 ºC	None
J	June 28, 2011 7:40-9:00	nil	clear	15 ºC	None
K	June 28, 2011 5:20-6:35	nil	clear	10 ºC	None
L	June 28, 2011 6:45-7:30	Beaufort 1	clear	14 ºC	None
M	June 30, 2011 5:26-6:45	nil	100% overcast	14 ºC	Light rain
N	June 30, 2011 7:00-8:10	nil	100% overcast	13 ºC	Mist
O	June 30, 2011 8:15-9:20	Beaufort 1	100% overcast	15 ºC	None

APPENDIX M

SMALL MAMMAL SURVEY

Contract No 30075 EA3351

Brunswick Smelter Ecological Risk Assessment
Belledune Small Mammals

2011 Report
Final

Prepared for

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Cover photos:

From left to right: Maple Leaf; Black-backed Gull (*Larus marinus*), Blue-spotted Salamander (*Ambystoma laterale*), dark phase Southern Red-backed Vole (*Myodes gabberi*). Photos © Janean Sharkey, Virgil Hawkes, and James Fenneman, LGL Limited.

EXECUTIVE SUMMARY

A small mammal trapping program in fall 2011 provided a preliminary assessment of the occurrence and distribution of small mammals living in the vicinity of the Brunswick Smelter in Belledune, New Brunswick. Small mammal trapping was conducted to provide data to data related to abundance and diversity, and metals loadings in small mammals within the study area, both of which provide further context for risk characterization. Small mammal trapping occurred in five high metal concentration areas (the study area) representing two different habitat types (shrub/meadow and mixed wood forest) and reference areas ~ 25 km northwest of the smelter for a period of three to seven nights. Soil samples were collected from all small mammal trapping sites to assess the metal concentrations of each trapping location. Five species of small mammal were trapped [(Northern Short-tailed Shrew (*Blarina brevicauda*), Common Shrew (*Sorex cinereus*), Meadow Vole (*Microtus pennsylvanicus*), Southern Red-backed Vole (*Myodes gapperi*), and Deer Mouse (*Peromyscus maniculatus*)]. Southern Red-backed Voles were the most frequently trapped mammal followed by Deer Mouse and Common Shrew. Morphometric data (i.e., mass, body length, tail length, hind foot length, and ear length), age class, and sex were recorded for trapped small mammals. Most small mammals trapped were sacrificed via cervical dislocation and kidney, liver, and whole body samples were analysed for metals.

The data collected provide a preliminary indication of the distribution and occurrence of small mammals in the study area. These data cannot be used to definitively assess whether the small mammal fauna differs relative to metal category or habitat type as data collected in fall 2011 were too few; however, they do provide supplementary data that can be used in the risk characterization. Where comparisons between sites having high metal levels and reference areas were possible, there were no apparent morphometric differences noted and all animals captured had an outward appearance of good health (i.e., there were no abnormalities or obvious signs of malnourishment observed). Effects related to metals exposures are not expected to manifest as physical malformations that affect the appearance of the small mammals. It is more likely that internal organs and bone would be affected, which required an assessment of renal edema using kidney to body weight ratios for trapped insectivorous small mammals. In addition, Intrinsik (2012) compared metal levels in small mammal liver and kidney (collected for this study) to tissue residue effects data from the scientific literature. Diet, physiology, metabolism, behaviour, home range size, and habitat selection of each species should be considered when assessing the overall risk to small mammals resulting from high metal concentrations. Some of these aspects are further discussed in Intrinsik (2012) Ecological Risk Assessment for the Brunswick Smelter, using data obtained from the literature. At present it appears that there is little evidence of impact to small mammals from elevated metal concentrations; however, additional sampling would reduce uncertainties in this assessment and would strengthen our conclusions.

ACKNOWLEDGEMENTS

This project was completed under contract to Intrinsik Environmental Sciences Inc. with technical assistance and direction from Christine Moore. Assistance was provided by the following individuals: Yves Guitard (Xstrata Zinc Canada) provided staff orientation, training and support, Mark Mullin (Xstrata Zinc Canada) assisted with laboratory arrangements and Lisa Marshall (Intrinsik Environmental Sciences Inc.) assisted with laboratory and shipping questions. Fred Wilkenson completed the nutrient soil analysis and Maxxam Analytics, Bedford, Nova Scotia provided the tissue and metals analysis. Virgil Hawkes was project manager while Jamie Fenneman and Janean Sharkey conducted the fall 2011 small mammal trapping, soil sampling and necropsy lab work. Robin Tamasi of LGL Limited provided GIS support.

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1 Introduction

The Brunswick Smelter operates a primary lead smelter with a nominal production capacity of 120,000 tonnes per annum. The plant commenced production in 1967 and was originally designed to process combined lead-zinc concentrate; thereby producing final products of both lead and zinc metals (Glasbergen et al. 2008). A zinc smelter was in operation for a short period and closed in 1972. In 1968, a sulphuric acid plant entered service, along with a phosphoric acid and diammonium phosphate fertilizer plant on an adjacent property to the west (this plant closed in 1996).

The smelter was converted to operate only as a lead smelter in 1972 and now processes lead concentrate, produced by the company's Brunswick #12 mine near Bathurst, New Brunswick, custom concentrates and other lead-bearing materials from a variety of other sources. The smelter produces refined lead, lead alloys, silver doré, sulphuric acid and refinery coproducts containing copper, antimony, bismuth and other impurities. The Brunswick #12 mine processes the ore that is mined on location near Bathurst, to a concentrate of approximately 50% lead, prior to delivering it to the smelter (Xstrata background information memo 2008).

A variety of metals are released into the air from the smelter. These metals are emitted into the atmosphere attached to other particulates, which are returned back to the surface by wet and dry deposition (Pilgrim and Hughes 1994). The soils surrounding the Belledune smelter show increased levels of certain metals compared to reference locations and soil quality guidelines, which may pose risks of accumulation in food webs and toxicologic effects on flora and fauna.

An Ecological Risk Assessment (ERA) is being conducted by Intrinsik Environmental Sciences (2012) on lands in the vicinity of the smelter to characterize potential risks to vegetation and wildlife using standard risk assessment methodologies. Preliminary risk modelling conducted as part of the ERA has identified potentially elevated risks to insectivorous small mammals in the vicinity of the smelter as a result of exposure to antimony, cadmium, lead, thallium and zinc. This elevated has been attributed to the modelled effects of elevated soil metals associated with areal deposition from smelter emissions that may increase the toxicity of insects and other invertebrates, which comprise a significant portion of the diet of insectivorous small mammals. Because the methods used to assess the risk to small mammal populations are predictive, and therefore theoretical, it was necessary to collect field data to reduce uncertainties associated with the model approach.

The biological effect on mammals from exposure to lead or cadmium is normally reflected initially by renal disorders and subsequently by more diverse histopathological changes at higher levels of intoxication (Johnson et al. 1978). Because soil is a major receptacle of chemical contaminants emitted from urban and industrial sources the impact of soil pollution on ecosystems can by studied by focusing on small mammals (Reinecke et al. 2000). Small mammals fulfill important functional and trophic roles in terrestrial systems. They have a widespread occurrence, have a limited home range, and are easily collected. Their small body size and high metabolic rate render them more susceptible to environmental contaminants than large mammals. This is especially true for carnivorous predators of soil invertebrates. Ground-living insectivorous small mammals, such as shrews, may therefore be vulnerable to environmental contaminants, especially metals, which accumulate in invertebrates.

The aim of this project was to collect biological data on the small mammals living in the vicinity of the Belledune smelter that could be correlated with toxicological and soils data to provide additional lines of evidence related to abundance and diversity, and metals loadings in small mammals within the study area to provide further context for risk characterization.

2 Background and Objectives

The objectives of this project were to collect data on small mammal populations to provide additional lines of evidence for the ERA related to abundance, diversity, morphometrics (e.g., body length, tail length, ear length, etc.), and general health and metals loadings in small mammals within the study area to provide further context for risk characterization. Soils were collected to assess metal and nutrient content, and, insects[1] were collected incidentally from pitfall traps to assess the availability of food resources.

3 Methods

3.1 Study Area

The Brunswick Smelter is located in Belledune, New Brunswick, which is located along the north shore of the Province, along the coastline of the Bay of Chaleur (Figure 1). Small mammal trapping occurred on five plots (i.e., the study area; two meadow and three forest, all high metal concentrations in the soil) in the vicinity (2 km) of the Xstrata Zinc – Brunswick Smelter and two reference plots (one forest, one meadow) located ~25 km northwest of the smelter, which are considered outside of the potential area of impact of smelter emissions. General sampling locations and risk polygons were provided by Intrinsik Environmental Sciences Inc. The soil metal concentrations associated with the study area and reference sites are based on mean concentrations of lead and other heavy metals found from previous soil analyses and were verified via soil sampling in fall 2011 (simultaneously with the small mammal trapping work). Sampling locations (study area and reference sites) are provided in Figure 2. Photos of the primary habitat associated with each sampling location are provided in Figure 3.

Figure 1. Distribution of small mammal trapping sites relative to Belledune, New Brunswick. Reference sites are approximately 25 km west of the study area.

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[1] Fall is not the optimal time of year to sample insects

Figure 2. **Distribution of plots sampled in the vicinity of the Belledune smelter (top) and reference site (bottom) in fall 2011.** Blue polygons in top panel represent areas of similar habitat types. Not all habitat blocks were sampled in 2011. Image © Google Earth 2011.

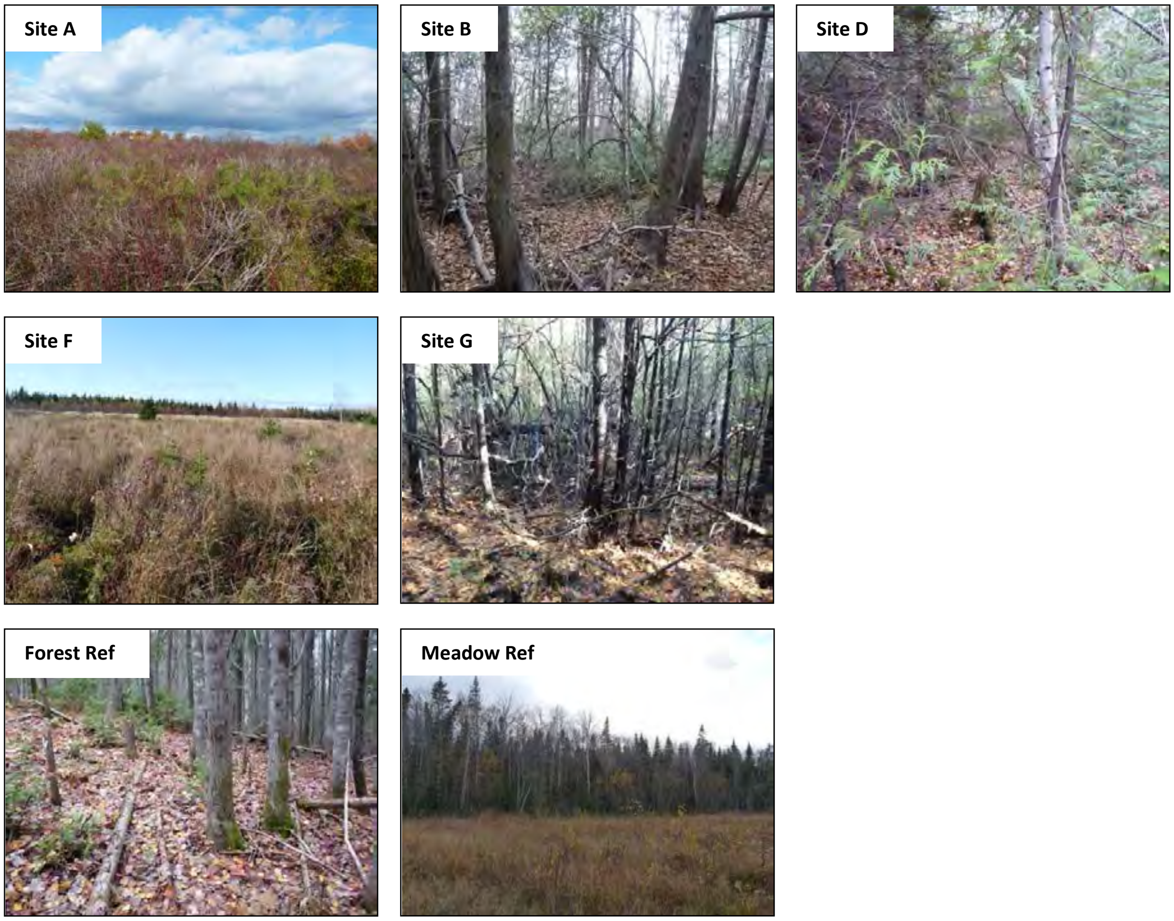

Figure 3. **Representative photos of each small mammal trapping plot sampled in fall 2011.** Sites A, B, D, F, and G comprise the study area. The forest ref and Meadow ref comprise the two reference sites.

3.2 Field Sampling

Small mammal trapping (see Section 3.4) occurred between 17 October and 24 October 2011. Potential small mammal species to be trapped during this period included Northern Short-tailed Shrew *(Blarina brevicauda),* Common Shrew *(Sorex cinereus),* Smoky Shrew *(Sorex fumeus),* Pygmy Shrew *(Sorex hoyi),* Water Shrew *(Sorex palustris),* Star-nosed Mole *(Condylura cristata),* Woodland Jumping Mouse *(Napaeozapus insignis),* Meadow Jumping Mouse *(Zapus hudsonius),* Southern Red-backed Vole *(Myodes gapperi),* Rock Vole *(Microtus chrotorrhinus),* Meadow Vole *(Microtus pennsylvanicus),* Deer Mouse *(Peromyscus maniculatus),* Northern Flying Squirrel *(Glaucomys sabrinus*), Eastern Chipmunk (*Tamias striatus),* Red Squirrel *(Tamiasciurus hudsonicus)* and Ermine *(Mustela erminea).*

Small mammal traps were placed in each of the seven plots (5 study area and 2 reference) using a standardized experimental unit that consisted of a 100 m^2 small mammal sampling grid and 5 pitfall cans placed 1.5 m apart from each other 100 m away from the sampling grid (Figure 4). Drift fences were used in association with the pitfall traps. This design was used to ensure that data collected within a given plot could be attributed to a given suite of plot characteristics.

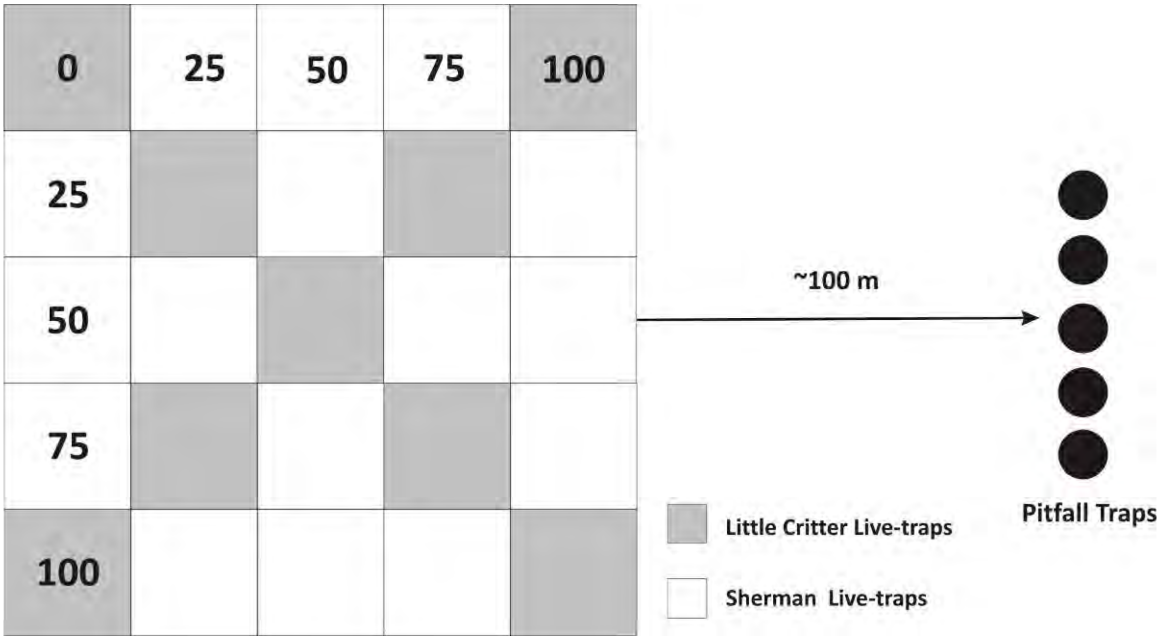

Figure 4. **Schematic of live-trap and pitfall trap set up used for each of the seven small mammal trapping sites.**

3.3 Site Selection

Sampling was performed at seven locations; five sites to the south of the smelter (i.e., the study area) and two reference sites (Figure 2 and Figure 3). The habitat blocks (Figure 2) to be sampled were selected prior to going into the field and the location of each small mammal trapping grid was determined in the field to ensure that each trapping grid was positioned within the dominant habitat of the polygon. The reference sites sampled in this study were the same as those used previously in vegetation and bird studies (Noel and Myler, 2010).

3.4 Small Mammal Trapping

Sherman and Little-Critter (Longworth style) live traps and pitfall traps were used to sample small mammals. Sherman and Little-Critter traps were baited with peanut butter and oats and raw cotton was placed in the traps to provide bedding material for captured small mammals. Pitfall traps (with drift fences) were used to target shrews (e.g., Common Shrew). Traps were checked once daily between the hours of 8:00 am and 4:30 pm and sites were generally checked in the same order each day so that the amount of time that a small mammal was potentially in a trap was the same between sites. All captured small mammals were identified to species, assigned to an age class (juvenile or adult), weighed to the nearest 0.1 gram (using a Pesola® scale), marked (guard hairs clipped with scissors) and sex was determined. Morphometric information such as ear length, hind-foot length, body length (i.e., snout-vent length), and tail length were recorded for all individuals captured.

To assess tissue metal levels we sacrificed all shrew species captured via cervical dislocation, which is considered an accepted humane euthanization technique for animals weighing <200 g (Mills et al., 1995). From 18 to 20 October only shrews were sacrificed; however, because the number of shrews being trapped per site was small (< 5) all small mammals captured from October 21 to October 24 were sacrificed to increase sample size. Specimens were collected in the field and stored in a zip-loc style freezer bag and placed in a cooler. At the end of each field day all collected specimens were transferred to a freezer until necropsies could be performed at the Xstrata Zinc laboratory on October 25 2011. All specimens were thawed before necropsies were performed.

3.5 Laboratory

The number of specimens retained for toxicological analyses depended on the total mass of organ tissue (kidney and liver) required for analysis, which was estimated at 1.0 g (wet weight) per sample. Estimating the approximate number of specimens per species that were required to satisfy the 1.0 g of tissue requirements was inferred from the literature. Hendriks et al. (1995) reported that the liver weight of *Sorex araneus* (Eurasian Shrew), ranged from 0.27 to 1.02 grams, which represents between 5.2 and 7.3% of the total body weight in this species (which ranges from 5 to 14 grams, a range similar to that of the species trapped during this investigation). This suggests that between 1 and 4 specimens of each *Sorex* species were required for one sample for liver tissue analysis. Because it is uncertain what the exact liver and kidney mass is in the expected species to be sampled, we proposed to collect organs from a minimum of 5 and a maximum of 15 individuals per species per plot.

Necropsies were performed at the Belledune Smelter - Xstrata Zinc laboratory. Specimens were kept frozen until the morning of the dissections. Morphometric data were recorded for all specimens and overall condition of body and organs was noted. The kidney and liver of each animal was removed, weighed separately and placed in a Nasco Whirl-Pac® bag. Samples were grouped based on organ type, species and site and each sample bag was labeled accordingly. If not enough tissue was available to satisfy the 1.0 g tissue detection limit then samples were combined based on similar taxon and diet, (i.e. seed-eating rodents livers were grouped together, Deer Mice and Red-backed Voles). Data from multiple sites were combined if the sites were from the same habitat type and risk polygon (e.g. high forest sites G and B). Shrew bodies were also used for whole body analysis. Tissues were then placed in a cooler, covered with loose ice and sent for homogenization of tissues and available metals analysis (3050B) at the following facility:

MAXXAM ANALYTICS
200 Bluewater Road, Suite 105
Bedford NS B4B 1G9
http://www.maxxam.ca

3.6 Soil Sampling

Twenty three soil samples were collected between 17 and 24 of October 2011 (Table 3). Soil samples were collected for nutrient analysis (*n* = 17) and for heavy metals analysis (*n* = 6). Soils collected for nutrient analysis and metal analysis were collected using slightly different methods. In both cases a composite sample was derived from multiple sub-samples; however, the depth from which soils were collected and the number of sub-samples used to derive the composite sample differed. In both cases soil samples were collected using a fence post digger and a stainless steel trowel that was rinsed with distilled water and dried with clean paper towels between sites.

Soils collected for heavy metals analysis were collected from each of the five study area sites and the forest reference site only. Soils were not collected from the meadow reference site because the soils at that site were very rocky and filled with debris such as asphalt, making them unsuitable for collection as outlined in the soil sampling protocol (Intrinsik Environmental Sciences Inc. 2009). For each composite sample, five sub-samples were collected a depth of 0 to 5 cm. Each sub-sample was homogenized into one sample after mixing in stainless steel container. The composite sample was transferred into a large (~1 litre) Ziploc® style bag and all leaf litter, vegetation, twigs and rocks were removed. The six composite soil samples were submitted for soil pH (soil: DI water); total organic carbon (LECO method) and available metals analysis (3050 B) to Maxxam Analytics.

Soils collected for nutrient sampling were collected using the same tools as described above. For each composite sample (*n* = 17), eight sub-samples were collected from a 10 x 10 m^2 plot (two from each 5 X 5m^2 quadrant of the 10 x 10 m^2) and homogenized into one sample and transferred to a large Ziploc® style bag following the procedures outlined above. Soil collected for nutrient analysis was collected from a depth of ~15 cm. The soils were submitted to an independent consultant, (Fred Wilkenson, Oakville, Ontario) for paste pH, organic matter and available nutrients (P, K, Mg, Ca, Na, Fe, Al, Mn, B, Cu, Zn and S) analysis. Results of the nutrient analysis are reported in Wilkinson (2012), within Intrinsik (2012).

3.7 Terrestrial Arthropod Sampling

Some terrestrial arthropods (i.e. insects, spiders), particularly carnivorous arthropods, have the potential to be used as a bioinidicators of heavy metal concentrations such as lead as they have the ability to cycle lead through their bodies from the soil (CCME, 1999). Terrestrial arthropods are an expected by-catch of the pitfall trapping efforts for small mammals. At the end of the trapping session arthropods were collected from the pitfall traps and placed in a Nasco Whirl-Pac® bag labeled with site and date. A small amount of alcohol was added as preservative and the specimens were kept cold or frozen.

3.8 Data analysis

Trapping data were standardized to the number of catches per 100 trap nights as a measure of relative abundance for each species adjusted for missed nights or non-functional traps (Nelson and Clark, 1973). Trap night totals were a function of trap status where traps that were functional and baited on the day of the check were attributed one trap night. Traps that were closed, missing bait, not functional for some other reason, or missing, were assigned 0.5 trap nights. Similarly, for traps that captured an animal, a value of 0.5 trap nights was assigned. The total number of small mammals captured per site is used as a measure of species richness. Diversity is also calculated and is a measure of community composition that combines both the number of species and their relative abundances and is not simply a reflection of the total number of species, or species richness (Hawkes and Tuttle, 2011). Similarity of abundance between species is a measure of evenness.

Shannon's entropy index (H), a measure of community composition combining both the number of species and their relative abundances (Legendre and Legendre, 1998), was applied to compute the diversity associated with each site. Shannon's entropy index (H) utilizes the proportional abundances (pi) of each species:

$$\mathbf{H = -\Sigma\ (pi\ log\ pi)}$$

A value of 0 means that the sampling unit contains only one species; H then increases along with the number of species recorded in the sampling unit. A high value of H means that many species were recorded.

The diversity value calculated by Shannon's Entropy index (H) does not indicate how the species are distributed within each plot. To determine the distribution of the species at each plot Pielou's evenness was computed (Pielou, 1966). This adds a measure of the evenness of the distribution of each species to the index of diversity. Pielou's evenness corresponds to:

$\mathbf{J=H/Hmax= (-\Sigma\ (pi\ log\ pi))/\ log\ q,}$ where q is species richness.

The more J tends towards 1, the more evenly the species are distributed, and conversely, a value of J close to zero means that one or more species are dominating the community (i.e., the distribution is uneven).

Using both diversity and evenness indices together provides insight into the composition of the communities, as well as the distribution of species within each plot. For example, the diversity of a plot could be high, but its evenness index low, suggesting that although the plot has a high diversity of species, one or two are dominating and the other species are rather infrequent in the plot (interspecific competition is high). However, the same high diversity index combined with a high evenness index would mean that the plot has a diversity of species that are equally frequent (interspecific competition is low).

Box plots were used to portray differences in body mass by species, sex and site. Box plots display the differences between groups of data without making any assumptions about their underlying statistical distributions and show their dispersion and skewness (Massart et al., 2005). Boxes represent between 25 per cent and 75 per cent of the ranked data. The horizontal line inside the box is the median. The length of the boxes is their interquartile range (Sokal and Rohlf, 1995). A small box indicates that most data are found around the median (small dispersion of the data). The opposite is true for a long box: the data are dispersed and not concentrated around the median. Whiskers are drawn from the top of the box to the largest observation within 1.5 interquartile range of the top, and from the bottom of the box to the smallest observation within 1.5 interquantile range of the bottom of the box.

4 Results

4.1 Site Descriptions

General site descriptions are provided below and additional information on vegetation species composition can be found in Noel and Myler (2010). Sites A, B, D, F, and G are collectively referred to as the study sites. The forest and meadow reference sites are referred to as the reference sites.

Site A

This is a previously-disturbed area with an abundance of deciduous shrubs, including mountain-ash (*Sorbus*), Red Raspberry (*Rubus idaeus*), cherries (*Prunus* sp.), Speckled Alder (*Alnus tenuifolia* ssp.*rugosa*), and Red-osier Dogwood (*Cornus stolonifera*). Stands of young Trembling Aspen (*Populus tremuloides*) are also present at the site.

Site B

This is a young mixed forest that is dominated by Balsam Fir (*Abies balsamea*), Paper Birch (*Betula papyrifera*), and spruces (*Picea* spp.) with a relatively open understory of elderberry (*Sambucus* sp.), Speckled Alder, and other deciduous shrubs, as well as young Eastern White-cedars (*Thuja occidentalis*).

Site D

This is a young mixed forest with stands of spruces and Paper Birch; some areas of young spruce were particularly densely forested, resulting in little available light at the forest floor. As a result, the understory was very poorly developed, with few deciduous shrubs.

Site F

This is a disturbed grassy meadow that is dominated by exotic grasses and weedy forbs such as Burnet-saxifrage. Occasional patches of Red Raspberry are scattered throughout the site.

Site G

This is a wet Eastern White-cedar swamp with saturated soils and numerous patches of standing water. The understory is patchily distributed, with willows (*Salix* spp.) and Red-osier Dogwood being the most common deciduous shrubs. This site is characterized by extensive blowdown of mature cedar trees.

Forest Reference

This is an older mixed forest with a diverse canopy that includes Red Maple (*Acer rubrum*), Sugar Maple (*Acer saccharum*), Balsam Fir, spruces, Paper Birch, and Trembling Aspen. The understory was relatively sparse but included species such as Red-osier Dogwood and Speckled Alder.

Meadow Reference

This is a heavily disturbed area with very little woody vegetation. It is characterized by an open, gravelly area that supports exotic grasses, introduced weeds, and occasional seedlings of Trembling Aspen, willow, and Balsam Poplar (*Populus balsamifera*). The peripheral areas supported young pole-stage Trembling Aspen.

The distribution of each polygon (site) is shown in Figure 2. Habitat polygons do not delineate discrete habitat types, but served as a guide for habitat-based studies. The forest reference site was older than the forests near the Belledune smelter and the meadow reference site is a heavily impacted site that should be replaced if future studies are conducted.

4.2 Small Mammals

Small mammal trapping occurred between 17 and 24 October 2011. Environmental conditions (measured at Bathurst) did not vary during the sampling period (Table 1) and can be generally described as mixed with periods of light rain. Total trapping effort varied by plot for a total of 1,242.5 trap nights (all trap types combined) and was largely a function of the total nights trapped per site (min = 119; max = 204; mean = 177.5 nights per site; Figure 5). The meadow reference plot had to be taken down early due to disturbance from human activity (camping); trapping occurred for only four nights with 1 capture made (n = 119 trap nights).

Table 1. **Summary of environmental conditions (measured at Bathurst, NB) for the period 17 to 24 October 2011.**

	Temperature (°C)					
Date	Max	Min	Mean	SD	RH (%)	Wind Speed (km/h)
17-Oct-11	11.9	4.0	7.3	2.4	85.4	8.8
18-Oct-11	12.5	3.9	7.2	3.1	80.7	6.2
19-Oct-11	12.6	3.0	7.2	3.3	80.2	8.1
20-Oct-11	9.0	5.8	8.3	0.7	95.3	15.0
21-Oct-11	14.5	6.0	10.6	2.3	89.1	7.8
22-Oct-11	13.7	4.1	9.1	3.0	85.7	4.6
23-Oct-11	13.4	7.4	9.5	2.0	79.3	5.0
24-Oct-11	11.2	5.6	7.8	1.7	83.4	0.3

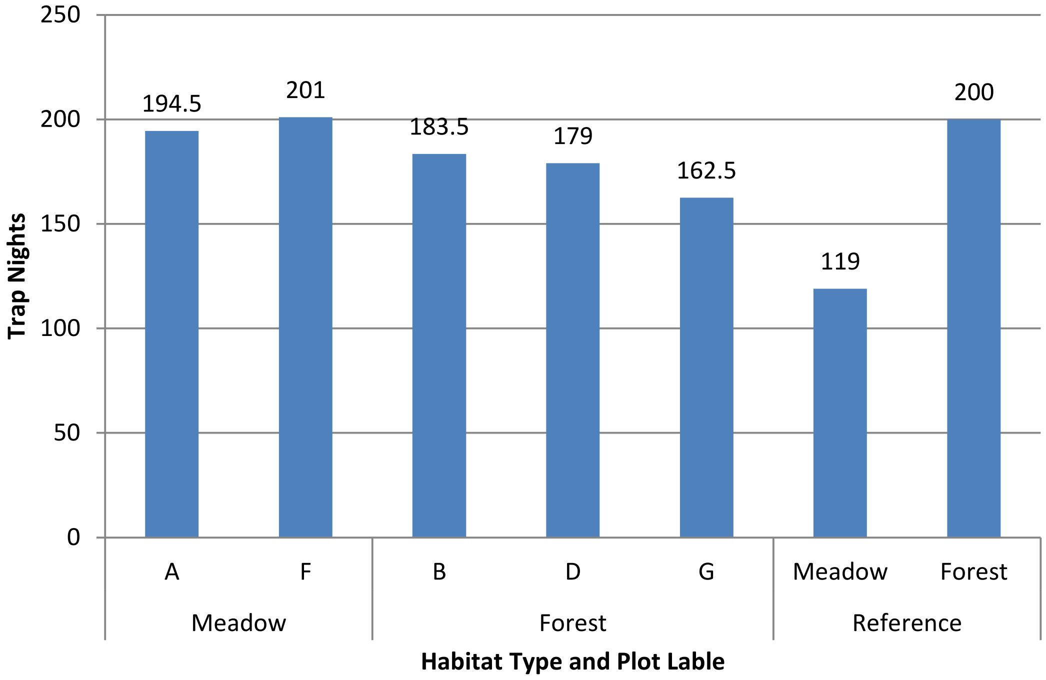

Figure 5. **Total trap nights per sampling location.**

A total of 48 mammal captures were made during the fall trapping sessions (Table 2). The trapping session yielded five species of mammal including Meadow Vole, Southern Red-backed Vole, Deer Mouse, Northern-short-tailed Shrew, and Common Shrew.

Table 2. **Mammal species captured at each plot during fall 2011 small mammal trapping surveys.**

			Number of Captures							
			Study Area					Reference		
Common Name	**Scientific Name**	**Species Code**	**A Meadow**	**B Forest**	**D Forest**	**F Meadow**	**G Forest**	**Meadow**	**Forest**	**Total**
Northern Short-tailed Shrew	*Blarina brevicauda*	BLBR				2	2			2
Common Shrew	*Sorex cinereus*	SOCI	2		3	2	2		1	8
Meadow Vole	*Microtus pennsylvanicus*	MIPE	3			1	1			4
Southern Red-backed Vole	*Myodes gapperi*	MYGA		4			6		14	24
Deer Mouse	*Peromyscus maniculatus*	PEMA	5	1		1	1	1	2	10
		Totals	**10**	**5**	**3**	**6**	**12**	**1**	**17**	**48**

The 48 mammal captures represented 40 unique individuals. The remaining 8 captures were either recaptures (*n* = 4) or it was unclear if the individual had been previously marked during our trapping session (*n* = 4). Mortality rates associated with live traps were low with no mortalities associated with Sherman traps and two associated with Little Critter traps (both were Northern Short-tailed Shrew). One Common Shrew and three juvenile Meadow Voles were found dead in pitfall traps. All dead animals were retained for tissue analysis. Southern Red-backed Vole (MYGA) was the most abundant species captured followed by Deer Mice (PEMA), Common Shrew (SOCI), Meadow Vole (MIPE) and Northern Short-tailed Shrew (BLBR) (Figure 6).

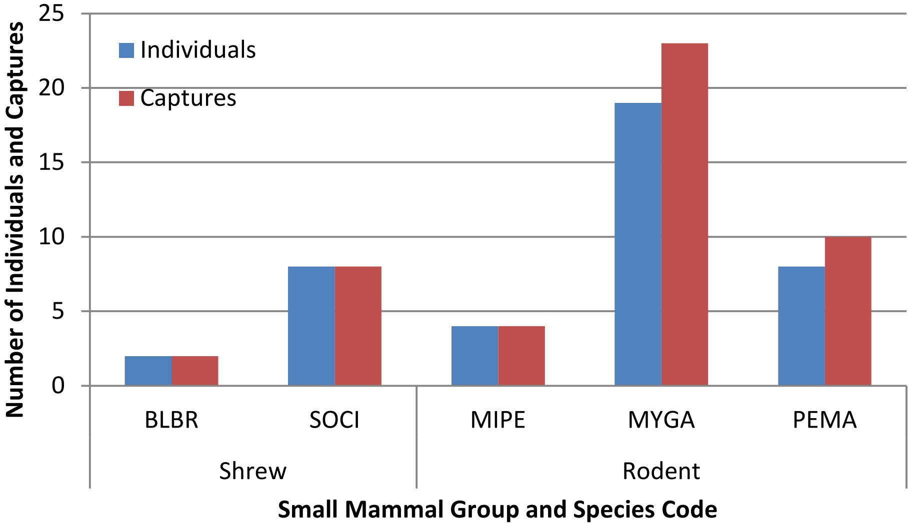

Figure 6. **Total captures for all species of small mammals captured on all seven plots in fall 2011 (not adjusted for survey effort).** Individuals = uniquely captured individuals of a species; Captures = total number of captured animals per species (including recaptures). BLBR = *Blarina Bravicauda*; SOCI = *Sorex cinereus*; MIPE = *Microtus pennsylvanicus*; MYGA = *Myodes gapperi*; PEMA = *Peromyscus maniculatus*.

4.2.1 Relative Abundance

The relationship between trap effort and species captures was calculated using the total trap nights amassed for all seven plots (Figure 5). This enabled a comparison of the relative abundance (catch per unit effort or CPUE) of each species captured relative to total trap effort.

Northern Short-tailed Shrews (BLBR) were caught only twice and therefore have the lowest CPUE of all species. Southern Red-backed Voles (MYGA) were the most abundant species followed by Deer Mice (PEMA) and Common Shrews (SOCI), which were caught at the same rate, and Meadow Voles (MIPE).

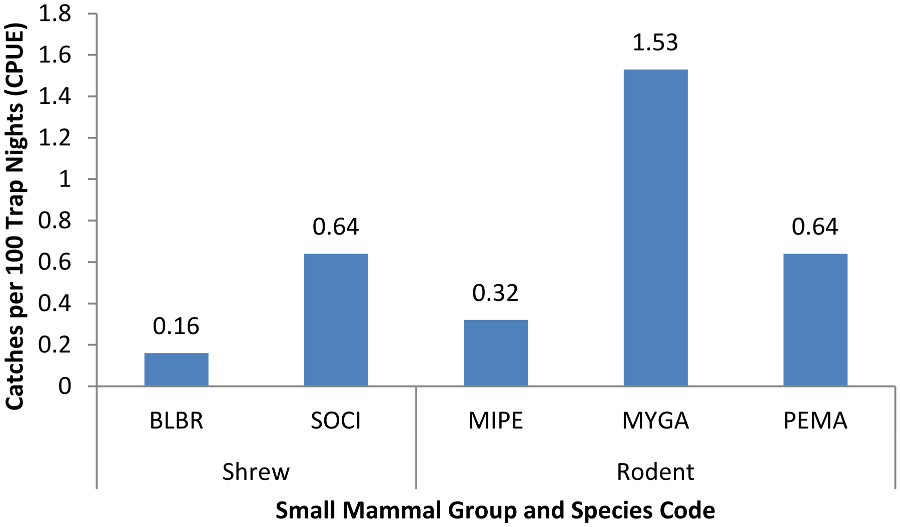

Figure 7. **Comparison of the catch per unit effort (catches per 100 trap nights) for all mammal species captured on all seven plots in fall 2011.** The catch per unit effort was calculated for unique individuals only (i.e., recaptures were excluded). Species codes as per Figure 6.

The presence and relative abundance of each species varied by site (Table 3). Deer Mice (PEMA) and Common Shrews (SOCI) were the most common species captured between all sites, at five and four sites respectively. Northern Short-tailed Shrews (BLBR) were found at only one site.

Table 3. **Relative abundance (catch per unit effort, CPUE) for all mammals trapped on each small mammal trapping site sampled in fall 2011.**

	Plot and CPUE[2]									
	Study Area					Reference				
Species Code[1]	A Meadow	B Forest	D Forest	F Meadow	G Forest	Meadow	Forest	Mean	SD[3]	No. Sites
SOCI	0.16	0	0.24	0.16	0	0	0.08	0.09	0.1	4
BLBR	0	0	0	0.16	0	0	0	0.02	0.06	1
MIPE	0.24	0	0	0.08	0	0	0	0.05	0.09	3
MYGA	0	0.24	0	0	0.4	0	0.89	0.22	0.33	3
PEMA	0.24	0.08	0	0.08	0	0.08	0.16	0.09	0.09	5
Species	3	2	1	4	1	1	3			

[1] SOCI = *Sorex cinereus*; BLBR = *Blarina Bravicauda*; MIPE = *Microtus pennsylvanicus*; MYGA = *Myodes gapperi*; PEMA = *Peromyscus maniculatus*.

[2] Non-zero values are in bold. 'No. Sites' indicates the number of sites that each species was caught at.

[3] SD = standard deviation.

The relative abundance of the three species that dominated the total catch (Southern Red-backed Vole, Deer Mice, Common Shrew) varied by site (Table 3). The relative abundance of Southern Red-backed Voles was highest at the forest reference site and the second highest at site G (a forested site with high metal concentrations in the soil). Common Shrews were most abundant at site D (a forested site with high metal concentrations in the soil), in fact being the only mammal caught at that site and Meadow Voles and Deer Mice were most abundant at site A (a meadow site with high metal concentrations in the soil). The lack of captures associated with species at each site may be attributable to trapping effort or the lack of suitable (and species-specific) habitat features at each site; however the latter was not investigated as part of this study.

When considering all species documented per plot, the forest reference site had the highest catch per unit effort followed by site A, G and F (Figure 8). The forest reference site also had the highest total number of unique individuals captured. To determine whether the forest reference site provides better habitat for small mammals would require further study.

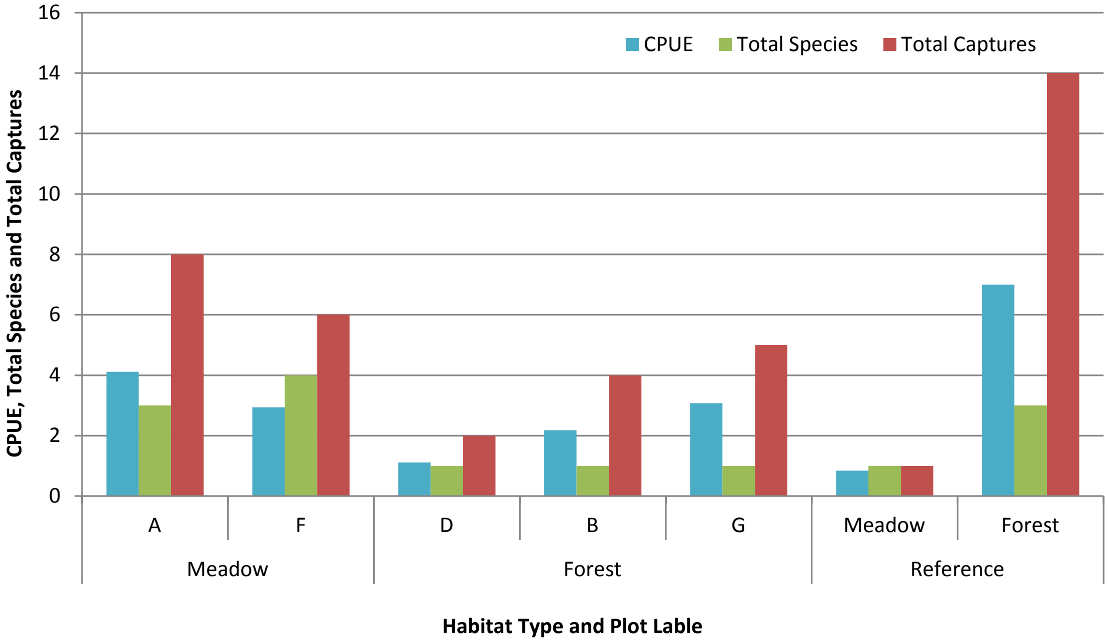

Figure 8. **Small mammal trapping capture data summary (Catch per unit effort, total number of species, and total number of unique captures) per site.** CPUE = catch per unit effort (number of catches per 100 trap nights).

4.2.2 Morphometrics

Due to sample size, data collected from all study area sites and both habitat types (i.e., meadow and forest) were pooled for analysis; the same was done for reference sites. Differences between sexes or age class cannot be assessed for the same reason. As such, the results reported are not indicative of potential age or sex-specific differences.

Body mass can be used a measure of population health (Pearson et al., 2003) and was assessed for all small mammals captured at each site. In general, Meadow Voles (MIPE) were heavier than both Southern Red-backed Voles (MYGA) and Deer Mice (PEMA) and Common Shrews (SOCI) were the smallest mammal captured (Figure 9). Body mass does not appear to differ between study area sites and reference habitats for all species assessed. Again, sample size is limiting and data from both sexes and age categories have been pooled, which may be masking any relationship between metals exposure levels and mass.

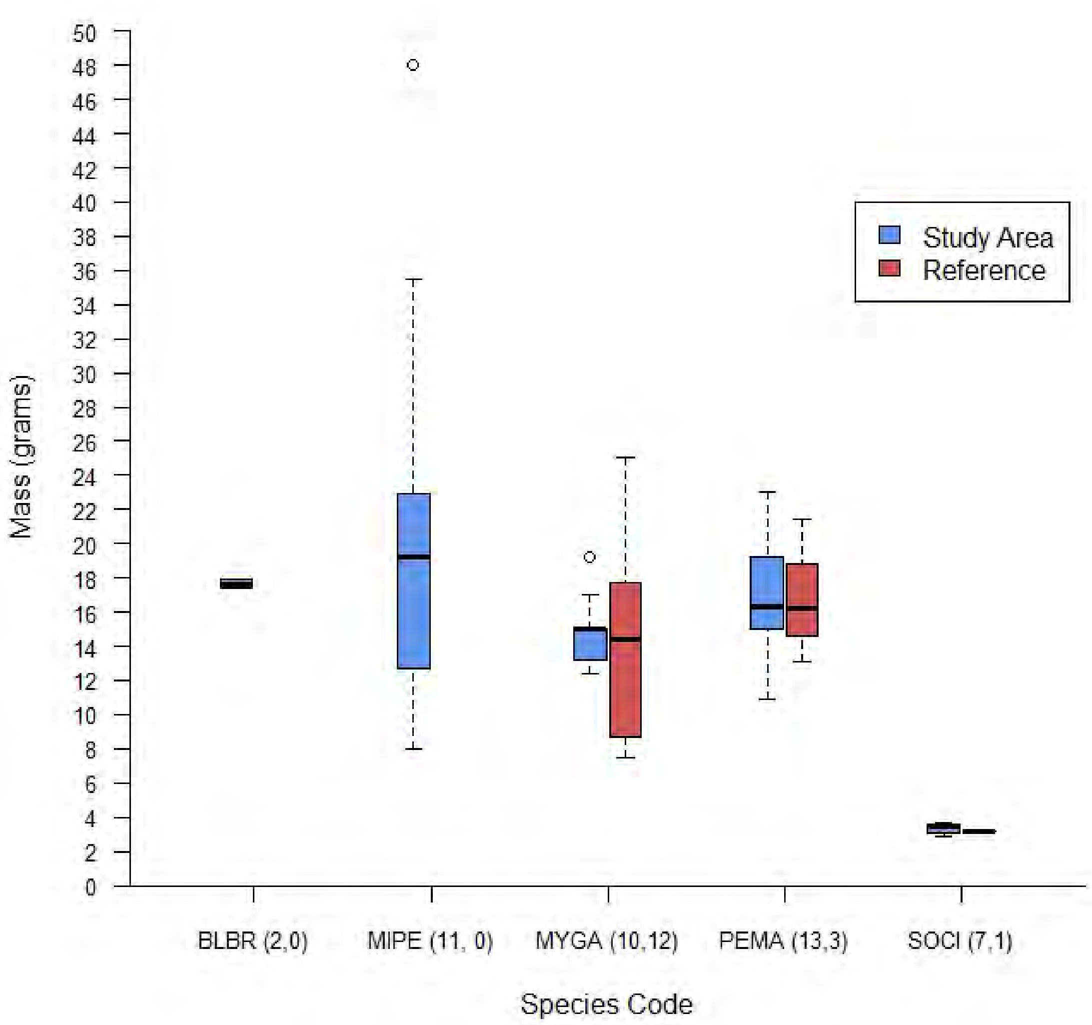

Figure 9. **Distribution of mass (grams) by species and metal concentration (study area vs. reference sites).** Data from all study areas combined. Numbers in parentheses indicate samples size associated with the study area and reference sites, respectively. BLBR = *Blarina brevicauda*; MIPE = *Microtus pennsylvanicus*; MYGA = *Myodes gapperi*; PEMA = *Peromyscus maniculatus*; SOCI = *Sorex cinereus*.

Distribution of Body and Tail Length by Species and Risk Category

The interpretation provided for body mass applies to both body and tail length (Figure 10) and the patterns for body and tail length are similar. For those species captured in both the study area and reference sites (MYGA, PEMA, SOCI) there does not appear to be a difference between either body length or tail length; however, pooling of all sex and age class data by species may be masking these relationships and more data are required to properly assess whether differences exist.

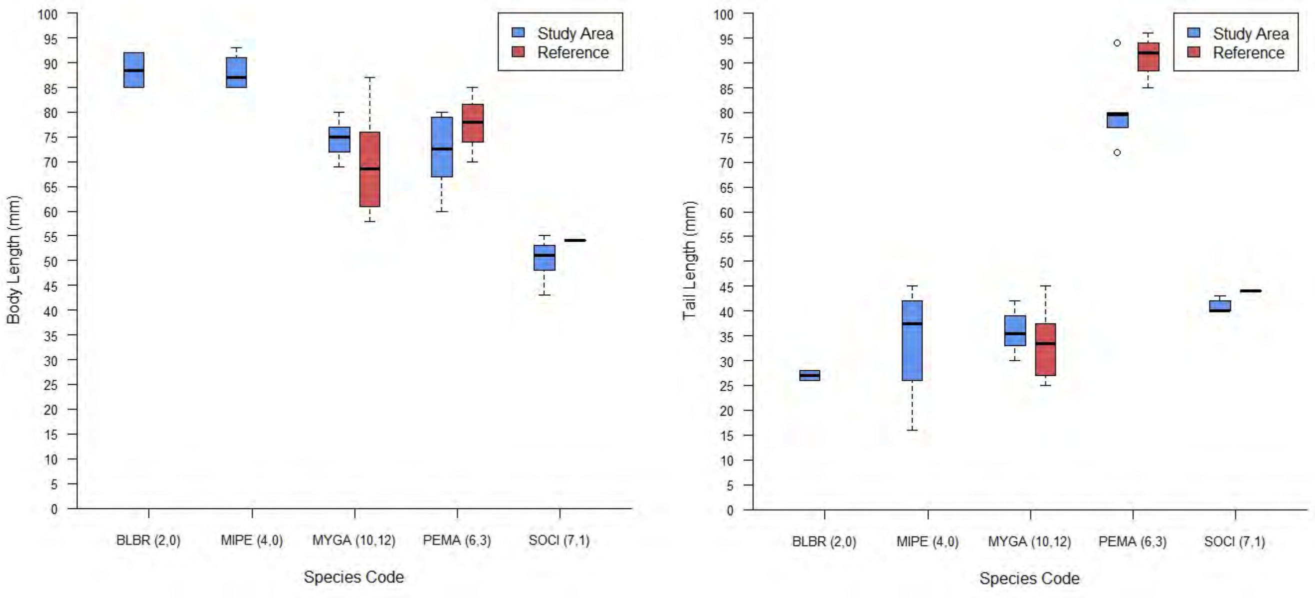

Figure 10. **Distribution of body (left) and tail length (right) by species and metal concentration (study area vs. reference sites).** Numbers in parentheses indicate samples size associated with the study area and reference sites, respectively. BLBR = *Blarina brevicauda*; MIPE = *Microtus pennsylvanicus*; MYGA = *Myodes gapperi*; PEMA = *Peromyscus maniculatus*; SOCI = *Sorex cinereus*.

Distribution of hind foot and ear length by Species and Risk Category

There are no apparent differences in hind foot length or ear length between study areas and refernce sites (Figure 11). However, not all species were captured in reference sites so comparisons betweenstudy areas and refence sites are not possible at this time.

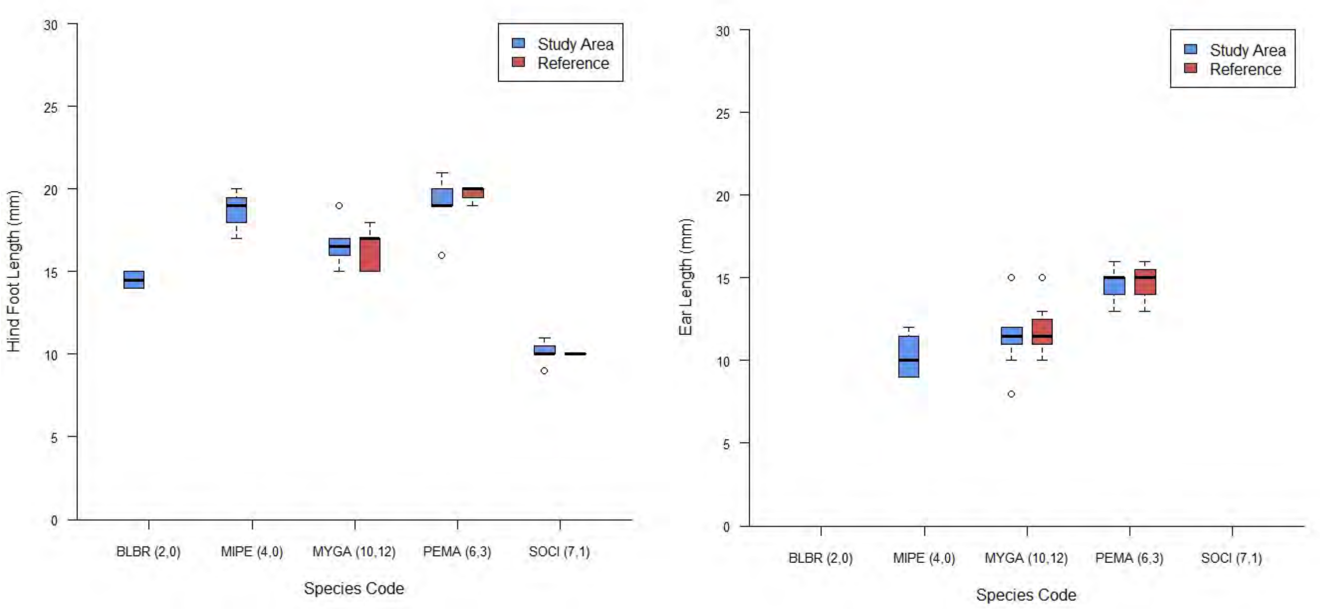

Figure 11. **Distribution of hind foot length (left) and ear length (right) by species and metal concentration (study area vs. reference sites).** Numbers in parentheses indicate samples size associated with the study area and reference sites, respectively. BLBR = *Blarina brevicauda*; MIPE = *Microtus pennsylvanicus*; MYGA = *Myodes gapperi*; PEMA = *Peromyscus maniculatus*; SOCI = *Sorex cinereus*.

4.2.3 Species Richness and Diversity

Species richness (i.e., the number of species of small mammals capture per plot) varied from one to four (Figure 12). Site F had the most species followed by Site A and the forest reference site. Only one species was documented from Sites D, G, and the meadow reference site (Figure 12). As such, these three sites had the lowest species diversity relative to the other sites (Table 4). The documentation of only one species at the meadow reference site is likely related to low trap effort (only one night), history of previous disturbance, and possibly to vegetation structure and species composition. There are currently not enough data available to determine whether differences in species richness can be related to trapping duration, the time of year, habitat suitability, or risk (as indicated by metal concentrations in the soil). Based on the data collected to date, the largest number of species was associated with Site F, a high metal exposure meadow site, which may suggest little evidence of impact to small mammal populations.

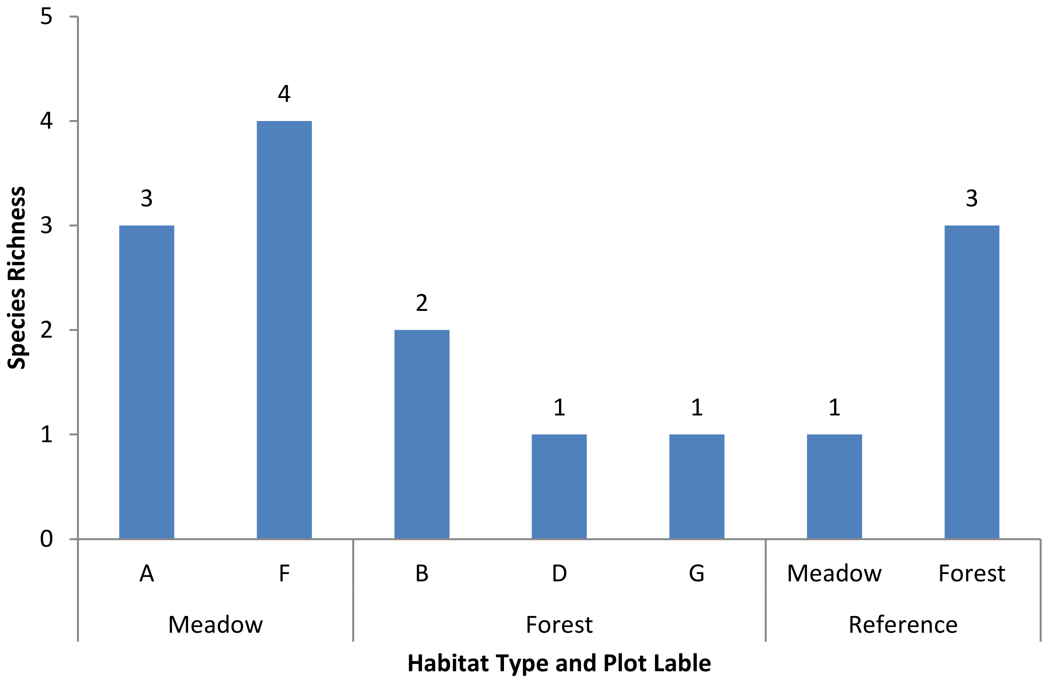

Figure 12. **Total species captured per plot during fall 2011.**

Table 4. **Summary of species richness (q=number of species), diversity (H), and evenness (J) metrics calculated for small mammals captured on each plot in 2011.**

Plot Type and Habitat	Plot	q	H	J
Study Area Meadow	A	3	0.45	0.94
	F	4	0.58	0.96
Study Area Forest	B	2	0.22	0.72
	D	1	0	--
	G	1	0	--
Reference	Meadow	1	0	--
	Forest	3	0.25	0.53

4.2.4 Toxicology

The average weight of kidneys and livers organs (by species) obtained for this study is provided in Table 5. These data may be useful when considering the sample size required when assessing the toxicity of these organs in future studies.

Table 5. **Average mass (wet weight) of kidney, liver and whole body samples submitted for toxicology analysis.** Average weights determined by dividing the total mass by N.

Common Name	Site	Habitat	Metal Concentration	Organ / Tissue	N	Mass (g)	Avg. Mass (g)
Northern short-tailed shrew	F	Meadow	High	Kidney	2	0.5	0.25
Meadow Vole	A	Meadow	High		2	0.7	0.35
Southern Red-backed Vole	B	Forest	High		2	0.3	0.15
Southern Red-backed Vole	G	Forest	High		5	1.2	0.24
Southern Red-backed Vole	Ref	Forest	-		12	2.3	0.19
Deer Mouse	A	Meadow	High		3	0.8	0.27
Deer Mouse	B	Forest	High		1	0.1	0.1
Deer Mouse	F	Meadow	High		1	0.3	0.3
Deer Mouse	Ref	Forest	-		3	0.7	0.23
Common Shrew	A	Meadow	High		2	0.2	0.1
Common Shrew	D	Forest	High		3	0.4	0.13
Common Shrew	F	Meadow	High		2	0.1	0.05
Northern Short-tailed Shrew	F	Meadow	High	Liver	2	2	1
Meadow Vole	A	Meadow	High		2	2.3	1.15
Southern Red-backed Vole	B	Forest	High		2	1.4	0.7
Southern Red-backed Vole	G	Forest	High		5	4.7	0.94
Southern Red-backed Vole	Ref	Forest	-		12	8.8	0.73
Deer Mouse	A	Meadow	High		3	2.7	0.9
Deer Mouse	B	Forest	High		1	0.6	0.6
Deer Mouse	F	Meadow	High		1	1.1	1.1
Deer Mouse	Ref	Forest	-		3	3.6	1.2
Common Shrew	A	Meadow	High		2	0.2	0.1
Common Shrew	D	Forest	High		3	0.5	0.17
Common Shrew	F	Meadow	High		2	0.4	0.2
Common Shrew	Ref	Forest	-		1	0.2	0.2
Common Shrew	Ref	Forest	-		1	0.1	0.1
Northern Short-tailed Shrew	F	Meadow	High	Whole Body	2	35.3	17.65
Common Shrew	A	Meadow	High		2	6.6	3.3
Common Shrew	D	Forest	High		3	9.5	3.17
Common Shrew	F	Meadow	High		2	7.3	3.65
Common Shrew	Ref	Forest	-		1	3.2	3.2

For those species trapped in the study area and reference sites, an assessment of kidney:body weight was made to determine if certain species of small mammal were manifesting the effects of lead exposure via renal edema. In this case, the kidney:body weight ratio of both Southern Red-backed Vole and Deer Mouse was similar in both the study area and reference sites (Table 6). This result was expected given that the two species are seed-eaters and the predicted risk to seed-eating small mammals was low (Intrinsik 2012). Unfortunately kidneys were not obtained for Common Shrew trapped in no risk habitats so a similar comparison was not currently possible.

Table 6. **Average kidney and body weight (grams) used to calculate kidney:body weight (K:BW) ratios for Southern Red-backed Vole and Deer Mouse in the study area and reference sites.**

	Study Area			Reference Sites		
Common Name	**Kidney[1] (N)**	**Mass (N)**	**K:BW**	**Kidney[1] (N)**	**Mass (N)**	**K:BW**
Southern Red-backed Vole	0.21 (7)	15.25 (7)	0.014	0.19 (12)	13.86 (11)	0.014
Deer Mouse	0.24 (5)	15.99 (8)	0.015	0.23 (3)	16.9 (3)	0.014

[1] Average kidney weight was calculated by taking the total weight obtained for all kidneys and dividing it by the number of specimens that contributed to the sample. Individual kidney weights are not available.

The results of the tissue metals analyses and interpretation of these data are presented in the Ecological Risk Assessment report produced by Intrinsik Environmental Sciences Inc. (2012).

4.3 Soils

The results of the soil analyses (metals and nutrients) are presented in the Ecological Risk Assessment report produced by Intrinsik Environmental Sciences Inc. (2012). The soils data collected in 2011 (during small mammal trapping) were used to verify the metal concentration associated with each site sampled and those results indicate that all study area sites sampled have elevated metal concentrations.

4.4 Terrestrial Arthropods

Several specimens of beetles and spiders were collected from the pitfall traps; however, the number and diversity of species collected was not sufficient to assess relationships between food availability and metal concentrations. Sampling for insects should occur in the spring and summer to better assess the suitability of each site for small mammals relative to available food resources.

4.5 Incidental Wildlife Observations

Incidental wildlife observations (i.e., observations of non-target wildlife species) were made on each plot. A total of 56 animal captures were made during the fall trapping sessions (Table 7). The vast majority of captures (*n* = 48; 86%) were mammals while the remaining (n = 8; 14%) were terrestrial salamanders captured in pitfall traps [Blue-spotted Salamander (*Ambystoma laterale*) and Yellow-spotted Salamander (*Ambystoma maculatum*)]. In addition to the species captured, several additional species of wildlife were observed at each site (Table 7). One Eastern Red-backed Salamander (*Plethodon cinereus*) was observed in the leaf litter at site B. Moose (*Alces alces*) tracks and skeletal remains were found at site A, a Red Squirrel (*Tamiasciurus hudsonicus*) was heard at site B and an American Woodcock was seen at sight D. In total 70 animal observations were recorded. The species listed in Table 7 are those species that were observed from each trapping grid during the fall trapping period and do not represent all wildlife that occur at each site.

Table 7. **Wildlife species documented at each site during fall 2011 small mammal trapping surveys. Blanks indicate species not documented.**

			Number of Captures							
			Study Area					Reference		
Common Name	**Scientific Name**	**Species Code**	**A Meadow**	**B Forest**	**D Forest**	**F Meadow**	**G Forest**	**Meadow**	**Forest**	**Total**
Northern Short-tailed Shrew	*Blarina brevicauda*	BLBR				2	2			2
Common Shrew	*Sorex cinereus*	SOCI	2		3	2	2		1	8
Meadow Vole	*Microtus pennsylvanicus*	MIPE	3			1	1			4
Red-backed Vole	*Myodes gapperi*	MYGA		4			6		14	24
Deer Mouse	*Peromyscus maniculatus*	PEMA	5	1		1	1	1	2	10
Blue-spotted Salamander	*Ambystoma laterale*	AMLA			4				2	6
Yellow-spotted Salamander	*Ambystoma maculatum*	AMMA			2					1
Eastern-red backed Salamander	*Plethodon cinereus*	PLCI		1						1
Red Squirrel	*Tamiasciurus hudsonicus*	TAHU	1							3
Moose	*Alces alces*	ALAL	1							4
American Woodcock	*Scolopax minor*	AMWO			1					2
		Plot Totals	**12**	**6**	**10**	**6**	**6**	**1**	**19**	**60**

5 Discussion

Elevated soil and dietary metal concentrations were predicted to pose a risk to insectivorous small mammal populations based on preliminary modelling conducted in the ERA (Intrinsik, 2012). Theoretical increased risk levels, which are based on conservative assumptions, were attributed to the effects of airborne emissions deposited on soils that increase the accumulation of metals within insects and other invertebrates (e.g., gastropods), which comprise a significant portion of the diet of insectivorous small mammals. Small mammal sampling during fall 2011 provided a preliminary assessment of the distribution and occurrence of small mammals living in the vicinity of the Brunswick Smelter in Belledune, New Brunswick, an area considered to have higher than normal levels of metal concentrations in the soils. A similar assessment was made for unaffected (i.e., reference sites); however, only one site was sampled, so comparisons between study area sites (i.e., those with high metal concentrations) with elevated metal concentrations and reference sites are limited.

The data collected provide a preliminary indication of the distribution and occurrence of small mammals in the study area. Where comparisons between study area and reference sites were possible, there were no apparent morphometric differences noted and all animals captured had an outward appearance of good health (i.e., there were no abnormalities or obvious signs of malnourishment observed). Further, although we pooled all age class and sex-specific data collected at each site to generate the figures in Section 4.2.2, adults and juveniles of both Meadow Vole and Deer Mouse were captured, suggesting that populations of these two species are viable[2]. The lack of difference in morphometric data and the overall appearance of good health suggest that there is little evidence of elevated risk to small mammal populations. However, because data were limited, additional data collection would reduce the uncertainty in this conclusion and would provide additional information on relationships between metal exposures and small mammal richness, diversity, or morphometric data.

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[2] A viable population is defined as a self-sustaining, reproductively active population

The overall appearance of the small mammals captured during fall 2011 provides little evidence of effect from increased metal concentrations. However, the effects are not expected to manifest as physical malformations that affect the appearance of the small mammals. It is more likely that internal organs and bone will be affected (Stansely and Roscoe 1996). For example, kidney to body weight ratios in specimens in the study area sites are expected to be higher than those in reference areas. A higher kidney:body weight would likely be indicative of renal edema resulting from lead exposure (Stansely and Roscoe 1996). In this study, kidney:body weight ratio did not vary between study area and reference sites, at least not for Southern Red-backed Vole and Deer Mouse (those were the only species for which this comparison was possible; Table 6). Given that these two species are seed-eaters and that there was low predicted risk to seed-eating small mammals in the ERA (Intrinsik, 2012), these results were expected and correlate well with the results of the ERA. Too few shrews were caught in the current study to enable similar comparisons for ground-feeding insectivorous small mammals.

Diet is an important factor influencing the uptake and accumulation of metals by different species, but physiology and metabolism are also influential (Roberts and Johnson 1978). Behaviour, home range size and habitat selection have also been correlated with lead uptake in small mammals (Welch and Dick 1975; Laerm and Carothers 1977). The relatively high levels of metals in the soils in the vicinity of the Brunswick Smelter were predicted by the ERA to pose a risk to insectivorous small mammal populations. Based on our data, small mammal populations do not appear to be limited or restricted; however, additional data would strengthen conclusions about the relationship between metal concentrations and small mammal populations in the vicinity of the Belledune smelter.

6 Conclusions

Based on the data collected there appears to be little difference in species richness, diversity, relative abundance, or morphometrics (body mass, body length, tail length, hind foot length, or ear length) between animals inhabiting study area and reference sites. However, because sample size was limiting, the strength of the evidence is limited and additional data data collection would strengthen conclusions regarding relationships between insectivorous small mammal populations in the study area and reference sites. Ideally, males and females would be assessed separately as would adults and juveniles. Given that we sampled in the fall, a spring sampling session would likely provide additional data that could also be used to assess reproductive success of females.

7 Literature Cited

Canadian Council of Ministers of the Environment (CCME). 1999. Canadian soil quality guidelines for the protection of environmental and human health: Lead (1999). In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

Glasbergen, K., D. Summach, A. Lewin, and K. Chung. 2008. Assessment of biodiversity near Canadian operations. Brunswick Smelter New Brunswick. LGL Project TA4547. Unpublished report by LGL Limited environmental research associates, Burlington, ON for Xstrata Zinc. 119 pp.

Hawkes, V.C. and K.N. Tuttle. 2011. Early successional wildlife monitoring on reclaimed plots in the oil sands region. Year 1 2010–2011 annual report. LGL Report EA3248. Unpublished report by LGL Limited environmental research associates, Sidney, BC, for CEMA – The Reclamation Working Group (RWG), Fort McMurray, AB. 51 pp + Appendices.

Hendriks, A.J., W. –C. Ma, J.J., Brouns, E.M. de Ruiter-Dijkman, and R. Gast. 1995. Modelling and monitoring organochlorine and heavy metal accumulation in soils, earthworks, and shrews in Rhine-Delta floodplains. Archives of Environmental Contamination and Toxicology, 29, 115–127.

Intrinsik Environmental Sciences Inc. 2009. Phase I Soil Sampling Protocol, Belledune Lead Smelter. Intrinsic Project #30075. Report by Intrinsic Environmental Sciences Inc. Halifax, NS for Xstrata Zinc, Belledune, NB. 16 pp + Appendices.

Intrinsik Environmental Sciences Inc. 2012. Ecological risk assessment of off-site terrestrial and freshwater aquatic areas near the Xstrata zinc lead smelter in Belledune, NB. Draft Report. Unpublished report by Intrinsik Environmental Sciences. Prepared for Bob Butler, Environmental Manager, Brunswick Smelter, Belledune, NB.

Johnson, M.S., R.D. Roberts, M. Hutton, and M.J. Inskip. 1978. Distribution of lead, zinc and cadmium in small mammals from polluted environments. Oikos, 30:153–159

Laerm, J. and S.W. Carothers. 1977. Lead Concentration in Small Mammals Not Correlated with Exposures of Tetraethyl Lead. American Midland Naturalist, 98: 250–254.

Legendre, P. and L. Legendre. 1998. Numerical Ecology, Developments in Environmental Modelling, Second English Edition. Elsevier, Amsterdam, 853 pages.

Massart, D.L., Smeyers-Verbeke, J., Capron, X., and Schlesrer, K. 2005. Visual presentation of data by means of box-plots. Lc-Gc Europe 18: 215–218.

Mills, J.N., J.E. Childs, T.G. Ksiazek, C.J. Peters, W.M. Velleca. 1995. Methods for Trapping and Sampling Small Mammals for Virologic Testing. U.S. Dept. of Health and Human Services, Centers for Disease Control and Prevention, Atlanta, Georgia. 35 pp + Appendices.

Nelson, L., Jr. and R.W. Clark. 1973. Correction for sprung traps in catch/effort calculations of trapping results. Journal of Mammalogy, 54: 295–298.

Noel, J. and B. Myler, 2010. Xstrata lead Belledune smelter, vegetation health study. LGL Report TA4803. Unpublished report by LGL Limited environmental research associates, Burlington, ON. 15 pp + Appendices.

Pielou, E.C. 1966. The measurement of diversity in different types of biological collections. Journal of Theoretical Biology 13:131–144.

Pilgrim, W. and R.N. Hughes. 1994. Lead, cadmium, arsenic and zinc in the ecosystem surrounding a lead smelter. Environmental Monitoring and Assessment 32: 1–20.

Reinecke, A. J., S. A. Reinecke, D. E. Musilbono, and A. Chapman. 2000. The Transfer of Lead (Pb) from Earthworms to Shrews (*Myosorex varius*). Archives of Environmental Contamination and Toxicology, 39, 392–397.

Roberts, R.D. and M.S. Johnson. 1978. Dispersal of heavy metals from abandoned mine workings and their transference through terrestrial food chains. Environmental Pollution, 16: 293–310.

Sokal, R.R. and F. J. Rohlf. 1995. Biometry (Third Edition). W.H Freeman and Company, 850 pages.

Stansley, W. and D. Roscoe. 1996. The uptake and effects of lead in small mammals and frogs at a trap and skeet range. Archives of Environmental Contamination and Toxicology, 30, 220–226.

Welch, W.R. and D.L. Dick. 1975. Lead concentrations in tissues of roadside mice. Environmental Pollution, 8: 15–21.

Wilkinson, F. 2011. Xstrata Belledune lead smelter soil analysis program. Draft Report. Unpublished report by F.H.W. Consulting, Oakville, ON for Intrinsik Environmental Sciences, Halifax, NS. 12 pp.

Xstrata. 2008. Sustainable Development Practices.

APPENDIX N

RARE VASCULAR PLANT SURVEY

RARE VASCULAR PLANT SURVEY

OF

Lower 2.5 km of Hendry Brook
Gloucester County, NB

Submitted to

Neil Brodie, P.Eng. Project Manager
Conestoga-Rovers & Associates
466 Hodgson Road, Fredericton, NB E3C 2G5

Waterfall near mouth of Hendry Br.

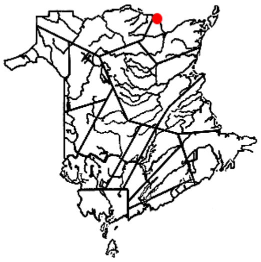
30 September 2011

B&B
Botanical

Survey Conducted by
G. Bishop, B&B Botanical
16 Pitt St., Sussex, NB
E4E 1J1

Rare Plant Survey of Hendry Brook, Belledune, Gloucester County New Brunswick

Introduction



G. Bishop of B& B Botanical was contacted by Neil Brodie of Conestoga-Rovers & Associates to conduct a rare vascular plant search 100 m along either side of the lower 2.5 km of Hendry Brook, which is just south of the Xstrata's Belledune Smelter.
The survey was conducted by G. Bishop and M. Connell on 23-24 of August 2011.

Requested was:

1. Visit sites of previously recorded rare species *Carex vaginata* and *Carex gynocrates* on Hendry Brook and ascertain present status of populations
2. List of rare vascular plants observed and provide a brief comment on their ecology and their provincial and North American distribution
3. Map showing rare plant location
4. List of specimens collected
5. General inventory of plants observed
6. Provide a conclusion on habitat quality and how this relates to Atlantic Canada Conservation Data Centre (ACCDC) information.

Rare plant surveys can be conducted from May to October. In spring one will have the possibility of locating some of the spring ephemerals, such as the violets, the flowers of which disappear by early summer. Surveys conducted in late August and September will not find spring ephemerals, but may find rare asters, goldenrods or orchids such as Ladies Tresses (*Spiranthes sp*.). Ideally, surveys would be conducted twice, to cover both periods.

Flora nomenclature used in this report principally follows that of the second edition of The Flora of New Brunswick by H.R. Hinds.

Acknowledgements
Mark Mullin, an employee from the Xstrata smelter was very gracious in showing us the various roads and access points to Hendry Br and the slag pond. We greatly appreciate his wonderful introduction to the area and local history which made our work easier and more understandable.

Method

The ACCDC listing of the rare vascular within 5 km of the survey area was obtained. Special permission was received to have the exact coordinates for these species, as initially only approximate locations had been given. Air photos, topographic maps and ACCDC data were consulted to determine access and to select different potential habitat types. Within ACCDC data for the lower 2.5 km of Hendry Brook and within 100 m on either side, only the following two species were noted: *Carex vaginata* (Sheathed Sedge) and *Carex gynocrates* (Northern Bog Sedge)

Plant rarity was assessed following the standards of the Atlantic Canada Conservation Data Center (ACCDC 2010), which is as follows:

The ‘S’ rankings refer to sub-national (provincial, in this case New Brunswick) level, and have the following definitions:

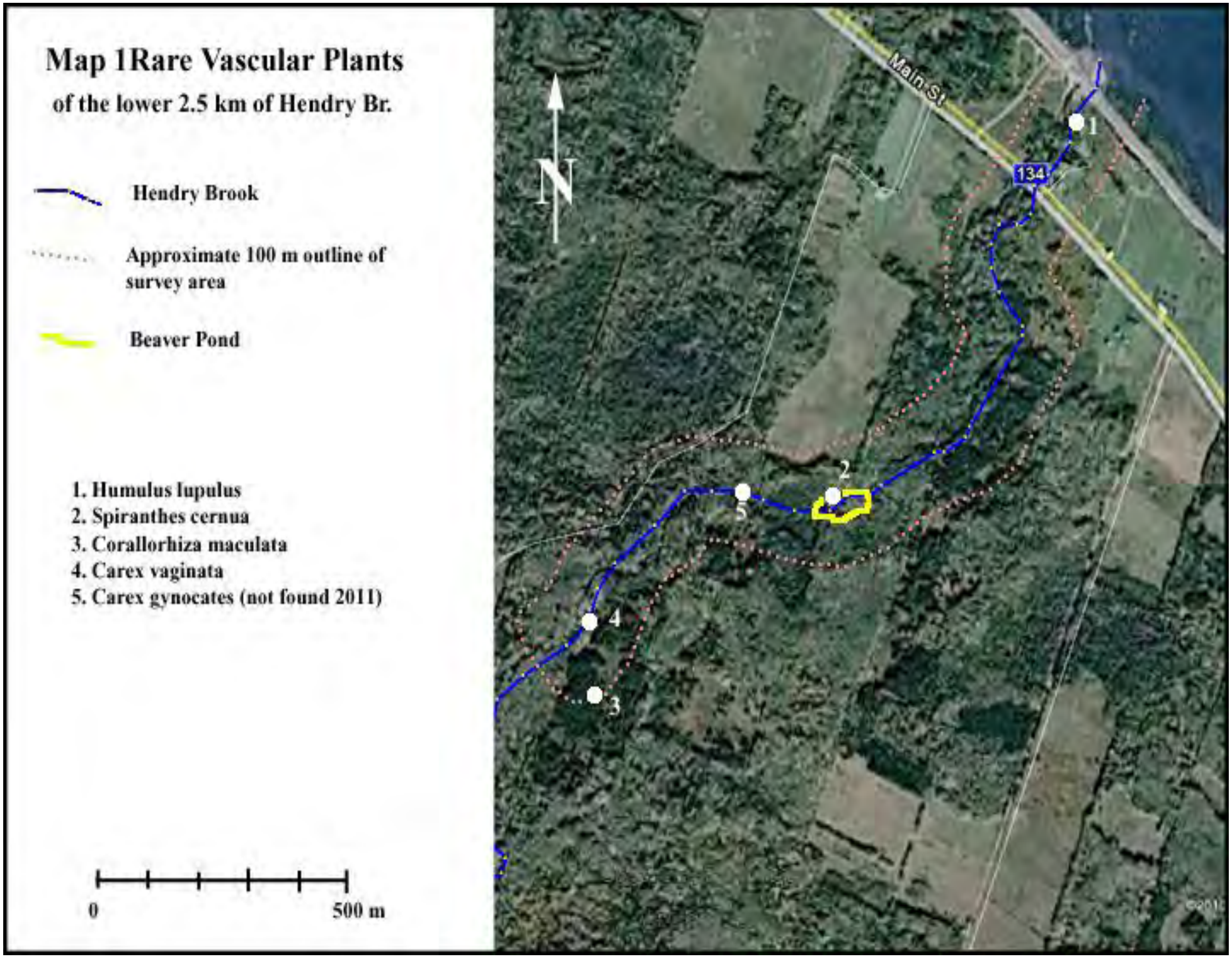
S1	Extremely rare: May be especially vulnerable to extirpation (typically 5 or fewer occurrences or very few remaining individuals).
S2	Rare: May be vulnerable to extirpation due to rarity or other factors (6 to 20 occurrences or few remaining individuals).
S3	Uncommon, or found only in a restricted range, even if abundant at some locations (21 to 100 occurrences).
S4	Usually widespread, fairly common, and apparently secure with many occurrences, but of longer-term concern (e.g., watch list) (100+ occurrences).
S5	Widespread, abundant, and secure, under present conditions.
S#S#	Numeric range rank: A range between two consecutive ranks for a species/community. Denotes uncertainty about the exact rarity (e.g., S1S2).
SH	Historical: Previously occurred in the province but may have been overlooked during the past 20-70 years. Presence is suspected and will likely be rediscovered, depending on species/community.
SU	Unrankable: Possibly in peril, but status is uncertain - need more information.
SX	Extinct/Extirpated: believed to be extirpated from its former range.
SE	Exotic: An exotic established in the province (e.g., Purple Loosestrife or Coltsfoot); may be native in nearby regions.
SR	Reported but without persuasive documentation (e.g., misidentified specimen).
SRF	Reported falsely: erroneously reported and the error has persisted in the literature.
SRD	Reported but doubtful
SNA	Not yet ranked
?	Indicates uncertainty of rank

The plant survey was conducted on foot by walking a zig-zag pattern to ensure surveying all habitat changes. South of the brook was surveyed on August 23, and north of the brook on August 24.

Results

The brook has a small series of water falls near its mouth (between the coast and Hwy 134); much of which is likely a result of an old bridge abutment. It is only here where *Cystopteris tenuis* (MacKay’s Brittle Fern) was found. West of Hwy 134, the brook is relatively flat with very little outcrop. Frequent flood plain terraces rise less than 1 m above the brook. These terraces vary in size from small (<3 m) to large (50 m) and can be found on either side of the brook. One active beaver pond is present as is indicated on Map 1.

A total of 149 species were identified within 100 m of the lower 2.5 km of Hendry Br (See Appendix 1). Four of these are rare to very rare and are shown in Table 1 and their locations indicated on Map 1.



Map 1Rare Vascular Plants of the lower 2.5 km of Hendry Br.

Table 1 – Rare Plants on lower 2.5 km of Hendry Br.

Botanical Name	Common Name	Rarity	Latitude 2011	Longitude 2011	Latitude (ACCDC)	Longitude (ACCDC)
Humulus lupulus var. lupuloides	American Hops	S1S2	47.88922	65.81423		
Spiranthes cernua	Nodding Ladies Tresses	S2	47.88342	65.82046		
Corallorhiza maculata var. maculata	Spotted Coralroot	S2S3	47.88032	65.82661		
Carex vaginata	Sheathed Sedge	S3	47.88144	65.82697	47.88142	65.82698
Carex gynocrates (not found 2011)	Northern Bog Sedge	S2			47.88345	65.82283

Humulus lupulus var *lupuloides* S1S2 (American Hops) was found near the house on the SE corner of Hendry Br and Hwy 134. While this variety of Hops is currently listed as a S1/S2 species, in recent discussion with the botanist at ACCDC, it is felt that this rank will likely be changed in the near future, as following the current definitions for the variety, it is much more common than previously noted. There is also some question as to the distinctiveness of this variety from the European Hops (*Humulus lupulus* var *lupulus*) as hybridization is felt to occur. Given the close proximity to habitation, it is most likely that this species' presence here is a result of gardening practices, and is not natural occurring at this site.

Along the north side of a beaver pond, 12 plants of *Spiranthes cernua* S2 (Nodding Ladies Tresses) were located. This is a plant that has been mostly found in the southern part of the province, but has recently been found along the Northumberland coast. This will be a new record for Gloucester County.

Typically it is found in overgrown gravel pits, roadsides and springy slopes, from Nova Scotia and Quebec south to Florida and Texas. It is a species which takes advantage of areas of disturbance, both human and naturally occurring.

Spiranthes cernua
Photo to the left by G. Bell

Perhaps the most delightful find was a population of a 1000+ plants of *Corallorhiza maculata* var. *maculata* S2/S3 (Spotted Coralroot) which were discovered beneath a dry *Picea glauca* (White Spruce) stand.

Although the photos do not show it, it was a very impressive sight to see so many orchids within an area of less than ¼ of a hectare. There was nothing else growing there, so they were easily visible. This species is typically found in dry coniferous, deciduous or mixed woods from Newfoundland to British Columbia south to California and Georgia. It is very difficult to predict where it will occur as it preferred habitat is widespread.

Distribution Map for *Corallorhiza maculata* var. *maculata*
(from Flora of North America)

One plant of *Carex vaginata* was found at the site listed by ACCDC. This species was not observed elsewhere along the brook. Typically *C. vaginata* is found in rich fens and meadows, which this was not. On Hendry Brook the habitat site was a mixed Cedar/Fir flood plain, with *Athyrium filix-femina* (Lady Fern), *Brachyelytrum septentrionalis* (Tucker Northern Short-Husk), *Fraxinus nigra* (Black Ash), *Chelone glabra* (Turtlehead) and *Thalictrum pubescens* (Tall Meadow-rue). All associated species are common along brooks and not particularly indicative of a fen or fen-like condition, where there would be abundant free calcium available to the plants.

Unfortunately *Carex gynocrates* that was reported by ACCDC was not observed at the previously known site, nor was it observed anywhere along the brook.

Discussion of ACCDC Data

Of the 18 species listed by ACCDC as occurring within 5 km of Hendry Br (see Map 2 & Table 2), they can be grouped into the following habitats. Those marked with an asterisk are habitats that are not present on the surveyed section of Hendry Br.

Table 2. Habitats of Rare Plants Listed by ACCDC

Rich Cedar (fen)*	**Coastal headland, salt marsh***	**Streams,wooded margins**	**Coastal Sandspit***
Amerorchis rotundifolia	*Zigadenus elegans ssp. glaucus*	*Listera auriculata*	*Draba glabella*
Goodyera oblongifolia	*Blysmus rufus*	*Galium obtusum*	*Botrychium campestre*
Cypripedium parviflorum var. makasin			
Carex vaginata			
Carex gynocrates			

Tolerant Hardwoods*	**Sand/gravel beach**	**Bog, bog margin***	**Dry woods**
Botrychium lanceolatum var. angustisegmentum	*Stellaria longipes*	*Geocaulon lividum*	*Corallorhiza maculata var. maculata*
	Sagina nodosa	*Carex gynocrates*	
	Polygonum raii		
	Artemisia campestris ssp. caudata		

As one can see, 5 of the above 8 habitats were not encountered during the Hendry Br survey, so it is not surprising that many of the above species were not observed. The beach at the mouth of Hendry Br is likely quite different than the beach at Belledune Point—especially before industrial development. *Listera auriculata* is a tough species to predict accurately where it might occur; one can walk many kilometers of swampy aldery brookside without success in finding this species. *Galium obtusum* is also difficult to predict.

In summary, the brook itself and immediate borders (25 m either side) are not rich habitats, do not have many rocky outcrops, and have only one wetland development (beaver pond). Beyond the 25 m, most of the land has been subjected to farming and a high level of disturbance. Such areas usually have a low potential for rare species.

Map 2 Rare Plant Locations as listed by the ACCDC

Amerorchis rotundifolia (Small Round-leaved Orchis)
Artemisia campestris (Field Wormwood)
Blysmus rufus (Red Bulrush)
Botrychium campestre (Prairie Moonwort)
Carex gynocrates (Northern Bog Sedge)
Carex vaginata (Sheathed Sedge)
Corallorhiza maculata (Spotted Coralroot)
Cypripedium parviflorum (Yellow Lady's-slipper)
Draba glabella (Rock Whitlow-Grass)
Galium obtusum (Blunt-leaved Bedstraw)
Geocaulon lividum (Northern Comandra)
Goodyera oblongifolia (Menzies' Rattlesnake-plantain)
Listera auriculata (Auricled Twayblade)
Polygonum raii (Sharp-fruited Knotweed)
Sagina nodosa (Knotted Pearlwort)
Stellaria longipes (Long-stalked Starwort)
Zigadenus elegans (Mountain Death Camas)

Collections

Twenty-one specimen collections were made and will be deposited at one of our provincial herbaria. These are listed in Appendix 2. These will become part of a permanent record of the various species' presence and will assist in future re-assessment of species' rarity and their distribution.

Conclusions

For the most part, the surveyed portion of Hendry Br and those areas 100 m to either side are not typical of the rich habitat defined by the other species listed by ACCDC for the area. Much the area is either old fields or pastures that have become wooded. The mouth of Hendry Brook is a gravel beach, with the change between fresh water and sea being abrupt and not developed into salt marsh conditions. While cedar is common along the small flood terraces on either side of the brook, these terraces never approach a richness (calcium induced) required for some of the rarer species. *Corallorhiza maculata* (Spotted Coralroot) thrives in a habitat of disturbance, in this case where the *Picea glauca* (White Spruce) has taken over what was once an old field. *Spiranthes cernua* (Nodding Ladys Tresses) has taken advantage of the recent disturbance of beaver to find a new home.

In closing, Hendry Br is a good example of a typical brook found in the area.

References

ACCDC (Atlantic Canada Conservation Data Centre) 2011. http://www.accdc.com/products/NBCounties.htm

Hinds, H.R. 2000. Second Edition Flora of New Brunswick. Department of Biology, University of New Brunswick, Fredericton NB.

Flora of North America, Vol 26. 2002, eflora http://www.efloras.org/object_page.aspx?object_id=8245&flora_id=1

Appendix 1 Species observed within 100 m along lower 2.5 km of Hendry Br.

Abies balsamea	Balsam Fir	S5
Acer rubrum	Red Maple	S5
Acer saccharum	Sugar Maple	S4S5
Acer spicatum	Mountain Maple	S5
Actaea rubra	Red Baneberry	S5
Agrimonia striata	Striate Agrimony	S5
Agropyron trachycaulum var. glaucum	Dog Couch-grass	S4S5
Alnus incana ssp. rugosa	Speckled Alder	S5
Amelanchier sp.	Serviceberry	-
Anaphalis margaritacea	Pearly Everlasting	S5
Anemone canadensis	Canada Anemone	S5
Apocynum androsaemifolium var. incanum	Spreading Dogbane	S5
Arctium minus	Common Burdock	SE

Arisaema triphyllum ssp. stewardsonii	Jack-in-the-pulpit	S4S5
Artemisia vulgaris	Mugwort	SE
Aster cordifolius	Heart-leaved Aster	S5
Aster macrophyllus	Large-leaved Aster	S5
Aster novi-belgii var. novi-belgii	New York Aster	S5
Aster umbellatus	Flat-topped White Aster	S5
Athyrium filix-femina var. angustum	Lady-fern	S5
Atriplex prostrata	Orache	S5
Betula cordifolia	Heart-leaved Birch	S5
Brachyelytrum septentrionale	Bearded Short-husk	S5
Bromus ciliatus	Fringed Brome-grass	S5
Cakile edentula	Sea Rocket	S5
Callitriche sp.	Water-starwort	-
Caltha palustris	Marsh Marigold	S4/S5
Calystegia sepium ssp. americana	Hedge Bindweed	S5
Carex arctata	Compressed Sedge	S5
Carex crinita	Fringed Sedge	S5
Carex echinata	Bur Sedge	S5
Carex flava	Yellow Sedge	S5
Carex gracillima	Filiform Sedge	S5
Carex gynandra	Gynandrous Sedge	S5
Carex intumescens	Bladder Sedge	S5
Carex leptalea	Bristle-stalked Sedge	S5
Carex paleacea	Scaly Sedge	S5
Carex retrorsa	Retrorse Sedge	S4
Carex retrorsa	Retrorse Sedge	S4
Carex stipata	Stipitate Sedge	S5
Carex vaginata	Sheathed Sedge	S3
Chelone glabra	Turtlehead	S5
Chenopodium album	Lamb's Quarters	SE
Cicuta maculata	Spotted Cowbane	S5
Cinna latifolia	Drooping Wood Reed	S5
Circaea alpina	Dwarf Enchanter's Nightshade	S5
Clintonia borealis	Yellow Clintonia	S5
Corallorhiza maculata var. maculata	Spotted Coralroot	S2/S3
Cornus sericea	Red-osier Dogwood	S5
Corylus cornuta	Beaked Hazelnut	S5
Cystopteris fragilis	Fragile Fern	S4
Cystopteris tenuis	Mackay’s Brittle Fern	S4
Diervilla lonicera	Bush-honeysuckle	S5
Diphasiastrum digitatum	Ground Cedar	S5

Dryopteris campyloptera	Mountain Wood Fern	S5
Dryopteris intermedia	Glandular Wood Fern	S5
Dryopteris X bootii	Boott's Fern	HYB
Eleocharis obtusa	Blunt Spike-rush	S5
Epilobium ciliatum subsp. ciliatum	Glandular Willow-herb	S5
Epipactus helleborine	Helleborine	SE
Equisetum arvense	Common Field Horsetail	S5
Erysimum cheiranthoides	Wormseed Mustard	S5
Eupatorium maculatum	Joe-pye-weed	S5
Eupatorium perfoliatum	Boneset	S5
Fallopia japonica	Japanese Knotweed	SE
Fraxinus nigra	Black Ash	S5
Galeopsis tetrahit	Common Hemp-nettle	SE
Galium aparine	Cleavers	SE?
Galium mollugo	Wild Madder	SE
Galium trifidum ssp. halophilum	Dyer's Cleavers	S5
Geum laciniatum	Avens	S5
Glyceria striata var. striata	Fowl Manna-grass	S5
Gymnocarpium dryopteris	Oak Fern	S5
Halenia deflexa	Spurred Gentian	S4S5
Heracleum maximum	Cow-parsnip	S5
Hierochloe odorata	Sweet Grass	S5
Hordeum jubatum	Foxtail Barley	S5
Humulus lupulus var. lupuloides	Common Hop	S1/S2
Hypericum ellipticum	Pale St. John's-wort	S5
Hypericum perforatum	Common St. John's-wort	SE
Impatiens capensis	Spotted Touch-me-not	S5
Iris versicolor	Larger Blueflag	S5
Juncus arcticus var. balticus	Baltic Rush	S5
Lactuca biennis	Tall Blue Lettuce	S5
Larix laricina	Tamarack	S5
Linaria vulgaris	Butter-and-eggs	SE
Linnaea borealis	Twinflower	S5
Lonicera canadensis	Fly-honeysuckle	S5
Lycopodium annotinum	Bristly Clubmoss	S5
Lycopodium clavatum	Running Clubmoss	S5
Lycopodium dendroideum	Prickly Tree Clubmoss	S5
Maianthemum stellatum	Starry False Solomon's Seal	S4S5
Malus pumila	Wild Apple	SE
Matteuccia struthiopteris	Ostrich Fern	S5
Mollugo verticillata	Carpetweed	SE

Moneses uniflora	One-flowered Pyrola	S5
Monotropa uniflora	Indian Pipe	S5
Oenothera parviflora	Evening Primrose	S5
Osmunda claytoniana	Interrupted Fern	S5
Parthenocissus quinquefolia	Virginia Creeper	SE?
Persicaria pensylvanica	Pinkweed, Pepperwort	S4
Petasites frigidus	Sweet Colt's-foot	S4S5
Phegopteris connectilis	Northern Beech Fern	S5
Phleum pratense	Common Timothy	SE
Picea glauca	White Spruce	S5
Pimpinella saxifraga	Burnet Saxifrage	SE
Platanthera aquilonis	Northern Green Orchis	S4
Polystichum braunii	Braun's Holly Fern	S4
Populus balsamifera	Balsam Poplar	S5
Populus tremuloides	Trembling Aspen	S5
Prenanthes altissima	White Lettuce	S5
Prunella vulgaris	Self Heal	S5
Prunus virginiana	Choke-cherry	S5
Pyrola asarifolia	Pink Pyrola	S5
Ranunculus repens var. glabratus	Creeping Buttercup	SE
Ribes hirtellum	Bristly Gooseberry	S5
Ribes lacustre	Bristly Black Currant	S5
Rosa cinnamomea	Cinnamon Rose	SRD, SE
Rubus idaeus var. strigosus	Red Raspberry	S5
Rubus pubescens	Dwarf Raspberry	S5
Rudbeckia hirta var. pulcherrima	Black-eyed Susan	SE
Rumex longifolius	Long-leaved Dock	SE
Rumex salicifolius ssp. triangulivalvis	Narrow-leaved Water Dock	S4/S5
Sambucus racemosa ssp. pubens	Red Elderberry	S5
Sanicula marilandica	Black Snakeroot	S4S5
Schizachne purpurascens	False Melic-grass	S4S5
Scirpus cyperinus	Common Wool-grass	S5
Scirpus hattorianus	Mosquito Bulrush	S4
Scutellaria lateriflora	Mad-dog Skullcap	S5
Senecio aureus	Golden Ragwort	-
Solidago bicolor	Silverod	S5
Solidago canadensis var. canadensis	Canada Goldenrod	S5
Solidago flexicaulis	Zigzag Goldenrod	S5
Sonchus arvensis subsp. uliginosus	Field Sow Thistle	SE
Sorbus americana	Mountain-ash	S5
Spartina pectinata	Freshwater Cord-grass	S5

Spiranthes cernua	Nodding Ladies'-tresses	S2
Streptopus lanceolatus	Rose Twisted Stalk	S5
Thalictrum pubescens	Tall Meadow-rue	S5
Thlaspi arvense	Field Penny Cress	SE
Triadenum fraseri	Marsh St. John's-wort	S5
Trientalis borealis	Starflower	S5
Trifolium pratense	Red Clover	SE
Triglochin maritima	Seaside Arrow-grass	S5
Trillium cernuum	Nodding Trillium	S5
Tussilago farfara	Coltsfoot	S4S5
Viburnum edule	Squashberry	S4
Viola blanda var. palustriformis	Large-leaved White Violet	S5
Viola pubescens var. scabriuscula	Smooth Yellow Violet	SD4/S5

Appendix 2 Vascular Plant Collections

Botanical Name	Sample #	Date	Common Name	French Name	Abundance	Notes	Habitat/Location	Lat	Long
Atriplex prostrata Boucher	11-918.2	23 Aug 2011	Orache	arroche des champs	scattered		sandy, gravelly beach beach at mouth of Hendry Brook	47.88963	65.81318
Carex arctata Boott.	11-926	23 Aug 2011	Compressed Sedge	Carex comprimé	scattered		mixed woods near brook Hendry Brook west of hwy 134	47.88229	65.82541
Carex flava L.	11-924.1	23 Aug 2011	Yellow Sedge	Carex jaune	scattered		margin of beaver pond Hendry Brook west of hwy 134	47.88296	65.82078
Carex retrorsa Schw.	11-924.2	23 Aug 2011	Retrorse Sedge	Carex réfléchi	uncommon		margin of beaver pond Hendry Brook west of hwy 134	47.88296	65.82078
Carex retrorsa Schw.	11-931	24 Aug 2011	Retrorse Sedge	Carex réfléchi	scattered	with populus tremuloides, Populus balsamifera and Thuja occidentalis	floodplain beside brook Hendry Br, aprox. west of hwy 135	47.88363	65.82433
Corallorhiza maculata (Raf.) Raf. var. maculata	11-927	23 Aug 2011	Spotted Coralroot	Corallorhize maculée	thousand +		under dry white spruce about 200 m south of Hendry Brook west of hwy 134	47.88032	65.82661
Eleocharis obtusa (Willd.) Shultes	11-930.1	24 Aug 2011	Blunt Spike-rush	Éléocharide	scattered		margin of active beaver pond Hendry Brook	47.88342	65.82046
Geum laciniatum Murr.	11-923	23 Aug 2011	Avens		scattered		flood plain with Acer spicatum, and Solidago flexicaulis Hendry Brook west of hwy 134	47.88572	65.81590
Hierochloe odorata (L.) Beauv.	11-919.4	23 Aug 2011	Sweet Grass	Foin d'odeur	uncommon		grassy meadow beach at mouth of Hendry Brook	47.88983	65.81383
Humulus lupulus L. var. lupuloidesE. Small	11-921	23 Aug 2011	Common Hop	Houblon	local		dry upper bank of brook beside residence between mouth of Hendry Brook and hwy 134	47.88922	65.81423
Persicaria pensylvanica (L.) J.K. Small	11-919.2	23 Aug 2011	Pinkweed, Pepperwort	Renouée de Pennsylvanie	scattered		grassy meadow beach at mouth of Hendry Brook	47.88983	65.81383
Rosa cinnamomea L.	11-919.3	23 Aug 2011	Cinnamon Rose	Rosier cannelle	common	S.Blaney calls this R. majalis	grassy meadow beach at mouth of Hendry Brook	47.88983	65.81383
Rumex longifolius D.C.	11-920.3	23 Aug 2011	Long-leaved Dock	Rumex à longues feuilles	uncommon		brook side beach at mouth of Hendry Brook	47.88948	65.81414

Appendix 2 Vascular Plant Collections

Botanical Name	Sample #	Date	Common Name	French Name	Abundance	Notes	Habitat/Location		
Sanicula marilandica L.	11-928	23 Aug 2011	Black Snakeroot	Sanicle du Maryland	scattered		wet cedar woods, with Cirsium muticum Hendry Br, aprox. 1 km west of hwy 135	Lat 47.88218	Long 65.82663
Schizachne purpurascens (Torr.) Swallen	11-922	23 Aug 2011	False Melic-grass	Schizachné pourpre	large patch		cedar flood plain with Acer spicatum, Clintonia borealis and Solidago flexicaulis Hendry Brook west of hwy 134	Lat 47.88775	Long 65.81594
Scirpus cyperinus (L.) Kunth	11-915.1	22 Aug 2011	Common Wool-grass	Scirpe souchet	common		cat-tail/sedge margin margin of Belledune smelter settling pond	Lat 47.89257	Long 65.84351
Sonchus arvensis L. subsp. uliginosus (Bieb.)	11-918.1	23 Aug 2011	Field Sow Thistle	Laiteron des champs	scattered		sandy, gravelly beach beach at mouth of Hendry Brook	Lat 47.88963	Long 65.81318
Spiranthes cernua	11-930.2	24 Aug 2011	Nodding Ladies'-tresses		12 plants		margin of active beaver pond Hendry Brook	Lat 47.88342	Long 65.82046
Thlaspi arvense L.	11-919.1	23 Aug 2011	Field Penny Cress	Thlaspi des champs	common		grassy meadow beach at mouth of Hendry Brook	Lat 47.88983	Long 65.81383
Viburnum edule (Michx.) Raf.	11-929	24 Aug 2011	Squashberry	Viorne comestible	uncommon		Cedar flood plain with Populus balsamifera and Solidago flexicaulis Hendry Br, aprox. west of hwy 135	Lat 47.88237	Long 65.81851
Viola blanda Willd. var. palustriformis Gray	11-925	23 Aug 2011	Large-leaved White Violet	Violette méconnue	uncommon		along dry brook side trail Hendry Brook west of hwy 134	Lat 47.88258	Long 65.82410

APPENDIX O

FISH HABITAT AND ELECTRO-FISHING SURVEY

BELLEDUNE STREAM HABITAT SURVEY

Submitted to:

Conestoga Rovers and Associates

November 2011

R. A. Currie Ltd.
P. O. Box 1484
Fredericton, New Brunswick
E3B 5E3

R.A. CURRIE LTD.
BIOLOGICAL CONSULTANT

1 November, 2011

Mr. Neil Brodie, P. Eng.
Conestoga Rovers & Associates
466 Hodgson Road
Fredericton, NB E3C 2G5

Dear Mr. Brodie:

Re: Results of Aquatic Habitat Surveys of Three Streams at Belledune, NB

During September, 2011, R. A. Currie conducted inventories of aquatic habitat, and resident fish communities, for three watercourses in the vicinity of the Belledune smelter. The watercourses involved in the assessment were Hendry Brook, Armstrong Brook and a small watercourse adjacent to the smelter that was designated Unnamed Brook.

The surveys determined all three watercourses represent viable salmonid habitat and support moderate to dense fish communities. Brook trout proved to be the most abundant species of fish at each of the sites, while various combinations of other common species (blacknose dace, American eel, slimy sculpin and Atlantic salmon) were also found at each location.

The assessments determined that despite being closest to the smelter and slag pile, and having the most modified habitat, the highest total density of fish was found in the Unnamed Brook. In addition to having the highest total density of fish, the Unnamed Brook also supported the highest density of brook trout. The captured trout represented several age classes including young of the year which indicates this species is reproducing successfully at this location. Based on the fish sampling results, there is no overt evidence the operation of the smelter, or the presence of the slag pile, is having a negative impact on fish populations in the Unnamed Brook.

I trust this report meets your requirements. If you have any questions or comments concerning this study, please do not hesitate to contact me.

Sincerely,

Rod Currie

R. A. Currie
Biological Consultant.

Belledune Stream Habitat Survey

Hendry Brook:

The stream habitat survey of Hendry Brook was completed on 12-13 September, 2011. Although higher than normal stream flows occurred throughout the summer and fall of 2011, the survey of Hendry Brook was conducted under normal stream flow conditions.

Habitat

The survey began at the head of the tide and proceeded upstream for a linear distance of approximately 2400 m. Riffle habitat was the dominant habitat type in the initial section of Hendry Brook (downstream of Route 134). Further upstream, run habitat was the dominant habitat type. A number of pools were identified, however these features were generally small and shallow. The survey found high amounts of exposed bedrock in the streambed and stream banks in the initial 100 m of the surveyed length. However, with increasing distance from the Baie des Chaleurs, the representation of bedrock gradually deceased and the percentage of smaller substrates (sand gravel fines) gradually increased. For the most part, stream banks were stable and the proportion of fines in the streambed was very low. As a result, the degree of embeddedness (the extent to which gravel or rock is buried by sand or fines) was extremely low throughout much of the surveyed stream length. The only areas where embeddedness was slightly elevated was related to areas of where Hendry Brook ran through cedar swamps. In these areas the stream generally had a braided channel, perhaps resulting from the stream trying to flow around fallen trees and debris piles (the amount of large woody debris was also highest in these locations). For most of its length, Hendry Brook has a high degree of shade cover. Hiding cover for fish occurs in the form of coarse substrate and riffle habitat in the stream section downstream of Route 134. Further upstream, fish cover occurred mainly in the form of overhanging vegetation, undercut stream banks and large woody debris.

With respect to the overall quality of habitat, a recognized salmonid classification system was proposed by Beak (1982) to summarize salmonid habitat quality. Although this system was developed for larger watercourses and salmon, if one accounts for the generally shallow nature of these study streams, this classification system can be used to classify brook trout habitat. In the case of Hendry Brook, the lower 20 percent of the surveyed stream section would be described as Type II habitat. This category describes good rearing habitat with limited spawning potential due to the high amounts of bedrock. The remainder of the surveyed stream section would be classified as Type I habitat that reflects both good rearing and spawning potential. In summary, for the most part, the surveyed section of Hendry Brook provides both good spawning and good rearing habitat for brook trout.

A detailed record of all habitat features observed during the stream survey of Hendry Brook may be found in the habitat sheets in Appendix AAA.

Obstructions

Only one obstruction to upstream fish passage was noted along the 2400 m surveyed section of Hendry Brook. Approximately 80 m upstream of the head of tide was an old wooden dam structure. Although the structure was quite deteriorated, it still presented a complete obstruction to upstream fish passage.

Fish

Spot electrofishing was conducted in the lower end of Hendry Brook in the vicinity of the bridge on Route 134. This location was upstream of the obstruction posed by the old wooden dam structure. The purpose of electrofishing was to gain knowledge concerning the species of fish inhabiting this watercourse. Additionally, the duration of sampling was noted in order to quantify the catch per unit effort. The electrofisher that was used was a Smith-Root Model LR24 backpack unit. The unit automatically selected a power output level of 265 volts based on water conductivity, and this level of output was maintained for this site. Also, it should be noted, the midday stream temperature measured 14°C.

During 1019 seconds of electrofishing, 18 fish were caught (0.018 fish per second). This total was composed of 4 blacknose dace, 1 American eel and 13 brook trout. The brook trout appeared to represent 3 age classes based on size class as follows: 4 were age class 0+, 6 were age class 1+ and 3 were age class 2+. All of these fish were caught upstream of the obstruction formed by the old wooden dam structure. In our experience, a catch rate of 0.018 fish per second indicates a moderate fish density.

Unnamed Brook:

The stream survey of Unnamed Brook was completed on 20 September,2011. At this time the brook was experiencing low to normal flow conditions.

Habitat

The stream section of Unnamed Brook that was surveyed ran from the upstream edge of the old airstrip, upstream to the water sampling station (UNSED1), a linear distance of 966 m. The survey confirmed this watercourse is very small with an average wet width of approximately 1.5 m. The habitat types were alternating riffle and run habitat and often the differences between these habitat types was indistinct. This circumstance was acknowledged in the field data sheets by first listing the more dominant type, then the less dominant type (i.e. 3/8 which would be interpreted as mainly riffle features with some run features).

The dominant substrate component is for the surveyed stream section was gravel, however, all types of substrate are present in varying amounts. Although fines are present, the degree of embeddedness is low throughout the section. For the most part, the stream banks were stable and well vegetated. It is important to note, a significant length of the stream (from chain measurement 273 m to 630 m) was obviously channelized approximately 25 years ago. At that time it appears a rock-lined ditch was constructed to replace the natural stream channel. Although this channel is beginning to develop some natural characteristics, its origin is still obvious. The stream has considerable shade cover along its entire length from shrubs and small trees. Because the trees along the riparian zone are young/small, there is little large woody debris in this stream. Cover is available for fish in the form of undercut stream banks, overhanging grass and shrub vegetation, as well as surface turbulence in relation to riffle habitat.

Upstream of the road crossing, the stream splits into two branches. The main stream flow is provided by the branch on the right (north), however, the water sampling station UNSED1 is associated with the left branch where there is less flow.

The Unnamed Brook is a very small watercourse to be subjected to the Beak (1982) salmonid habitat classification system. However, if one ignores the suggested depth indicators, and relies solely on the substrate component, 95 percent of the lower surveyed stream section would be Type I habitat which describes both good spawning and rearing potential for salmonids. The remaining 5 percent of the surveyed stream segment refers to the stream section in the vicinity of sampling station UNSED1 where there was little flow and abundant bedrock. This stream segment provides rearing and spawning potential and would only rate as Type III or Type IV habitat.

A detailed record of all of the habitat features noted during the stream survey of Unnamed Brook may be found in the stream habitat sheets contained in Appendix AAA.

Obstructions

Two obstructions to upstream fish passage were noted during the habitat survey. At the start point of the survey it was noted the upstream end of the culvert running under the old airstrip is mostly blocked with brush debris. Additionally, the culverts further upstream at the road crossing also block upstream fish passage. Three separate corrugated steel pipes (2 are 0.5 m dia, 1 is 1.2 m dia) are present to pass water at this location, however, all three pipes have vertical drops at their outlets that preclude upstream fish passage.

Fish

On 13 September, a limited amount of spot electrofishing was conducted in Unnamed Brook in the vicinity of the water sampling station UNSED1 to determine if fish were present at this location. This effort resulted in the capture of 7 small blacknose dace and two small brook trout (age class 1+) during 693 seconds of operating time. Additionally, on 20 September, more electrofishing was conducted further downstream below the road crossing. At this location, 30 brook trout were captured during 206 seconds of sampling. These combined efforts resulted in the capture of 39 fish during 899 seconds of sampling. These numbers indicate a catch per unit effort of 0.043 fish per second. In our experience, a catch rate of 0.043 fish per second suggests a high fish density.

Armstrong Brook

The stream survey of Armstrong Brook was completed on 20-21 September, 2011. At that time the brook appeared to be at/near normal flow conditions. However, there was evidence of recent high storm flows that over topped the stream banks and flowed through areas of the flood plain,

Habitat

Approximately 250 m upstream of the railway crossing, Armstrong Brook splits into two branches. The habitat survey concentrated on the right hand (eastern) branch. The stream section that was surveyed extended from the head of tide upstream of the unpaved road that runs to Mitchell settlement. This section measured 2023 m in length.

The survey determined that at this location, Armstrong Brook represents a medium sized watercourse with an average channel width of approximately 5 m. the habitat types were determined to be alternating sections of riffle and run habitat with a number of small lateral and plunge pools. One of the more unusual features of Armstrong Brook was a stream section that ran completely underground through a cave. This feature was located under the railway tracks.

Although all substrate types were found to be present in the surveyed stream section, the most dominant substrate was gravel, while sand and rubble were co-dominant substrate types. Fines were present, however, the degree of embeddedness was uniformly low throughout the surveyed section. For the most part, stream banks were stable, however, there was evidence of recent erosion in the form of bare soil and exposed plant roots at numerous locations. Much of the erosion appeared to have resulted from recent extreme flows. Generally the stream had a moderate degree of shade cover (50% - 60%) in the forested section. Further downstream near the mouth of the brook, however, the degree of shade cover is very low. Hiding cover for fish was found to be abundant. Cover features occurred in the form of increased water depth in pool habitat, surface turbulence associated with riffle habitat, large woody debris, coarse rock substrate, undercut stream banks and over hanging riparian vegetation.

For the most part, the habitat of Armstrong Brook reflects good salmonid habitat, and can be classified as Type I and Type II salmonid habitat. These classifications reflect good rearing habitat with fair to good spawning potential. However, the short stream segment immediately upstream of the railway tracks that contains the ponded stream section would only rate as Type IV habitat due to the complete absence of spawning and rearing potential.

A detailed record of all of the habitat features noted during the stream survey of Armstrong Brook may be found in the habitat field forms contained in Appendix AAA.

Obstructions

No serious obstructions to fish passage were found within the surveyed section of Armstrong Brook.

Fish

Spot electrofishing was conducted at the upstream end of the surveyed steam section where access was provided at the road crossing. The electrofisher automatically selected an optimum output power setting of 300 volts for this watercourse, and this power setting was maintained for this project. During 1006 seconds of operating time, 23 fish were captured, providing a catch per unit effort of 0.023 fish per second. The total catch was comprised of 1 Atlantic salmon parr (age class 1+), 6 slimy sculpin, 2 blacknose dace and 14 brook trout (1 was age class 0+, 12 were age class 1+ and 1 was age class 2+). In our opinion, a catch rate of 0.023 fish per second describes a moderate fish density.

In addition to the fish, 1 frog (species unknown) and 1 salamander were also captured.

Summary

The September, 2011 field survey determined all three of the study streams in the vicinity of the Belledune smelter represent viable fish habitat. Additionally, spot electrofishing surveys in each stream confirmed the presence of fish inhabiting each stream. The fish surveys determined brook trout to be the most abundant fish species in each of the watercourses. All of the other fish species are commonly found in streams in this area of the province. Although brook trout is a common species in watercourses in this area of the province, it is also recognized as a species that is very sensitive to environmental degradation. With this in mind, it is interesting to note the highest density of brook trout was found in the Unnamed Brook which is closest to the smelter and slag pile, and is the watercourse that has been most heavily modified in the past through vegetation clearing, culvert installation and channelization. It should also be noted that the captured brook trout represented multiple age classes including young of the year. This population structure indicates brook trout are reproducing successfully in the Unnamed Brook, and are maintaining a robust community. Based on the fish sampling results, there is no overt evidence that the operation of the smelter, or the presence of the slag pile, on fish populations in the Unnamed Brook.

LEGEND:

● STREAM SAMPLING LOCATIONS (JULY 2010)

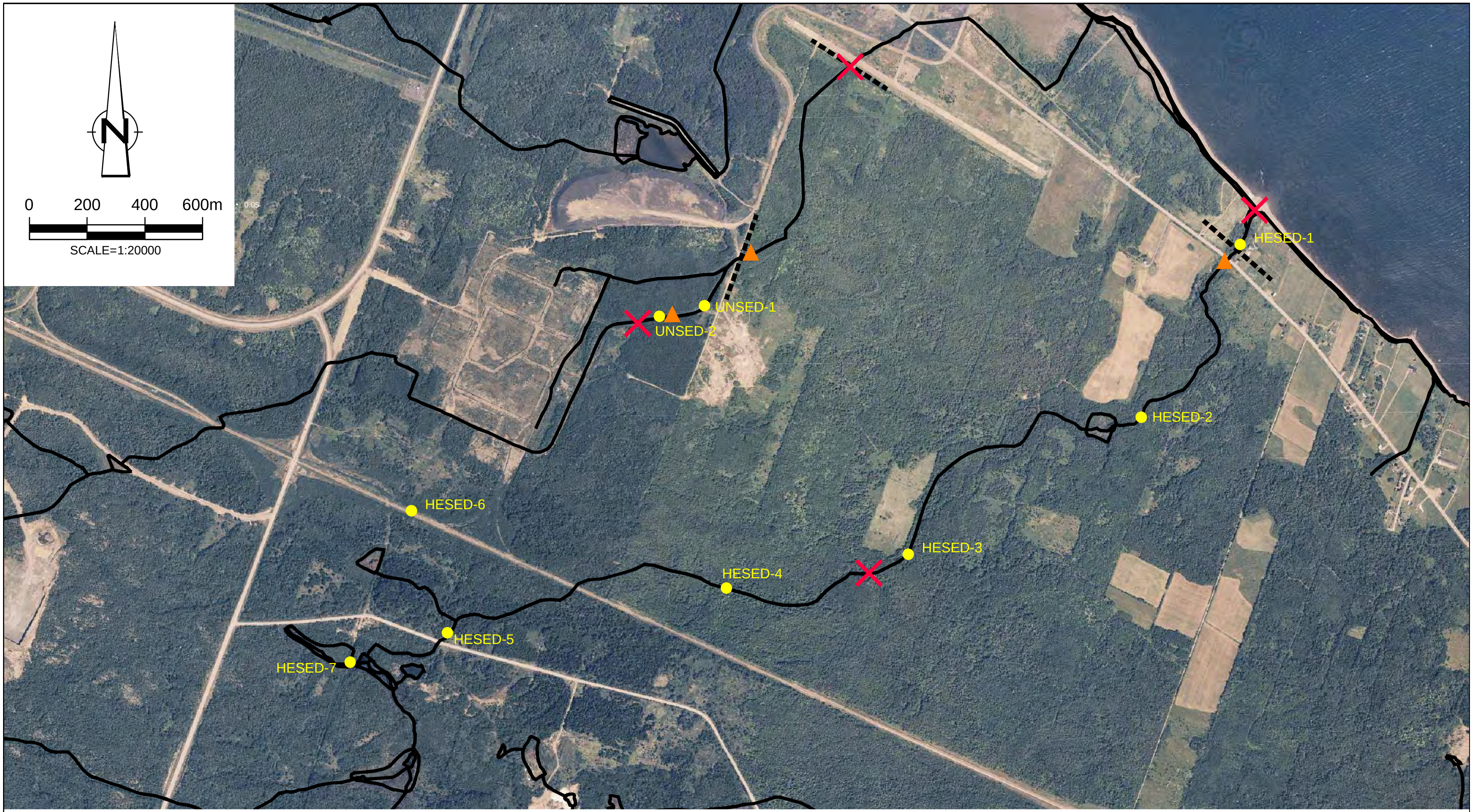
〜 RIVERS, STREAMS, LAKES & COASTLINE (SOURCE: SNB DIGITAL TOPOGRAPHIC BASE MAPS)

(SOURCE: SERVICE NB DIGITAL TOPOGRAPHIC BASE MAPS AND ORTHOPHOTOS)

figure 1

SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS
BELLEDUNE STREAM HABITAT SURVEY
INTRINSIK ENVIRONMENTAL SERVICES INC.
Belledune, New Brunswick

055453-03(MOORE001)GN-FROO1 NOV 08/2011



LEGEND:

● STREAM SAMPLING LOCATIONS (JULY 2010)

〰 RIVERS, STREAMS, LAKES & COASTLINE (SOURCE: SNB DIGITAL TOPOGRAPHIC BASE MAPS)

✕ LIMITS OF HABITAT SURVEY

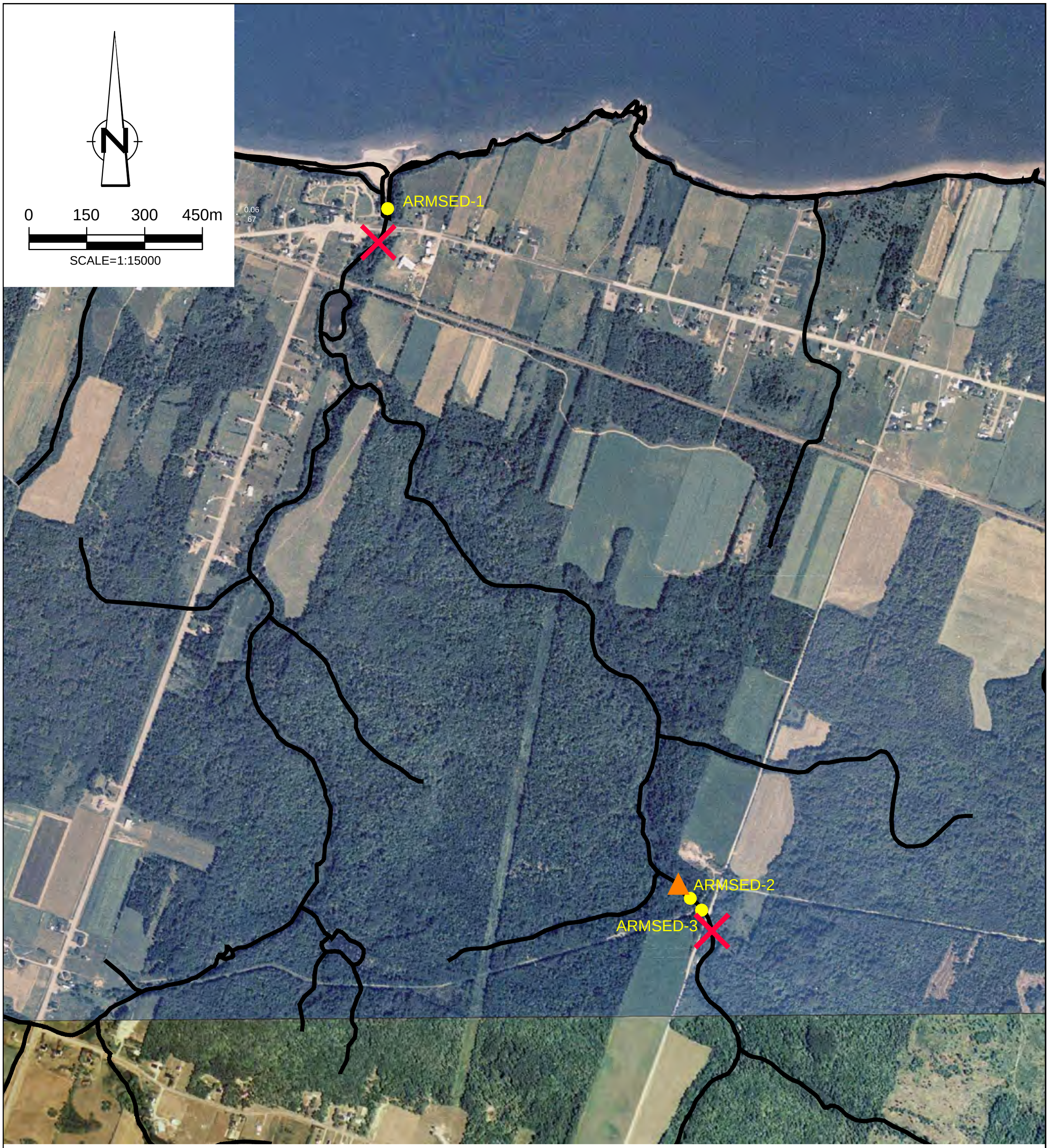
▲ ELECTROFISH LOCATION

- - - - FISH PASSAGE OBSTRUCTION (PARTIAL)

figure 2

BELLEDUNE STREAM HABITAT SURVEY
HENDRY BROOK & UNNAMED BROOK
INTRINSIK ENVIRONMENTAL SERVICES INC.
Belledune, New Brunswick

055453-03(MOORE001)GN-FR002 NOV 08/2011



LEGEND:

● STREAM SAMPLING LOCATIONS (JULY 2010)

〰 RIVERS, STREAMS, LAKES & COASTLINE (SOURCE: SNB DIGITAL TOPOGRAPHIC BASE MAPS)

✕ LIMITS OF HABITAT SURVEY

▲ ELECTROFISH LOCATION

figure 3

BELLEDUNE STREAM HABITAT SURVEY
ARMSTRONG BROOK - REFERENCE STREAM
INTRINSIK ENVIRONMENTAL SERVICES INC.
Belledune, New Brunswick

055453-03(MOORE001)GN-FR002 NOV 08/2011

APPENDIX A

STREAM SURVEY TRANSECTS

08-94

DNR&E / DFO - NEW BRUNSWICK
STREAM SURVEY and HABITAT ASSESSMENT

River: Hendry Brook　　Start Point head of tide　　End Point: approx 2400 m upstream of start　　Drainage Code GG GG GG　　Stream/River No.

Personnel R. C, MG, MG　　Date: 12 September 2011　　GIS Map No. Point-Verte 21P/13　　Stream Order No. 2　　Page: 1 of 6

REACH NO. *	UNIT NO.	STREAM TYPE	CHANNEL TYPE	LENGTH (m) *	AVE WIDTH (m) *		SUBSTRATE (%) *							AVE DEPTH - WET WIDTH (cm) *	0-50% UNDERCUT BANK *		0-50% OVER-HANGING BANK VEGETATION *		LARGE WOODY DEBRIS IN STREAM (m) *	FLOWS *					EMBEDDEDNESS (CRITERIA) 1 : # 20% 2 : 20% - 35% 3 : 35% - 50% 4 : ∃ 50%	COMMENTS	CHECKLIST OF LAND USE ATTRIBUTES (COMMENTS)
					WET	BANK CHANNEL	BED-ROCK	BOULDER	ROCK	RUBBLE	GRAVEL	SAND	FINES		L	R	L	R		TYPE	FLOW (cms)	TIME	TEMP EC W	TEMP EC A			
1	1	8/3	1	11	4	5.5	70	5	5	10	10			18	0	0	5	5	0						1	Start at head of tide	
1	2	15	1	18	4	7	85	5	5	5				70	10	5	5	0	3						1		
1	3	4	1	25	3	6	80	10	10					12	10	0	5	5	0						1		
1	4	8	1	33	3	5	80	10	10					20	0	0	5	5	2						1		
1	5	4	1	44	4	6	80	10	10					15	0	30	5	5	0						1		
1	6	8	1	54	3.5	6	70		10		20			20	5	0	5	5	2						1		
1	7	4	1	64	3.5	6	80	10	10					18	5	5	5	0	0						1		
1	8	12	1	72	3	8	40		10	10	40			50	10	0	0	10	2						1		
1	9	7	1	76	5	8	90	10						12	0	0	10	5	0						1	Old wooden dam at 80 m	
1	10	23	1	82	6	8			10	15	60	15		10	0	0	40	40	20						1		
1	11	8	1	94	4	6		5	15	15	60	5		50	10	10	10	10	0						1		

STREAM TYPE						CHANNEL TYPE	SUBSTRATE	FLOW TYPE	POOL RATING (reverse side)	
FASTWATER		POOLS							CRITERIA (NO.)	% OF POOLS IN SITE (LETTER)
1. Fall 2. Cascade 3. Riffle (GR/RB) 4. Riffle (R/B) 5. Riffle (Sand)	6. Sheet (ledge) 7. Chute 8. Run 9. Rapid	10. Midchannel 11. Convergence 12. Lateral 13. Beaver	14. Trench 15. Plunge 16. 17. Bogan	18. Eddy 19. Gabion 20. Log Structure 21. Road Crossing	22. Wood Debris 23. Man-Made Dam 24. Natural Deadwater	1. Main (if measurement refers to main area of river) * 2. Side Channel (water diverted by islands) * 3. Split (if river is split into various different stream types) * 4. Bogan * - Specify Left (L), Right (R) or Middle (M)	1. Bedrock , Ledge 2. Boulder = > 461 mm 3. Rock = 180 - 460 mm 4. Rubble = 54 - 179 mm 5. Gravel = 2.6 - 53 mm 6. Sand = 0.06 - 2.5 mm 7. Fines = 0.0005 - 0.05 mm	1. Survey Stream 2. Spring 3. Brook/River Trib 4. Spring Seep	Pool Depth ∃ 1.5 m 1 - Instream Cover ∃ 30% 2 - Instream Cover < 30% Pool Depth .5 to 1.5m 3 - Instream Cover 5 - 30% 4 - Instream Cover > 30%	a - ∃ 30% b - ∃ 10% to 30% c - < 10% a - ∃ 50% b - < 50%

Note: Stream surveys should be undertaken only during summer base (low) flow conditions. Also, minimum size of stream type is 4m^2 for larger streams.

REACH NO.	SITE (50m - interval)	% SITE		SHADE (%)	STREAM BANKS										O_2 (mg/l)	pH	DEPTH						POOL RATING (CRITERIA ON OTHER SIDE)		POOL TAIL			% TURBUL-ENCE
					VEGETATION (%)				EROSION (%)								1/4 (m)		1/2 (m)		3/4 (m)				EMBEDDEDNESS (CRITERIA) 1: # 20% 2: 20% - 35% 3: 35% - 50% 4: ∃ 50%	MEAN SUBSTRATE SIZE (cm)	% FINE	
		RIFFLE / RUN	POOLS		BARE GROUND	GRASSES	SHRUBS	TREES	LEFT BANK (0-50%)			RIGHT BANK (0-50%)					WET	CHANNEL	WET	CHANNEL	WET	CHANNEL	NO.	LETTER				
									STABLE	BARE STABLE	ERODING	STABLE	BARE STABLE	ERODING														
1	1	100		50	80	10	10		10	40		10	40															
1	2		100	60	90		10		5	45		5	45															
1	3	100		80	90		10		5	45		5	45															
1	4	100		80	90		10		5	45		5	45															
1	5	100		75	60	30	10		20	30		25	25															
1	6	100		70	70	20	10		10	40		10	40															
1	7	100		30	80	10	10		10	40		10	40															
1	8		100	30	70	15	15			50		15	35															
1	9	100		30	70	10	20		10	40		20	30															
1	10	100		30	30	20	50		30	20		30	20															
1	11	100		50	30	20	50		25	25		25	20	5														

NOTE: * For selected site study, these columns (reverse side) should be done for a habitat assessment

WATER FLOW MEASUREMENT

REACH NO.	CORRESPONDING LOCATION		STREAM TYPE	WET WIDTH (m)	DEPTH (cm)			AVERAGE DEPTH SUM / 4		COEFFICIENT (0.9 - smooth) (0.8 - rough)	LENGTH (3m)	FLOAT TIME (sec)				COMMENTS (LOCATION)
	UNIT NO.	SITE (50 - interval)			1/4 way	1/2 way	3/4 way	CENTIMETERS (cm)	METERS (m)			1/4 way	1/2 way	3/4 way	AVERAGE	

Formula (CMS) = W (m) x D (m) x A x L (m) Where: W = width, D = depth, L = length, A is a coefficient for the stream bottom
T ____(sec)

08-94

DNR&E / DFO - NEW BRUNSWICK
STREAM SURVEY and HABITAT ASSESSMENT

River: Hendry Brook
Start Point head of tide
End Point: approx 2400 m upstream of start
Drainage Code GG GG GG
Stream/River No.
Personnel R. C, MG, MG
Date: 12 September 2011
GIS Map No. Point-Verte 21P/13
Stream Order No. 2
Page: 2 of 6

REACH NO. *	UNIT NO.	STREAM TYPE	CHANNEL TYPE	LENGTH (m) *	AVE WIDTH (m) *		SUBSTRATE (%) *							AVE DEPTH - WET WIDTH (cm) *	0-50% UNDERCUT BANK *		0-50% OVER-HANGING BANK VEGETATION *		LARGE WOODY DEBRIS IN STREAM (m) *	FLOWS *					EMBEDDEDNESS (CRITERIA) 1 : # 20% 2 : 20% - 35% 3 : 35% - 50% 4 : ∃ 50%	COMMENTS	CHECKLIST OF LAND USE ATTRIBUTES (COMMENTS)
					WET	BANK CHANNEL	BED-ROCK	BOULDER	ROCK	RUBBLE	GRAVEL	SAND	FINES		L	R	L	R		TYPE	FLOW (cms)	TIME	TEMP EC				
																							W	A			
1	12	3	1	101	8	11			20	20	60			15	10	0	10	10	1						1		
1	13	8	1	119	4	7	10	10	20	20	50			45	5	0	30	30	5						1		
1	14	3	1	131	4	6		5	10	25	60			15	0	5	20	25	0						1		
1	15	8	1	141	5	6	5	5	10	20	60			12	0	0	0	0	0						1	Under highway bridge	
2	1	8	1	159	4	5	5	5	10	30	50			15	10	10	20	20	6						1		
2	2	3	1	180	3	6	5	5	10	30	50			17	5	0	5	5	1						1		
2	3	8	1	212	3.5	5	15	5	10	30	40			40	0	0	0	5	1						1		
2	4	3/8	1	226	3	5	15	5	10	30	40			25	0	15	5	15	1						1		
2	5	8/3	1	268	4.5	6	5		5	10	80			26	5	5	15	15	1						1		
2	6	3/8	1	304	4	6	20		10	20	50			20	10	0	10	10	1						1		
2	7	8	1	327	4	6	20	5	10	15	50			25	10	10	15	15	2						1		

STREAM TYPE						CHANNEL TYPE	SUBSTRATE	FLOW TYPE	POOL RATING (reverse side)	
FASTWATER		POOLS							CRITERIA (NO.)	% OF POOLS IN SITE (LETTER)
1. Fall 2. Cascade 3. Riffle (GR/RB) 4. Riffle (R/B) 5. Riffle (Sand)	6. Sheet (ledge) 7. Chute 8. Run 9. Rapid	10. Midchannel 11. Convergence 12. Lateral 13. Beaver	14. Trench 15. Plunge 16. 17. Bogan	18. Eddy 19. Gabion 20. Log Structure 21. Road Crossing	22. Wood Debris 23. Man-Made Dam 24. Natural Deadwater	1. Main (if measurement refers to main area of river) * 2. Side Channel (water diverted by islands) * 3. Split (if river is split into various different stream types) * 4. Bogan * - Specify Left (L), Right (R) or Middle (M)	1. Bedrock , Ledge 2. Boulder = > 461 mm 3. Rock = 180 - 460 mm 4. Rubble = 54 - 179 mm 5. Gravel = 2.6 - 53 mm 6. Sand = 0.06 - 2.5 mm 7. Fines = 0.0005 - 0.05 mm	1. Survey Stream 2. Spring 3. Brook/River Trib 4. Spring Seep	Pool Depth ∃ 1.5 m 1 - Instream Cover ∃ 30% 2 - Instream Cover < 30% Pool Depth .5 to 1.5m 3 - Instream Cover 5 - 30% 4 - Instream Cover > 30%	a - ∃ 30% b - ∃ 10% to 30% c - < 10% a - ∃ 50% b - < 50%

Note: Stream surveys should be undertaken only during summer base (low) flow conditions. Also, minimum size of stream type is $4m^2$ for larger streams.

REACH NO.	SITE (50m - interval)	% SITE		SHADE (%)	STREAM BANKS										O_2 (mg/l)	pH	DEPTH						POOL RATING (CRITERIA ON OTHER SIDE)		POOL TAIL			% TURBUL-ENCE
					VEGETATION (%)				EROSION (%)								1/4 (m)		1/2 (m)		3/4 (m)				EMBEDDEDNESS (CRITERIA) 1: # 20% 2: 20% - 35% 3: 35% - 50% 4: ∃ 50%	MEAN SUBSTRATE SIZE (cm)	% FINE	
		RIFFLE / RUN	POOLS		BARE GROUND	GRASSES	SHRUBS	TREES	LEFT BANK (0-50%)			RIGHT BANK (0-50%)					WET	CHANNEL	WET	CHANNEL	WET	CHANNEL	NO.	LETTER				
									STABLE	BARE STABLE	ERODING	STABLE	BARE STABLE	ERODING														
1	12	100		30	10	30	60		30	20		40	10															
1	13	100		50	10	20	70		45	5		45	5															
1	14	100		50	10	30	60		45	5		45	5															
1	15	100		90	90	5	5		5	45		5	45	Under	Bridge													
2	1	100		20	10	20	70		40	10		50																
2	2	100		50	70	10	20		10	40		10	40															
2	3	100		50	60	10	30			50		20	30															
2	4	100		60	60	10	30			5		30	20															
2	5	100		40	10	20	60	10	35	15		45		5														
2	6	100		50	50	10	30	10	15	35		10	40															
2	7	100		50	40	20	30	10	30	20		30	20															

NOTE: * For selected site study, these columns (reverse side) should be done for a habitat assessment

WATER FLOW MEASUREMENT

REACH NO.	CORRESPONDING LOCATION		STREAM TYPE	WET WIDTH (m)	DEPTH (cm)			AVERAGE DEPTH SUM / 4		COEFFICIENT (0.9 - smooth) (0.8 - rough)	LENGTH (3m)	FLOAT TIME (sec)				COMMENTS (LOCATION)
	UNIT NO.	SITE (50 - interval)			1/4 way	1/2 way	3/4 way	CENTIMETERS (cm)	METERS (m)			1/4 way	1/2 way	3/4 way	AVERAGE	

Formula (CMS) = W____(m) x D____(m) x A_____x L______(m)   Where: W = width, D = depth, L = length, A is a coefficient for the stream bottom
T ____(sec)

08-94

DNR&E / DFO - NEW BRUNSWICK
STREAM SURVEY and HABITAT ASSESSMENT

River: Hendry Brook

Start Point head of tide

End Point: approx 2400 m upstream of start

Drainage Code GG GG GG

Stream/River No.

Personnel R. C, MG, MG

Date: 12 September 2011

GIS Map No. Point-Verte 21P/13

Stream Order No. 2

Page: 3 of 6

REACH NO. *	UNIT NO.	STREAM TYPE	CHANNEL TYPE	LENGTH (m) *	AVE WIDTH (m) *		SUBSTRATE (%) *							AVE DEPTH - WET WIDTH (cm) *	0-50% UNDERCUT BANK *		0-50% OVER-HANGING BANK VEGETATION *		LARGE WOODY DEBRIS IN STREAM (m) *	FLOWS *					EMBEDDEDNESS (CRITERIA) 1 : # 20% 2 : 20% - 35% 3 : 35% - 50% 4 : ∃ 50%	COMMENTS	CHECKLIST OF LAND USE ATTRIBUTES (COMMENTS)
					WET	BANK CHANNEL	BED-ROCK	BOULDER	ROCK	RUBBLE	GRAVEL	SAND	FINES		L	R	L	R		TYPE	FLOW (cms)	TIME	TEMP EC W	TEMP EC A			
2	8	3	1	340	3	5			20	20	60			20	5	5	10	10	2						1		
2	9	8	1	355	4	6	20	15	10	10	40	5		22	5	5	10	10	7						1	Braided channel	
2	10	3/8	1	385	4	10			20	20	60			22	5	5	10	15	15						1		
2	11	8	1	413	6	10			5	15	70	10		20	20	20	5	5	30						1		
2	12	3	1	428	3	5				10	80	10		17	20	20	30	30	10						1		
2	13	8	1	494	4	6				20	70	10		20	5	5	5	5	14						1		
2	14	3/8	1	534	3.5	5				25	75			15	5	20	30	30	6						1		
2	15	8	1	563	3.5	5	10		10	20	60			45	0	0	25	5	1						1		
2	16	3	1	631	3.5	5	15	5	10	30	40			25	5	5	5	5	0						1		
2	17	3	1	680	3.5	5	20	10	10	30	30			30	5	5	5	5	2						1		
2	18	10	1	691	4	5	50	10	10	10	20			75	10	10	5	5	1						1		

STREAM TYPE						CHANNEL TYPE	SUBSTRATE	FLOW TYPE	POOL RATING (reverse side)	
FASTWATER		POOLS							CRITERIA (NO.)	% OF POOLS IN SITE (LETTER)
1. Fall	6. Sheet (ledge)	10. Midchannel	14. Trench	18. Eddy	22. Wood Debris	1. Main (if measurement refers to main area of river)	1. Bedrock , Ledge 2. Boulder = > 461 mm	1. Survey Stream	Pool Depth ∃ 1.5 m 1 - Instream Cover ∃ 30%	a - ∃ 30%
2. Cascade	7. Chute	11. Convergence	15. Plunge	19. Gabion	23. Man-Made Dam	* 2. Side Channel (water diverted by islands)	3. Rock = 180 - 460 mm 4. Rubble = 54 - 179 mm	2. Spring	2 - Instream Cover < 30%	b - ∃ 10% to 30% c - < 10%
3. Riffle (GR/RB)	8. Run	12. Lateral	16.	20. Log Structure	24. Natural Deadwater	* 3. Split (if river is split into various different stream types)	5. Gravel = 2.6 - 53 mm 6. Sand = 0.06 - 2.5 mm	3. Brook/River Trib		
4. Riffle (R/B)	9. Rapid	13. Beaver	17. Bogan	21. Road Crossing		* 4. Bogan	7. Fines = 0.0005 - 0.05 mm	4. Spring Seep	Pool Depth .5 to 1.5m 3 - Instream Cover 5 - 30%	a - ∃ 50%
5. Riffle (Sand)						* - Specify Left (L), Right (R) or Middle (M)			4 - Instream Cover > 30%	b - < 50%

Note: Stream surveys should be undertaken only during summer base (low) flow conditions. Also, minimum size of stream type is $4m^2$ for larger streams.

REACH NO.	SITE (50m - interval)	% SITE		SHADE (%)	STREAM BANKS										O_2 (mg/l)	pH	DEPTH						POOL RATING (CRITERIA ON OTHER SIDE)		POOL TAIL			% TURBUL-ENCE
		RIFFLE / RUN	POOLS		VEGETATION (%)				EROSION (%)								1/4 (m)		1/2 (m)		3/4 (m)		NO.	LETTER	EMBEDDEDNESS (CRITERIA) 1: # 20% 2: 20% - 35% 3: 35% - 50% 4: ∃ 50%	MEAN SUBSTRATE SIZE (cm)	% FINE	
					BARE GROUND	GRASSES	SHRUBS	TREES	LEFT BANK (0-50%)			RIGHT BANK (0-50%)					WET	CHANNEL	WET	CHANNEL	WET	CHANNEL						
									STABLE	BARE STABLE	ERODING	STABLE	BARE STABLE	ERODING														
2	8	100		30	20	40	30	10	40	10		40	10															
2	9	100		30	20	30	40	10	40	5	5	40	10															
2	10	100		40	20	20	50	10	40	5	5	40	5	5														
2	11	100		50	10	30	50	10	40	5	5	40	5	5														
2	12	100		40	10	30	50	10	50			40	10															
2	13	100		30	50	10	30	10	25	25		25	25															
2	14	100		20	20	30	40	10	40	10		40	5	5														
2	15	100		30	30	30	30	10	40	10		30	20															
2	16	100		60	30	40	20	10	40	10		30	20															
2	17	100		60	40	30	20	10	20	30		40	10															
2	18		100	40	40	25	25	10	40	10		10	40															

NOTE: * For selected site study, these columns (reverse side) should be done for a habitat assessment

WATER FLOW MEASUREMENT

REACH NO.	CORRESPONDING LOCATION		STREAM TYPE	WET WIDTH (m)	DEPTH (cm)			AVERAGE DEPTH SUM / 4		COEFFICIENT (0.9 - smooth) (0.8 - rough)	LENGTH (3m)	FLOAT TIME (sec)				COMMENTS (LOCATION)
	UNIT NO.	SITE (50 - interval)			1/4 way	1/2 way	3/4 way	CENTIMETERS (cm)	METERS (m)			1/4 way	1/2 way	3/4 way	AVERAGE	

Formula (CMS) = W____(m) x D____(m) x A____x L______(m)
T ____(sec)

Where: W = width, D = depth, L = length, A is a coefficient for the stream bottom

08-94

DNR&E / DFO - NEW BRUNSWICK
STREAM SURVEY and HABITAT ASSESSMENT

River: Hendry Brook
Start Point head of tide
End Point: approx 2400 m upstream of start
Drainage Code GG GG GG
Stream/River No.
Personnel R. C, MG, MG
Date: 12 September 2011
GIS Map No. Point-Verte 21P/13
Stream Order No. 2
Page: 4 of 6

REACH NO. *	UNIT NO.	STREAM TYPE	CHANNEL TYPE	LENGTH (m) *	AVE WIDTH (m) *		SUBSTRATE (%) *							AVE DEPTH - WET WIDTH (cm) *	0-50% UNDERCUT BANK *		0-50% OVER-HANGING BANK VEGETATION *		LARGE WOODY DEBRIS IN STREAM (m) *	FLOWS *					EMBEDDEDNESS (CRITERIA) 1 : # 20% 2 : 20% - 35% 3 : 35% - 50% 4 : ∃ 50%	COMMENTS	CHECKLIST OF LAND USE ATTRIBUTES (COMMENTS)
					WET	BANK CHANNEL	BED-ROCK	BOULDER	ROCK	RUBBLE	GRAVEL	SAND	FINES		L	R	L	R		TYPE	FLOW (cms)	TIME	TEMP EC				
																							W	A			
2	19	3/8	1	776	4	5	10	5	5	15	60	5		17	5	10	15	15	4						1		
2	20	3/8	1	786	3.5	5	20		5	15	50	10		30	25	0	20	25	0						1		
2	21	3	1	807	3.5	5	10	5	5	5	60	5		15	10	10	10	10	4						1		
2	22	8	1	905	4	5.5				10	80	10		20	15	5	20	20	38						1		
2	23	3	1	917	5	6			5	25	60	10		15	0	0	10	10	7			2 pm	14		1	#2 water sample	
2	24	8/3	1	1003	5	6			5	20	60	10	5	20	5	5	5	5	40						1	Braided, old beaver dam	
2	25	13	1	1044	10	22					20	40	40	30	10	10	30	30	50						3	Old beaver dam	
2	26	13	1	1124	5	8				5	50	30	15	30	10	10	30	30	40						2	Old beaver dam	
2	27	8	1	1176	5	12				5	50	40	5	25	10	10	25	25	27						2	Lots of alders	
2	28	8	1	1225	5	9				5	50	40	5	30	10	10	25	25	15						2	ATV trail at 1225 m	
2	29	8	1	1273	6	8				5	50	40	5	40	10	10	20	20	15						2	Trib at 1273 m	

STREAM TYPE						CHANNEL TYPE	SUBSTRATE	FLOW TYPE	POOL RATING (reverse side)	
FASTWATER		POOLS							CRITERIA (NO.)	% OF POOLS IN SITE (LETTER)
1. Fall	6. Sheet (ledge)	10. Midchannel	14. Trench	18. Eddy	22. Wood Debris	1. Main (if measurement refers to main area of river)	1. Bedrock , Ledge 2. Boulder = > 461 mm	1. Survey Stream	Pool Depth ∃ 1.5 m 1 - Instream Cover ∃ 30% 2 - Instream Cover < 30%	a - ∃ 30% b - ∃ 10% to 30% c - < 10%
2. Cascade	7. Chute	11. Convergence	15. Plunge	19. Gabion	23. Man-Made Dam	* 2. Side Channel (water diverted by islands)	3. Rock = 180 - 460 mm 4. Rubble = 54 - 179 mm	2. Spring		
3. Riffle (GR/RB)	8. Run	12. Lateral	16.	20. Log Structure	24. Natural Deadwater	* 3. Split (if river is split into various different stream types)	5. Gravel = 2.6 - 53 mm 6. Sand = 0.06 - 2.5 mm	3. Brook/River Trib		
4. Riffle (R/B)	9. Rapid	13. Beaver	17. Bogan	21. Road Crossing		* 4. Bogan	7. Fines = 0.0005 - 0.05 mm	4. Spring Seep	Pool Depth .5 to 1.5m 3 - Instream Cover 5 - 30% 4 - Instream Cover > 30%	a - ∃ 50% b - < 50%
5. Riffle (Sand)						* - Specify Left (L), Right (R) or Middle (M)				

Note: Stream surveys should be undertaken only during summer base (low) flow conditions. Also, minimum size of stream type is $4m^2$ for larger streams.

REACH NO.	**SITE (50m - interval)**	**% SITE**		**SHADE (%)**	**STREAM BANKS**										**O$_2$ (mg/l)**	**pH**	**DEPTH**						**POOL RATING (CRITERIA ON OTHER SIDE)**		**POOL TAIL**			**% TURBUL- ENCE**
					VEGETATION (%)				**EROSION (%)**								**1/4 (m)**		**1/2 (m)**		**3/4 (m)**							
		RIFFLE / RUN	**POOLS**		**BARE GROUND**	**GRASSES**	**SHRUBS**	**TREES**	**LEFT BANK (0-50%)**			**RIGHT BANK (0-50%)**					**WET**	**CHANNEL**	**WET**	**CHANNEL**	**WET**	**CHANNEL**	**NO.**	**LETTER**	**EMBEDDEDNESS (CRITERIA)** **1: # 20%** **2: 20% - 35%** **3: 35% - 50%** **4: ∃ 50%**	**MEAN SUBSTRATE SIZE (cm)**	**% FINE**	
									STABLE	**BARE STABLE**	**ERODING**	**STABLE**	**BARE STABLE**	**ERODING**														
2	19	100		40	10	30	50	10	45	5		50																
2	20	100		40	10	40	40	10	50			35	15															
2	21	100		40	5	45	40	10	45	5		45	5															
2	22	100		30	10	40	40	10	45	5		40	5	5														
2	23	100		40	10	40	40	10	45	5		45	5															
2	24	100		50	40	25	25	10	30	10	10	30	10	10														
2	25	100		20		70	30		50			50																
2	26	100		30		50	40	10	50			50																
2	27	100		50	10	40	40	10	40	10		40	10															
2	28	100		40	10	40	40	10	40	10		45	5															
2	29	100		30	10	40	40	10	40	10		40	10															

NOTE: * For selected site study, these columns (reverse side) should be done for a habitat assessment

WATER FLOW MEASUREMENT

REACH NO.	**CORRESPONDING LOCATION**		**STREAM TYPE**	**WET WIDTH (m)**	**DEPTH (cm)**			**AVERAGE DEPTH SUM / 4**		**COEFFICIENT (0.9 - smooth) (0.8 - rough)**	**LENGTH (3m)**	**FLOAT TIME (sec)**				**COMMENTS (LOCATION)**
	UNIT NO.	**SITE (50 - interval)**			**1/4 way**	**1/2 way**	**3/4 way**	**CENTIMETERS (cm)**	**METERS (m)**			**1/4 way**	**1/2 way**	**3/4 way**	**AVERAGE**	

Formula (CMS) = W (m) x D (m) x A x L (m) Where: W = width, D = depth, L = length, A is a coefficient for the stream bottom
T ____(sec)

08-94

DNR&E / DFO - NEW BRUNSWICK
STREAM SURVEY and HABITAT ASSESSMENT

River: Hendry Brook Start Point head of tide End Point: approx 2400 m upstream of start Drainage Code GG GG GG Stream/River No.

Personnel R. C, MG, MG Date: 12 September 2011 GIS Map No. Point-Verte 21P/13 Stream Order No. 2 Page: 5 of 6

REACH NO. *	UNIT NO.	STREAM TYPE	CHANNEL TYPE	LENGTH (m) *	AVE WIDTH (m) *		SUBSTRATE (%) *							AVE DEPTH - WET WIDTH (cm) *	0-50% UNDERCUT BANK *		0-50% OVER-HANGING BANK VEGETATION *		LARGE WOODY DEBRIS IN STREAM (m) *	FLOWS *					EMBEDDEDNESS (CRITERIA) 1 : # 20% 2 : 20% - 35% 3 : 35% - 50% 4 : ∃ 50%	COMMENTS	CHECKLIST OF LAND USE ATTRIBUTES (COMMENTS)
					WET	BANK CHANNEL	BED-ROCK	BOULDER	ROCK	RUBBLE	GRAVEL	SAND	FINES		L	R	L	R		TYPE	FLOW (cms)	TIME	TEMP EC W	TEMP EC A			
2	30	8	1	1344	5	6				5	55	30	10	35	15	15	15	15	20						2	Cedar swamp	
2	31	8	1	1395	5	6					50	40	10	35	15	15	15	15	35						2	Cedar swamp	
2	32	8	1	1449	5	6				5	55	30	10	35	15	15	15	15	25						2	Braided channel	
2	33	8	1	1542	5.5	6				5	55	35	5	35	15	15	15	15	40						2	Braided channel	
2	34	8	1	1615	5	6				5	55	30	10	30	15	15	15	15	35						2	Braided channel	
2	35	8/3	1	1670	4	5				5	55	35	5	30	15	15	15	15	30						2/1	Braided channel	
2	36	8	1	1749	4	5				5	55	35	5	30	15	15	15	15	30						1	Mixed forest	
2	37	8	1	1841	4	5				5	55	30	10	20	15	15	15	15	22						½	Some clay deposits	
2	38	8	1	1910	4	5					50	35	15	25	15	20	15	15	20						2	Water sample	
2	39	8/3	1	2006	3	5				10	60	20	10	23	10	15	15	15	17						1		
2	40	3/8	1	2129	3	5				5	75	15	5	23	10	10	5	5	10						1		

STREAM TYPE

FASTWATER

1. Fall
2. Cascade
3. Riffle (GR/RB)
4. Riffle (R/B)
5. Riffle (Sand)
6. Sheet (ledge)
7. Chute
8. Run
9. Rapid

POOLS

10. Midchannel
11. Convergence
12. Lateral
13. Beaver
14. Trench
15. Plunge
16.
17. Bogan
18. Eddy
19. Gabion
20. Log Structure
21. Road Crossing
22. Wood Debris
23. Man-Made Dam
24. Natural Deadwater

CHANNEL TYPE

1. Main (if measurement refers to main area of river)
* 2. Side Channel (water diverted by islands)
* 3. Split (if river is split into various different stream types)
* 4. Bogan
* - Specify Left (L), Right (R) or Middle (M)

SUBSTRATE

1. Bedrock , Ledge
2. Boulder = > 461 mm
3. Rock = 180 - 460 mm
4. Rubble = 54 - 179 mm
5. Gravel = 2.6 - 53 mm
6. Sand = 0.06 - 2.5 mm
7. Fines = 0.0005 - 0.05 mm

FLOW TYPE

1. Survey Stream
2. Spring
3. Brook/River Trib
4. Spring Seep

POOL RATING (reverse side)

CRITERIA (NO.)	% OF POOLS IN SITE (LETTER)
Pool Depth ∃ 1.5 m 1 - Instream Cover ∃ 30% 2 - Instream Cover < 30%	a - ∃ 30% b - ∃ 10% to 30% c - < 10%
Pool Depth .5 to 1.5m 3 - Instream Cover 5 - 30% 4 - Instream Cover > 30%	a - ∃ 50% b - < 50%

Note: Stream surveys should be undertaken only during summer base (low) flow conditions. Also, minimum size of stream type is 4m^2 for larger streams.

REACH NO.	SITE (50m - interval)	% SITE		SHADE (%)	STREAM BANKS										O_2 (mg/l)	pH	DEPTH						POOL RATING (CRITERIA ON OTHER SIDE)		POOL TAIL			% TURBUL-ENCE
					VEGETATION (%)				EROSION (%)								1/4 (m)		1/2 (m)		3/4 (m)							
		RIFFLE / RUN	POOLS		BARE GROUND	GRASSES	SHRUBS	TREES	LEFT BANK (0-50%)			RIGHT BANK (0-50%)					WET	CHANNEL	WET	CHANNEL	WET	CHANNEL	NO.	LETTER	EMBEDDEDNESS (CRITERIA) 1: # 20% 2: 20% - 35% 3: 35% - 50% 4: ∃ 50%	MEAN SUBSTRATE SIZE (cm)	% FINE	
									STABLE	BARE STABLE	ERODING	STABLE	BARE STABLE	ERODING														
2	29	100		40	10	50	30	10	45	5		45	5															
2	30	100		50	20	40	30	10	30	10	10	30	10	10														
2	31	100		50	20	40	30	10	30	10	10	30	10	10														
2	32	100		40	20	40	30	10	30	10	10	30	10	10														
2	33	100		40	20	45	30	5	35	10	5	35	10	5														
2	34	100		45	10	40	40	10	35	10	5	35	10	5														
2	35	100		40	10	40	40	10	35	10	5	35	10	5														
2	36	100		40	10	40	40	10	35	10	5	35	10	5														
2	37	100		35	10	40	40	10	35	10	5	35	10	5														
2	38	100		35	10	40	40	10	40	10		40	10															
2	39	100		35	20	40	30	10	30	10	10	35	10	5														
	40	100		35	20	40	30	10	40	10		40	10															

NOTE: * For selected site study, these columns (reverse side) should be done for a habitat assessment

WATER FLOW MEASUREMENT

REACH NO.	CORRESPONDING LOCATION		STREAM TYPE	WET WIDTH (m)	DEPTH (cm)			AVERAGE DEPTH SUM / 4		COEFFICIENT (0.9 - smooth) (0.8 - rough)	LENGTH (3m)	FLOAT TIME (sec)				COMMENTS (LOCATION)
	UNIT NO.	SITE (50 - interval)			1/4 way	1/2 way	3/4 way	CENTIMETERS (cm)	METERS (m)			1/4 way	1/2 way	3/4 way	AVERAGE	

Formula (CMS) = W____(m) x D____(m) x A____ x L________(m) Where: W = width, D = depth, L = length, A is a coefficient for the stream bottom
T ____(sec)

08-94

DNR&E / DFO - NEW BRUNSWICK
STREAM SURVEY and HABITAT ASSESSMENT

River: Hendry Brook
Start Point head of tide
End Point: approx 2400 m upstream of start
Drainage Code GG GG GG
Stream/River No.
Personnel R. C, MG, MG
Date: 12 September 2011
GIS Map No. Point-Verte 21P/13
Stream Order No. 2
Page: 6 of 6

REACH NO. *	UNIT NO.	STREAM TYPE	CHANNEL TYPE	LENGTH (m) *	AVE WIDTH (m) *		SUBSTRATE (%) *							AVE DEPTH - WET WIDTH (cm) *	0-50% UNDERCUT BANK *		0-50% OVER-HANGING BANK VEGETATION *		LARGE WOODY DEBRIS IN STREAM (m) *	FLOWS *					EMBEDDEDNESS (CRITERIA) 1 : # 20% 2 : 20% - 35% 3 : 35% - 50% 4 : ∃ 50%	COMMENTS	CHECKLIST OF LAND USE ATTRIBUTES (COMMENTS)
					WET	BANK CHANNEL	BED-ROCK	BOULDER	ROCK	RUBBLE	GRAVEL	SAND	FINES		L	R	L	R		TYPE	FLOW (cms)	TIME	TEMP EC				
																							W	A			
2	41	8/3	1	2212	4	4.5				10	80	5	5	15	5	5	5	5	12						1	Little overhanging vegetation	
2	42	8/3	1	2347	4	4.5				10	70	15	5	22	5	5	15	10	38						1	Braided channel, cedar trees	
2	43	8	1	2411	4	4.5				5	60	30	5	25	5	5	10	10	30						½	Braided channel cedar trees	

STREAM TYPE						CHANNEL TYPE	SUBSTRATE	FLOW TYPE	POOL RATING (reverse side)	
FASTWATER		POOLS							CRITERIA (NO.)	% OF POOLS IN SITE (LETTER)
1. Fall	6. Sheet (ledge)	10. Midchannel	14. Trench	18. Eddy	22. Wood Debris	1. Main (if measurement refers to main area of river)	1. Bedrock , Ledge 2. Boulder = > 461 mm	1. Survey Stream	Pool Depth ∃ 1.5 m 1 - Instream Cover ∃ 30% 2 - Instream Cover < 30%	a - ∃ 30% b - ∃ 10% to 30% c - < 10%
2. Cascade	7. Chute	11. Convergence	15. Plunge	19. Gabion	23. Man-Made Dam	* 2. Side Channel (water diverted by islands)	3. Rock = 180 - 460 mm 4. Rubble = 54 - 179 mm	2. Spring		
3. Riffle (GR/RB)	8. Run	12. Lateral	16.	20. Log Structure	24. Natural Deadwater	* 3. Split (if river is split into various different stream types)	5. Gravel = 2.6 - 53 mm 6. Sand = 0.06 - 2.5 mm	3. Brook/River Trib		
4. Riffle (R/B)	9. Rapid	13. Beaver	17. Bogan	21. Road Crossing		* 4. Bogan	7. Fines = 0.0005 - 0.05 mm	4. Spring Seep	Pool Depth .5 to 1.5m 3 - Instream Cover 5 - 30% 4 - Instream Cover > 30%	a - ∃ 50% b - < 50%
5. Riffle (Sand)						* - Specify Left (L), Right (R) or Middle (M)				

Note: Stream surveys should be undertaken only during summer base (low) flow conditions. Also, minimum size of stream type is $4m^2$ for larger streams.

REACH NO.	SITE (50m - interval)	% SITE		SHADE (%)	STREAM BANKS										O$_2$ (mg/l)	pH	DEPTH						POOL RATING (CRITERIA ON OTHER SIDE)		POOL TAIL			% TURBUL-ENCE
					VEGETATION (%)				EROSION (%)								1/4 (m)		1/2 (m)		3/4 (m)				EMBEDDEDNESS (CRITERIA) 1: # 20% 2: 20% - 35% 3: 35% - 50% 4: ∃ 50%	MEAN SUBSTRATE SIZE (cm)	% FINE	
		RIFFLE / RUN	POOLS		BARE GROUND	GRASSES	SHRUBS	TREES	LEFT BANK (0-50%)			RIGHT BANK (0-50%)					WET	CHANNEL	WET	CHANNEL	WET	CHANNEL	NO.	LETTER				
									STABLE	BARE STABLE	ERODING	STABLE	BARE STABLE	ERODING														
2	41	100		50	20	40	30	10	40	10		40	10															
2	42	100		50	10	40	40	10	40	10		40	10															
2	43	100		50	10	40	40	10	40	10		40	10															

NOTE: * For selected site study, these columns (reverse side) should be done for a habitat assessment

WATER FLOW MEASUREMENT

REACH NO.	CORRESPONDING LOCATION		STREAM TYPE	WET WIDTH (m)	DEPTH (cm)			AVERAGE DEPTH SUM / 4		COEFFICIENT (0.9 - smooth) (0.8 - rough)	LENGTH (3m)	FLOAT TIME (sec)				COMMENTS (LOCATION)
	UNIT NO.	SITE (50 - interval)			1/4 way	1/2 way	3/4 way	CENTIMETERS (cm)	METERS (m)			1/4 way	1/2 way	3/4 way	AVERAGE	

Formula (CMS) = W   (m) x D   (m) x A   x L   (m)   Where: W = width, D = depth, L = length, A is a coefficient for the stream bottom
T ____(sec)

08-94

DNR&E / DFO - NEW BRUNSWICK
STREAM SURVEY and HABITAT ASSESSMENT

River: Unnamed Brook Start Point culvert at airstrip End Point: upstream water sampling station Drainage Code GG GG GG Stream/River No.

Personnel RAC, HBM Date: 12 September 2011 GIS Map No. Point-Verte 21P/13 Stream Order No. 1 Page: 1 of 4

REACH NO. *	UNIT NO.	STREAM TYPE	CHANNEL TYPE	LENGTH (m) *	AVE WIDTH (m) *		SUBSTRATE (%) *							AVE DEPTH - WET WIDTH (cm) *	0-50% UNDERCUT BANK *		0-50% OVER-HANGING BANK VEGETATION *		LARGE WOODY DEBRIS IN STREAM (m) *	FLOWS *					EMBEDDEDNESS (CRITERIA) 1 : # 20% 2 : 20% - 35% 3 : 35% - 50% 4 : ∃ 50%	COMMENTS	CHECKLIST OF LAND USE ATTRIBUTES (COMMENTS)
					WET	BANK CHANNEL	BED-ROCK	BOULDER	ROCK	RUBBLE	GRAVEL	SAND	FINES		L	R	L	R		TYPE	FLOW (cms)	TIME	TEMP EC W	TEMP EC A			
1	1	3	1	7	1	2					90	5	5	7	0	40	0	10	0						1	Start at culvert	
1	2	8	1	15	1.5	2					60	30	10	15	5	10	5	10	1						3		
1	3	3/8	1	28	1.5	2					80	10	10	12	10	10	10	5	0						1		
1	4	8/3	1	45	1.5	3				5	80	10	5	12	5	5	10	10	0						1		
1	5	3	1	51	1.3	2.3					85	10	5	12	5	0	10	0	0						1		
1	6	8	1	56	1.5	2.5				5	70	20	5	15	0	10	5	15	0						1		
1	7	3	1	67	1.3	2				5	70	20	5	12	0	5	5	5	0						1		
1	8	15	1	69	2	2					50	40	10	40	40	40	20	20	2						2	Debris pile	
1	9	8/3	1	95	2	2				10	75	10	5	18	5	15	10	10	1						1		
1	10	3/8	1	100	1.5	1.5				5	80	15		12	10	0	15	15	3						1	Debris pile	
1	11	8/3	1	122	2	2					80	15	5	20	10	5	15	15	0						1		

STREAM TYPE						CHANNEL TYPE	SUBSTRATE	FLOW TYPE	POOL RATING (reverse side)	
FASTWATER		POOLS							CRITERIA (NO.)	% OF POOLS IN SITE (LETTER)
1. Fall 2. Cascade 3. Riffle (GR/RB) 4. Riffle (R/B) 5. Riffle (Sand)	6. Sheet (ledge) 7. Chute 8. Run 9. Rapid	10. Midchannel 11. Convergence 12. Lateral 13. Beaver	14. Trench 15. Plunge 16. 17. Bogan	18. Eddy 19. Gabion 20. Log Structure 21. Road Crossing	22. Wood Debris 23. Man-Made Dam 24. Natural Deadwater	1. Main (if measurement refers to main area of river) * 2. Side Channel (water diverted by islands) * 3. Split (if river is split into various different stream types) * 4. Bogan * - Specify Left (L), Right (R) or Middle (M)	1. Bedrock , Ledge 2. Boulder = > 461 mm 3. Rock = 180 - 460 mm 4. Rubble = 54 - 179 mm 5. Gravel = 2.6 - 53 mm 6. Sand = 0.06 - 2.5 mm 7. Fines = 0.0005 - 0.05 mm	1. Survey Stream 2. Spring 3. Brook/River Trib 4. Spring Seep	Pool Depth ∃ 1.5 m 1 - Instream Cover ∃ 30% 2 - Instream Cover < 30% Pool Depth .5 to 1.5m 3 - Instream Cover 5 - 30% 4 - Instream Cover > 30%	a - ∃ 30% b - ∃ 10% to 30% c - < 10% a - ∃ 50% b - < 50%

Note: Stream surveys should be undertaken only during summer base (low) flow conditions. Also, minimum size of stream type is 4m^2 for larger streams.

REACH NO.	SITE (50m - interval)	% SITE		SHADE (%)	STREAM BANKS										O_2 (mg/l)	pH	DEPTH						POOL RATING (CRITERIA ON OTHER SIDE)		POOL TAIL			% TURBUL-ENCE
					VEGETATION (%)				EROSION (%)								1/4 (m)		1/2 (m)		3/4 (m)							
		RIFFLE / RUN	POOLS		BARE GROUND	GRASSES	SHRUBS	TREES	LEFT BANK (0-50%)			RIGHT BANK (0-50%)					WET	CHANNEL	WET	CHANNEL	WET	CHANNEL	NO.	LETTER	EMBEDDEDNESS (CRITERIA) 1: # 20% 2: 20% - 35% 3: 35% - 50% 4: ∃ 50%	MEAN SUBSTRATE SIZE (cm)	% FINE	
									STABLE	BARE STABLE	ERODING	STABLE	BARE STABLE	ERODING														
1	1	100		35	50	40	10			50		50																
1	2	100		85	50	30	20		25	25		40	10															
1	3	100		80	50	30	20		40	10		20	30															
1	4	100		85	40	30	20	10	40	10		40	10															
1	5	100		85	70	10	10	10	20	30		10	40															
1	6	100		80	70	10	10	10	10	40		30	20															
1	7	100		80	70	10	10	10	20	20	10	20	20	10														
1	8		100	75	50	20	20	10	30	10	10	10	20	20														
1	9	100		50	20	50	30		40	10		40	10															
1	10	100		65	25	40	30	5	35	15		40	10															
1	11	100		40	20	40	30	10	35	10	5	35	10	5														

NOTE: * For selected site study, these columns (reverse side) should be done for a habitat assessment

WATER FLOW MEASUREMENT

REACH NO.	CORRESPONDING LOCATION		STREAM TYPE	WET WIDTH (m)	DEPTH (cm)			AVERAGE DEPTH SUM / 4		COEFFICIENT (0.9 - smooth) (0.8 - rough)	LENGTH (3m)	FLOAT TIME (sec)				COMMENTS (LOCATION)
	UNIT NO.	SITE (50 - interval)			1/4 way	1/2 way	3/4 way	CENTIMETERS (cm)	METERS (m)			1/4 way	1/2 way	3/4 way	AVERAGE	

Formula (CMS) = W____(m) x D____(m) x A____ x L____(m)   Where: W = width, D = depth, L = length, A is a coefficient for the stream bottom
T ____(sec)

08-94

DNR&E / DFO - NEW BRUNSWICK
STREAM SURVEY and HABITAT ASSESSMENT

River: Unnamed Brook Start Point culvert at airstrip End Point: upstream water sampling station Drainage Code GG GG GG Stream/River No.

Personnel RAC, HBM Date: 20 September 2011 GIS Map No. Point-Verte 21P/13 Stream Order No. 1 Page: 2 of 4

REACH NO. *	UNIT NO.	STREAM TYPE	CHANNEL TYPE	LENGTH (m) *	AVE WIDTH (m) *		SUBSTRATE (%) *							AVE DEPTH - WET WIDTH (cm) *	0-50% UNDERCUT BANK *		0-50% OVER-HANGING BANK VEGETATION *		LARGE WOODY DEBRIS IN STREAM (m) *	FLOWS *					EMBEDDEDNESS (CRITERIA) 1 : # 20% 2 : 20% - 35% 3 : 35% - 50% 4 : ∃ 50%	COMMENTS	CHECKLIST OF LAND USE ATTRIBUTES (COMMENTS)
					WET	BANK CHANNEL	BED-ROCK	BOULDER	ROCK	RUBBLE	GRAVEL	SAND	FINES		L	R	L	R		TYPE	FLOW (cms)	TIME	TEMP EC W	TEMP EC A			
1	12	3	1	132	1.5	2					60	30	10	10	10	0	15	5	0						1		
1	13	8	1	140	1.5	2					60	30	10	18	10	0	10	10	0						1	Debris pile	
1	14	3	1	144	1.2	2				10	70	20		10	0	0	5	0							1		
1	15	8/3	1	177	1.5	2				5	60	30	5	18	0	10	10	10	0						1		
1	16	3	1	179	2	2.5				5	60	30	5	10	0	0	10	10	0						1		
1	17	8/3	1	191	2	2.5				5	60	30	5	12	0	0	10	0	0						1		
1	18	3	1	201	2	2.5				5	65	30		9	0	10	5	10	1						1		
1	19	8	1	208	2.3	2.5				5	90	5		12	0	10	10	10	0						1		
1	20	3	1	220	1.5	2.5				5	85	10		12	0	5	5	5	0						1		
1	21	8	1	228	1.5	1.5				5	85	10		12	0	5	5	5	0						1		
1	22	3	1	273	1.5	2			5	30	55	10		12	0	0	0	0	0						1	Ditch lined with blast rock	

STREAM TYPE

FASTWATER

1. Fall
2. Cascade
3. Riffle (GR/RB)
4. Riffle (R/B)
5. Riffle (Sand)
6. Sheet (ledge)
7. Chute
8. Run
9. Rapid

POOLS

10. Midchannel
11. Convergence
12. Lateral
13. Beaver
14. Trench
15. Plunge
16.
17. Bogan
18. Eddy
19. Gabion
20. Log Structure
21. Road Crossing
22. Wood Debris
23. Man-Made Dam
24. Natural Deadwater

CHANNEL TYPE

1. Main (if measurement refers to main area of river)
* 2. Side Channel (water diverted by islands)
* 3. Split (if river is split into various different stream types)
* 4. Bogan

* - Specify Left (L), Right (R) or Middle (M)

SUBSTRATE

1. Bedrock , Ledge
2. Boulder = > 461 mm
3. Rock = 180 - 460 mm
4. Rubble = 54 - 179 mm
5. Gravel = 2.6 - 53 mm
6. Sand = 0.06 - 2.5 mm
7. Fines = 0.0005 - 0.05 mm

FLOW TYPE

1. Survey Stream
2. Spring
3. Brook/River Trib
4. Spring Seep

POOL RATING (reverse side)

CRITERIA (NO.)	% OF POOLS IN SITE (LETTER)
Pool Depth ∃ 1.5 m 1 - Instream Cover ∃ 30% 2 - Instream Cover < 30%	a - ∃ 30% b - ∃ 10% to 30% c - < 10%
Pool Depth .5 to 1.5m 3 - Instream Cover 5 - 30% 4 - Instream Cover > 30%	a - ∃ 50% b - < 50%

Note: Stream surveys should be undertaken only during summer base (low) flow conditions. Also, minimum size of stream type is 4m^2 for larger streams.

REACH NO.	SITE (50m - interval)	% SITE		SHADE (%)	STREAM BANKS										O_2 (mg/l)	pH	DEPTH						POOL RATING (CRITERIA ON OTHER SIDE)		POOL TAIL			% TURBUL-ENCE
					VEGETATION (%)				EROSION (%)								1/4 (m)		1/2 (m)		3/4 (m)				EMBEDDEDNESS (CRITERIA) 1: # 20% 2: 20% - 35% 3: 35% - 50% 4: ∃ 50%	MEAN SUBSTRATE SIZE (cm)	% FINE	
		RIFFLE / RUN	POOLS		BARE GROUND	GRASSES	SHRUBS	TREES	LEFT BANK (0-50%)			RIGHT BANK (0-50%)					WET	CHANNEL	WET	CHANNEL	WET	CHANNEL	NO.	LETTER				
									STABLE	BARE STABLE	ERODING	STABLE	BARE STABLE	ERODING														
1	12	100		40	30	30	30	10	40	10		40	10															
1	13	100		70	20	30	30	20	40	10		40	10															
1	14	100		10	70	10	20		10	40		10	40															
1	15	100		75	30	30	30	10	30	10	10	40	10															
1	16	100		50	60	20	20		35	10	5	30	10	10														
1	17	100		50	50	20	20	10	35	15		35	15															
1	18	100		60	50	20	20	10	30	20		30	20															
1	19	100		70	60	15	15	10	20	30		30	20															
1	20	100		70	60	10	20	10	20	30		30	20															
1	21	100		65	65	10	20	5	20	20	10	20	20	10														
1	22	100		60	85	10	10	5	10	40		10	40															

NOTE: * For selected site study, these columns (reverse side) should be done for a habitat assessment

WATER FLOW MEASUREMENT

REACH NO.	CORRESPONDING LOCATION		STREAM TYPE	WET WIDTH (m)	DEPTH (cm)			AVERAGE DEPTH SUM / 4		COEFFICIENT (0.9 - smooth) (0.8 - rough)	LENGTH (3m)	FLOAT TIME (sec)				COMMENTS (LOCATION)
	UNIT NO.	SITE (50 - interval)			1/4 way	1/2 way	3/4 way	CENTIMETERS (cm)	METERS (m)			1/4 way	1/2 way	3/4 way	AVERAGE	

Formula (CMS) = W (m) x D (m) x A x L (m) Where: W = width, D = depth, L = length, A is a coefficient for the stream bottom
T ____(sec)

08-94

DNR&E / DFO - NEW BRUNSWICK
STREAM SURVEY and HABITAT ASSESSMENT

River: Unnamed Brook Start Point culvert at airstrip End Point: upstream water sampling station Drainage Code GG GG GG Stream/River No.

Personnel RAC, HBM Date: 20 September 2011 GIS Map No. Point-Verte 21P/13 Stream Order No. 1 Page: 3 of 4

REACH NO. *	UNIT NO.	STREAM TYPE	CHANNEL TYPE	LENGTH (m) *	AVE WIDTH (m) *		SUBSTRATE (%) *							AVE DEPTH - WET WIDTH (cm) *	0-50% UNDERCUT BANK *		0-50% OVER-HANGING BANK VEGETATION *		LARGE WOODY DEBRIS IN STREAM (m) *	FLOWS *					EMBEDDEDNESS (CRITERIA) 1 : # 20% 2 : 20% - 35% 3 : 35% - 50% 4 : ∃ 50%	COMMENTS	CHECKLIST OF LAND USE ATTRIBUTES (COMMENTS)
					WET	BANK CHANNEL	BED-ROCK	BOULDER	ROCK	RUBBLE	GRAVEL	SAND	FINES		L	R	L	R		TYPE	FLOW (cms)	TIME	TEMP ĒC W	A			
1	23	8	1	279	2	2.5				10	80	10		20	0	0	0	0	0						1	Rock-Lined ditch	
1	24	3	1	327	1.5	2				35	55	10		18	0	0	5	5	0						1	Rock-lined ditch	
1	25	8	1	337	1.5	2.5				10	80	10		12	0	0	5	10	0						1	Rock-lined ditch	
1	26	3/8	1	406	1.5	2				15	75	10		12	0	0	5	5	1						1	Ditch	
1	27	8	1	414	1.5	2	10		10	25	50	5		20	0	0	0	0	0						1	Ditch	
1	28	7	1	417	0.5	1.7	50		20	20	10			10	0	0	0	20	1						1	Ditch	
1	29	3/8	1	454	1.2	1.7	15	5	20	25	25	10		15	0	0	5	5	0						1	Ditch	
1	30	8/3	1	494	1.2	1.7			5	20	65	10		15	0	0	5	5	0			1 pm	11.5		1	Ditch	
1	31	3/8	1	548	1.4	1.7			5	20	65	10	5	15	0	0	5	5	0						1	Ditch	
1	32	8/3	1	548	1.4	1.7				10	75	10	5	15	5	5	5	5	1						1	ditch	
1	33	8	1	572	1.4	1.7				10	75	10	5	15	5	5	5	5	0						1	Ditch	

STREAM TYPE					
FASTWATER		POOLS			
1. Fall	6. Sheet (ledge)	10. Midchannel	14. Trench	18. Eddy	22. Wood Debris
2. Cascade	7. Chute	11. Convergence	15. Plunge	19. Gabion	23. Man-Made Dam
3. Riffle (GR/RB)	8. Run	12. Lateral	16.	20. Log Structure	24. Natural Deadwater
4. Riffle (R/B)	9. Rapid	13. Beaver	17. Bogan	21. Road Crossing	
5. Riffle (Sand)					

CHANNEL TYPE

1. Main (if measurement refers to main area of river)
* 2. Side Channel (water diverted by islands)
* 3. Split (if river is split into various different stream types)
* 4. Bogan

* - Specify Left (L), Right (R) or Middle (M)

SUBSTRATE

1. Bedrock , Ledge
2. Boulder = > 461 mm
3. Rock = 180 - 460 mm
4. Rubble = 54 - 179 mm
5. Gravel = 2.6 - 53 mm
6. Sand = 0.06 - 2.5 mm
7. Fines = 0.0005 - 0.05 mm

FLOW TYPE

1. Survey Stream
2. Spring
3. Brook/River Trib
4. Spring Seep

POOL RATING (reverse side)

CRITERIA (NO.)	% OF POOLS IN SITE (LETTER)
Pool Depth ∃ 1.5 m 1 - Instream Cover ∃ 30% 2 - Instream Cover < 30%	a - ∃ 30% b - ∃ 10% to 30% c - < 10%
Pool Depth .5 to 1.5m 3 - Instream Cover 5 - 30% 4 - Instream Cover > 30%	a - ∃ 50% b - < 50%

Note: Stream surveys should be undertaken only during summer base (low) flow conditions. Also, minimum size of stream type is 4m^2 for larger streams.

REACH NO.	SITE (50m - interval)	% SITE		SHADE (%)	STREAM BANKS										O_2 (mg/l)	pH	DEPTH						POOL RATING (CRITERIA ON OTHER SIDE)		POOL TAIL			% TURBUL-ENCE
					VEGETATION (%)				EROSION (%)								1/4 (m)		1/2 (m)		3/4 (m)				EMBEDDEDNESS (CRITERIA) 1: # 20% 2: 20% - 35% 3: 35% - 50% 4: ∃ 50%	MEAN SUBSTRATE SIZE (cm)	% FINE	
		RIFFLE / RUN	POOLS		BARE GROUND	GRASSES	SHRUBS	TREES	LEFT BANK (0-50%)			RIGHT BANK (0-50%)					WET	CHANNEL	WET	CHANNEL	WET	CHANNEL	NO.	LETTER				
									STABLE	BARE STABLE	ERODING	STABLE	BARE STABLE	ERODING														
1	23	100		60	80	10	10		10	40		10	40															
1	24	100		55	80	10	10		10	40		10	40															
1	25	100		60	70	10	10	10	20	30		10	40															
1	26	100		60	70	10	10	10	10	40		10	40															
1	27	100		70	80	5	5	10	5	45		5	45															
1	28	100		70	90		5	5	5	45		5	45															
1	29	100		70	85	5	5	5	10	40		10	40															
1	30	100		70	30	30	30	10	40	10		40	10															
1	31	100		65	10	50	30	10	45	5		45	5															
1	32	100		65	10	50	30	10	45	5		45	5															
1	33	100		65	10	50	30	10	45	5		45	5															

NOTE: * For selected site study, these columns (reverse side) should be done for a habitat assessment

WATER FLOW MEASUREMENT

REACH NO.	CORRESPONDING LOCATION		STREAM TYPE	WET WIDTH (m)	DEPTH (cm)			AVERAGE DEPTH SUM / 4		COEFFICIENT (0.9 - smooth) (0.8 - rough)	LENGTH (3m)	FLOAT TIME (sec)				COMMENTS (LOCATION)
	UNIT NO.	SITE (50 - interval)			1/4 way	1/2 way	3/4 way	CENTIMETERS (cm)	METERS (m)			1/4 way	1/2 way	3/4 way	AVERAGE	

Formula (CMS) = W (m) x D (m) x A x L (m)   Where: W = width, D = depth, L = length, A is a coefficient for the stream bottom
T ____(sec)

08-94

DNR&E / DFO - NEW BRUNSWICK
STREAM SURVEY and HABITAT ASSESSMENT

River: Unnamed Brook
Start Point culvert at airstrip
End Point: upstream water sampling station
Drainage Code GG GG GG
Stream/River No.
Personnel RAC, HBM
Date: 20 September 2011
GIS Map No. Point-Verte 21P/13
Stream Order No. 1
Page: 4 of 4

REACH NO. *	UNIT NO.	STREAM TYPE	CHANNEL TYPE	LENGTH (m) *	AVE WIDTH (m) *		SUBSTRATE (%) *							AVE DEPTH - WET WIDTH (cm) *	0-50% UNDERCUT BANK *		0-50% OVER-HANGING BANK VEGETATION *		LARGE WOODY DEBRIS IN STREAM (m) *	FLOWS *					EMBEDDEDNESS (CRITERIA) 1 : # 20% 2 : 20% - 35% 3 : 35% - 50% 4 : ∃ 50%	COMMENTS	CHECKLIST OF LAND USE ATTRIBUTES (COMMENTS)
					WET	BANK CHANNEL	BED-ROCK	BOULDER	ROCK	RUBBLE	GRAVEL	SAND	FINES		L	R	L	R		TYPE	FLOW (cms)	TIME	TEMP EC W	TEMP EC A			
1	34	3	1	582	1.2	1.5					90	10		10	5	0	5	0	0						1	Ditched channel	
1	35	8	1	587	1.5	1.5				5	85	10		15	10	5	5	10	0						1	Ditched channel	
1	36	8/3	1	630	1.5	1.8				5	80	10	5	15	5	10	5	5	0						1	Natural channel	
1	37	8	1	686	1.8	2.2				5	60	20	15	15	10	10	25	25	1						1	Areas of clay	
1	38	8/3	1	743	1.5	2				5	60	20	15	15	5	5	10	10	0						1	Areas of clay	
1	39	8/3	1	781	1.5	2.2		2	3	5	70	10	10	15	5	0	10	15	0						1	Culverts at 781 m	
2	1	8/3	1	832	1.2	2.5					70	20	10	15	0	0	5	5	0						1	Trib on right at 832 m	
2	2	8	3	859	2	2.5					60	30	10	12	0	0	0	0	0						1		
2	3	3/8	3	876	1	1.7				10	50	30	10	10	0	0	5	5	0						1	Very small flow	
2	4	7	3	878	1.5	1.6	100							2	0	0	0	5	0						1	Bedrock outcrop	
2	5	3/8	3	966	1.1	1.6	5			10	45	30	10	6	0	0	5	5	0						1	Water sampling station	

STREAM TYPE

FASTWATER

1. Fall
2. Cascade
3. Riffle (GR/RB)
4. Riffle (R/B)
5. Riffle (Sand)
6. Sheet (ledge)
7. Chute
8. Run
9. Rapid

POOLS

10. Midchannel
11. Convergence
12. Lateral
13. Beaver
14. Trench
15. Plunge
16.
17. Bogan
18. Eddy
19. Gabion
20. Log Structure
21. Road Crossing
22. Wood Debris
23. Man-Made Dam
24. Natural Deadwater

CHANNEL TYPE

1. Main (if measurement refers to main area of river)
* 2. Side Channel (water diverted by islands)
* 3. Split (if river is split into various different stream types)
* 4. Bogan

* - Specify Left (L), Right (R) or Middle (M)

SUBSTRATE

1. Bedrock , Ledge
2. Boulder = > 461 mm
3. Rock = 180 - 460 mm
4. Rubble = 54 - 179 mm
5. Gravel = 2.6 - 53 mm
6. Sand = 0.06 - 2.5 mm
7. Fines = 0.0005 - 0.05 mm

FLOW TYPE

1. Survey Stream
2. Spring
3. Brook/River Trib
4. Spring Seep

POOL RATING (reverse side)

CRITERIA (NO.)	% OF POOLS IN SITE (LETTER)
Pool Depth ∃ 1.5 m 1 - Instream Cover ∃ 30% 2 - Instream Cover < 30%	a - ∃ 30% b - ∃ 10% to 30% c - < 10%
Pool Depth .5 to 1.5m 3 - Instream Cover 5 - 30% 4 - Instream Cover > 30%	a - ∃ 50% b - < 50%

Note: Stream surveys should be undertaken only during summer base (low) flow conditions. Also, minimum size of stream type is 4m^2 for larger streams.

REACH NO.	SITE (50m - interval)	% SITE		SHADE (%)	STREAM BANKS										O₂ (mg/l)	pH	DEPTH						POOL RATING (CRITERIA ON OTHER SIDE)		POOL TAIL			% TURBUL-ENCE
					VEGETATION (%)				EROSION (%)								1/4 (m)		1/2 (m)		3/4 (m)				EMBEDDEDNESS (CRITERIA) 1: # 20% 2: 20% - 35% 3: 35% - 50% 4: ∃ 50%	MEAN SUBSTRATE SIZE (cm)	% FINE	
		RIFFLE / RUN	POOLS		BARE GROUND	GRASSES	SHRUBS	TREES	LEFT BANK (0-50%)			RIGHT BANK (0-50%)					WET	CHANNEL	WET	CHANNEL	WET	CHANNEL	NO.	LETTER				
									STABLE	BARE STABLE	ERODING	STABLE	BARE STABLE	ERODING														
1	34	100		50	5	65	20	10	45	5		45	5															
1	35	100		55	5	65	20	10	45	5		45	5															
1	36	100		60	10	60	20	10	40	10		45	5															
1	37	100		60	10	60	20	10	40	10		40	10															
1	38	100		50	30	30	30	10	30	20		35	15															
1	39	100		50	30	30	30	10	30	20		30	20															
1	Culvert																											
2	1	100		60	50	25	25		20	20	10	20	20	10														
2	2	100		75	30	30	40		35	15		35	15															
2	3	100		75	30	30	40		35	15		35	15															
2	4	100		75	50	25	25		10	40		10	40															
2	5	100		80	70	10	20		10	40		10	40															

NOTE: * For selected site study, these columns (reverse side) should be done for a habitat assessment

WATER FLOW MEASUREMENT

REACH NO.	CORRESPONDING LOCATION		STREAM TYPE	WET WIDTH (m)	DEPTH (cm)			AVERAGE DEPTH SUM / 4		COEFFICIENT (0.9 - smooth) (0.8 - rough)	LENGTH (3m)	FLOAT TIME (sec)				COMMENTS (LOCATION)
	UNIT NO.	SITE (50 - interval)			1/4 way	1/2 way	3/4 way	CENTIMETERS (cm)	METERS (m)			1/4 way	1/2 way	3/4 way	AVERAGE	

Formula (CMS) = W ____ (m) x D ____ (m) x A ____ x L ____ (m)   Where: W = width, D = depth, L = length, A is a coefficient for the stream bottom

T ____(sec)

08-94

DNR&E / DFO - NEW BRUNSWICK
STREAM SURVEY and HABITAT ASSESSMENT

River: Armstrong Brook
Start Point head of tide
End Point: approx 2023 m upstream of start
Drainage Code GG GG GG
Stream/River No.
Personnel RAC, HBM
Date: 20 September 2011
GIS Map No. Point-Verte 21P/13
Stream Order No. 2
Page: 1 of 6

REACH NO. *	UNIT NO.	STREAM TYPE	CHANNEL TYPE	LENGTH (m) *	AVE WIDTH (m) *		SUBSTRATE (%) *							AVE DEPTH - WET WIDTH (cm) *	0-50% UNDERCUT BANK *		0-50% OVER-HANGING BANK VEGETATION *		LARGE WOODY DEBRIS IN STREAM (m) *	FLOWS *					EMBEDDEDNESS (CRITERIA) 1 : # 20% 2 : 20% - 35% 3 : 35% - 50% 4 : ∃ 50%	COMMENTS	CHECKLIST OF LAND USE ATTRIBUTES (COMMENTS)
					WET	BANK CHANNEL	BED-ROCK	BOULDER	ROCK	RUBBLE	GRAVEL	SAND	FINES		L	R	L	R		TYPE	FLOW (cms)	TIME	TEMP EC W	TEMP EC A			
1	1	8/3	1	49	4	16				5	45	40	10	18	0	0	5	0	8						3	Start at head of tide	
1	2	8	1	55	2	8		5		5	40	40	10	18	5	0	5	0	1						2	Braided channel	
1	3	4	1	80	4	8		20	20	30	20	10		13	0	0	5	5	1						1	braided channel	
1	4	15	1	98	11	16	35	5	5	15	15	15	10	80	5	0	5	0	1						2	Plunge pool	
1	5	7	1	124	2.5	3.5	100							20	0	0	0	0	0						1	Cave	
1	6	24	1	194	40	44							100	30	0	0	15	10	1						4	Pond	
1	7	8	1	274	5	5					60	30	10	28	10	5	20	20	10						2		
1	8	8	1	347	4	4.5					20	30	50	40	10	10	25	25	10						3		
1	9	11	1	354	5	6					15	55	30	90	0	0	5	5	13						3	Channel splits at 354 m	
1	10	8	1	386	4	5					20	55	25	25	10	10	15	15	4						3		
1	11	3	1	389	4	5					40	40	20	0	0	30	30	2								Debris pile	

STREAM TYPE

FASTWATER

1. Fall
2. Cascade
3. Riffle (GR/RB)
4. Riffle (R/B)
5. Riffle (Sand)
6. Sheet (ledge)
7. Chute
8. Run
9. Rapid

POOLS

10. Midchannel
11. Convergence
12. Lateral
13. Beaver
14. Trench
15. Plunge
16.
17. Bogan
18. Eddy
19. Gabion
20. Log Structure
21. Road Crossing
22. Wood Debris
23. Man-Made Dam
24. Natural Deadwater

CHANNEL TYPE

1. Main (if measurement refers to main area of river)
* 2. Side Channel (water diverted by islands)
* 3. Split (if river is split into various different stream types)
* 4. Bogan

* - Specify Left (L), Right (R) or Middle (M)

SUBSTRATE

1. Bedrock , Ledge
2. Boulder = > 461 mm
3. Rock = 180 - 460 mm
4. Rubble = 54 - 179 mm
5. Gravel = 2.6 - 53 mm
6. Sand = 0.06 - 2.5 mm
7. Fines = 0.0005 - 0.05 mm

FLOW TYPE

1. Survey Stream
2. Spring
3. Brook/River Trib
4. Spring Seep

POOL RATING (reverse side)

CRITERIA (NO.)	% OF POOLS IN SITE (LETTER)
Pool Depth ∃ 1.5 m 1 - Instream Cover ∃ 30% 2 - Instream Cover < 30%	a - ∃ 30% b - ∃ 10% to 30% c - < 10%
Pool Depth .5 to 1.5m 3 - Instream Cover 5 - 30% 4 - Instream Cover > 30%	a - ∃ 50% b - < 50%

Note: Stream surveys should be undertaken only during summer base (low) flow conditions. Also, minimum size of stream type is 4m^2 for larger streams.

REACH NO.	SITE (50m - interval)	% SITE		SHADE (%)	STREAM BANKS									
					VEGETATION (%)				EROSION (%)					
		RIFFLE / RUN	POOLS		BARE GROUND	GRASSES	SHRUBS	TREES	LEFT BANK (0-50%)			RIGHT BANK (0-50%)		
									STABLE	BARE STABLE	ERODING	STABLE	BARE STABLE	ERODING
1	1	100		5	85	5	5	5	10	40		10	40	
1	2	100		30	85	5	5	5	10	40		10	40	
1	3	100		20	70	10	10	10	20	30		20	30	
1	4		100	10	85	5	5	5	5	45			40	10
1	5	100		90	100					40	10		45	5
1	6		100	0		90	10		50			50		
1	7	100		5	30	55	10	5	50			20	20	10
1	8	100		5	30	60	10		30	10	10	30	10	10
1	9	100		5	30	60	10		40	10		40	10	
1	10	100		10	30	50	10	10	40	10		40	10	
1	11	100		10	30	50	10	10	40	10		40	10	

REACH NO.	SITE (50m - interval)	O_2 (mg/l)	pH	DEPTH						POOL RATING (CRITERIA ON OTHER SIDE)		POOL TAIL			% TURBULENCE
				1/4 (m)		1/2 (m)		3/4 (m)				EMBEDDEDNESS (CRITERIA) 1: # 20% 2: 20% - 35% 3: 35% - 50% 4: ∃ 50%	MEAN SUBSTRATE SIZE (cm)	% FINE	
				WET	CHANNEL	WET	CHANNEL	WET	CHANNEL	NO.	LETTER				
1	1														
1	2														
1	3														
1	4														
1	5														
1	6														
1	7														
1	8														
1	9														
1	10														
1	11														

NOTE: * For selected site study, these columns (reverse side) should be done for a habitat assessment

WATER FLOW MEASUREMENT

REACH NO.	CORRESPONDING LOCATION		STREAM TYPE	WET WIDTH (m)	DEPTH (cm)			AVERAGE DEPTH SUM / 4		COEFFICIENT (0.9 - smooth) (0.8 - rough)	LENGTH (3m)	FLOAT TIME (sec)				COMMENTS (LOCATION)
	UNIT NO.	SITE (50 - interval)			1/4 way	1/2 way	3/4 way	CENTIMETERS (cm)	METERS (m)			1/4 way	1/2 way	3/4 way	AVERAGE	

Formula (CMS) = W (m) x D (m) x A x L (m)   Where: W = width, D = depth, L = length, A is a coefficient for the stream bottom
T ____(sec)

08-94

DNR&E / DFO - NEW BRUNSWICK
STREAM SURVEY and HABITAT ASSESSMENT

River: Armstrong Brook Start Point head of tide End Point: approx 2023 m upstream of start Drainage Code GG GG GG Stream/River No.

Personnel RAC, HBM Date: 20 September 2011 GIS Map No. Point-Verte 21P/13 Stream Order No. 2 Page: 2 of 6

REACH NO. *	UNIT NO.	STREAM TYPE	CHANNEL TYPE	LENGTH (m) *	AVE WIDTH (m) *		SUBSTRATE (%) *							AVE DEPTH - WET WIDTH (cm) *	0-50% UNDERCUT BANK *		0-50% OVER-HANGING BANK VEGETATION *		LARGE WOODY DEBRIS IN STREAM (m) *	FLOWS *					EMBEDDEDNESS (CRITERIA) 1 : # 20% 2 : 20% - 35% 3 : 35% - 50% 4 : ∃ 50%	COMMENTS	CHECKLIST OF LAND USE ATTRIBUTES (COMMENTS)
					WET	BANK CHANNEL	BED-ROCK	BOULDER	ROCK	RUBBLE	GRAVEL	SAND	FINES		L	R	L	R		TYPE	FLOW (cms)	TIME	TEMP EC W	TEMP EC A			
1	12	8	1	440	4	5					40	40	20	30	10	10	15	15	0						2		
1	13	10	1	453	5.5	7				5	35	40	25	85	5	0	10	10	0						2		
1	14	8/3	1	490	4	5			5	15	50	25	5	25	5	0	0	0	0						1	Entering woods	
1	15	4	1	510	4	5		10	20	45	25			20	0	10	0	10	2						1		
1	16	8	1	531	4	5		5	10	40	35	10		20	0	0	5	5	1						1		
1	17	3/8	1	598	4	5		5	10	40	35	10		22	5	5	10	10	3						1		
1	18	8	1	621	4	5	15			10	40	20	10	40	5	10	15	10	8						1		
1	19	3	1	626	4	5		5	5	40	40	10		12	0	0	30	20	0						1		
1	20	8/3	1	654	4	5	5	5	5	35	40	10		20	5	0	25	20	2						1		
1	21	23/8	1	691	4	5	5		5	25	55	10		25	0	0	20	20	2						1		
1	22	8	1	700	4	5				10	40	40	10	20	0	0	5	20	0						1		

STREAM TYPE

FASTWATER

1. Fall
2. Cascade
3. Riffle (GR/RB)
4. Riffle (R/B)
5. Riffle (Sand)
6. Sheet (ledge)
7. Chute
8. Run
9. Rapid

POOLS

10. Midchannel
11. Convergence
12. Lateral
13. Beaver
14. Trench
15. Plunge
16.
17. Bogan
18. Eddy
19. Gabion
20. Log Structure
21. Road Crossing
22. Wood Debris
23. Man-Made Dam
24. Natural Deadwater

CHANNEL TYPE

1. Main (if measurement refers to main area of river)
* 2. Side Channel (water diverted by islands)
* 3. Split (if river is split into various different stream types)
* 4. Bogan

* - Specify Left (L), Right (R) or Middle (M)

SUBSTRATE

1. Bedrock , Ledge
2. Boulder = > 461 mm
3. Rock = 180 - 460 mm
4. Rubble = 54 - 179 mm
5. Gravel = 2.6 - 53 mm
6. Sand = 0.06 - 2.5 mm
7. Fines = 0.0005 - 0.05 mm

FLOW TYPE

1. Survey Stream
2. Spring
3. Brook/River Trib
4. Spring Seep

POOL RATING (reverse side)

CRITERIA (NO.)	% OF POOLS IN SITE (LETTER)
Pool Depth ∃ 1.5 m 1 - Instream Cover ∃ 30% 2 - Instream Cover < 30%	a - ∃ 30% b - ∃ 10% to 30% c - < 10%
Pool Depth .5 to 1.5m 3 - Instream Cover 5 - 30% 4 - Instream Cover > 30%	a - ∃ 50% b - < 50%

Note: Stream surveys should be undertaken only during summer base (low) flow conditions. Also, minimum size of stream type is $4m^2$ for larger streams.

REACH NO.	SITE (50m - interval)	% SITE		SHADE (%)	STREAM BANKS										O_2 (mg/l)	pH	DEPTH						POOL RATING (CRITERIA ON OTHER SIDE)		POOL TAIL			% TURBUL-ENCE
					VEGETATION (%)				EROSION (%)								1/4 (m)		1/2 (m)		3/4 (m)							
		RIFFLE / RUN	POOLS		BARE GROUND	GRASSES	SHRUBS	TREES	LEFT BANK (0-50%)			RIGHT BANK (0-50%)					WET	CHANNEL	WET	CHANNEL	WET	CHANNEL	NO.	LETTER	EMBEDDEDNESS (CRITERIA) 1: # 20% 2: 20% - 35% 3: 35% - 50% 4: ∃ 50%	MEAN SUBSTRATE SIZE (cm)	% FINE	
									STABLE	BARE STABLE	ERODING	STABLE	BARE STABLE	ERODING														
1	12	100		20	15	65	20		45	5		30	15	5														
1	13		100	20	30	30	30	10	30	20		30	20															
1	14	100		40	60	20	10	10	30	20		30	20															
1	15	100		60	70	10	10	10	10	40		20	20	10														
1	16	100		60	70	10	10	10	10	40		20	20	10														
1	17	100		50	60	20	10	10	35	10	5	35	10	5														
1	18	100		50	50	20	20	10	35	10	5	35	10	5														
1	19	100		50	50	25	25		30	20		20	30															
1	20	100		50	50	25	20	5	35	10	5	35	10	5														
1	21	100		70	60	10	20	10	30	20		30	20															
1	22	100		70	60	10	20	10	25	25		25	25															

NOTE: * For selected site study, these columns (reverse side) should be done for a habitat assessment

WATER FLOW MEASUREMENT

REACH NO.	CORRESPONDING LOCATION		STREAM TYPE	WET WIDTH (m)	DEPTH (cm)			AVERAGE DEPTH SUM / 4		COEFFICIENT (0.9 - smooth) (0.8 - rough)	LENGTH (3m)	FLOAT TIME (sec)				COMMENTS (LOCATION)
	UNIT NO.	SITE (50 - interval)			1/4 way	1/2 way	3/4 way	CENTIMETERS (cm)	METERS (m)			1/4 way	1/2 way	3/4 way	AVERAGE	

Formula (CMS) = W____(m) x D____(m) x A____ x L____(m) Where: W = width, D = depth, L = length, A is a coefficient for the stream bottom
T ____(sec)

08-94

DNR&E / DFO - NEW BRUNSWICK
STREAM SURVEY and HABITAT ASSESSMENT

River: Armstrong Brook Start Point head of tide End Point: approx 2023 m upstream of start Drainage Code GG GG GG Stream/River No.

Personnel RAC, HBM Date: 21 September 2011 GIS Map No. Point-Verte 21P/13 Stream Order No. 2 Page: 3 of 6

REACH NO. *	UNIT NO.	STREAM TYPE	CHANNEL TYPE	LENGTH (m) *	AVE WIDTH (m) *		SUBSTRATE (%) *							AVE DEPTH - WET WIDTH (cm) *	0-50% UNDERCUT BANK *		0-50% OVER-HANGING BANK VEGETATION *		LARGE WOODY DEBRIS IN STREAM (m) *	FLOWS *					EMBEDDEDNESS (CRITERIA) 1 : # 20% 2 : 20% - 35% 3 : 35% - 50% 4 : ∃ 50%	COMMENTS	CHECKLIST OF LAND USE ATTRIBUTES (COMMENTS)
					WET	BANK CHANNEL	BED-ROCK	BOULDER	ROCK	RUBBLE	GRAVEL	SAND	FINES		L	R	L	R		TYPE	FLOW (cms)	TIME	TEMP EC W	TEMP EC A			
1	23	3/8	3	720	3.5	4.5				10	60	20	10	30	10	15	15	10	4						1	Small island	
1	24	8	1	739	4	5				5	55	40	5	20	10	10	15	15	3						2	ATV crossing at 733 m	
1	25	15	1	741	4.5	6	20				40	35	5	70	30	0	30	10	6						2	Natural Digger log	
1	26	12	1	747	3	5	10				70	15	5	90	50	0	50	0	0						1		
1	27	3/8	1	763	4	5					60	40		22	10	10	10	10	16						1	Braided channel	
1	28	8	1	805	4	5					50	45	5	22	0	20	5	10	2						1		
1	29	15	1	808	4	4.5				10	70	20		90	10	30	40	40	7						1		
1	30	8	1	822	4	5				5	60	30	5	25	5	30	10	30	8						1		
1	31	15	1	825	4.5	5.5	30				50	20		80	0	50	50	10	10						1		
1	32	8	1	854	4	6	5			10	60	25		22	5	20	15	15	15						1		
1	33	15	1	857	4.5	6	30			10	50	10		80	40	30	0	10	11						1		
1	34	8	1	898	5.5	7	5			10	60	20	5	22	20	10	15	15	15						1		

STREAM TYPE						CHANNEL TYPE	SUBSTRATE	FLOW TYPE	POOL RATING (reverse side)	
FASTWATER		POOLS							CRITERIA (NO.)	% OF POOLS IN SITE (LETTER)
1. Fall	6. Sheet (ledge)	10. Midchannel	14. Trench	18. Eddy	22. Wood Debris	1. Main (if measurement refers to main area of river)	1. Bedrock , Ledge 2. Boulder = > 461 mm	1. Survey Stream	Pool Depth ∃ 1.5 m 1 - Instream Cover ∃ 30%	a - ∃ 30%
2. Cascade	7. Chute	11. Convergence	15. Plunge	19. Gabion	23. Man-Made Dam	* 2. Side Channel (water diverted by islands)	3. Rock = 180 - 460 mm 4. Rubble = 54 - 179 mm	2. Spring	2 - Instream Cover < 30%	b - ∃ 10% to 30% c - < 10%
3. Riffle (GR/RB)	8. Run	12. Lateral	16.	20. Log Structure	24. Natural Deadwater	* 3. Split (if river is split into various different stream types)	5. Gravel = 2.6 - 53 mm 6. Sand = 0.06 - 2.5 mm	3. Brook/River Trib		
4. Riffle (R/B)	9. Rapid	13. Beaver	17. Bogan	21. Road Crossing		* 4. Bogan	7. Fines = 0.0005 - 0.05 mm	4. Spring Seep	Pool Depth .5 to 1.5m 3 - Instream Cover 5 - 30%	a - ∃ 50%
5. Riffle (Sand)						* - Specify Left (L), Right (R) or Middle (M)			4 - Instream Cover > 30%	b - < 50%

Note: Stream surveys should be undertaken only during summer base (low) flow conditions. Also, minimum size of stream type is $4m^2$ for larger streams.

REACH NO.	SITE (50m - interval)	% SITE		SHADE (%)	STREAM BANKS										O_2 (mg/l)	pH	DEPTH						POOL RATING (CRITERIA ON OTHER SIDE)		POOL TAIL			% TURBUL-ENCE
					VEGETATION (%)				EROSION (%)								1/4 (m)		1/2 (m)		3/4 (m)				EMBEDDEDNESS (CRITERIA) 1: # 20% 2: 20% - 35% 3: 35% - 50% 4: ∃ 50%	MEAN SUBSTRATE SIZE (cm)	% FINE	
		RIFFLE / RUN	POOLS		BARE GROUND	GRASSES	SHRUBS	TREES	LEFT BANK (0-50%)			RIGHT BANK (0-50%)					WET	CHANNEL	WET	CHANNEL	WET	CHANNEL	NO.	LETTER				
									STABLE	BARE STABLE	ERODING	STABLE	BARE STABLE	ERODING														
1	23	100		70	20	40	30	10	35	10	5	35	10	5														
1	24	100		50	10	40	40	10	40	5	5	40	5	5														
1	25		100	50	60	10	15	15	30	20		30	20															
1	26		100	40	70	10	10	10	20	20	10		50															
1	27	100		50	50	20	20	10	25	25		25	25															
1	28	100		50	50	20	20	10	15	25	10	30	15	5														
1	29		100	40	30	30	30	10	30	20		30	20															
1	30	100		40	30	30	30	10	30	15	5	30	15	5														
1	31		100	40	60	10	10	20	20	30		10	30	10														
1	32	100		30	70	10	10	10	20	20	10	20	20	10														
1	33		100	50	60	10	20	10	20	20	10	20	30															
	34	100		50	40	20	20	20	25	25		20	20	10														

NOTE: * For selected site study, these columns (reverse side) should be done for a habitat assessment

WATER FLOW MEASUREMENT

REACH NO.	CORRESPONDING LOCATION		STREAM TYPE	WET WIDTH (m)	DEPTH (cm)			AVERAGE DEPTH SUM / 4		COEFFICIENT (0.9 - smooth) (0.8 - rough)	LENGTH (3m)	FLOAT TIME (sec)				COMMENTS (LOCATION)
	UNIT NO.	SITE (50 - interval)			1/4 way	1/2 way	3/4 way	CENTIMETERS (cm)	METERS (m)			1/4 way	1/2 way	3/4 way	AVERAGE	

Formula (CMS) = W (m) x D (m) x A x L (m)   Where: W = width, D = depth, L = length, A is a coefficient for the stream bottom
T ____(sec)

08-94

DNR&E / DFO - NEW BRUNSWICK
STREAM SURVEY and HABITAT ASSESSMENT

River: Armstrong Brook　Start Point head of tide　End Point: approx 2023 m upstream of start　Drainage Code GG GG GG　Stream/River No.

Personnel RAC, HBM　Date: 21 September 2011　GIS Map No. Point-Verte 21P/13　Stream Order No. 2　Page: 4 of 6

REACH NO. *	UNIT NO.	STREAM TYPE	CHANNEL TYPE	LENGTH (m) *	AVE WIDTH (m) *		SUBSTRATE (%) *							AVE DEPTH - WET WIDTH (cm) *	0-50% UNDERCUT BANK *		0-50% OVER-HANGING BANK VEGETATION *		LARGE WOODY DEBRIS IN STREAM (m) *	FLOWS *					EMBEDDEDNESS (CRITERIA) 1 : # 20% 2 : 20% - 35% 3 : 35% - 50% 4 : ∃ 50%	COMMENTS	CHECKLIST OF LAND USE ATTRIBUTES (COMMENTS)
					WET	BANK CHANNEL	BED-ROCK	BOULDER	ROCK	RUBBLE	GRAVEL	SAND	FINES		L	R	L	R		TYPE	FLOW (cms)	TIME	TEMP EC W	TEMP EC A			
1	35	8/3	1	914	5.5	7				5	70	20	5	25	25	5	10	0	18						1		
1	36	12	1	922	4	6	20			5	65	10		85	50	0	20	0	0						1		
1	37	8/3	1	960	4	6				5	75	20		20	5	25	5	10	43						1		
1	38	3	1	965	3	5				30	70			15	0	10	0	0	0						1		
1	39	8	1	980	5	6	15			15	60	10		20	10	10	5	10	20						1		
1	40	3/8	1	1017	2.5	6	10			10	60	20		20	5	10	5	10	20						1		
1	41	3/8	1	1052	3	4.5	5			10	65	20		25	15	10	20	20	5						1		
1	42	8/3	1	1116	4.5	6	5			10	75	10		20	10	10	10	10	5						1		
1	43	3/8	1	1175	4	5.5	5			10	75	10		20	10	15	10	10	10						1		
1	44	3/8	1	1206	3.5	5.5	5	5	5	10	60	10	5	25	5	10	10	10	10						1		
1	45	8/3	1	1263	3.5	5.5	5		5	10	60	20		22	5	5	10	10	2						1		
1	46	3/8	1	1297	3.5	5.5	5			10	60	20	5	20	5	5	15	15	5						1		

STREAM TYPE

FASTWATER

1. Fall
2. Cascade
3. Riffle (GR/RB)
4. Riffle (R/B)
5. Riffle (Sand)
6. Sheet (ledge)
7. Chute
8. Run
9. Rapid

POOLS

10. Midchannel
11. Convergence
12. Lateral
13. Beaver
14. Trench
15. Plunge
16.
17. Bogan
18. Eddy
19. Gabion
20. Log Structure
21. Road Crossing
22. Wood Debris
23. Man-Made Dam
24. Natural Deadwater

CHANNEL TYPE

1. Main (if measurement refers to main area of river)
* 2. Side Channel (water diverted by islands)
* 3. Split (if river is split into various different stream types)
* 4. Bogan

* - Specify Left (L), Right (R) or Middle (M)

SUBSTRATE

1. Bedrock , Ledge
2. Boulder = > 461 mm
3. Rock = 180 - 460 mm
4. Rubble = 54 - 179 mm
5. Gravel = 2.6 - 53 mm
6. Sand = 0.06 - 2.5 mm
7. Fines = 0.0005 - 0.05 mm

FLOW TYPE

1. Survey Stream
2. Spring
3. Brook/River Trib
4. Spring Seep

POOL RATING (reverse side)

CRITERIA (NO.)	% OF POOLS IN SITE (LETTER)
Pool Depth ∃ 1.5 m 1 - Instream Cover ∃ 30% 2 - Instream Cover < 30%	a - ∃ 30% b - ∃ 10% to 30% c - < 10%
Pool Depth .5 to 1.5m 3 - Instream Cover 5 - 30% 4 - Instream Cover > 30%	a - ∃ 50% b - < 50%

Note: Stream surveys should be undertaken only during summer base (low) flow conditions. Also, minimum size of stream type is 4m² for larger streams.

REACH NO.	SITE (50m - interval)	% SITE		SHADE (%)	STREAM BANKS										O_2 (mg/l)	pH	DEPTH						POOL RATING (CRITERIA ON OTHER SIDE)		POOL TAIL			% TURBUL-ENCE
					VEGETATION (%)				EROSION (%)								1/4 (m)		1/2 (m)		3/4 (m)							
		RIFFLE / RUN	POOLS		BARE GROUND	GRASSES	SHRUBS	TREES	LEFT BANK (0-50%)			RIGHT BANK (0-50%)					WET	CHANNEL	WET	CHANNEL	WET	CHANNEL	NO.	LETTER	EMBEDDEDNESS (CRITERIA) 1: # 20% 2: 20% - 35% 3: 35% - 50% 4: ∃ 50%	MEAN SUBSTRATE SIZE (cm)	% FINE	
									STABLE	BARE STABLE	ERODING	STABLE	BARE STABLE	ERODING														
1	35	100		40	70	10	10	10	25	20	5	25	20	5														
1	36		100	40	70	10	10	10	10	20	20	10	40															
1	37	100		40	60	20	10	10	20	30		20	20	10														
1	38	100		40	80	10	10			50		20	30															
1	39	100		50	60	15	15	10	20	20	10	20	20	10														
1	40	100		50	70	10	10	10	20	30		20	20	10														
1	41	100		60	50	20	20	10	25	20	5	25	20	5														
1	42	100		50	60	15	15	10	25	20	5	20	25	5														
1	43	100		50	65	5	20	10	20	20	10	20	20	10														
1	44	100		50	65	15	15	5	25	20	5	15	30	5														
1	45	100		50	65	15	15	5	20	25	5	20	25	5														
1	46	100		50	50	30	20		20	25	5	20	25	5														

NOTE: * For selected site study, these columns (reverse side) should be done for a habitat assessment

WATER FLOW MEASUREMENT

REACH NO.	CORRESPONDING LOCATION		STREAM TYPE	WET WIDTH (m)	DEPTH (cm)			AVERAGE DEPTH SUM / 4		COEFFICIENT (0.9 - smooth) (0.8 - rough)	LENGTH (3m)	FLOAT TIME (sec)				COMMENTS (LOCATION)
	UNIT NO.	SITE (50 - interval)			1/4 way	1/2 way	3/4 way	CENTIMETERS (cm)	METERS (m)			1/4 way	1/2 way	3/4 way	AVERAGE	

Formula (CMS) = W (m) x D (m) x A x L (m)   Where: W = width, D = depth, L = length, A is a coefficient for the stream bottom
T ____(sec)

08-94

DNR&E / DFO - NEW BRUNSWICK
STREAM SURVEY and HABITAT ASSESSMENT

River: Armstrong Brook
Start Point head of tide
End Point: approx 2023 m upstream of start
Drainage Code GG GG GG
Stream/River No.
Personnel RAC, HBM
Date: 21 September 2011
GIS Map No. Point-Verte 21P/13
Stream Order No. 2
Page: 5 of 6

REACH NO. *	UNIT NO.	STREAM TYPE	CHANNEL TYPE	LENGTH (m) *	AVE WIDTH (m) *		SUBSTRATE (%) *							AVE DEPTH - WET WIDTH (cm) *	0-50% UNDERCUT BANK *		0-50% OVER-HANGING BANK VEGETATION *		LARGE WOODY DEBRIS IN STREAM (m) *	FLOWS *					EMBEDDEDNESS (CRITERIA) 1 : # 20% 2 : 20% - 35% 3 : 35% - 50% 4 : ∃ 50%	COMMENTS	CHECKLIST OF LAND USE ATTRIBUTES (COMMENTS)
					WET	BANK CHANNEL	BED-ROCK	BOULDER	ROCK	RUBBLE	GRAVEL	SAND	FINES		L	R	L	R		TYPE	FLOW (cms)	TIME	TEMP ΕC				
																							W	A			
1	47	8/3	1	1368	4.5	5.5				5	80	10	5	25	5	5	20	20	12						1		
1	48	8/3	1	1448	4	5.5				5	80	10	5	20	10	10	20	20	10						1		
1	49	22	1	1458	6	7					80	20		30	10	10	10	10	17						1		
1	50	8	1	1505	5	6	5			5	85	5		30	10	10	15	15	11						1		
1	51	3/8	1	1540	3.5	5				5	90	5		22	10	5	10	0	5						1		
1	52	8/3	1	1583	3.5	5.5	10			10	75	5		25	10	0	10	10	8						1		
1	53	3/8	1	1601	4.5	6				5	90	5		20	10	0	10	5	8						1		
1	54	12	1	1612	4	6	10			5	60	20	5	80	0	30	5	20	17						1		
1	55	8/3	1	1642	4	6	10			10	65	10	5	20	10	10	10	10	10						1		
1	56	15	1	1650	5	6	35		10	20	30	5		80	0	0	10	10	5						1		
1	57	8/3	1	1695	4	5	20			5	65	5	5	20	10	10	10	10	6						1		
1	58	3	1	1700	3	5	10			10	80			18	20	20	15	20	8						1		

STREAM TYPE						CHANNEL TYPE	SUBSTRATE	FLOW TYPE	POOL RATING (reverse side)	
FASTWATER		POOLS							CRITERIA (NO.)	% OF POOLS IN SITE (LETTER)
1. Fall 2. Cascade 3. Riffle (GR/RB) 4. Riffle (R/B) 5. Riffle (Sand)	6. Sheet (ledge) 7. Chute 8. Run 9. Rapid	10. Midchannel 11. Convergence 12. Lateral 13. Beaver	14. Trench 15. Plunge 16. 17. Bogan	18. Eddy 19. Gabion 20. Log Structure 21. Road Crossing	22. Wood Debris 23. Man-Made Dam 24. Natural Deadwater	1. Main (if measurement refers to main area of river) * 2. Side Channel (water diverted by islands) * 3. Split (if river is split into various different stream types) * 4. Bogan * - Specify Left (L), Right (R) or Middle (M)	1. Bedrock , Ledge 2. Boulder = > 461 mm 3. Rock = 180 - 460 mm 4. Rubble = 54 - 179 mm 5. Gravel = 2.6 - 53 mm 6. Sand = 0.06 - 2.5 mm 7. Fines = 0.0005 - 0.05 mm	1. Survey Stream 2. Spring 3. Brook/River Trib 4. Spring Seep	Pool Depth ∃ 1.5 m 1 - Instream Cover ∃ 30% 2 - Instream Cover < 30% Pool Depth .5 to 1.5m 3 - Instream Cover 5 - 30% 4 - Instream Cover > 30%	a - ∃ 30% b - ∃ 10% to 30% c - < 10% a - ∃ 50% b - < 50%

Note: Stream surveys should be undertaken only during summer base (low) flow conditions. Also, minimum size of stream type is $4m^2$ for larger streams.

REACH NO.	SITE (50m - interval)	% SITE		SHADE (%)	STREAM BANKS										O_2 (mg/l)	pH	DEPTH						POOL RATING (CRITERIA ON OTHER SIDE)		POOL TAIL			% TURBUL-ENCE
					VEGETATION (%)				EROSION (%)								1/4 (m)		1/2 (m)		3/4 (m)							
		RIFFLE / RUN	POOLS		BARE GROUND	GRASSES	SHRUBS	TREES	LEFT BANK (0-50%)			RIGHT BANK (0-50%)					WET	CHANNEL	WET	CHANNEL	WET	CHANNEL	NO.	LETTER	EMBEDDEDNESS (CRITERIA) 1: # 20% 2: 20% - 35% 3: 35% - 50% 4: ∃ 50%	MEAN SUBSTRATE SIZE (cm)	% FINE	
									STABLE	BARE STABLE	ERODING	STABLE	BARE STABLE	ERODING														
1	47	100		50	40	30	30		20	25	5	20	25	5														
1	48	100		50	40	30	30		30	20		30	20															
1	49	100		30	10	45	35	10	45	5		45	5															
1	50	100		40	20	35	35	10	40	10		40	10															
1	51	100		40	30	30	30	10	40	5	5	25	25															
1	52	100		40	30	30	30	10	40	5	5	30	20															
1	53	100		40	30	30	30	10	40	10		40	10															
1	54	100		60	70		10	20	10	40		10	30	10														
1	55	100		40	50	10	20	10	20	25	5	20	25	5														
1	56		100	50	80		10	10	10	40		10	40															
1	57	100		50	50	20	20	10	20	25	5	20	25	5														
1	58	100		70	60	20	10	10	40	10		20	20	10														

NOTE: * For selected site study, these columns (reverse side) should be done for a habitat assessment

WATER FLOW MEASUREMENT

REACH NO.	CORRESPONDING LOCATION		STREAM TYPE	WET WIDTH (m)	DEPTH (cm)			AVERAGE DEPTH SUM / 4		COEFFICIENT (0.9 - smooth) (0.8 - rough)	LENGTH (3m)	FLOAT TIME (sec)				COMMENTS (LOCATION)
	UNIT NO.	SITE (50 - interval)			1/4 way	1/2 way	3/4 way	CENTIMETERS (cm)	METERS (m)			1/4 way	1/2 way	3/4 way	AVERAGE	

Formula (CMS) = W ___ (m) x D ___ (m) x A ___ x L ___ (m)   Where: W = width, D = depth, L = length, A is a coefficient for the stream bottom
T ____(sec)

08-94

DNR&E / DFO - NEW BRUNSWICK
STREAM SURVEY and HABITAT ASSESSMENT

River: Armstrong Brook Start Point head of tide End Point: approx 2023 m upstream of start Drainage Code GG GG GG Stream/River No.
Personnel RAC, HBM Date: 21 September 2011 GIS Map No. Point-Verte 21P/13 Stream Order No. 2 Page: 6 of 6

REACH NO. *	UNIT NO.	STREAM TYPE	CHANNEL TYPE	LENGTH (m) *	AVE WIDTH (m) *		SUBSTRATE (%) *							AVE DEPTH - WET WIDTH (cm) *	0-50% UNDERCUT BANK *		0-50% OVER-HANGING BANK VEGETATION *		LARGE WOODY DEBRIS IN STREAM (m) *	FLOWS *					EMBEDDEDNESS (CRITERIA) 1 : # 20% 2 : 20% - 35% 3 : 35% - 50% 4 : ∃ 50%	COMMENTS	CHECKLIST OF LAND USE ATTRIBUTES (COMMENTS)
					WET	BANK CHANNEL	BED-ROCK	BOULDER	ROCK	RUBBLE	GRAVEL	SAND	FINES		L	R	L	R		TYPE	FLOW (cms)	TIME	TEMP EC W	TEMP EC A			
1	59	8/3	1	1737	3	5	20			10	60	10		25	10	10	20	20	9						1		
1	60	3/8	1	1786	4	5.5	15			10	70	5		20	10	0	20	20	4						1		
1	61	8/3	1	1797	4	5.5	15			10	70	5		25	10	0	15	15	0						1		
1	62	3	1	1802	3	5				30	70			12	0	0	5	0	0						1		
1	63	8/3	1	1869	3	5	5			10	75	10		20	5	5	10	10	6						1	Braided channel	
1	64	8/3	1	1931	3.5	5				5	85	10		22	5	5	15	15	12						1	Braided channel	
1	65	8/3	1	1995	4	5	10			10	70	10		20	5	10	10	10	4						1		
1	66	3	1	2013	4	5			10	20	70			20	0	10	5	10	0						1	Buried water line	
1	67	8	1	2023	5	6			10	20	60	5	5	40	0	0	0	5	3						1	Road crossing	

STREAM TYPE						CHANNEL TYPE	SUBSTRATE	FLOW TYPE	POOL RATING (reverse side)	
FASTWATER		POOLS							CRITERIA (NO.)	% OF POOLS IN SITE (LETTER)
1. Fall	6. Sheet (ledge)	10. Midchannel	14. Trench	18. Eddy	22. Wood Debris	1. Main (if measurement refers to main area of river)	1. Bedrock , Ledge 2. Boulder = > 461 mm	1. Survey Stream	Pool Depth ∃ 1.5 m 1 - Instream Cover ∃ 30%	a - ∃ 30%
2. Cascade	7. Chute	11. Convergence	15. Plunge	19. Gabion	23. Man-Made Dam	* 2. Side Channel (water diverted by islands)	3. Rock = 180 - 460 mm 4. Rubble = 54 - 179 mm	2. Spring	2 - Instream Cover < 30%	b - ∃ 10% to 30% c - < 10%
3. Riffle (GR/RB)	8. Run	12. Lateral	16.	20. Log Structure	24. Natural Deadwater	* 3. Split (if river is split into various different stream types)	5. Gravel = 2.6 - 53 mm 6. Sand = 0.06 - 2.5 mm	3. Brook/River Trib		
4. Riffle (R/B)	9. Rapid	13. Beaver	17. Bogan	21. Road Crossing		* 4. Bogan	7. Fines = 0.0005 - 0.05 mm	4. Spring Seep	Pool Depth .5 to 1.5m	
5. Riffle (Sand)						* - Specify Left (L), Right (R) or Middle (M)			3 - Instream Cover 5 - 30% 4 - Instream Cover > 30%	a - ∃ 50% b - < 50%

Note: Stream surveys should be undertaken only during summer base (low) flow conditions. Also, minimum size of stream type is $4m^2$ for larger streams.

REACH NO.	SITE (50m - interval)	% SITE		SHADE (%)	STREAM BANKS										O_2 (mg/l)	pH	DEPTH						POOL RATING (CRITERIA ON OTHER SIDE)		POOL TAIL			% TURBUL-ENCE
					VEGETATION (%)				EROSION (%)								1/4 (m)		1/2 (m)		3/4 (m)							
		RIFFLE / RUN	POOLS		BARE GROUND	GRASSES	SHRUBS	TREES	LEFT BANK (0-50%)			RIGHT BANK (0-50%)					WET	CHANNEL	WET	CHANNEL	WET	CHANNEL	NO.	LETTER	EMBEDDEDNESS (CRITERIA) 1: # 20% 2: 20% - 35% 3: 35% - 50% 4: ∃ 50%	MEAN SUBSTRATE SIZE (cm)	% FINE	
									STABLE	BARE STABLE	ERODING	STABLE	BARE STABLE	ERODING														
1	59	100		30	40	20	30	10	20	20	10	20	20	10														
1	60	100		40	40	20	30	10	20	25	5	30	20															
1	61	100		40	40	20	30	10	20	25	5	30	20															
1	62	100		10	80		20		10	40		10	40															
1	63	100		35	40	20	30	10	30	20		30	20															
1	64	100		35	40	20	30	10	25	20	5	25	20	5														
1	65	100		35	40	20	30	10	25	20	5	25	20	5														
1	66	100		30	50	20	20	10	20	30		20	30															
1	67	100		40	80		10	10	20	20	10	20	20	10														

NOTE: * For selected site study, these columns (reverse side) should be done for a habitat assessment

WATER FLOW MEASUREMENT

REACH NO.	CORRESPONDING LOCATION		STREAM TYPE	WET WIDTH (m)	DEPTH (cm)			AVERAGE DEPTH SUM / 4		COEFFICIENT (0.9 - smooth) (0.8 - rough)	LENGTH (3m)	FLOAT TIME (sec)				COMMENTS (LOCATION)
	UNIT NO.	SITE (50 - interval)			1/4 way	1/2 way	3/4 way	CENTIMETERS (cm)	METERS (m)			1/4 way	1/2 way	3/4 way	AVERAGE	

Formula (CMS) = W ___ (m) x D ___ (m) x A ___ x L ___ (m)　　Where: W = width, D = depth, L = length, A is a coefficient for the stream bottom
T ____(sec)

APPENDIX P

SOIL NUTRIENT ANALYSIS

XSTRATA BELLEDUNE LEAD SMELTER

SOIL ANALYSIS PROGRAM

Report prepared for

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1.0 INTRODUCTION

At Xstrata's Belledune Lead Smelter, environmental studies conducted during 2009 revealed that soil at some sites in the vicinity of the Smelter had high concentrations of metals, some of which exceeded vegetative health guidelines. As a follow up, LGL Limited (2010) conducted a Vegetation Health Study at the Xstrata Belledune Lead Smelter.

In the Vegetation Health Study, five transects were established radiating from a single point closest to the Smelter and extending for a distance of up to 2 km from the site. Community assessments were conducted on 17 transect stations along the transects and at four reference stations established approximately 21 km upwind of the site. LGL Limited concluded, based on the community assessments, that the effects were largely restricted to Transect 1 and Transect 5.

FHW Consulting was retained by Intrinsik Inc. to assess soil nutrient availability in the transect stations and reference sites used in the LGL Limited Vegetation Health Study at the Xstrata Belledune Lead Smelter.

1.1 Objectives

The objectives of Belledune Soil Analysis Program were to:

- Identify soil nutrient deficiencies and/or toxicities that would affect vegetation growth in the vicinity of the Belledune Lead Smelter;
- Determine differences in available soil nutrients between transects and at various intervals from the smelter.

2.0 METHOD

LGL Limited conducted a Vegetation Health Study at the Xstrata Belledune Lead Smelter in the summer of 2009 (LGL Limited, 2009). In the study, five transects were established radiating from a single point closest to the Smelter and extending for a distance of up to 2 km from the site. A total of 17 transect stations were established along the transects (Figure 1). Four reference stations were also established approximately 21 km upwind of the Smelter.

For the Soil Analysis Program, between October 21 and 25, 2011 LGL Limited sampled the following locations:

- Reference Sites (1, 2, 3 and 4)
- Transect 1 (station 1, 2 and 3)
- Transect 2 (station 1, 2 and 3)
- Transect 3 (station 1, 2 and 3)
- Transect 4 (station 1 and 2)
- Transect 5 (station 1 and 2)

The reference sites and transect stations were located with a GPS. At each location, eight samples from a 0 to 15 cm depth were collected from a 10 x 10 m plot using a stainless steel soil corer. The samples were combined in a Zip-Lock freezer bag with all vegetation, moss, sticks, pebbles and rocks removed.

The 19 soil samples were shipped to FHW Consulting for examination, before being submitted to A & L Laboratory in London, Ontario and analyzed for the following parameters:

- paste pH;
- organic matter;
- available nutrients (P, K, Mg, Ca, Na, Fe, Al, Mn, B, Cu, Zn and S).

The soil analysis results were compared to the nutrient sufficient rating (very low, low, medium, high or very high) and the typical soil range which would indicate potential nutrient deficiencies or excesses (A & L Laboratories, 2001).

Statistical analyses were performed using IBM's statistical analysis software SPSS Vision 20 for Windows. Pearson correlation coefficients were used to investigate the relationship between pH, organic matter and available nutrients. A probability level of <0.05 was used in all comparisons.

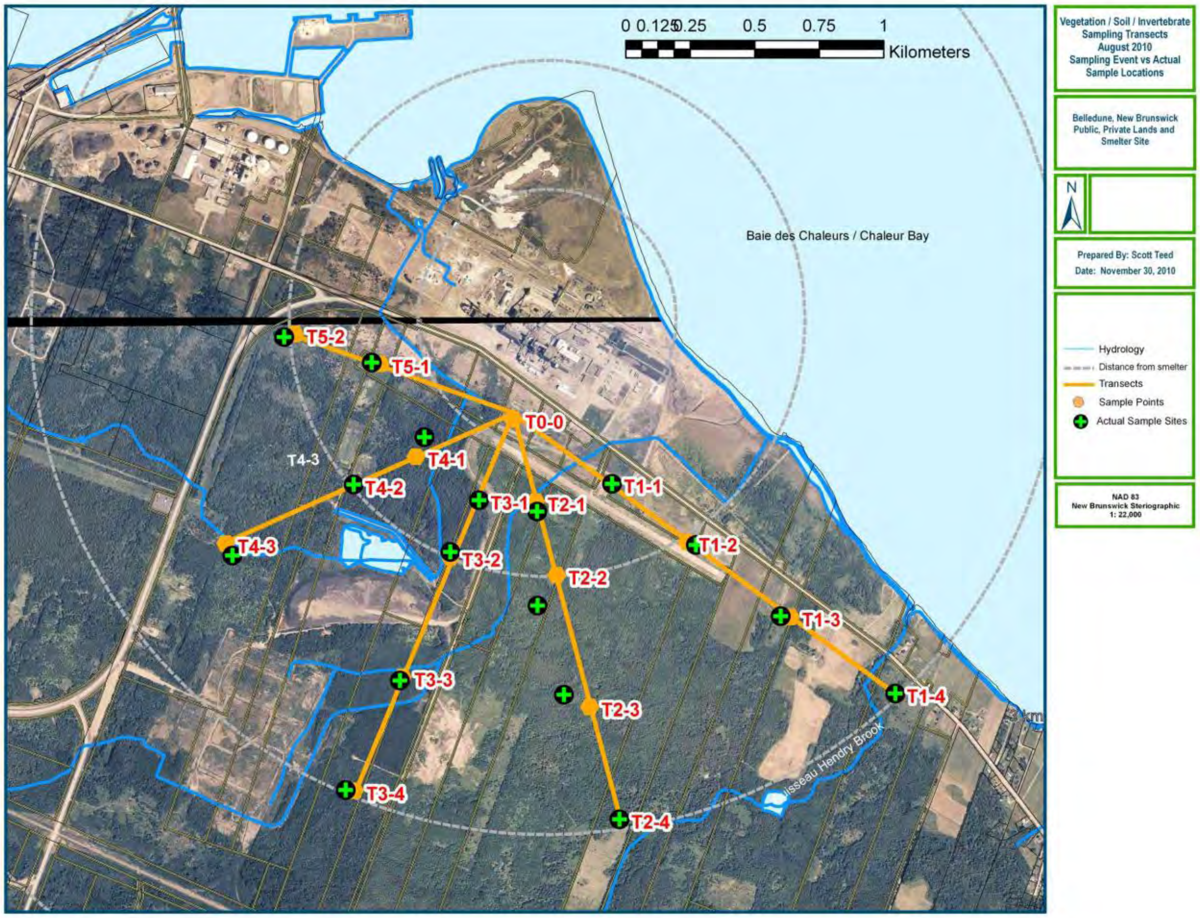

Figure 1: Location of LGL Limited transect stations.

3.0 RESULTS

3.1 Soil Results

Soil analysis results for the reference sites (4) and transect stations (13) are contained in Tables 2 and 3.

Based on Soil Textural Classification, the soils in the study were classified as sandy loam, except for T5-2 which was classified as loam. When visually examined, the soils appeared to fall into two groups. Soils from transect stations T2-1, T2-3, T3-1, T3-3 and T5-2 were black and appeared to have a higher moisture content, particularly at T2-3. Soils from the other transect stations and reference sites were brown or reddish brown in colour.

In the 0 -15 cm layer, soil pH ranged from 4.8 to 5.5 in the reference sites and from 4.5 to 7.3 in the transect stations, with five stations having soil pH <5.7. These five stations were T1-1, T2-1 and T3-1, nearest to the Smelter, along with T2-3 and T3-3, farthest from the Smelter. Based on Pearson's correlations (n=17), soil pH was positively correlated for available boron (r=.741**), calcium (r=.707**) and magnesium (r=.651**) and negatively correlated for aluminum (r=-.687**).

Organic matter ranged from 7.0 to 14.8 % in the reference sites and from 4.0 to 35.5 % in the transect stations. At stations T1-1, T1-2, T1-3, T2-1 and T5-2 organic matter was lower than at the reference sites and, except for T2-1, were identified as being disturbed areas (LGL Limited, 2009). At stations T2-1, T2-2, T3-1 and T5-2 organic matter was greater than at the reference sites. Based on Pearson's correlations (n=17), organic matter was positively correlated with available sodium (r=.752**) and calcium (r=.711**).

The nutrient sufficiency rating in the reference sites was generally lower or similar to the ratings observed in the transect stations. In the reference sites, the nutrient sufficiently rating was considered very low or low for phosphorous (8 - 15 ppm), potassium (23 - 58 ppm), calcium (520 - 1370 ppm), magnesium (30 - 55 ppm), sodium (10 -18 ppm), manganese (4 - 13 ppm) and boron (0.3 - 0.4 ppm).. The nutrient sufficiency ratings for the transect stations were:

- phosphorus (5 - 30 ppm) was medium or high in seven stations
- potassium (40 -127 ppm) was medium in two stations
- calcium (620 - 3620 ppm) was medium or high in six stations, which all had pH < 5.7
- magnesium (40 - 285 ppm) was still very low to low except at T1-1 (pH 7.3), which was medium
- sodium (7 - 60 ppm) was medium in six stations
- manganese (6 - 100 ppm) was medium to high in eight stations
- boron (0.4 - 1.1 ppm) was medium in eight stations.

In the reference sites, the following nutrient sufficiency ratings were observed:

- sulphur (10 - 33 ppm) was medium to very high
- iron (61 - 103 ppm) was very high
- zinc (2.2 - 7.6 ppm) was low to high
- copper (0.3 - 0.5 ppm) was low to medium.

The nutrient sufficiency rating in the reference sites was generally lower or similar to that observed in the transect stations where:

- sulphur (12 -118 ppm) was higher than the reference sites at T1-3,
- iron (47 - 131 ppm) was higher than the reference sites at T4-2 and T5-1,
- zinc (9.1 - 127.6 ppm) was higher than in the reference sites and above the typical range (1 - 20 ppm), except at T1-3,
- copper (2.4 - 527) was higher than in the reference sites and above the typical range (0.1 - 4.0) at T1-1, T1-2, T5-1 and T5-2.

4.0 DISCUSSION

4.1 Nutrient Availability

Macronutrients and micronutrients are essential for plant growth and deficiencies can cause stunted growth or death. Nutrient deficiencies can occur because; 1) the elements are lacking; 2) the elements are bound in the soil and not available to the plants or; 3) imbalances affect uptake.

Five transect stations (T1-1, T2-1, T2-3, T3-1 & T3-3) had soil pH ranging from 6.3 to 7.3 which were higher than the ranges observed in the reference sites or the other transect stations (<5.7). The LGL Limited (2010) Study identified T1-1 as being a disturbed area, while along Transects 2, 3 and 4, stations were established in areas of mixed or deciduous forest which has regenerated since being harvested approximately 35 to 45 years ago. It is not clear why soil pH was high at T2-1, T2-3 T3-1 and T3-3 but not in the other forested sites at T2-2, T3-2 or along Transect 4. The soils at the stations with the highest pH were observed to be black in colour, which may be related to forest cover (deciduous versus mixed) at the stations. Other factors, such as proximity to the slag heap, historical disturbances etc. could have an impact, but without physically observing the reference stations this cannot be determined conclusively.

In the transect stations, nutrient levels were generally similar or higher than those observed in the refence stations, which was partly due to higher soil pH and organic matter. In the reference sites, nutrient availability was very low or low for phosphorus, potassium, calcium, magnesium, sodium, boron and manganese. Low nutrient availability in both the transect stations and refence sites is likely due to a general lack of these elements in the soil and restricted release due to the soil pH. In acidic soil (pH

<5.5), hydrogen ion concentrations cause inactivation of plant enzyme systems which can restrict respiration and nutrient uptake (Williams *et al*, 1982). The plant nutrients; nitrogen, phosphorus, potash, calcium and magnesium, show a marked reduction in availability leading to potential deficiencies, while increases in zinc, copper and manganese availability could lead to potential toxicities (U.S. EPA, 2007).

In the LGL Limited (2010) Study, nutrient deficiency symptoms were not observed in vegetation established at the reference sites. As nutrient levels were generally similar or higher in the transect stations, nutrient deficiency symptoms were not expected to be observed in vegetation established at the transect stations. However, although nutrient deficiency symptoms were not observed, nitrogen, phosphorus and potassium are likely growth limiting and amendments would be beneficial at all transect stations, particularly in areas with low organic matter. In a self-sustaining system, organic matter and the associated microbes are major sources of nutrients for plant uptake. With low organic matter, nutrients are rapidly leached from the soil. Nitrogen, phosphorus and potassium are likely to be the most limiting in these sites. In the study, the highest concentrations of phosphorus and potassium were observed at Station T1-2, a fallow field where fertilizer amendments would likely have been applied historically.

4.2 Chemicals of Potential Concern

Macronutrients and micronutrients are essential for plant growth. However, these elements can be accumulated by the plant beyond the critical concentration, where the elements accumulate in the plant tissue without any further yield increase and at some point reach concentrations that could have a phytotoxic effect on the plant. The phytotoxic effect of these elements is related to the bioavailability in the soil and, therefore, how readily the element can be taken up through the root system (U.S. EPA, 2007). Similarly, non-essential elements (lead and arsenic) can be available in the soil at concentrations that could be phytotoxic to plants.

In the transect stations available copper and zinc were above the range observed in the reference sites, with the highest availability along Transect 1 and Transect 5. In the Intrinsik 2009 sampling program (which sampled at depths of 0 – 5 cm), copper, zinc, arsenic and lead were identified in some transect stations at concentrations above the U.S. EPA Eco-SSLs (ecological soil screening levels) that could potentially affect vegetation. The highest concentrations of these metals were along Transect 1 and Transect 5.

Transect 1 is located south of the Smelter along Highway 134. Station T1-1 was established next to fill piles in an area previously disturbed and now dominated by dogwoods. Stations T1-2 & T1-3 appear to have been recently ploughed and fallowed with limited woody species present. No signs of vegetative stress were observed.

Transect 5 is located South West of the Smelter along Highway 134. Station T5-1 is established in a highly disturbed cultural thicket with vegetation showing signs of stunted growth, twig die back and chlorosis. Station T5-2 is established in a deciduous forest with trembling aspen having cankers along the stems. LGL Limited (2010) indicated that the vegetation stress could have been due to a combination of factors, including phytotoxic effect of metals (copper, zinc, lead or arsenic).

5.0 CONCLUSION

Nutrient levels in the transect stations were generally similar or higher than the reference sites partly due to higher pH and organic matter. In the LGL Limited (2010) Study, nutrient deficiency symptoms were not observed in vegetation established at the reference sites and therefore symptoms associated with nutrient deficiencies are not expected in vegetation established at the transect stations.

In the study, five transect stations (T1-1, T2-1, 2-3, T3-1 & T3-3) had soil pH ranging from 6.3 to 7.3, which were higher than the ranges observed in the other transect stations or reference sites. These transect stations, with the exception of T1-1, were in mixed or deciduous forest areas which had regenerated since being harvested approximately 35 to 45 years ago. It is not clear if the difference in soil pH is related to forest cover (deciduous versus mixed) or to other factors (proximity to the slag heap, historical disturbances etc).

Although essential for plant growth, copper and zinc levels were above those of the reference sites and the typical range, particularly along Transect 1 and Transect 5 (see Table 1 and 2). Similarly, Intrinsik observed copper, zinc, arsenic and lead above the U.S. EPA ECO-SSLs soil screening levels that could potentially affect vegetation in these Transects, albeit at shallower sampling depths than those used in this program (0- 5 cm, versus 0 – 15 cm).

Nitrogen, phosphorus and potassium deficiencies are likely growth limiting, but this is occurring in both the reference sites and transect stations sampled (see table 1 and 2) and might be most severe in areas with low organic matter.

REFERENCES

A and L Laboratories. 2001. Agronomy Handbook. London, Ontario.

Lautnebach, W.E., J. Miller, P.J. Beckett, J.J. Negusanti and K. Winterhalder. 1995. Municipal land restoration program: The regreeening process, pp.109-122. *In*: J.M. Gunn (eds.). Restoration and recovery of an industrial region. Springer-Verlag, New York.

LGL Limited. 2010. Xstrata Lead Belledune Smelter Vegetative Health Study. LGL Project TA4803.

U.S. Environmental Protection Agency. 2007. The use of soil amendments for the remediation revitalization and reuse. EPA 542-R-07-013 December, 2007, www.epa.gov.

Williamson, N.A., M.S. Johnson and A.D. Bradshaw. 1982. Mine waste reclamation. The establishment of vegetation on metal mine wastes. Mining Journal Books Ltd., London.

Table 1: Reference site pH, CEC, organic matter and available nutrient analyses.

Site	pH	Buffer pH	CEC Meq/100g	Organic Matter%	P (ppm)	K (ppm)	Mg (ppm)	Ca (ppm)	S (ppm)	Na (ppm)	B (ppm)	Zn (ppm)	Mn (ppm)	Fe (ppm)	Cu (ppm)	Al (ppm)
Field 1	5.5	6.2	16.9	7.3	8 L	42 L	40 VL	1370 VL	17 H	11VL	0.3 VL	6.9 H	6 L	61 VH	0.6 M	2497
Field 2	4.8	5.7	21.4	14.8	11 L	53 L	55 VL	1040 VL	33 VH	10 VL	0.4 L	7.6 H	13 L	86 VH	0.5 M	2055
Forest 1	5.3	6.2	16.1	7.0	15 L	58 L	50 VL	1170 VL	15 H	18 L	0.3 VL	4.6 M	11 L	72 VH	0.4 L	2132
Forest 2	5.3	6.2	12.6	8.3	11 L	23 L	30 VL	520 VL	10 M	10 VL	0.4 L	2.2 L	4 VL	103 VH	0.3 L	1004
Min	4.8	5.7	16.1	7.3	8	23	30	520	10	10	0.3	2.2	4	61	0.3	1004
Max	5.5	6.2	21.4	14.8	15	58	55	1370	33	18	0.4	7.6	13	103	0.6	2497
Mean	5.2	6.1	16.8	9.4	11.3	44.0	43.8	1025	18.8	12.3	0.35	5.3	8.5	80.5	0.45	1922

Table 2: Transect station pH, organic matter and available nutrient analyses.

Site	pH	Buffer pH	CEC Meq/100gn	Organic Matter%	P (ppm)	K (ppm)	Mg (ppm)	Ca (ppm)	S (ppm)	Na (ppm)	B (ppm)	Zn (ppm)	Mn (ppm)	Fe (ppm)	Cu (ppm)	Al (ppm)
T1-1	7.3		16.6	5.7	19 M	65 L	285 M	2800 H	118 VH	20 L	1.1 M	124.1 VH	12 L	47 H	527.0 VH	205
T1-2	4.9	6.1	16.5	4.6	29 H	127 M	65 VL	950 VL	29 VH	11 VL	0.5 L	34.7 VH	32 H	94 VH	22.3 VH	1692
T1-3	5.3	6.4	13.0	4.0	15 L	77 M	40 VL	1040 VL	17 H	8 VL	0.4 L	9.1 H	6 L	70 VH	4.0 VH	1832
T2-1	6.2	6.5	25.2	30.5	7 L	48 L	100 VL	3620 M	19 VH	31 L	1.0 M	53.4 VH	13 L	74 VH	3.3 VH	446
T2-2	5.5	6.3	12.2	6.3	5 VL	64 L	60 VL	620 VL	15 H	15 L	0.4 L	30.5 VH	8 L	94 VH	2.4 H	1152
T2-3	6.3	6.9	12.8	27.6	20 M	58 L	90 L	2110 H	15 H	28 M	0.9 M	89.7 VH	73 VH	104 VH	2.8 H	316
T3-1	6.3	6.7	20.6	21.3	11 L	50 L	105 LV	3160 H	16 H	36 M	0.9 M	104.3 VH	15 M	78 VH	3.9 VH	300
T3-2	5.1	6.0	17.1	9.0	11 L	64 L	65 LV	860 VL	18 VH	11 VL	0.5 L	81.6 VH	12 L	114 VH	3.3 VH	1315
T3-3	6.8	6.9	12.6	12.7	8 L	53 L	85 L	2080 H	12 M	27 M	0.7 M	68.4 VH	30 H	97 VH	2.9 H	804
T4-1	5.7	6.8	11.5	11.0	16 M	40 L	70 L	1670 M	14 H	10 L	0.6 M	43.1 VH	39 H	93 VH	2.8 H	768
T4-2	4.5	5.6	22.3	11.5	20 M	76 L	50 VL	950 VL	25 VH	29 M	0.6 M	30.8 VH	17 M	131 VH	4.0 VH	1462
T5-1	4.9	6.0	16.8	3.6	18 M	61 L	40 VL	850 VL	29 VH	7 VL	0.5 L	70.7 VH	21 M	113 VH	5.5 VH	1564
T5-2	5.0	5.7	29.0	26.3	18 M	60 L	155 VL	2340 VL	27 VH	60 M	0.6 M	127.6 VH	100 VH	99 VH	6.3 VH	871
Min	4.5	5.6	11.5	3.6	5	40	40	620	12	7	0.4	9.1	6	47	2.4	205
Max	7.3	6.9	29	30.5	30	127	285	3620	119	60	1.1	127.6	100	131	527	1832
Mean	5.7	6.3	17.4	13.4	17.2	64.7	93.1	1773	27.2	22.5	0.7	66.8	29.1	92.9	45.4	979

APPENDIX Q

LIMITATIONS, UNCERTAINTIES AND CONSERVATIVE ASSUMPTIONS

APPENDIX Q LIMITATIONS, UNCERTAINTIES AND CONSERVATIVE ASSUMPTIONS

Q-1.0 INTRODUCTION

Ecological risk assessment involves assigning numerical values to various input parameters in models to obtain estimates of exposure and risk. Numerical values are typically required to describe chemical concentrations in environmental media, their fate and transport, wildlife exposure and receptor parameters and toxicity. Variability and uncertainty in these input parameters will result in variability and uncertainty in the estimates of exposure and risk. The conclusions of any risk assessment are dependent on the data and assumptions that are evaluated within it, and are greatly influenced by the variability and uncertainty that is associated with these data and assumptions. Therefore, it is important to characterize and understand the key areas of variability and uncertainty, and any major study limitations, so as to avoid possible underestimating of risks to the extent possible. Risk managers need this information to make informed decisions regarding whether or not risks need to be managed, to what extent, and how the risks can best be managed. By understanding variability and uncertainty, risk managers can identify situations where the use of more sophisticated approaches and/or further data collection can reduce or refine key sources of uncertainty and/or variability before making final risk management decisions.

Uncertainty should not be confused with variability. Uncertainty is a lack of confidence in a result or estimate stemming from limited data, or missing information. Variability describes differences in parameter values such as metal concentrations at different locations in the Study Area, differences in body weight or food intake rates for individual animals (*i.e.*, population heterogeneity). In other words, variability is defined by the range or “spread” of values in a given population, and is influenced by sample size, repeated measures and area of coverage.

Gaining and maintaining an open acknowledgement and characterization of uncertainty and variability in an assessment is crucial to the success of the decision-making process (Moore and Bartell, 2000). The method used to assess the uncertainty surrounding the exposure estimates depends on the complexity of the model, the information available, and sources of uncertainty.

In the evaluation of uncertainty and variability, what is ultimately most important is that one has reasonably high certainty that the ERA does not under-predict exposures and risks, and that the models used will rarely predict the absence of risk when there is indeed a risk (*i.e.*, avoid or minimize the occurrence of false negatives or Type II errors).

Therefore, the objective for the analysis of variability and uncertainty in any ERA is to demonstrate the following:

- Model input variables reflect the natural variability in the environment; and,
- Model input variables are assigned conservative values in the face of uncertainty.

A key question when characterizing uncertainty and variability in relation to a particular model input parameter is: "Will the collection of more information dramatically improve the understanding of the variability, and/or reduce uncertainty?"At some point, the collection of additional data will reach the point of diminishing returns, when the effort and resources that are expended to further understand variability and reduce uncertainty are no longer producing meaningful improvements. For example, if additional soil chemistry data collection were to occur, and the new data yielded concentrations that fell well within the range of existing data, with no substantial changes to values that measure the "spread" of the data (such as variance, standard error, standard deviation, coefficient of variation etc.), then the need for still further data collection would be considered unnecessary and impractical, particularly if data collection efforts are time and resource (or cost) intensive.

Where variability and uncertainty are known to exist, it is standard risk assessment practice to make assumptions and select data that overestimate, rather than underestimate potential exposure and risk. Given the tendency for the numerous conservative assumptions used in the ERA to overestimate potential exposure and hazards for the COPCs, it is considered extremely likely that the ERA has overestimated potential COPC exposures and risks in the receptors evaluated.

The inherent tendency of ERAs to overestimate exposures and risks to ecological receptors favours Type I errors (false positives), and reduce the probability of Type II errors (false negatives). For example, in the COPC identification approach used in the Phase II ERA, both simple comparisons of maximum Study Area soil concentrations to soil guidelines and/or reference concentration statistics, and statistical comparison tests are prone to a high Type I error rate (Myers and Thorbjornsen, 2004; Leadon et al., 2007; CalEPA, 1997; U.S. EPA, 2001; 2002). Some reasons why these approaches tend to have a high rate of false positives is that trace element distributions in soil tend to have very large ranges (two or three orders of magnitude are not uncommon), and are highly right-skewed, often having, or resembling lognormal distributions. The accurate characterization of the upper tails of such skewed distributions requires a large number of background samples, which are often not available. The probability of false positives increases if the site dataset is larger than the background dataset (which is common, and was the case for all media and biota samples in the three phases of the overall ERA Study). In addition, statistical comparison tests treat each analyte as an independently behaving entity, and do not consider the geochemical, ecological or biological contexts in which each element occurs (Myers and Thorbjornsen, 2004). The U.S. EPA (2001) notes that a Type I error is less serious than a Type II error (false negative) when selecting COPCs, and the use of approaches that favour Type I errors are inherently more protective of environmental health.

Q-2.0 LIMITATIONS, UNCERTAINTIES AND CONSERVATIVE ASSUMPTIONS SPECIFIC TO THE ERA

The major limitations, uncertainties and conservative assumptions applicable to the ERA of the Brunswick Smelter Study boundary are as follows.

- Treatment of data for the ERA was conducted in a manner that is intentionally conservative. This approach was taken to ensure that exposures and risks associated with the COPCs would not be underestimated. For example, concentrations of COPCs in any media evaluated that were below the laboratory RDL were assumed to be present at the RDL, and the higher of field duplicate or original samples were selected for evaluation. This approach is likely to overestimate exposures and risks.

- All A layer (0-5 cm) soil data for the COPCs were used in the ERA, regardless of whether or not the areas where the samples were collected contained suitable habitat for the ecological receptors that were assessed. It was assumed that receptors could potentially come into contact with all measured soil concentrations of COPCs.
- The ERA was not able to explicitly incorporate habitat quality or suitability information (such as habitat suitability index) into exposure and risk estimates. While there are spatially explicit or habitat-based ERA methods that exist (e.g., Freshman and Menzie, 1996; Hope, 2000), the data requirements for these approaches are large. Furthermore, successful use of these approaches requires detailed habitat characterization information. In general, such information needs to exist prior to the ERA as it is can be extremely costly and time-intensive to gather such data in a *de novo* manner. In many regions of Canada (including northern New Brunswick, where the current ERA Study Area is located), pre-existing detailed habitat information for species that are candidate receptors in an ERA does not exist in a form or level of detail that is insufficient for use or application in an ERA.

  However, the inability to use spatially explicit or habitat-based ERA approaches is not considered a major limitation. Such approaches are inherently less conservative as they restrict or refine exposure potential to only those areas where there is considered to be sufficient habitat for a given receptor. If areas of poor habitat are the most contaminated (which is a common occurrence and is the case for the current Study Area), then exposures and risks to a given receptor will be lower than if the receptors were assumed to have an equal likelihood of occurrence in all locations within a Study Area. There can often be high uncertainty in these approaches as well, if the habitat within the Study Area is not adequately characterized for the receptors under investigation. The current ERA exposure model is based on the assumption that the entire Study Area is suitable habitat for each receptor (which is unlikely). This is a more conservative approach than spatially explicit or habitat-based ERA approaches as it does not restrict exposure to any particular areas, but rather, assumes that receptors could be incurring exposures in areas with the highest COPC media concentrations, even if those areas are not their preferred habitat type.

- The ERA does not address the variability or changes in exposures that could occur over time (*i.e*., in the future). COPC concentrations in biota (*e.g*., plants, insects and small mammals) that are consumed by wildlife may fluctuate over time based on seasonal and annual differences in environmental conditions that impact organism physiology and growth, and exposure levels. Complex ecological and physiological factors and variations in exposure, organism growth, accumulation and depuration determine the metal concentrations in biota within years and over extended periods of time.

- Predicted concentrations of COPCs in biota (woody browse, non-woody browse and soil invertebrates) were estimated using trophic transfer models (BCFs, regression models) and measured soil concentrations. Prey concentrations of COPCs were estimated using regression models and uptake factors from Sample *et al*. (1998) and the (US EPA, 2005). While there is some uncertainty associated with the use of these uptake factors and regression equations, as they are not specific to the Study Area, the underlying models are considered robust, reasonably accurate, conservative, and are commonly used in ERAs where site-specific data on prey concentrations are not available. Measured concentrations of COPCs in small mammals and soil invertebrates were collected as part of the assessment, but sample numbers were low, which limits the robustness of the data. A comparison of measured versus predicted concentrations is provided in Attachment Q-1 of this appendix. Results of these comparisons for small mammals show that antimony was not detected in any Study boundary sample and was predicted to be present at very small concentrations. Predicted arsenic and thallium tissue concentrations were lower than measured concentrations. The predicted UCLM cadmium tissue concentration fell within the range of measured values while predicted lead and zinc were greater than measured values. For soil invertebrates, the measured concentrations were highly variable. Given this in addition to the small number of samples collected (N=3 at 0 to 1 km and N=3 at 1 to 2 km), and since soil invertebrates were not depurated (i.e., the measured values include soil that could be contained within the invertebrates gut, or adhered to the surface), the soil invertebrate results do not support or refute the modeling. Collection of additional soil invertebrate data would aid in reducing uncertainities in the existing dataset.

- All uptake models or factors used in the ERA do not account for extreme situations of excessively high or very low COPC uptake (i.e., hyper- or hypoaccumulation), but rather, reflect reasonable upper bounds or upper estimates of central tendency. Such extreme uptake conditions are difficult to account for in any generic or study area-specific uptake models or factors used in ERAs, as these conditions are usually specific to certain species and do not reflect assemblages or communities as a whole.

- Toxicity data directly related to the receptors being evaluated are often unavailable or limited in nature. Therefore, many of the TRVs used in an ERA are derived from similar or related species exposed to the COPCs under controlled laboratory conditions that are designed to maximize the potential for measurable adverse effects. Extrapolation of laboratory toxicity data to other species typically involves the use of uncertainty factors. The TRVs used in the wildlife risk modeling were selected from the toxicology literature to be as appropriate as possible to the receptors of interest, while trying to ensure that potential risks would not be underestimated. Initial risks were derived using No-adverse-effect-level (NOAEL)-based TRVs, which provide a high degree of conservatism. Receptors that had exposure rations greater than the critical value of 1.0 were re-evaluated using an effects-based TRV (*e.g.*, a LOAEL (lowest-observable adverse effects level) TRV or an EC20 (the concentration affecting 20% of the test population). An uncertainty factor was generally applied to mammalian LOAEL-based TRVs if species were not that closely related. LOAEL-based TRVs were selected to provide a conservative estimate of potential risks (*e.g.*, selecting a lowest LOAEL, a geometric mean of available LOAELs with an uncertainty factor, or an EC20).

- Receptor body weights were obtained from reliable literature sources (*e.g.*, U.S. EPA, 1993). There is some uncertainty associated with these values though, as the body weights are not Study Area-specific. Thus, where possible, preference was given to lower reported body weights in the literature to ensure that a conservative assessment was conducted.

- Data on food intake rates (FIR) are only available for a few species, primarily due to the difficulties in measuring intakes for free-ranging wildlife. Allometric equations developed from measurements of FMR (free metabolic rate) in free-ranging animals were used to estimate food intake rate for each representative wildlife species evaluated in the ERA. Similarly, water intake rates were estimated using standard allometric equations.

- Based on the available literature on dietary items for each receptor of interest, representative diets with fixed proportions of dietary items were selected for all of the receptors evaluated in the ERA. However, there is uncertainty associated with the proportion of dietary items assumed for each receptor as diets will vary between locations, between individuals, and across seasons, and only limited dietary data are available for some species. To be conservative, diets were selected such that dietary items for each surrogate receptor represented a maximal exposure to that dietary item, where possible. For example, the shrew was assumed to eat 100% invertebrates and the snowshoe hare was assumed to eat 100% vegetation. The shrew and other small mammals may eat less than 100% invertebrates, but by selecting 100% invertebrates all receptors that eat invertebrates are assessed to the maximum exposure extent. Similarly, by assessing the hare at 100% vegetation, receptors ingesting less of these dietary items are accounted for.

- Bioavailability of the COPCs in food items and soil was conservatively assumed to be 100%. This assumption likely substantially overestimates COPC exposure as the gastrointestinal absorption of metals from complex matrices such as foods and soil are rarely 100%, depending on such factors as metal speciation, and the physical and chemical properties of the food items and soil.

- Soil ingestion for mammalian and avian receptors was assumed to represent a certain percentage of the receptor's overall diet (as direct soil ingestion rates are largely unavailable for ecological receptors). The most closely related receptor was used where possible.

- COPC exposures for terrestrial vegetation and soil invertebrates were assumed to equal measured soil concentrations. This is considered to be a conservative assumption as there are limits to the amount of metals that can be taken up from soil by plants and soil invertebrates that are a function of the solubility or extractability of the metals from the soil matrix. These assumed exposures were then compared to generic soil quality guidelines derived to be protective of vegetation and soil invertebrates. There is uncertainty in the use of such generic soil quality guideline to determine potential risks to vegetation and soil invertebrates. First, the generic guideline values tend to be based on laboratory studies with sensitive species that may not be representative of the vegetation or soil invertebrate community within a particular study area. They are also highly conservative values for which exceedance does not imply a potential for risk, but rather, indicates that further evaluation is warranted. In addition, terrestrial plants and invertebrates have evolved mechanisms to regulate the uptake, metabolism and elimination of both essential and non-essential metals. Thus, adaptation and/or acclimation may occur within populations or individuals at a metals contaminated site (U.S. EPA, 2007), particularly if the contamination has been present for multiple generations of plants and invertebrates. Since the smelter has been in operation for many years, many plant and invertebrate generations would have occurred, suggesting the possibility that these receptor groups may have adapted or acclimated to soil metals concentrations over this time period. The natural geology of the Study boundary and surrounding areas also show enrichment of many metals, further suggesting that native plants and invertebrates could be acclimated or adapted to elevated soil metals concentrations. Furthermore, soil conditions (other than concentrations of the COPCs of interest) such as mineralogy, pH, Eh, organic carbon content, grain size *etc*., can strongly influence bioavailability and the potential for toxicity.

  As such, the soil concentration of a COPC may have the potential to adversely affect plants or soil invertebrates in one area, but the same or higher concentration in another area may have limited potential to cause toxicity.

- The assumption that COPC exposures for terrestrial vegetation, soil invertebrates and freshwater aquatic life equal the measured concentrations in soil, water and sediments overestimates the actual exposure potential, as it ignores organisms' natural barriers to chemical uptake (*i.e.* bioavailability considerations), and biochemical transformation processes that may occur within cells, tissues and organs, which may reduce the actual dose that reaches a target site within the organism.

- For some metals, there is a lack of regulatory water (total or dissolved) or sediment quality guidelines for which measured media concentrations can be compared against. However, the use of reference area data and comparisons to aquatic toxicity data overcomes this limitation for the most part.

- There are limited data on the presence and status of amphibians within the Study boundary, and extremely limited data related to toxicity for amphibians from soil and sediment exposures. Therefore, only a qualitative assessment was conducted for amphibians based on surface water concentrations.

- The ERA only assesses chemical stressors and does not account for other stressors such as predation, disease, habitat loss, competition, *etc*. In any natural system, non-chemical stressors may interact with chemical stressors in complex ways, and can often be of greater biological or ecological significance than the presence of chemical contaminants.

Q-3.0 REFERENCES

CalEPA. 1997. Selecting Inorganic Constituents of Chemicals of Potential Concern at Risk Assessments at Hazardous Waste Sites and Permitted Facilities. Final Policy. Prepared by: Human and Ecological Risk Division, Department of Toxic Substances Control, California Environmental Protection Agency. February, 1997.

Freshman J.S. and Menzie C.A. 1996. Two wildlife exposure models to assess impacts at the individual and population levels and the efficacy of remedial actions. HERA: Vol. 2, No. 3, pp. 481-498.

Hope, B.K. 2000. Generating probabilistic spatially-explicit individual and population exposure estimates for ecological risk assessments. Risk Analysis. Vol. 20, No. 5, pp573-589.

Leadon, C.J., McDonnell, T.R., Laer, J., and Barclift, D. 2007. Calculating Background Levels for Ecological Risk Parameters in Toxic Harbour Sediment. Soil and Sediment Contamination 16:433-350.

Moore, D.R.J. and S.M. Bartell. 2000. Estimating ecological risks of multiple stressors: Advanced methods and difficult issues. In Multiple Stressors in Ecological Risk and Impact Assessment: Approaches to Risk Estimation, J. Foran and S. Ferenc (eds.). SETAC Press, Pensacola, FL. pp. 117-168.

Myers, J., and Thorbjornsen, K. 2004. Identifying Metals Contamination in Soil: A Geochemical Approach. Soil and Sediment Contamination 13:1-16.

Sample B.E., J.J. Beauchamp, R.A. Efroymson, and G.W. Suter. 1998. Development and Validation of Bioaccumulation Models for Small Mammals. Prepared for The U.S. Department of Energy. By Lockheed Martin Energy Systems Inc. (LMES). February, 1998.

Suter, G.W., Efroymson, R.A., Sample, B.E., and Jones, D.S. 2000. Ecological Risk Assessment for Contaminated Sites. Lewis Publishers, Boca Raton.

U.S. EPA (Environmental Protection Agency). 2007. Framework for Metals Risk Assessment. Office of the Science Advisor, Risk Assessment Forum, U.S. Environmental Protection Agency. Washington, DC. EPA 120/R-07/001. March, 2007.

U.S. EPA. 2002. Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites. United States Environmental Protection Agency, Office of Emergency and Remedial Response. EPA 540-R-01-003. OSWER 9285.7-41. September, 2002.

U.S. EPA. 2001. Guidance for Characterizing Background Chemicals in Soil at Superfund Sites. External Review Draft. United States Environmental Protection Agency, Office of Emergency and Remedial Response. EPA 540-R-01-003. OSWER 9285.7-41. June, 2001.

U.S. EPA. 1993. Wildlife Exposure Factors Handbook. Volumes I and II. Office of Research and Development. ORD. EPA-600-R-93-187. December 1993.

ATTACHMENT Q-1

COMPARISON OF MEASURED VERSUS PREDICTED INVERTEBRATE AND SMALL MAMMAL TISSUE CONCENTRATIONS TO MEASURED CONCENTRATIONS

ATTACHMENT Q-1: OF MEASURED VERSUS PREDICTED INVERTEBRATE AND SMALL MAMMAL TISSUE CONCENTRATIONS TO MEASURED CONCENTRATIONS

Q-1-1.0 SOIL INVERTEBRATES

Soil invertebrate tissue concentrations were estimated using soil concentrations and uptake models (for more information, refer to Appendix J). Soil invertebrate tissue samples were also collected at 0 to 1 km (N=3) and 1 to 2 km (N=3) from the facility and in reference areas, albeit sample numbers were small (due to the low sample weights, samples from the different sampling stations needed to be combined, resulting in 3 composite samples from 0 to 1 km and 3 composite samples from 1 to 2 km). These measured metal tissue residue data from these invertebrates are presented in Appendix D.

The measured concentrations in the soil invertebrates were highly variable, and since soil invertebrates were not depurated, the measured values include soil that could be contained within the invertebrates gut, or adhered to the surface. The means of the measured COPC soil invertebrate tissue concentrations were compared to the mean modelled values (See Table Q-1). Results of the comparison of measured to modelled data are variable. In some cases mean measured tissue concentrations are less than or similar to the modelled tissue concentration while in other cases they are higher.

Table Q-1 Comparison of Mean Measured to Predicted Soil Invertebrate Concentrations (mg/kg dry weight)

Chemical	0 to 1 km		1 to 2 km	
	Mean Measured [1]	Predicted (Mean)[3]	Mean Measured [2]	Predicted (Mean) [3]
Antimony	0.89	4.6	0.85	3.9
Arsenic	16	2.3	8.0	2.2
Cadmium	29.9	38	30.2	17.2
Lead	217	128	46	64
Thallium	1.69	0.55	0.509	0.14
Zinc	756	507	482	572

Notes:
UCLM95 = 95% upper confidence level on the mean.
Soil invertebrates collected by LGL and analyzed by Maxxam.
1 N=3
2 N=3
3 Soil invertebrate tissue concentrations were estimated using site soil data and uptake models (See Appendix J for more details).

Q-1-2.0 SMALL MAMMALS

Predicted small mammal tissue concentrations were estimated using measured soil concentrations and trophic transfer models (Sample *et al.*, 1998) or BCFs (US EPA, 2005). Prey concentrations were estimated to assess the exposure to species that eat prey such as small mammals (*i.e.*, short-tailed weasel and saw whet owl). Small mammals were collected as part of the small mammal survey and some of these samples were submitted for whole body metals analysis (LGL, 2012; See Appendix M).

A comparison of the measured to predicted small mammal chemistry data (based on UCLM 95 soil concentrations within 1 to 3 km of the smelter) was conducted for the COPCs for the Belledune ERA and is presented in Table Q-2. Raw small mammal analytical data are presented in Appendix D.

Antimony was not detected in any Study boundary sample and was predicted to be present at very small concentrations. Predicted arsenic and thallium tissue concentrations were lower than measured concentrations. The predicted UCLM cadmium tissue concentration fell within the range of measured values while predicted lead and zinc were greater than measured values.

Table Q-2 Comparison of Measured Metal Concentrations in Small Mammal Whole Body Collected from Study Boundary in 2011 to Predicted Tissue Concentrations

Metals	Predicted Whole Body (UCLM 95; mg/kg ww) [1]	Whole Body Study Boundary (mg/kg ww)			
		F-SOCI-Bodies	F-BLBR-Bodies	A-SOCI-Bodies	D-SOCI-Bodies
Antimony (Sb)	0.05	<0.5	<0.5	<0.5	<0.5
Arsenic (As)	0.04	0.91	2.81	1.08	1.06
Cadmium (Cd)	1.5	2.89	0.885	2.65	2.41
Lead (Pb)	45	27.3	18.5	30.8	23.9
Thallium (Tl)	0.16	1.56	1.40	4.11	1.24
Zinc (Zn)	44	36.7	35.2	31.3	32.5

Notes:
BLBR = northern short tailed shrew
SOCI = common shrew
ww = wet weight
1 Modelled tissue concentrations converted from dry weight to wet weight using the following equation: Tissue concentration dw * (1-% moisture) = wet weight. Percent moisture content was assumed to be 68% in liver and kidney based on a prey water content of 68% reported by Suter et al. (2000).

Q-1-3.0 REFERENCES

Sample, B.E., Beauchamp, J. J., Efroymson, R.A., Suter II, G.W., and Ashwood, T.L. 1998. Development and Validation of Bioaccumulation Models for Earthworms. ES/ER/TM-220. February, 1998. Prepared for the U.S. Department of Energy, Office of Environmental Management.

Suter, GW, RA Efroymson, BE Sample and DS Jones. 2000. Ecological Risk Assessment for Contaminated Sites. Lewis Publishers, CRC Press LLC.

U.S. EPA. 2005. Guidance for Developing Ecological Soil Screening Levels. OSWER Directive 9285.7-55. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. Revised February, 2005.