APPENDIX A

PROBLEM FORMULATION

SCIENCE INTEGRITY KNOWLEDGE

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MARINE ECOLOGICAL RISK ASSESSMENT (ERA) OF THE GLENCORE BRUNSWICK SMELTER – PROBLEM FORMULATION AND ERA STRATEGY

FINAL REPORT
March 13, 2015

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MARINE ECOLOGICAL RISK ASSESSMENT (ERA) OF THE GLENCORE BRUNSWICK SMELTER – PROBLEM FORMULATION AND ERA STRATEGY

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SUMMARY

This document outlines the problem formulation and a proposed study design for a marine ecological risk assessment associated with the Brunswick Smelter, located in Belledune, NB. It presents historical context and data related to the operations of the facility, and environmental monitoring data which has been collected in recent years, as well as identified potential exposure pathways, receptors, and assessment and measurement endpoints for assessing ecological risks to the various components of the environment. Based on identified data gaps, a study design is presented to gather additional data, which will feed into the ecological risk assessment following standard risk assessment guidance. This report was originally prepared in July of 2014. It was subsequently updated in March 2015 to reflect the field program that was undertaken.

MARINE ECOLOGICAL RISK ASSESSMENT (ERA) OF THE GLENCORE BRUNSWICK SMELTER – PROBLEM FORMULATION AND ERA STRATEGY

1.0 INTRODUCTION

Glencore Canada (Glencore) has been operating the Brunswick Smelter in Belledune, New Brunswick, since the mid-1960s. Several detailed risk assessment studies have been 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), as well as potential ecological risks in the terrestrial and freshwater environments (Intrinsik Environmental Sciences Inc, 2013). Glencore is now interested in examining the potential for ecological risks in the marine 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 the marine areas, and species foraging in those areas, near the smelter. Intrinsik is conducting this study with Minnow Environmental Inc., who specialize in aquatic surveys, and have conducted monitoring associated with the facility for many years.

There have been decades of environmental monitoring in the marine area near the facility [as part of Glencore Canada's Environmental Effects Monitoring Program (or EEM)], as well as several specialty studies conducted on key issues over the years. The purpose of this document is to present the relevant data and background material from these monitoring studies which can be used in the ERA; identify data gaps and lay out the approach to address these data gaps and conduct the ERA.

This document provides the Problem Formulation of the ERA, as well as the ERA strategy. Within the ERA strategy the Study Design for all supplementary sampling to be undertaken in 2014 to fill data gaps to conduct the ERA is presented. Other steps of the ERA (i.e., Exposure Assessment, Hazard Assessment and Risk Characterization) will be conducted once the ERA strategy is reviewed by relevant stakeholders and required data have been collected.

The approach being taken to conduct the ERA is based on widely accepted ecological risk assessment frameworks, methodologies and guidance published and endorsed by Environment Canada (e.g., FCSAP, 2013a; 2012a, b; 2010 a,b) and the U.S. EPA (i.e., 2007a) and the International Council on Mining and Metals (ICMM, 2007). The methods used to conduct the Problem Formulation are provided in Section 2.0, while outcomes of the Problem Formulation are provided in Section 3.0 with the subsequent Study Design particulars in Section 4.0.

2.0 ERA METHODOLOGY

The basic steps of an ERA are illustrated in Figure 2-1 and include the Problem Formulation, Exposure Assessment, Effects Assessment and Risk Characterization. The ERA Strategy provides the overall plan for how all phases the risk assessment are going to be conducted and is established either within the Problem Formulation stage or after it. The ERA is conducted using an iterative approach with continual feedback between the steps.

A brief outline of each step of the ERA is provided in the following sections. The methodology outlined in this section provides a framework for the assessment, and the specific approaches to be implemented will be further developed in the fall of 2014.

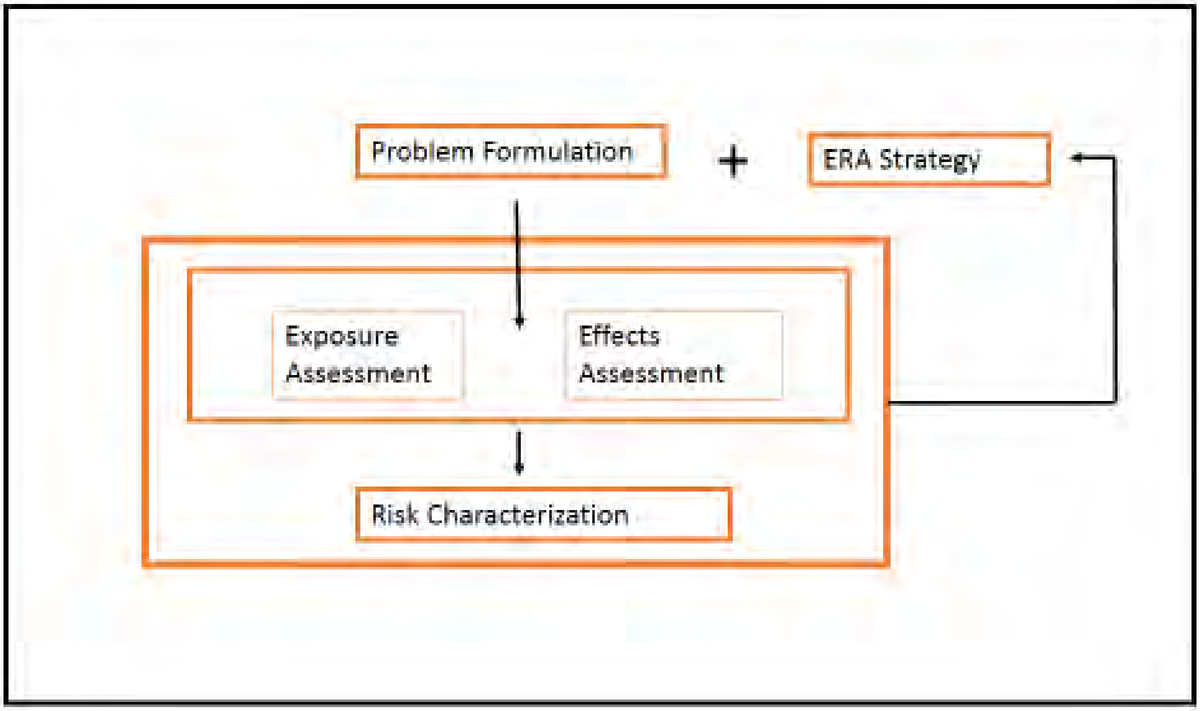

Figure 2-1 Steps of an Ecological Risk Assessment (taken from FCSAP, 2013b)

2.1 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 site management goals (*i.e.*, the central questions to be answered by the ERA);

- Providing regulatory context (*i.e.*, acts and policies that apply to site; land use for which the ERA is being conducted);
- Review existing site information and identify gaps;
- Select contaminants of concern (COC) from greater list of on-site chemicals of potential concern (COPC);
- Select receptors of concern (ROC);
- Identify relevant exposure pathways;
- Develop a conceptual site model;
- Clarify protection goals (*i.e.*, statements describing the level to which ROC should be protected) and acceptable effect levels (AELs; which operationalizes the protection goal);
- Identify assessment endpoints (*i.e.,* what is to be protected) and measurement endpoints (*i.e.,* methods used to describe a change in the assessment endpoint);
- Develop Lines of Evidence (LOE) for each assessment endpoint (i.e., one or more LOE is selected for each assessment endpoint and combines information on exposure and effects); and
- Develop the general ERA strategy.

The outcomes of the Problem Formulation stage form the basis of the approach to be taken in the ERA. Details of the Problem Formulation are provided in Section 3.0.

2.2 Exposure Assessment

In the Exposure Assessment, the mechanisms by which the ROC are exposed to COC are characterized and the magnitude of these exposures are quantified or categorized. The types of exposure data needed for each line of evidence can include the following:

- External exposure media (*e.g.*, contaminant concentration in various site media);
- Internal exposure media (*e.g.*, contaminant concentration in receptor tissue);
- Estimation of total doses (*e.g.*, total contaminant intake from all exposure pathways); and
- Categorical measure of exposure (*e.g.*, on-site versus reference; site versus lab; spatial gradient categories such as near-field; far-field).

Details of the Exposure Assessment will be undertaken following implementation of the sampling program in 2014, and will be presented in a separate report.

2.3 Effects Assessment

In the Effects Assessment, the type / nature of effect caused by each COC under specific exposure conditions is characterized. Effects information is required along with exposure information for each line of evidence. There are four main types of effects assessment methods, which include:

- Site-specific toxicity studies;
- Indirect toxicity studies;
- Site-specific biology studies; and
- Indirect biology studies.

Details of the Effects Assessment will be undertaken following sampling in 2014, and will be provided in a separate report.

2.4 Risk Characterization

Risk Characterization is comprised of several steps including:

- Relevance checks;
- Interpretation and evaluation of each line of evidence;
- Preparation of a compiled data summary;
- Application of weight of evidence procedure;
- Evaluation of uncertainties in ERA;
- Consideration of extrapolation / interpolation (how representative the ERA is in terms of the site management goal);
- Development of site-specific remediation objectives (if necessary);
- Summarization of risk conclusions; and
- Recommendations for follow-up actions (if necessary).

The Risk Characterization integrates the results of the exposure and effects assessments. In the risk characterization, a Weight of Evidence (WOE) approach is used that considers the results of each LOE evaluation to provide an overall conclusion. Figure 2-2 illustrates conceptually how the LOE can be used an overall WOE evaluation.

Details of the Risk Characterization will be undertaken following the sampling program in 2014, and will be provided in a separate report.

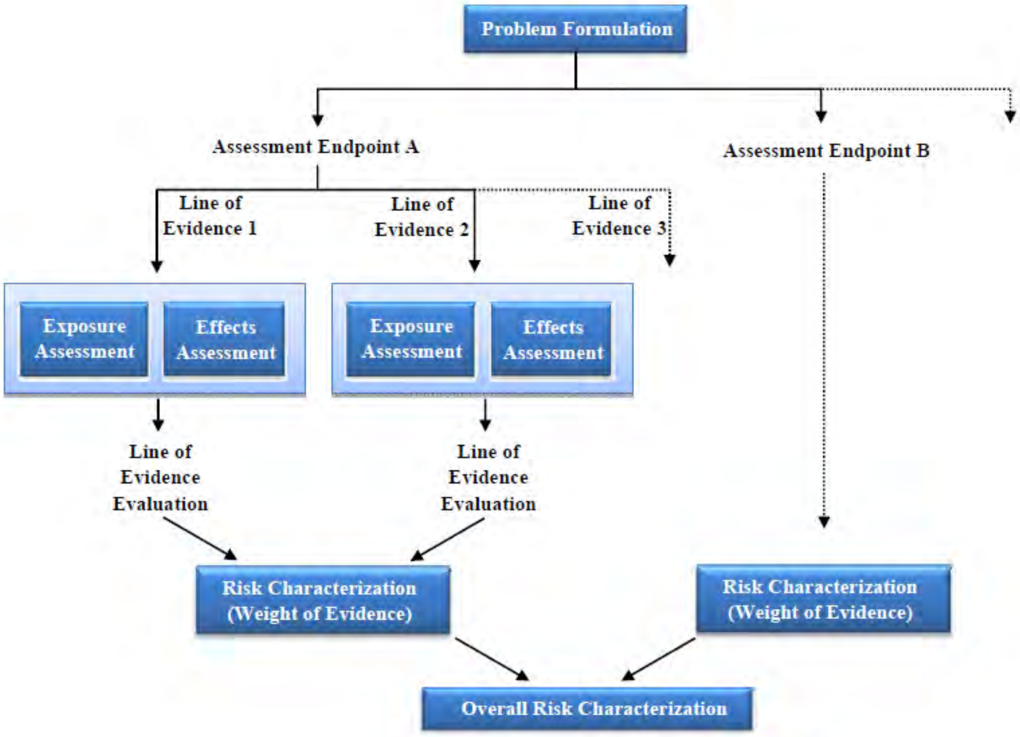

Figure 2-2 Conceptual Weight of Evidence Approach to ERA (taken from FCSAP, 2012a)

2.5 ERA Strategy

The ERA Strategy provides details on how one plans to conduct an ERA. The ERA strategy for this site, in addition to details of the Study Design for all supplementary sampling to be undertaken in 2014 to fill data gaps to conduct the ERA, are presented in Section 4.0.

3.0 PROBLEM FORMULATION

3.1 Site Management Goal and Regulatory Context

The site management goal of the ERA from the Brunswick Smelting operations is to determine whether COCs present in the marine environment related to past or current operations have the potential to adversely affect ecological receptors inhabiting, or foraging in the area. Glencore is not required to conduct this study, but rather, has elected to undertake it in preparation for either retrofitting of the facility, or closure.

3.2 Existing Site Information Based on Past Investigations and Data Gaps

3.2.1 Facility Overview and Historical Studies

The Brunswick 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 1966, and is currently a lead smelter, but formerly included a zinc smelter and fertilizing plant (which closed in 1995). The fertilizer plant produced a di-ammonium phosphate product, using by-products from the smelting process. Adjacent to the site is the NB Power Belledune Thermal Generating Station, which burns coal, and opened in 1993. 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 primary releases to the environment from the Brunswick smelting facility include atmospheric stack emissions and fugitive dusts, as well as direct effluent discharge, and storm water drainage/runoff. Predominant metals in the atmospheric or effluent emissions profile include lead (Pb), zinc (Zn), cadmium (Cd), arsenic (As) and thallium (Tl), as well as sulphur dioxide (SO_2) and nitrogen oxides (NO_2)(the latter two being restricted to stack emissions). Predominant wind directions in the area are largely to the east, with the next most significant directions being to the south east, with some seasonally winds also in a westerly direction. With this in mind, atmospheric deposition (of both stack and fugitive emissions) over Chaleur Bay would be a direct contribution to the marine environment. Effluent release from the historic fertilizer plant, as well as the smelter processing facility, are also prime sources of contaminants. The fertilizer plant, when it was operating, produced a gypsum-based (calcium sulphate) slurry which was released into Chaleur Bay through a conveyer belt (see Figure 3-1). Due to limited dispersion at this location, gypsum accumulated at this location, creating a hard-pack which affected sediment habitat in the immediate area.

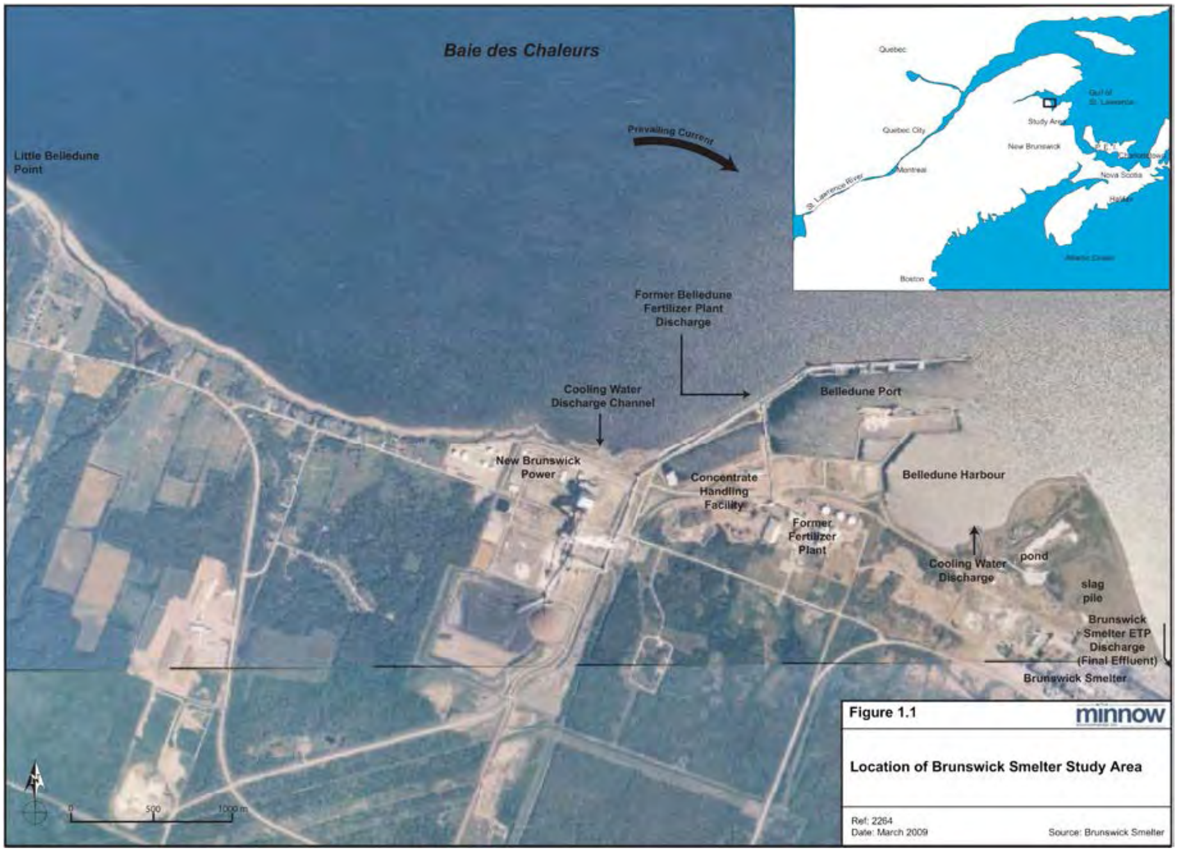

Figure 3-1 Location of Brunswick Smelter and Various Aspects of the Facility and Harbour (Minnow Environmental, 2009)

Between 1966 and 1980, waste products from the smelting facility were discharged directly into a slag disposal lagoon that drained into Belledune Harbour. A leak of processing water discovered in the late 1970s, resulted in significant metal contamination of sediments (especially Cd, Pb and Zn), particularly in Belledune Harbour. This subsequently affected lobster, and the lobster fishery in Belledune Harbour was closed in 1980 due to human health concerns related to Cd concentrations in lobster tissue. A controlled fishery was then established in the outer harbour area. Glencore (then known as Noranda), identified the source of leak and with modified treatment of the effluent, Cd levels decreased by 97% by the mid-1980's, and the lobster fishery in the outer harbour area was re-opened in 1985.

There have been a considerable number of studies related to impacts to the marine environment associated with historical operations, particularly in response to the Cd leak and lobster contamination issue. These studies are not summarized herein, for brevities sake. Rather, the reader is referred to a detailed study of metals transport throughout the Baie des Chaleurs, conducted by Parsons and Cranston (2005), which provides historical context and information related to the large number of sources of metals throughout the entire Chaleur Bay.

Parsons and Cranston (2005) provide a comprehensive assessment of the entire Chaleur Bay, and the various metals-related sources influencing sediment chemistry within the bay. Predominant sources were identified as the Brunswick Smelter, the NB Power facilities in both Belledune and Dalhousie, the former Dalhousie concentrate handling facility (also owned by Noranda/Glencore), a former chlor-alkali facility (in Dalhousie), a former ocean dumping site, sewage from various communities, combustion of leaded gasoline, and the large number of natural metals deposits in the region, which make northern New Brunswick a premiere mining area. The purpose of the Parsons and Cranston (2005) study was to assess dispersal patterns of metals within the Bay, to evaluate historical sediment chemistry data and to characterize chemical and physical processes that transport metals throughout the bay. A sediment sampling campaign was conducted in 1998 and 1999, wherein a total of 76 cores and 48 surface-sediment samples were collected up to 100 km away from the smelter. Surficial and cored profiles of the sediments underwent analysis for a variety of parameters, including organic carbon, Cd, Cu (copper), Fe (iron), Mn (manganese), Ni, Pb, Zn, As, Hg (mercury). Pore water analyses was also conducted and were field analyzed for ammonium, sulphate and salinity. Lead isotope analysis was also undertaken on a subset of samples. The authors concluded the following with respect to investigations near the smelter:

Concentration profiles with sediment depth: In areas close to the smelter (within 2-3 kilometers), metals concentrations in most cores were noticeably elevated at 15 – 30 cm below the surface of the core, and reached peak values at 5 – 10 cm below the surface, and then decreased substantially. The measured concentrations of Zn, Pb, and Cd were above the Probable Effects Levels (PEL) sediment quality guidelines in the upper 20 cm of the cores in this area, whereas Cu and Hg exceeded only the Interim Sediment Quality Guidelines (ISQG). Exceedance of these guideline levels (ISQG or PEL) is not necessarily indicative of the presence of adverse effects, as these guidelines do not account for site specific bioavailability or other modifying factors, but it does suggest a high potential for effects in areas where PEL levels are exceeded. The authors suggest that the reduced concentrations in the top 5 cm are likely a result of significant smelter emissions reductions since the 1980s. With respect to Hg, smelter emissions were considered a predominant factor in detected concentrations in early years, but Hg present in the top 1-2 cm is likely also related to releases from the Belledune coal-fired power facility.

Sediment Accumulation Rates: Accumulation rates vary across Chaleur Bay, ranging from < 10 to 600 cm/ka (centimeters/kiloannum). Rates in the Belledune Harbour area are greater than 100 cm/ka.

Regional Distribution of Metals in Sediments: Some of the highest concentrations of metals in the Belledune area surface sediments were within 1 – 2 km of the facility. The authors defined background levels of As, Cd, Hg, and Pb in marine sediments as 19, 0.26, 0.04 and 7.3 mg/kg (respectively), based on the 95th- percentile of each element within the pre-industrial sediment core bottoms. Background As levels in marine sediments are notably elevated within Chaleur Bay as they are above the generic ISQG of 7.2 mg/kg (CCME, 2009).

Spatial Extent of Contaminated Surface Sediments: Nickel in sediments in the Belledune area is not considered to be elevated, and the relative contamination distances for other metals of interest vary. Copper contaminated sediments near the smelter are restricted to within 1 – 2 km (relative to background), and Cd levels near the smelter decrease rapidly outside of Belledune Harbour. During the early 1980s, when a significant release of Cd occurred, levels of Cd dropped off to background levels within 2 – 3 km of the harbour. Pb, Hg, and Zn appear to affect a wider area, based on the analysis conducted. Zinc and Pb appear to influence sediments as much as 20 km away from the smelter, relative to background levels. Hg levels are complicated by the multiple sources, and the difficulty in determining source contributions (since both a coal-fired power plant and smelter are located in Belledune, and other sources are present in the bay area).

Source Apportionment Lead Isotope Analysis: This analysis found that it was difficult to identify dominant sources of Pb in surface sediments throughout Chaleur Bay. Pb levels in surface sediments were summarized as most likely being related to historical combustion of fuels and smelter emissions (particularly in downwind areas), but it was not possible to determine the relative importance of these sources (Parsons and Cranston, 2005).

3.2.2 Environmental Effects Monitoring Program – Marine Environment

Under the Certificate of Approval (C of A) for the facility, Glencore undertakes numerous types of monitoring programs in the marine environment which have been conducted since the early years of operations. This monitoring includes the following:

- Effluent sampling
- Salt water outlet sampling
- Outfall sampling at the East and West Diversion Ditch outlets
- Native Mussel sampling
- Beach sand sampling
- Native Mussel Culture sampling
- Lobster sampling
- Benthic community and sediment sampling

Recent data (2008 – 2012) from each of these monitoring programs is presented in the sections which follow, to give an overview of measured concentrations in site media in recent years.

Effluent, Salt Water, and Diversion Ditch Sampling

Weekly and bi-weekly water sampling is conducted at several locations around the facility including the final effluent discharge location, the salt water outlet discharge point, the east and west diversion ditches, and the slag disposal area (Glencore EEM, 2013). Yearly average data for each of these locations in presented in Table 3-1, with the exception of the slag disposal area data, which does not directly discharge to the marine environment, and therefore is not presented (Glencore EEM, 2013). Average concentrations of As, Cd, Cu, Fe, Pb, and Zn are less than 1 mg/L at all four discharge points, and meet C of A discharge limits.

Table 3-1 Yearly Average Trace Metal Concentrations (mg/L) from 2008 to 2012 of Various Effluent Locations Near the Brunswick Smelter

Location	2008	2009	2010	2011	2012
Final Effluent					
Lead	0.032	0.042	0.020	0.016	0.026
Zinc	0.345	0.237	0.156	0.210	0.476
Cadmium	0.023	0.021	0.010	0.024	0.028
Arsenic	0.031	0.027	0.017	0.017	0.019
Copper	0.010	0.011	0.006	0.010	0.009
Iron	0.096	0.054	0.023	0.100	0.083
Salt Water Outlet					
Lead	0.051	0.068	0.034	0.049	0.030
Zinc	0.089	0.091	0.099	0.103	0.109
Cadmium	0.034	0.054	0.017	0.020	0.016
Arsenic	0.017	0.018	0.011	0.012	0.012
Copper	0.030	0.040	0.015	0.016	0.015
Iron	0.491	<0.5	<0.5	<0.5	<0.5
West Diversion Ditch Outfall to the Harbour					
Lead	<0.02	0.03	0.11	0.060	0.072
Zinc	0.06	0.03	0.04	0.038	0.045
Cadmium	<0.01	0.01	0.02	<0.01	<0.01
Arsenic	<0.02	0.03	0.02	<0.02	<0.02
Copper	<0.01	0.01	0.03	<0.01	<0.01
Iron	0.03	0.03	0.09	0.050	0.045
East Diversion Ditch Outfall to the Bay					
Lead	0.040	0.028	0.025	0.042	0.020
Zinc	0.068	0.036	0.040	0.059	0.053
Cadmium	<0.010	<0.010	<0.010	< 0.01	<0.01
Arsenic	<0.020	<0.020	<0.020	< 0.02	< 0.02
Copper	<0.010	<0.010	0.010	<0.01	<0.01
Iron	0.054	0.038	0.065	0.183	0.103

Notes:
< Indicates that the concentration is lower than the value presented but cannot be more accurately represented (detection limit is cited).

Native Mussel and Beach Sand Sampling

Native mussel and beach sand sampling has occurred along the coast, to the east and west of the facility, for many years. Figure 3-2 illustrates the sampling locations. Ref4, 4W and 2W are distant to the facility, and are against the prevailing currents, which tend to flow to the east and down the shore. The facility is located just north west of Station 1E in Figure 3-2 (Belledune Point is visible in the figure). The program involves collecting three replicates of each of two sizes of mussels (30 large and 50 small mussels, per replicate) along the shoreline at each of the stations identified. Sampling usually occurs at low tide, along rock outcroppings, in May/June of each year.

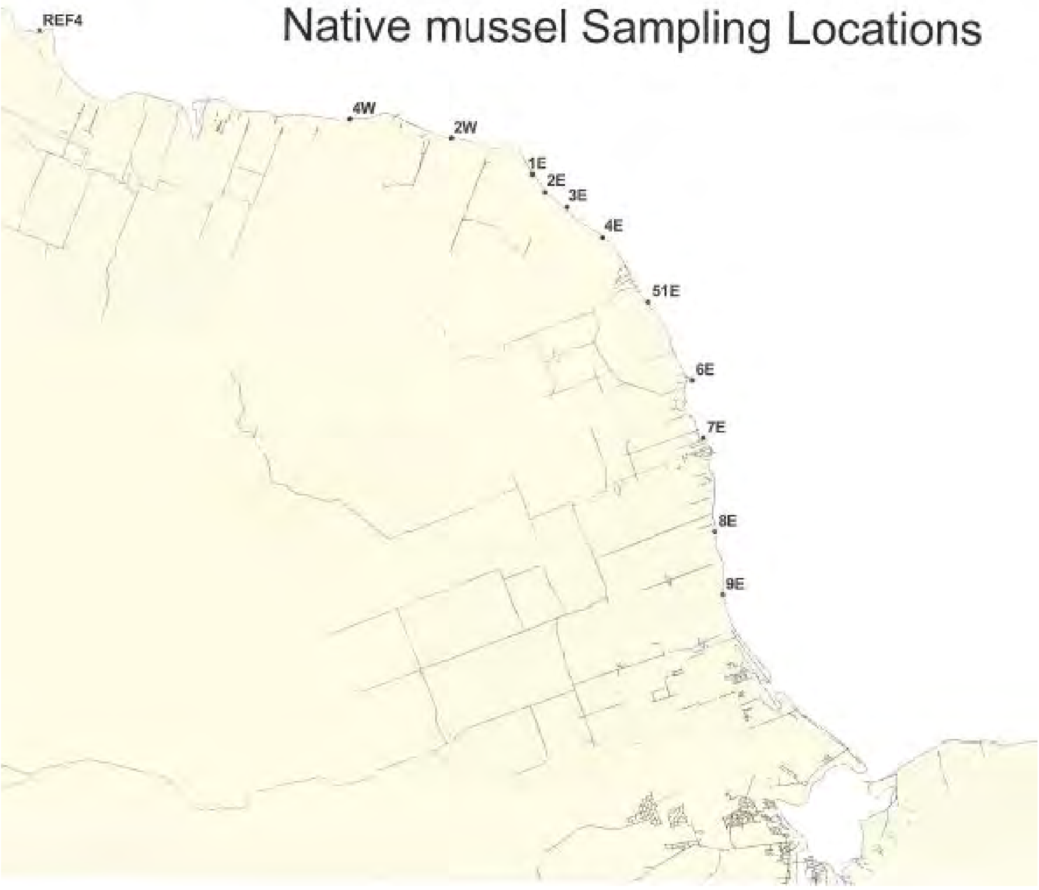

Figure 3-2 Native Mussel sampling Stations (Glencore EEM Report, 2013)

Data for mussels are illustrated in Figures 3-3 for Pb, Zn and Cd, from 2008 – 2012 (Glencore EEM report, 2013). Cd is largely non-detect, and trends are difficult to see in the dataset presented, but Pb shows a distinct trend in the easterly direction, with concentrations in mussels decreasing with distance of about 6 km. Lead data from 2012 appears elevated in many stations, relative to previous years, and zinc also shows a reduction in values with increased distance, and the 2012 data appear to be anomalously low, relative to previous years. These two trends suggest data quality issues with the 2012 dataset.

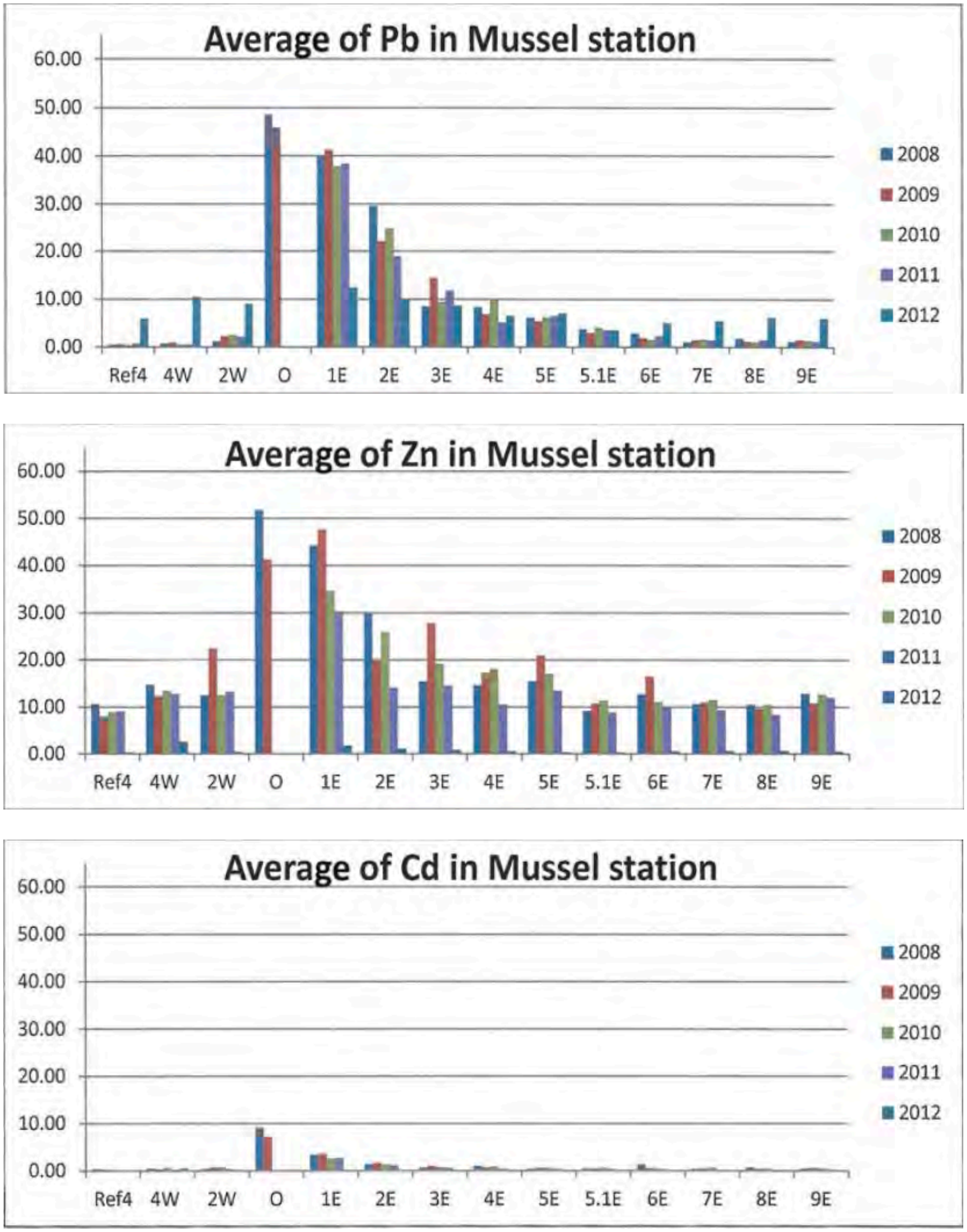

Figure 3-3 Lead, Zinc and Cadmium Metal Levels in Native Mussel Tissues Along the Baie de Chaleurs (µg/g; wet weight) by Station (Glencore EEM report, 2013)

Beach sand is collected for analysis at the same stations as mussels, at the same time. A grab sand sample is collected at or near the high water mark. Data from recent years of sampling

(2008 – 2012) are presented for Pb and As in Figures 3-4 and 3-5. Lead levels in beach sand seem to reduce to levels similar to background in 2011 at 5 km east of the facility, but values appear elevated in 2012 and suggest an increasing trend from Station 2E from 2009 to 2012. Increases in 2012 could be related to quality assurance issues (similar trend in mussel tissue metal data). Arsenic data east of the facility is complicated by natural geological enrichment in this area, relative to geology west of the facility.

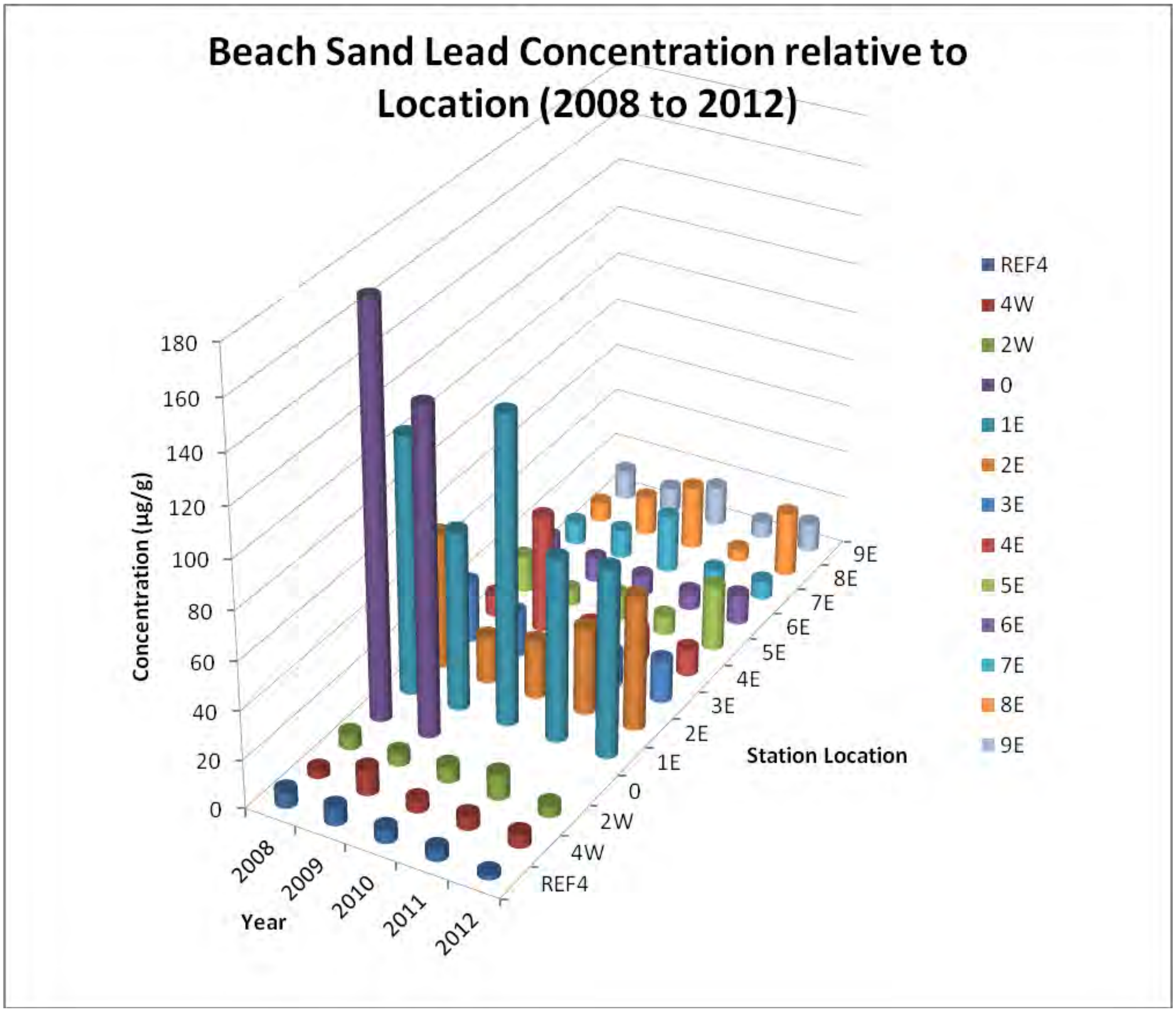

Figure 3-4 Beach Sand Lead Concentrations Near the Brunswick Smelting Facility (2008 – 2012; µg/g)

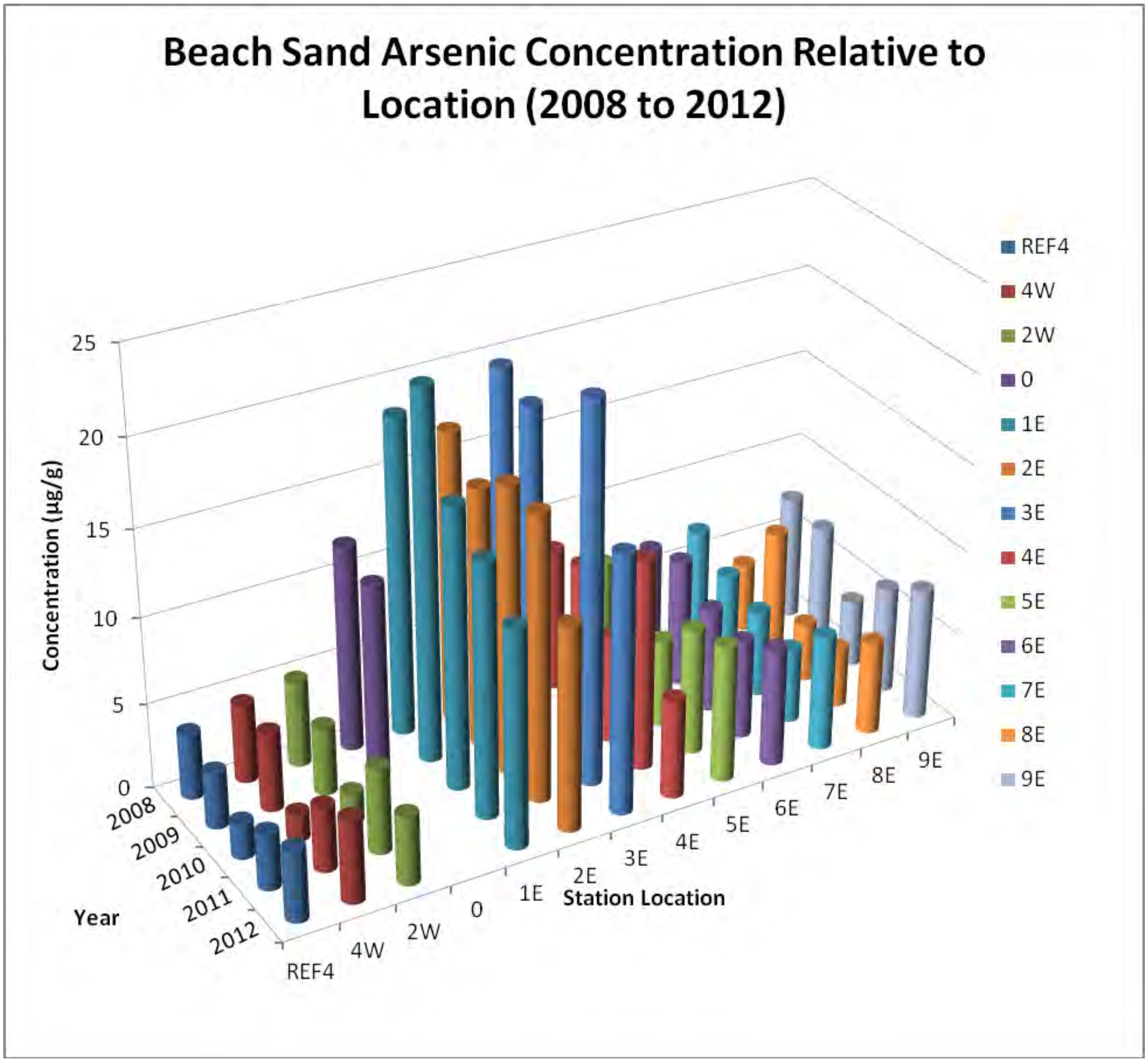

Figure 3-5 Beach Sand Arsenic Concentrations Near the Brunswick Smelting Facility (2008 – 2012; µg/g)

Cultured Mussel Deployment and Sampling Program

In addition to native mussel sampling, cultured mussels have been deployed at several locations near the facility over a time frame of approximately 90 days, typically commencing in June of each year. Mussels are collected at Ref 4 station, west of the facility, and divided into groups of 30 and placed in mesh bags, which are installed at marker buoys (see Figure 3-6 for most recent station locations). Samples are then collected at 30-day intervals, and metals analysis is conducted in the soft tissues.

Figure 3-6 Cultured Mussel Deployment Stations 2010 (Glencore EEM Report, 2013)

Cultured mussel data from 2010 are presented in Figure 3-7. This year of data was collected during the Port of Belledune Harbour dredging project (see Section 3.2.3), and therefore may have been influenced by some release of suspended sediments over the summer months. Unfortunately, 2009 data (pre-dredging) are not available, as most of the mussel bags deployed that year were lost in storms during the season. Both MC-4 and MC-2 had noticeable elevated concentrations starting at the first 30 day sampling interval (July 6), which then decreased slightly in August, and noticeable increased in both September and October, relative to other stations. MC-3 and MC-1 are further off shore and exhibit lower concentrations, which are slightly above reference levels.

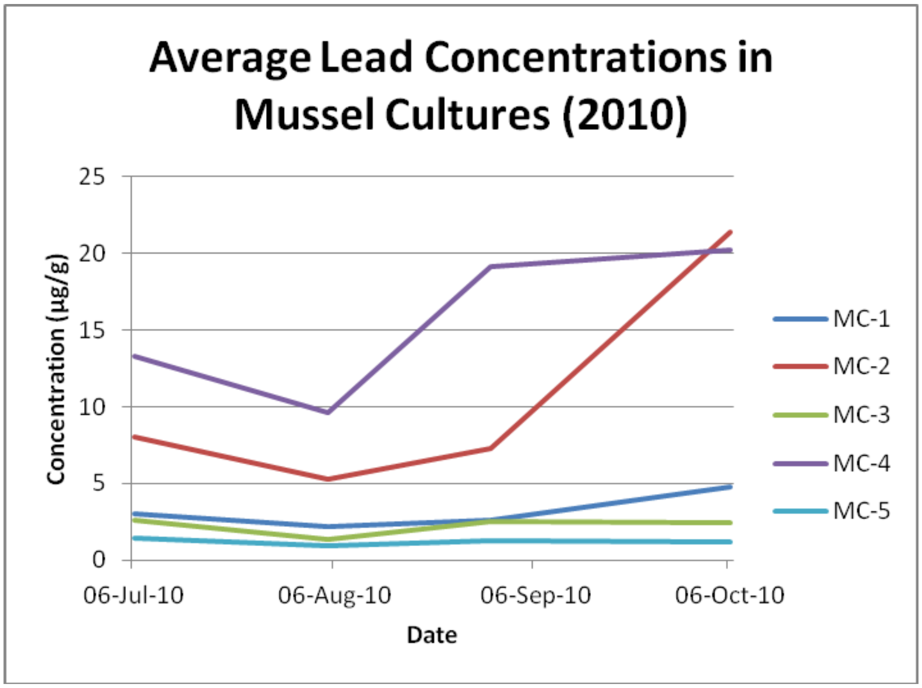

Figure 3-7 Lead Levels in Cultured Mussels Deployed During Harbour Dredging Project (µg/g wet weight)

Lobster Program

In the 1970s, the Brunswick Smelting monitoring program identified elevated cadmium concentrations in locally caught lobster meat and digestive gland (hepatopancreas) tissues. This finding led to a closed fishery zone in Belledune Harbour, and a controlled fishery zone from 1 mile NW of the Harbour to 4 miles SW (Chou and Uthe, 1993), as a result of human health concerns related to lobster consumption. The installation and commissioning of a waste water treatment plant and other process changes in November of 1980 led to a substantial decrease (95%) in cadmium discharge to the Baie de Chaleur (Noranda Inc., 1998; Uthe et al., 1986). By the early 1990s, the decreasing trend in cadmium concentrations within lobster tissues enabled the controlled fishery zone to be relocated to within Belledune Harbour, with the stations outside the Harbour being deemed safe for human harvesting and consumption. Glencore continued to monitor cadmium in hepatopancreas and muscle tissue, as well as other metals/metalloids (such as Pb, As, Hg) until 2011. The focus of the monitoring was related to human health concerns related to lobsters caught only within Belledune Harbour. Since the dredging and expansion of the harbor (See Section 3.2.3) has removed and/or covered most of the contaminated sediments from within the Harbour area, and since Health Canada indicated that they no longer had concerns related to human consumption, this monitoring program was ceased in 2012. Data are not presented for this reason.

Benthic Community Sampling

Under the Belledune facility's Certificate of Approval, sediment sampling and benthic community analysis has generally been conducted every 2 years since 1965, but was recently switched to every 5 years beginning in 2008. These data are collected to assess the effects of the process effluent on the surrounding marine system. The sampling program has evolved over the years, with Figure 3-8 illustrating both the historic sediment sampling locations (in orange) and the revised 2008 monitoring stations (for both benthos and sediment) (Minnow Environmental, 2009).

Figure 3-8 Historical and 2008 Benthic Community and/or Sediment Monitoring Stations (Minnow Environmental, 2009)

In the early years of monitoring, sediment metal levels were elevated, relative to government guidelines, and benthic community abundance and diversity indices were generally lower near the facility, than at stations further afield (Minnow Environmental, 2009). The most pronounced effects were reported in Belledune Harbour, part of which has recently been filled in as part of the Port of Belledune dredging project (See Section 3.2.3, below), as well as the former fertilizer operations outfall (see Figure 3-8). The most recent survey was conducted in 2008 by Minnow Environmental (2009)(prior to Belledune Harbour being dredged), and involved modifications to the stations, such that the focus was placed on evaluating the sediment quality and benthic community at the final effluent discharge outfall, as well as at areas under recovery, such as the former fertilizer plant outfall, and the historical smelter/slag discharge area (within Belledune Harbour). Minnow Environmental (2009) concluded the following (text is summarized from Minnow report):

- Final Effluent Outfall: Sediment metal concentrations were elevated relative to reference levels. Lead sediment concentrations were above Probable Effect Level (PEL) marine sediment quality guidelines, while As, Cd, Cu and Zn concentrations exceeded Interim Sediment Quality Guidelines (ISQG), but not PEL guidelines. Comparisons based on most benthic invertebrate community indices did not indicate adverse effects in the community. There were differences in the community assemblage between the Final Effluent Outfall and reference areas. These were considered to be associated with higher sediment metals at the effluent discharge area, however, the biota present in the outfall area had a higher proportion of metal sensitive taxa, and a significantly lower proportion of certain metal-tolerant taxa. These findings indicated than any biological effects were minor. With the relocation in 2008 of monitoring stations such that they are now closer to the actual outfall location (See Figure 3-8), higher metals levels in sediment, relative to previous years monitoring, were recorded at this area, which is not surprising. Due to the relocation of stations, temporal comparisons of benthic invertebrate metrics are difficult (since the exact locations were not monitored year-to-year). The outfall area in 2008 did indicate that taxon richness and organism density were lower in 2008 than in 2006, this was considered to be likely related to natural/seasonal variability rather than any changes in lead smelter effluent quality. The same trends were observed at the reference area, which supports this theory. Longer-term comparisons suggested that benthic invertebrate communities at the Final Effluent Outfall have changed little since 1990.

- Fertilizer Plant Outfall area: Sediment metal concentrations were generally similar to or were below reference levels and sediment quality guidelines. In this area, due to the presence of gypsum (from the fertilizer facility effluent), sediment Pb concentrations were less than the PEL, but greater than ISQG, and both uranium (U) and strontium (Sr) concentrations were notably elevated compared to reference levels. There has been physical habitat degradation in this area as gypsum deposition has created a hard pack at the outfall zone. As such, benthic invertebrate taxon richness is lower in this area, and highly variable organism density and differences in community assemblage are notable relative to other study areas (including reference). Comparisons of the sediment data to earlier years indicated that Cd, Pb and Zn concentrations at this location were among the lowest recorded in this area since 1988. Similar to the Final Effluent Outfall station, and reference areas, the benthic invertebrate community data at the Fertilizer Plant stations indicated lower taxon richness in 2008 relative to 2006. As per other stations, this was considered to be associated with natural and/or seasonal variability, but nevertheless was the lowest observed since 1992. In contrast, organism density at the Fertilizer Plant Outfall area was the highest observed since 1998. These contrasts likely reflect habitat alteration influences at this location and the varying states of recovery to natural substrate conditions.

- Belledune Harbour: This area had the highest sediment metal concentrations, when compared to all other areas sampled. Metal levels in sediments were well above concentrations in outer stations, and were greater than PEL (Pb, Cd, Zn) or ISQG (As, Cu, Hg) guidelines. While no other harbour habitat was sampled as reference comparison, the benthic data in this area exhibited low taxon richness, diversity, evenness and abundance of metal-sensitive indicators, high Bray-Curtis Index and high abundance of metal-tolerant indicators. These indices clearly indicate that the benthic community in the harbour is being influenced by sediment metal concentrations. Trending of data from earlier years suggests that there has not been any improvement in the community over time, and that Cd sediment levels have decreased, compared to early years, but other metals levels have not exhibited significant change. With the significant dredging activity and infilling undertaken from 2009 to 2011 (See Section 3.2.3), this area has been substantially altered, and much of these sediments have either been infilled, or removed.

3.2.3 Port of Belledune Harbour Dredging Project

In 2009 to 2011, a major harbour dredging project was undertaken by the Port of Belledune, to expand the port. The project involved dredging of approximately 170,000 cubic metres of sediment from the harbour (see Figure 3-9). The excavated sediments were placed within 3 cells adjacent to Glencore's property, which were formerly part of the harbour (See Figure 3-9). In total, 16 hectares of land were created with the creation of these cells, and the inner harbour area which was formerly part of the Environmental Effects Monitoring Program for benthic community impacts was effectively eliminated. Since marine habitat was lost in this project, a habitat compensation was undertaken, which involved the creation of 23,000 artificial lobster reefs, and release of 100,000 larval lobster (Gemtec, 2011).

In conjunction with this project, silt curtains were set up to minimize potential dispersion of sediments while cells were being filled. Turbidity was monitored as an indicator of potential sediment release.

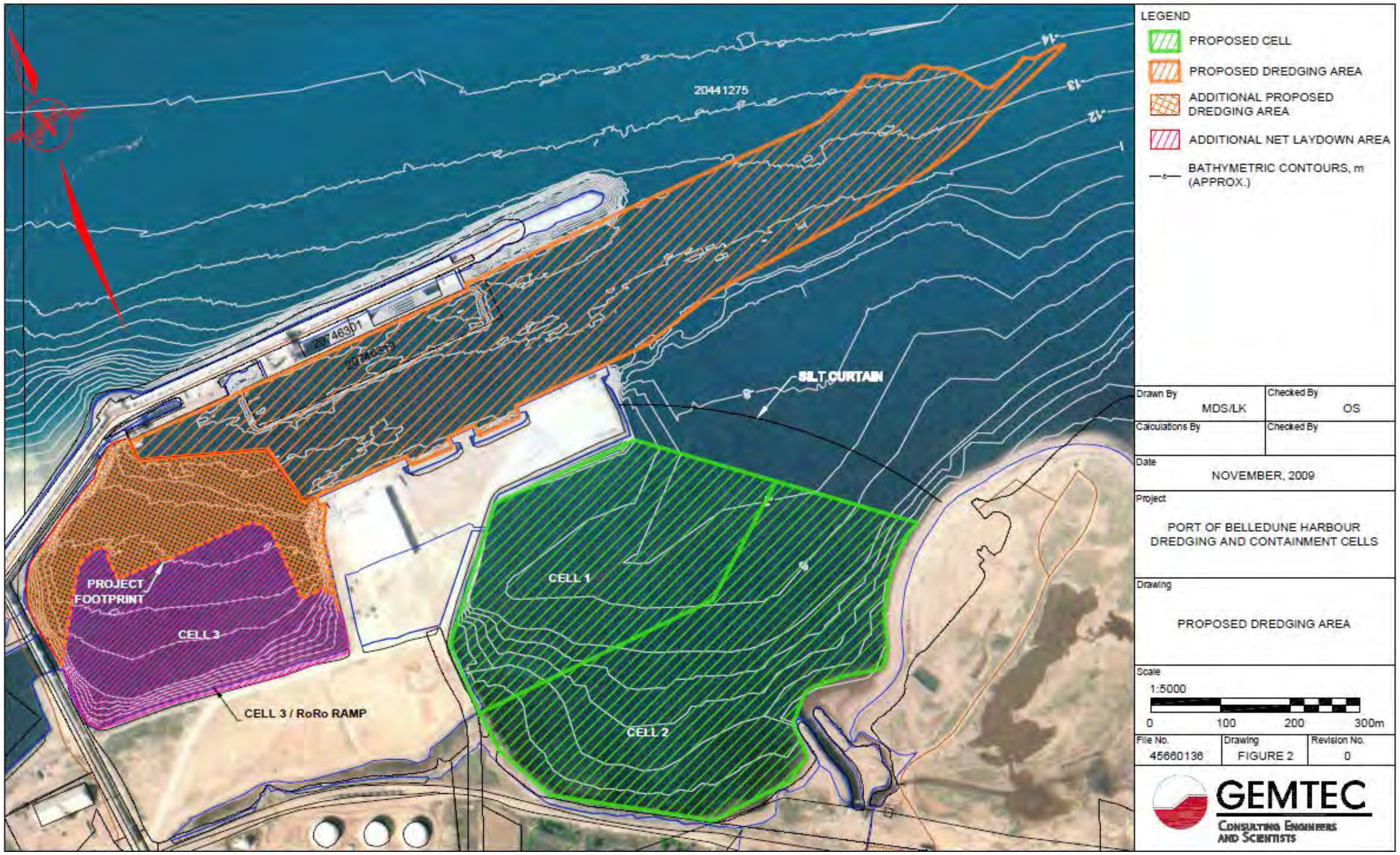

Figure 3-9 Illustration of Belledune Harbour Dredging Project (Gemtec, 2010)

3.2.4 Glencore Groundwater Monitoring Program

There is an active groundwater monitoring network within the industrial area of the smelter, as well as the bulk handling operations (BHO) area. Groundwater monitoring began in the late 1980s, when a significant Cd loss was detected from the recycled process water area of the facility, and Cd was leaking from underground piping into soils and groundwater, and ultimately, reaching Chaleur Bay. At that time, a network of 43 monitoring units were put into place to understand groundwater flow (36 in overburden; 4 shallow wells, and 3 deep wells), and these wells have undergone monitoring over the years since that time. In 1996, 9 additional wells were added to the system. In 2005, a groundwater sampling program was undertaken and 32 new groundwater monitoring wells were added to the network. Figure 3-10 illustrates groundwater monitoring locations (Glencore, pers comm.).

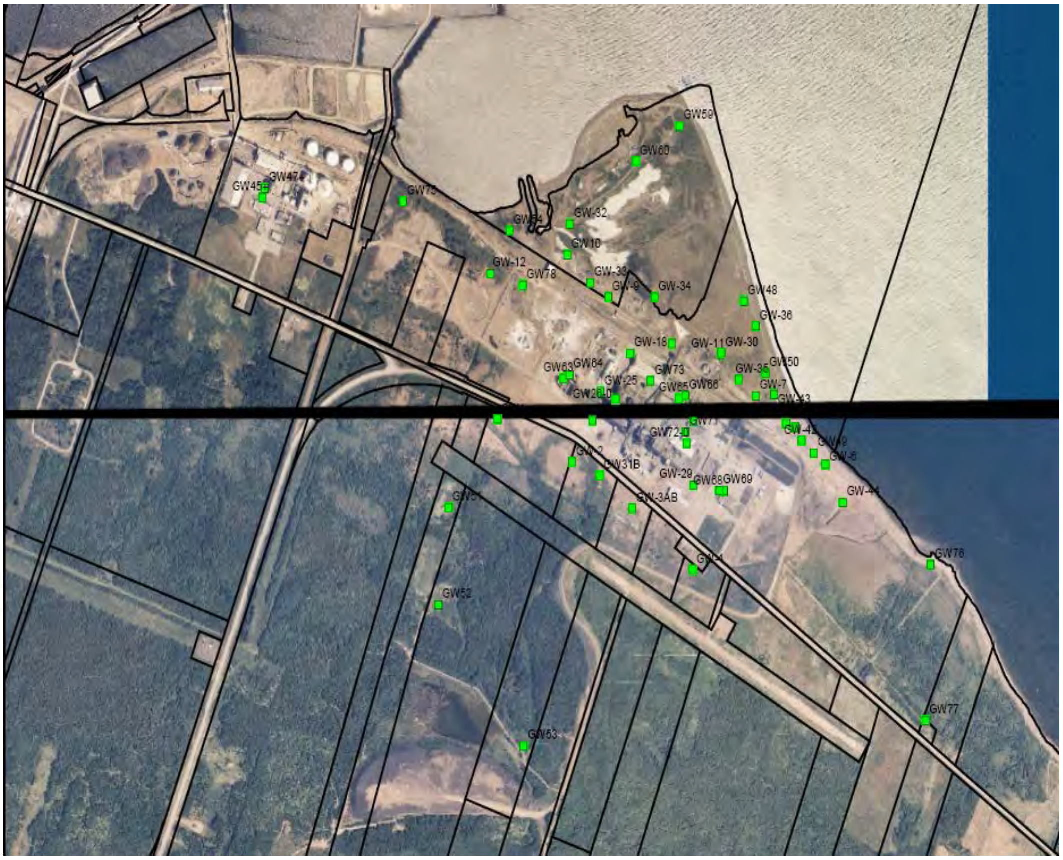

Figure 3-10 Groundwater Monitoring Well Locations

With respect to potential impacts to the marine environment, wells located along the shoreline of Baie des Chaleurs are of greatest interest. An evaluation of metals loadings to the Bay was undertaken from the site was undertaken in 2009 – 2010 (SNC, 2010). The study focused on key metals of interest, such as As, Cd, Cu, Pb, Tl and Zn. Of the various parts of facility, the smelter site was considered to contribute the majority of loadings to Chaleur Bay. SNC (2010) did not consider the estimated loadings elevated, and applied a number of conservative assumptions in their predictions. SNC (2010) indicate that environmental impacts of these loadings are expected to be insignificant.

Since the SNC study was conducted, the slag disposal area on Belledune Point has been relocated to an inland location, south of the smelter, which would be expected to reduce source loading and change modeling results conducted in 2010. An interception system is in place for some areas to capture groundwater and re-direct it to the CRP pond.

For the current ERA, groundwater is not directly assessed. Rather, the possible effects of groundwater contributions in the marine environment will be considered through the collection and assessment of sediment, surface water, and biota data.

3.2.5 Common Tern Study and Sampling

In 2011, a study was initiated to relocate a colony of Common terns (*Sterna hirundo*). This species had set up roosting and nesting sites in the active industrial area of the facility over the previous several years, and continued to return to the smelter annually. This nesting began during seasonal shut downs which occurred in 2002 through to 2005, wherein shut downs of 2 – 4 months provided an opportunity for terns to establish nesting areas on the roofs of several buildings, and in low lying areas around the facility. The terns usually arrive on-site in mid May and leave in mid to late August. By 2008, the size of the tern colony was large enough that it began to present a significant nuisance and a health concern to workers, as the terns are aggressive during nesting. Terns have disturbed smelter workers, in their attempts to protect their nests. In general, the intensity of the tern-worker interactions increases during egg incubation peaking when the earliest eggs hatch. Once chicks are a few days old, the interactions typically rapidly diminish (Nisbet, 2002). This pattern of tern aggression has been reported on the Brunswick Smelter site.

In addition to a human health concern, the presence of nesting terns also poses a potential ecological health risk. As the site is an active industrial site, it is not an ideal location for tern nests as on-site activities could result in the accidental harm of eggs or birds, and increases the potential for exposure to heavy metals.

As a result, Glencore began a Tern Management Program in 2009, and decided to actively pursue re-locating the terns to an alternative nesting area, in consultation with Canadian Wildlife Service (CWS). The Tern Management Program included placement of rigid plastic mesh on buildings, installation of a water sprinkler, etc. These initiatives have assisted in reducing nesting activities in certain key areas, and have resulted in a reduction of employee-bird interactions, but terns continue to nest in the active areas of the facility footprint. In 2010, nesting locations included building roofs, the banks of the CRP ponds, and various locations around the facility near fencing.

To minimize the potential for worker–tern interactions, alternative nesting locations were explored. The most viable option was to attempt to attract the colony to a reasonably inactive part of the smelter property known as Belledune Point. The habitat in this area is appropriate for common terns, based on an assessment conducted by an avian biologist (Morneau, 2010), and discussions and a site visit by Canadian Wildlife Service (CWS) staff. Since Belledune Point does have some historical contamination related to the presence of an old slag pile, Glencore was interested in conducting an Ecological Risk Assessment (ERA) to evaluate the potential for metals exposures to tern if they were relocated to this area. Preliminary modelling was conducted in fall of 2010 to assist in decision-making relative to relocation of the colony, and further data collection was undertaken in spring 2011. An attractive nesting site was established (with nesting materials, and an electric fence, to protect against predation), a series of decoys, and a tern calling audio. In addition, deterrents, such as heavy gauge plastic mesh, have been placed on several smelter buildings. Despite these efforts, the terns have not selected the new location for nesting, and currently still nest around the CRP pond, and on several building roofs. Nesting sites and counts from 2010 are presented in Figure 3-11 and Table 3-3.

Figure 3-11 Established Common Tern Nesting Locations in 2010 (CWS data). See Table 3-2 for Identification of Sites A - G

Table 3-3 Nest Counts and Clutch Sizes of Common Tern Colonies Surveyed by Ground along the Gulf of St. Lawrence Coast of New Brunswick (excluding colonies within Kouchibouguac National Park; CWS, 2010)

Location and Assessment Date	Clutch Size					Nests	Eggs	Clutch Size	
	1	2	3	4	5			Mean	SD
Belledune Smelter[1] (June 16)	54	92	123	1	0	276	611	2.26	0.78
Shediac Marina (June 14)	27	127	221	9	2	386	990	2.56	0.68
Tern Island, Tabusintac (June 18)	383	1013	1187	48	2	2633	6172	2.34	0.75
Tracadie (June 17)	209	407	918	21	0	1555	3861	2.48	0.74
Unnamed Island #1 near Val Comeau (June 16)	26	27	40	1	0	94	204	2.17	0.85
Total	699	1666	2489	80	4	4944	11838	2.40	0.75

[1] Clutch size could not be determined for six nests that were located on a small unreachable island (Figure 3-11). The mean clutch size and standard deviation was calculated using 270 nests, only.

Clutch sizes observed on the Glencore property are reported in Table 3-3 with the location of the tern nests shown in Figure 3-11. The majority of nests had a clutch size of 3 (46%), followed by 2 (34%), 1 (20%) and 4 (<1%). The average clutch size in Belledune was calculated to be 2.26 based on the data provided in Table 3-2. Clutch sizes in Belledune were on the lower end, but similar to, other colonies assessed in New Brunswick in 2010.

In order to better understand where terns were foraging, fishing observations were taken from Belledune Point over a week time interval in summer of 2010. The observation point, and distance grids are illustrated in Figure 3-12. The outcomes of these observations suggested that terns fished within 150 m of shore the least amount of time (24% of the time), and tended to fish further offshore the vast majority of time (between 150 – 340 m 42% of the time, and 340 m – 800 m 34% of the time). No foraging occurred on site, within the observation periods.

Figure 3-12 Common Tern Foraging Observation Zones

A limited number of forage fish were collected, to assist in characterization possible dietary exposures. Since there was inadequate time to obtain a permit for fishing from DFO, fish previously collected were used (collected from the East Diversion Ditch, and hence, have higher exposure potential), or fish bought from fishermen in Petit Rocher (n= 8). Species included sculpin, eel, atlantic silverside and stickleback, ranging in length from 5 – 13 cm. Measured metals data from whole body fish tissue analysis ware presented in Table 3-4. The data exclude fish number 4, as it was dropped by a tern into the back of a Glencore truck which had been carrying concentrate, and hence had external contamination.

Table 3-4 Whole Body Marine Fish Tissue Metals Analysis (mg/kg)

RPC ID:	**109561-1**	**109561-2**	**109561-3**	**109561-5**	**109561-6**	**109561-7**	**109561-8**
Client ID:	**Sample 1**	**Sample 2**	**Sample 3**	**Sample 5**	**Sample 6**	**Sample 7**	**Sample 8**
Analytes							
Aluminum	6.4	0.9	0.5	0.8	0.6	34.6	74.1
Antimony	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.02
Arsenic	0.6	0.7	0.6	0.9	1.0	0.4	0.3
Barium	0.3	< 0.2	< 0.2	0.2	0.2	0.4	0.5
Beryllium	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Bismuth	< 0.2	< 0.2	< 0.2	< 0.2	0.2	< 0.2	< 0.2
Boron	0.3	0.4	0.4	0.8	1.3	4.1	4.5
Cadmium	0.022	0.012	0.013	0.061	0.037	0.031	0.043
Calcium	9810	7870	7100	8530	6120	8820	8990
Chromium	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	0.2
Cobalt	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.03
Copper	0.8	0.4	0.3	0.7	0.6	0.4	0.4
Iron	19	14	13	21	17	40	75
Lead	0.50	0.28	0.37	0.66	0.12	1.43	2.34
Lithium	0.08	0.06	0.06	0.07	0.06	0.16	0.20
Magnesium	390	402	367	456	415	1040	1080
Manganese	0.7	1.2	1.2	4.4	2.5	7.1	6.7
Mercury	0.02	0.02	0.03	0.01	0.01	0.02	0.01
Molybdenum	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Nickel	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	0.2
Potassium	3090	3500	3320	4330	4210	724	568
Rubidium	0.63	0.74	0.66	0.70	0.69	0.20	0.23
Selenium	0.4	0.4	0.3	0.6	0.7	0.2	< 0.2
Silver	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Sodium	1490	1170	1120	1200	840	5960	6270
Strontium	54.4	49.5	50.9	32.8	26.4	52.5	48.9
Tellurium	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Thallium	< 0.02	0.03	0.03	< 0.02	< 0.02	0.02	0.03
Tin	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.02
Uranium	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.03	0.03
Vanadium	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	0.2
Zinc	16.3	28.0	33.6	32.4	31.9	11.7	9.3

Notes: '<' = detection limit; data collected by Xstrata in 2010
Fish tissue samples analyzed by RPC Laboratories in Fredericton, NB.

In addition to these data, soil samples were collected on Belledune Point at the possible future nesting sites. Data related to these samples are not presented, as there has been significant changes to Belledune Point over the past 3 years, related to the harbour dredging project, wherein the north west part of Belledune Point was used as a lay-down zone for construction related to the dredging cells, and the former Slag storage area has been excavated and moved to a new location south of Highway 134.

Other data collected included numerous dead chicks collected in 2010 (as a result of falling from nests, etc.; N=11). These carcasses were frozen, and sent to CWS for analysis, but data were not received until September 2014, and therefore are discussed in the main report of the ERA, as opposed to The Problem Formulation. In addition, 3 slightly cracked eggs were collected, which were thought to have rolled out of nests during high water events, and floated across the CRP pond. While these eggs were sent for analysis, data are not reported herein as the eggs had numerous small cracks and could have taken in metals loadings from the CRP pond as a result of floating.

The ERA investigating tern exposures if nesting were to occur at Belledune Point indicated that exposures were within acceptable levels if re-location were to occur.

3.3 Identification of Chemicals of Potential Concern (COPCs)

Formal screening of chemicals of potential concern (COPC) has not been conducted at this time to determine what chemicals of concern (COC) would be assessed in the ERA (FCSAP, 2012a).

Ecological receptors in the marine and near-shore environment could be exposed to a variety of COPCs as a result of the operation of the Brunswick Smelting facility, primarily metals. Emissions of particulate matter (including TSP, PM_{10} and $PM_{2.5}$) from the Brunswick Smelter contain various metals, metalloids, and likely trace amounts of polycyclic aromatic hydrocarbons and other hydrocarbons (from fuel combustion). The chemicals associated with large particulate matter could be deposited onto area near-shore sediments and deposit onto water. Effluent and discharge from the various outfalls could contribute to concentrations of various COPCs in surface waters and sediments. Similarly, chemicals in groundwater (as a result of slag storage over the years) and on surface soils could eventually be transported to surface water and sediments.

Following 2014 sampling, COCs will be selected from the data, using a standardized screening process, involving comparison of data to reference areas and appropriate ecologically based guidelines. Much of the existing data available is limited to only 5 or 6 metals/metalloids, and data collected in the area of Belledune Point is likely not representative of current conditions on the site, due to the recent harbour dredging project. Given this and that not all the data required to conduct this assessment have been collected, COC selection will commence once supplementary sampling has been completed and analytical results are available.

3.4 Identification of Ecological Receptors of Concern (ROC)

The goal of the receptor identification step is to identify ecological receptors of concern (ROCs) which occur within the study area, and that have the greatest potential for exposure to chemicals of concern (COCs), and/or are the most sensitive to the effects of the COCs. Therefore, since the focus of the assessment is on species which could potentially be living in (such as aquatic species), foraging in or on the immediately near-shore areas of the marine environment, species which fit these categories were considered. To identify potential ROCs, a variety of sources of information were used. In particular, two avian surveys were conducted in 2010 (Morneau, 2010) and 2011 (LGL, 2011) on Belledune Point, as part of the breeding bird survey conducted for the Intrinsik (2013) terrestrial ERA (LGL, 2011) to gather information related to potentially re-locating the common tern from the active industrial area of the facility to Belledune Point (Morneau, 2010). These surveys, in conjunction with data related to possible species at risk, were used to identify possible upper trophic level receptors.

3.4.1 Consideration of Threatened or Endangered Species

The New Brunswick Department of Natural Resources (NB DNR, 2015) list of species at risk in NB, and the Species and Status database were reviewed to examine the potential for threatened or endangered species to be present in the area of the smelter. While the harlequin duck, piping plover, bald eagle and peregrine falcon were identified as avian species at risk in NB, these species were not observed on-site in either of the bird surveys conducted (LGL, 2011; Morneau, 2010). The Canada lynx was the only mammal listed as a species at risk in NB but was not identified on-site nor would it feed in marine areas.

The COSEWIC (Committee on the Status of Endangered Wildlife in Canada; 2015) website was also reviewed to identify potential species of concern. The common tern, which was observed on-site, was listed as not at risk (COSEWIC, 2015). While the bank swallow had been observed on-site previously and is listed on the COSEWIC website as being threatened, this species is no longer resides on-site due to the removal of the slag pile. None of the bird species identified on-site during the bird surveys were on the candidate list for COSEWIC in NB with the exception of the killdeer which was listed as a low priority species. No mammals are currently listed as candidate species by COSEWIC (2015).

3.4.2 Selection of ROCs

Selected marine ROCs included primary producers, pelagic and benthic invertebrates, fish, and various upper trophic level species (see Table 3-5). Some of these were assessed as a group, rather than identifying specific species. As such, no specific surrogate receptor species were identified for these groups (see Table 3-5). For upper trophic level ROCs feeding in the aquatic environment, surrogate receptors were selected using information from two separate avian surveys conducted on Belledune Point (LGL, 2011; Morneau, 2010) in addition to data provided in General Status of Species in Canada report (CESCC, 2011).

The bird surveys confirmed that there are a number of species which feed in the marine environment present in the Belledune Point area, which were either confirmed or possible breeders. The confirmed breeding species included the common tern (currently breeding on the smelter property; not listed as being at risk (COSEWIC, 2015); the killdeer (2 breeding pairs were noted); spotted sandpiper (4 breeding pairs were noted); herring gull (1 breeding pair noted) (Morneau, 2010). In addition, a number of species were reported as being present on the Point and/or feeding in the adjacent marine areas, but were not confirmed to be breeding in the area (e.g., double-crested cormorant, black-crowned night heron, great blue heron). Waterfowl were also seen in the area (e.g., American black duck, mallard, common eider, red-breasted merganser), but there was no confirmed evidence of them breeding on-site, but a single breeding pair of the merganser and the black duck were reported as being present (Morneau, 2010). Bank swallows, which do not feed in the marine environment, but are listed as sensitive in New Brunswick, were reported in high numbers on Belledune Point in the LGL (2011) survey and active nests were confirmed. However; this species has moved due to a re-location of the slag pile in which they had been building their nests.

Table 3-5 provides the rationale for selection of the marine ecosystem ROCs.

Table 3-5 Receptor of Concern (ROC) Selection for the Marine Ecological Risk Assessment

Aquatic Receptor Group	Aquatic Receptor Type	Included in ERA?	Rationale	Surrogate ROC
Primary Producers	Phytoplankton	Yes	Phytoplankton would be expected to be found within the study area.	Assessed as a group
	Macrophyte	No	The heavy wave action in the vicinity of the site does not make habitat suitable for aquatic vegetation. As such, aquatic macrophyte vegetation was not included.	Not applicable
Pelagic Invertebrates	Zooplankton	Yes	Zooplankton would be expected to be found within the study area.	Assessed as a group
Benthic Invertebrates	Epifauna / Infauna	Yes	Benthic invertebrates would be expected to be found within the study area.	Assessed as a group
Fish	Benthivorous	Yes	Benthivorous fish could be exposed to Site COCs via eating benthic invertebrates from contaminated sediments or via the incidental ingestion of sediments.	Specific species to be selected under the Fish Health assessment (see Section 3.8)
	Piscivorous	No	Exposures to piscivorous fish are expected to be low given these fish and their food are highly mobile thereby limiting their exposures related to the sites.	Not applicable
Aquatic Feeding Mammals	Herbivorous	No	Aquatic marine vegetation are not expected to be plentiful in the near-shore area due to poor habitat and wave action; exposures to marine herbivorous mammals from site COCs is expected to be low.	Not applicable
	Piscivorous	No	While piscivorous mammals could be exposed to site COCs via ingestion of contaminated fish, given their large home range, the amount of fish they would ingest from areas affected by smelter releases is expected to be limited, thereby limiting their exposures. In addition, the small size of the site would provide inadequate habitat for an entire population of piscivorous mammals. As such, population level effects to this receptor group would not be expected.	Not applicable
	Omnivorous	No	Aquatic vegetation not expected to be plentiful in near-shore areas and the amount of fish omnivorous mammals would ingest from areas affected by smelter releases would expected to be limited and hence exposures to omnivorous mammals from the site is expected to be low. In addition, the small size of the study area would not provide adequate habitat for an entire population of omnivorous mammals. As such, population level effects to this receptor group would not be expected.	Not applicable
Aquatic	Herbivorous	No	Aquatic vegetation are not expected to be plentiful in the near-shore area due to poor	Not applicable

Table 3-5 Receptor of Concern (ROC) Selection for the Marine Ecological Risk Assessment

Aquatic Receptor Group	Aquatic Receptor Type	Included in ERA?	Rationale	Surrogate ROC
Feeding Birds			habitat and wave action; exposures to herbivorous mammals from site COCs is expected to be low.	
	Invertivorous	Yes	Invertivorous birds feeding in the nearshore were observed within the study area including the black-bellied plover, the killdeer and spotted sandpiper. The killdeer and spotted sandpiper have also been observed nesting in Belledune Point (Morneau, 2010). These species are listed as not at risk on the Species at Risk Public Registry (Government of Canada, 2015) and are listed as secure in New Brunswick (NB DNR, 2015). These birds could be exposed to chemicals in their food and via the incidental ingestion of sediments. As such, insectivorous birds feeding in the nearshore area were included in the `ERA. The diet of the killdeer is mainly terrestrial invertebrates, while the spotted sandpiper's diet is comprised more or marine and freshwater invertebrates (BNA on-line, 2015). As such, the spotted sandpiper was selected as the surrogate receptor for this group.	Spotted sandpiper *(Actitis macularius)*
	Piscivorous	Yes	A nesting colony of common tern are present on-site and could be exposed to site COCs via the ingestion of fish found within the study area. Double-crested cormorants were also observed feeding offshore of Belledune Point and the black-crowned night heron and great blue heron were observed hunting along the edge of the water, but neither were observed nesting in the area (LGL, 2011; Morneau, 2010). Piscivorous aquatic feeding birds were therefore assessed in the ERA. The common term was selected as the surrogate receptor for bird species feeding on pelagic fish as it nests in the area. The common tern is listed as not at risk on the Species at Risk Public Registry (Government of Canada, 2015) but is listed a sensitive species in New Brunswick (NB DNR, 2015).	Common tern (*Sterna hirundo*)
	Omnivorous	Yes	Aquatic vegetation are not expected to be plentiful in near-shore areas, and as such, was not included as a dietary item. The Black-crowned night heron was selected as a surrogate receptor for avian species that feed on a varied diet in the near-shore area, which could include fish, near-shore benthic species, or mussels. The black crowned night heron is listed as not at risk on the Species at Risk Public Registry (Government of Canada, 2015) but is listed a sensitive species in New Brusnwick (NB DNR, 2015).	Black crowned night heron (*Nycticorax nycticorax*)
Amphibians	Carnivorous	No	Not expected to be found within marine study area	Not applicable
Reptiles	Omnivorous	No	Not expected to be found within marine study area	Not applicable

3.5 Selection of Exposure Pathways, Routes and Scenarios

If there are no possible exposure pathways to chemicals of potential concern, there can be no potential for adverse effects from those chemicals. Therefore, it is an important step in any ERA to identify the major exposure pathways for each of the selected ROCs.

The exposure pathways identified for the Marine ROCs are provided in Table 3-6.

Table 3-6 Exposure Pathways Selected for ROC in Marine Ecosystem ERA

Receptor Group	Exposure Pathway	Included (Yes / No)	Rationale
Primary Producer	Direct Contact (Water)	Yes	Aquatic primary producers could be exposed to chemicals via direct contact with water impacted by the site.
Pelagic Invertebrate	Direct Contact (Water)	Yes	Pelagic invertebrates could come into direct contact with water impacted by the site.
Benthic Invertebrate	Direct Contact (Water)	Yes	Benthic invertebrates could come into direct contact with water and sediments impacted by the site.
	Direct Contact (Sediment)	Yes	
	Food Consumption (for macrofauna)	Yes	Benthic invertebrates ingest sediments and other foods in the environment.
Fish	Direct Contact (Water)	Yes	Benthic fish species could be exposed to chemicals in the environment through all of these pathways.
	Direct Contact (Sediment)	Yes	
	Food Consumption	Yes	
	Incidental Sediment Ingestion	Yes	
Avian	Water Consumption	Yes	Avian species could ingest water impacted by the site and could be exposed to site COCs via ingestion of fish or near-shore benthic species contaminated from site exposures or via incidental ingestion of sediments.
	Food Consumption	Yes	
	Incidental Sediment Ingestion	Yes	

3.6 Conceptual Site Model

A conceptual site model (CSM) provides a visual of the key elements of an ERA, including COCs and their sources, fate and transport of these contaminants throughout the Site, ROC and identification of exposure pathways. A CSM for the Brunswick Smelter facility ERA is provided in Figure 3-13.

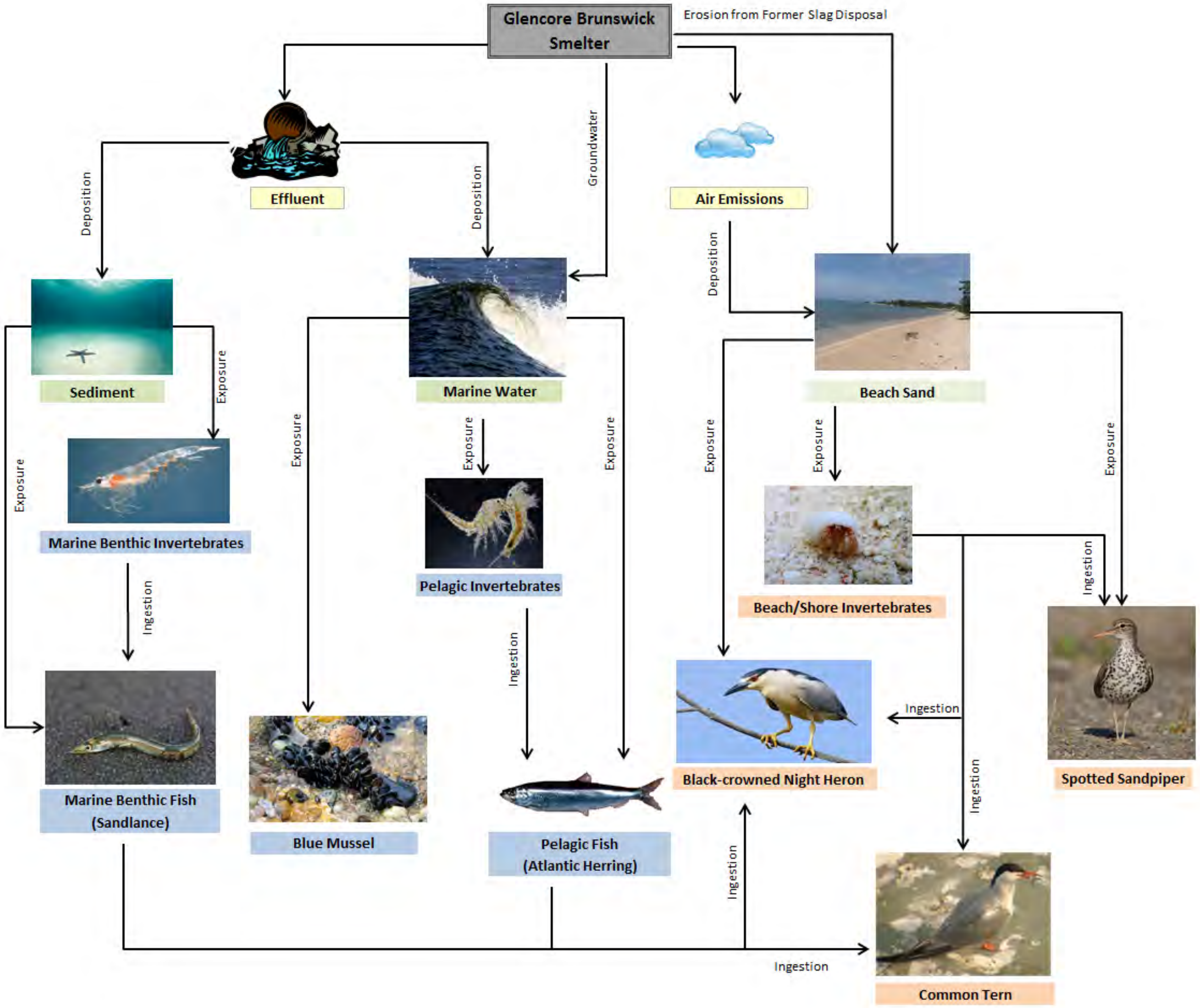

Figure 3-13 Conceptual Site Model for the Marine ERA for the Brunswick Smelter

Protection Goals and Acceptable Effect Levels (AELs)

The Protection Goal for this ERA is to maintain ROC communities / populations similar to background conditions for non-species at risk.

Therefore the protection goal for the common tern, black crowned night heron and spotted sandpiper is focussed on populations. While the common tern is identified as sensitive in NB, it is not identified as a species at risk and as such, the focus is at the population level. For bird species, published TRVs have been selected as the acceptable effect levels. The TRVs selected are based on lowest observed adverse effect levels (LOAELs) or some minimal level of risk (e.g., EC10 or EC20, where available). Risk is negligible if the estimated contaminant exposures for small mammals / bird species on-site do not exceed the TRV (i.e., if Hazard Quotient <1). Multiple lines of evidence will be used, where available, to draw conclusions with respect to risks.

The protection goal and acceptable effect levels (AELs) for primary producers and invertebrates were at the community level while for fish, it was at the population level. Concentrations of media below established surface water and sediment guidelines in addition to reference area media concentrations would be indicative of negligible risk levels. Multiple lines of evidence will be used, where available, to draw conclusions with respect to risks.

3.7 Assessment and Measurement Endpoints and Lines of Evidence (LOE)

Assessment endpoints express the environmental value to be protected and includes a receptor (what is being protected) and specific property or attribute of that receptor. Measurement endpoints describe (measure) the change in the attribute / property of the assessment endpoint or describes (measures) the exposure or effect for a ROC (FCSAP, 2012a). Lines of evidence used to estimate risks to the ROC are based on the measurement endpoints.

Assessment endpoints, measurement endpoints and lines of evidence used in this ERA are provided in Table 3-7.

Table 3-7 Assessment Endpoints, Measurement Endpoints and Lines of Evidence

Receptor Group	Assessment Endpoint	Measurement Endpoints	Lines of Evidence
Marine Primary Producer and Pelagic Invertebrate Community	Survival, growth and reproduction of marine primary producer and pelagic communities	Concentrations of COCs in marine surface water	Outcomes of the comparison of marine surface water COC concentrations to marine water SWQGs and to reference area concentrations Consider toxicological / biological information from other (literature) studies and extrapolate where applicable to this study.
Marine Benthic Community	Marine benthic community diversity and abundance	Concentrations of COCs in marine sediments Benthic community abundance and diversity study (density; richness and diversity)	Outcomes of the comparison of site sediment COC concentrations to marine Sediment Quality Guidelines (SED QGs) and to reference area concentrations. Statistical analysis of benthic community abundance and diversity endpoints, relative to reference.
Marine Shellfish (i.e., mussel)	Survival and growth of marine shellfish populations	Concentrations of COCs in marine surface water Caged mussel survey: metals analysis in tissues; survival (mortalities; age); growth (change in length between deployment/collection); and, condition	Outcomes of the comparison of marine surface water COC concentrations to marine water SWQGs and to reference area concentrations Assessment of caged mussel data relative to control/reference area, and relative to tissue metals residue data

Table 3-7 Assessment Endpoints, Measurement Endpoints and Lines of Evidence

Receptor Group	Assessment Endpoint	Measurement Endpoints	Lines of Evidence
Marine Fish (pelagic and bottom dwelling)	Survival, growth, reproduction of marine fish populations	Concentrations of COPCs in marine surface water Fish survey (benthic species only; pelagic species not selected due to more limited exposure potential): survival (age; age structure); growth (length-at-age; weight-at-age); reproduction (gonad weight-at-length; fecundity; egg size); condition (weight-at-length; liver size) Fish tissue metals levels (whole fish) Relevant literature, where available	Outcomes of the comparison of marine surface water COC concentrations to marine water SWQGs and to reference area concentrations. Outcomes of fish survey study Consider toxicological / biological information from other (literature) studies and extrapolate where applicable to this study.
Piscivorous avian (i.e., common tern) Populations	Survival, growth, reproduction of piscivorous populations	Marine fish (whole fish; pelagic / benthic) tissue concentrations Literature on fish tissue residue effects levels in upper trophic species (piscivores) Exposure modelling Tissue residue measurements in avian mortalities (e.g., chicks fallen from nests) and rejected eggs Literature studies discussing effects of COCs on piscivorous avian species at other relevant sites.	Predicted Exposure Ratios (ER) from food chain modelling (*i.e.*, comparison of estimated or measured COC exposures via ingestion of fish to Toxicity Reference Values (TRVs). Comparison of fish tissue residue data to tissue effects literature for piscivores Comparison of liver, kidney or egg tissue residues in avian mortalities to tissue effects literature Consider toxicological / biological information from other studies and extrapolate where applicable to this study

Table 3-7 Assessment Endpoints, Measurement Endpoints and Lines of Evidence

Receptor Group	Assessment Endpoint	Measurement Endpoints	Lines of Evidence
Omnivorous avian (i.e., black-crowned night heron) Populations	Survival, growth, reproduction of piscivorous populations	Marine fish (whole fish; benthic / pelagic) tissue concentrations Literature on fish tissue residue effects levels in upper trophic species (piscivores) Beach sand concentrations Tissue residues of possible food sources (*e.g.,* near-shore invertebrates, such as scuds) along beach, for input into food chain model (paired with beach sand samples) Observational counts to determine size of population in area Food chain modelling Literature studies discussing effects of COCs on similar avian species at other relevant sites	Predicted Exposure Ratios (ER) from food chain modelling (*i.e.*, comparison of estimated or measured COC exposures via oral ingestion of fish, beach sand, near-shore invertebrates; mussels, etc., to Toxicity Reference Values (TRVs). Consider toxicological / biological information from other studies and extrapolate where applicable to this study

Table 3-7 Assessment Endpoints, Measurement Endpoints and Lines of Evidence

Receptor Group	Assessment Endpoint	Measurement Endpoints	Lines of Evidence
Invertivore avian (i.e., spotted sandpiper) Populations	Survival, growth, and reproduction of avian invertivore populations;	Beach sand concentrations Tissue residues of possible food sources (*e.g.*, near-shore invertebrates, such as scuds) along beach, for input into food chain model (paired with beach sand samples) Observational counts to determine size of population in area Food chain modelling Consideration of bioaccessibility testing of beach sand and dietary items Literature studies discussing effects of COCs on similar avian species at other relevant sites	Predicted Exposure Ratios from food chain modelling (*i.e.*, comparison of estimated or measured COPC exposures via oral ingestion of beach sand and invertebrates to Toxicity Reference Values (TRVs). Observational counts Consider toxicological / biological information from other studies and extrapolate where applicable to this study

3.8 Summary of Data Gaps

Since the mid-1960s, Brunswick Smelter has amassed a substantial amount of information regarding the influences of its operations on marine environmental conditions in the vicinity of the smelter through implementation of numerous specialized investigative and environmental monitoring studies (Section 3.2). This information is directly relevant for identifying potential ecological risks to marine biota associated with current and on-going smelter operations as part of the Brunswick Smelter Marine ERA. However, during review of the available historical information, a number of data gaps were identified that require additional investigation to ensure a more complete understanding of potential environmental and biological effects and/or identification of risks to biota associated with the smelter operations. Specifically, additional information on the extent of smelter-related metal contamination of marine sediments, and influences of smelter operations on shellfish growth and condition, fish health, and avian receptors was considered important to quantifying effects and risks to biota of the Baie des Chaleurs in the vicinity of the Brunswick Smelter. Specific data gaps related to completion of the ERA include the following:

- Sediment metals data (last conducted in 2008; Minnow Environmental, 2009);
- Benthic Community Assessment (last conducted in 2008; Minnow Environmental, 2009);
- Surface water metals characterization data (conducted as part of the harbour dredging project; Gemtec, 2010, but data would have been affected by dredging activities, which are now complete);
- Benthic and pelagic fish metals data (last conducted opportunistically in 2010 on a limited number of samples, related to the potential re-location of the common tern colony);
- Cultured mussel study (conducted historically as part of Glencore EEM, but only examined tissue uptake, as opposed to growth and reproduction endpoints)
- Beach sand sampling (full ICP metals scan) (conducted as part of the Glencore EEM, but traditionally only analyzed for 4 or 5 metals/metalloids)
- Beach shore line invertebrate tissue sampling, which shore birds are foraging on
- Avian tissue residues (common tern). CWS permit SS2791 was obtained to collect salvaged tern chicks and eggs for metals residue analyses.

Accordingly, the objective of the ERA is to determine whether environmental conditions near the smelter are resulting in effects on the benthic community, shellfish, fish populations and/or avian receptors foraging in the marine environment. To meet provincial regulatory requirements, Brunswick Smelter is required to evaluate effects to marine sediment quality and benthic invertebrate communities near the smelter operation, and therefore meeting this requirement is included as an additional objective of the ERA Study.

The sampling plan used to address these gaps is presented in Section 4.0.

4.0 ERA STRATEGY AND SAMPLING PLAN

To address the data gaps identified in Section 3.9, the following Study Design was developed by Minnow Environmental, in consultation with Intrinsik. The data collected through this program will fit into the overall ERA, to enable an assessment of potential risks to the marine environment related to metals/metalloid releases associated with historic and on-going smelter operations.

The Brunswick Smelter 2014 ERA sampling program focused on five primary components, including sediment quality assessment, a benthic invertebrate community survey, a shellfish health assessment, a fish population survey, and avian receptor ERA support sampling, as well as supporting water quality and habitat measures required for data interpretation. Study areas, methodology, endpoints and study timing for each of these components are detailed in the sub-sections that follow.

This text has been revised (March 2015) to reflect the sampling that was undertaken in the field program.

4.1 Sediment Quality Assessment

The objective of the 2014 sediment quality assessment was to characterize marine sediment metal concentrations near the current smelter effluent discharge and, as part of the Brunswick Smelter's regulatory requirements, at the former fertilizer plant outfall as well. To provide improved spatial evaluation of any smelter-related influence to sediment of the Baie des Chaleurs, two sediment characterization transects were established beginning near the current smelter effluent discharge and extending to a distance of approximately 500 m offshore (Figure 4-1). One transect extended perpendicular to the shoreline (SST2), whereas the other extended at approximately 45° from the outfall location (SST1). Five sediment quality samples were collected at each transect, with as many as three additional samples collected and archived. Unfortunately, the samples from the transect SST1 were largely pea gravel, and hence that samples from that transect could not be sent for analysis. Transect sediment quality sampling was conducted in the in early October, 2014.

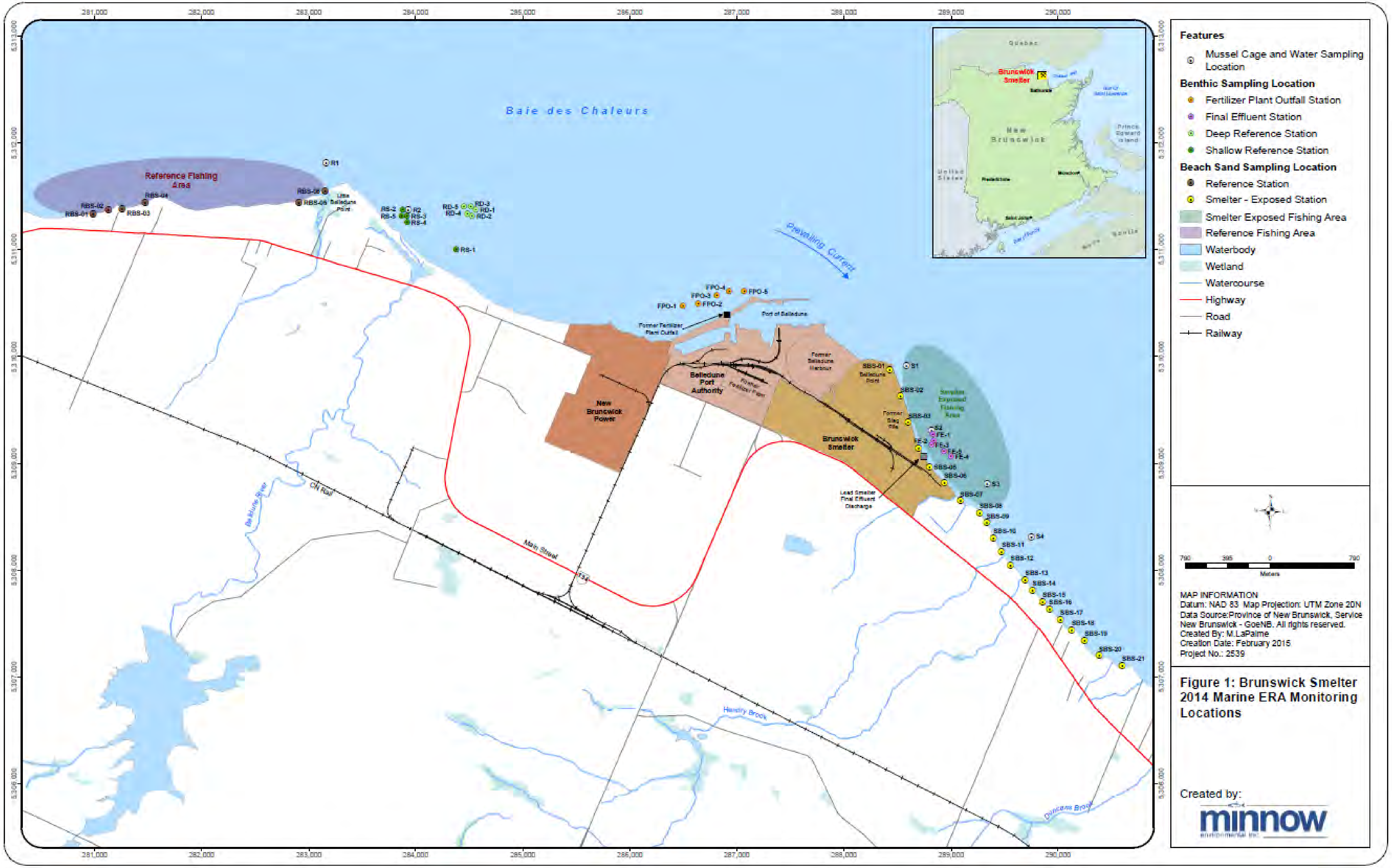

Figure 4-1 Sampling Locations for Sediment, Benthic Community, Fish, Beach Sand and Near-Shore Invertebrates

Sediment quality sampling was also undertaken concurrent with, and at the same locations as, benthic invertebrate community (benthic) sampling. Briefly, sediment was collected at the same five stations from each of the same four study areas used for benthic sampling (see Section 4.2; Figure 4-1). The sediment quality assessment used to support the benthic survey was conducted in early October, 2014.

4.1.1 Field Collection and Sample Processing

Sediment samples were collected using a standard Ponar sampler (0.052 m^2 sampling area). At each transect and benthic station, a composite sample was created by collecting the surficial three centimeters of sediment from each of two acceptable grabs (i.e., full to each edge of sampler) with a plastic spoon. The sediment from both acceptable grabs was thoroughly homogenized prior to placement into two separate, labelled 500 mL glass jars at each station. The samples were then placed in a cooler and later, upon return from the field, into a refrigerator for storage. Additional supporting sediment observations recorded at each station included sediment texture and colour, any unusual odour, and presence of algae or plants on or in the sediment. Sample quality control (QC) included the collection of field (split-sample) duplicates on a minimum of 10% of the total number of sediment samples collected to quantify field precision. Following program completion, all sediment samples were shipped to Research and Productivity Council in Fredericton, NB for analysis of total metals, total organic carbon (TOC) and sediment particle size using standard methods with detection limits below federal marine sediment quality criteria. At the laboratory, standard QC measures were applied to ensure analysis accuracy and precision acheived acceptable criteria.

4.1.2 Data Analysis

Sediment chemistry data collected at transect locations were plotted to allow visual assessment of the extent of smelter effluent-related influence in the Baie des Chaleurs. Based on the most recent EEM sampling, cadmium, lead and zinc concentrations may be used to identify the extent of any smelter-related influence on sediment quality. Sediment chemistry data were also evaluated relative to: 1) concentrations measured at reference areas; 2) Canadian Sediment Quality Guidelines for the protection of marine life (CSQG; CCME 2014); and, 3) historical data. Between benthic invertebrate community study areas, comparisons of sediment particle size, TOC and metal concentrations were compared using various statistical tests (e.g., Analysis-of-Variance [ANOVA], Principal Components Analysis [PCA], etc.), as appropriate, to evaluate any smelter-related effects. Sediment metal concentrations at each station were compared to CSQG Interim Sediment Quality Guidelines (ISQG) and Probable Effect Levels (PEL). To date, CSQG have been established only for arsenic, cadmium, chromium, copper, lead and zinc and therefore, these metals served as the focus for sediment metal chemistry comparisons. Historically, sediment cadmium, lead and zinc concentrations have been monitored as part of the Brunswick Smelter monitoring, and therefore a qualitative analysis of temporal trends based on mean concentrations of these metals over the period from 2004 to 2014 will be completed using visual analysis of plotted data.

4.2 Benthic Invertebrate Community Survey

The objective of the 2014 EEM benthic invertebrate community (benthic) survey was to evaluate any smelter-related effects on the marine bottom-dwelling invertebrate community. As indicated previously, the Brunswick Smelter has been monitoring the condition of benthic invertebrate communities in Belledune Harbour and the Baie des Chaleurs since 1965 to meet its provincial Certificate-of-Approval (C-of-A) requirements for effluent discharge. The 2014 EEM benthic invertebrate community (benthic) survey at Brunswick Smelter used the same study areas, methodology and endpoints as the most recent studies to provide consistency among studies, thereby facilitating determination of any changes in biological response near the smelter site over time. Briefly, the benthic survey utilized a Control-Impact approach, focusing on the evaluation of potential biological influences associated with the current (active) smelter discharge, as well as on the evaluation of biological recovery at the area historically influenced by the fertilizer plant discharge (i.e., the gypsum bed).

The 2014 EEM benthic survey focused on four study areas within the Baie des Chaleurs, including the immediate receiving environment for the active smelter discharge (i.e., effluent-exposed area, FE), an area historically influenced by the fertilizer plant discharge (FPO), and two reference areas located near Little Belledune Point (Figure 4-1). As in the past, shallow (RS) and deep (RD) reference areas were used for comparison to the effluent-exposed and former fertilizer plant outfall study areas, respectively, to minimize biological variability associated with differing sampling depth. Five stations were sampled at each area (Figure 4-1), which provided adequate statistical power to detect differences of ± two standard deviations at an α and β of 0.10 as recommended for EEM (Environment Canada 2012). To the extent possible, station locations at each area corresponded to those used previously, including historical long-term monitoring station locations. Habitat features (including tide-corrected sampling depth and substrate grain size properties) were carefully controlled during sampling to maintain consistency between paired study areas and stations in order to minimize natural influences on data variability. The Brunswick Smelter EEM benthic survey was conducted in early October 2014.

4.2.1 Sample Collection and Laboratory Analysis

Benthic samples were collected in areas dominated by coarse sand substrate using a stainless steel standard Ponar sampler (0.052 m^2). A single sample, consisting of a composite of three standard Ponar grabs (i.e., 0.157 m^2 total sampling area), was collected at each station with care taken to ensure that each grab was acceptable (i.e., grab captured the surface material and is full to each edge) and substrate characteristics and sampling depth were as comparable as possible within and among respective study areas. Any incomplete grabs were discarded. Each acceptable grab was field-sieved using 500-µm mesh with the retained material carefully transferred into a plastic sampling jar containing both external and internal station identification labels. All benthic samples were preserved to a level of 10% buffered formalin in ambient water. At each benthic station, supporting information including substrate description, sampling depth, general habitat notes (e.g., extent of marine vegetation, riparian features, surrounding land use, potential confounding influences, etc.), *in-situ* water quality at the sediment-water interface (including water temperature, dissolved oxygen, pH and salinity), Secchi depth, global positioning system (GPS) latitude-longitude coordinates, and any other information considered relevant to the interpretation of the benthic invertebrate community data, were recorded.

Benthic samples were submitted to Zeas Inc. (Nobleton, ON), which is a North American Benthological Society (NABS) certified laboratory, for processing using standard sorting methods that incorporate QA/QC measures (e.g., Environment Canada 2012). Sample material retained by the 500-µm mesh was examined under a stereomicroscope using a magnification of at least ten times. All benthic organisms were removed from the sample debris and placed into vials containing 70% ethanol by a technician. A senior taxonomist was used to enumerate and identify the benthic organisms to lowest practical level (typically genus or species) using up-to-date taxonomic keys.

4.2.2 Data Analysis

Benthic invertebrate communities were evaluated using endpoints traditionally used for EEM studies, including taxonomic richness (as identified to lowest practical level), invertebrate density (average number of organisms per m^2), Simpson's Evenness Index, Shannon-Wiener Diversity and the Bray-Curtis Index of Dissimilarity. Additional comparisons were also conducted using percent composition of dominant or indicator taxa (calculated as the abundance of each respective taxonomic group relative to the total number of organisms in the sample). All required and selected benthic invertebrate community endpoints were summarized by separately reporting mean, median, minimum, maximum, standard deviation, standard error and sample size for each study area.

The endpoints indicated above were compared statistically between the effluent-exposed and shallow reference areas, and separately between the fertilizer plant outfall and deep reference areas. Statistical analyses were preferentially conducted using univariate Analysis-of-Variance (ANOVA) tests. All data were assessed for normality and homogeneity of variance before conducting the ANOVA comparisons, with data transformed as required to satisfy the assumptions of ANOVA. If data significantly violated the assumption of normality following transformation, non-parametric statistics were applied. An effect on the benthic invertebrate community was defined as a statistically significant difference between the respective test and reference areas at an alpha level of 0.10, consistent with guidance recommended for EEM (Environment Canada 2012). All statistical analyses were described in detail in an interpretive report, including any transformations or alterations performed on the data. Lastly, temporal comparison of the 2014 benthic survey results was conducted to evaluate any changes since previous surveys conducted at the smelter.

4.3 Shellfish (Caged Mussel) Survey

The objective of the 2014 EEM shellfish survey was to evaluate any smelter-related effects on the health (i.e., survival, growth, condition) of blue mussel (*Mytilus edulis*) in the vicinity of the smelter in the Baie des Chaleurs. Although a number of historical studies conducted at the Brunswick Smelter have examined differences in native and introduced (i.e., cultured) blue mussel tissue metal accumulation near the site, these studies did not examine smelter influences on blue mussel growth and condition endpoints. Blue mussel represent a reasonable surrogate species for shellfish found in the area, in that they are reasonably sessile, and are known as excellent biomonitoring tools for environmental exposures in aquatic environments.

The Brunswick Smelter EEM shellfish survey employed a Multiple Control-Impact approach using caged mussels based on a design recommended for EEM (Andrews and Parker 1999, Environment Canada 2012). Caged mussels were deployed at four smelter-exposed stations, including one near Belledune Point to capture potential influences associated with Belledune Harbour and the former slag disposal area, and three at increasing distance from the smelter effluent discharge to evaluate cumulative effects associated with the effluent, potential releases from the former slag disposal area and other smelter influences (Figure 4-1). Caged mussels were also deployed at two reference stations located well up-gradient of the smelter, at Little Belledune Point (Figure 4-1). Standard methods for using caged mussels as biomonitoring tools recommend a 60 – 90 day exposure (Salazar et al. 1997, Environment Canada 2012), and therefore the EEM shellfish survey deployed the caged blue mussels in early August and retrieved them in mid-October, 2014. Details regarding test organism source, field survey methodology and data analysis area provided in the paragraphs that follow.

4.3.1 Mussel Source

Mussels were acquired from an Aquaculture Association of Canada approved supplier located within the Baie des Chaleurs. Ferme Maricole du Grand Large, a mussel farm located near Carleton (PQ) on the Baie des Chaleurs was used as a source for mussel stock. Blue mussels were hand collected from the farm to ensure relatively uniform size, in turn, reducing the effort and handling required for pre-sorting the mussels.

4.3.2 Methodology

Upon receipt from the supplier, the mussels were placed in mesh bags and kept on ice for transportation, cage preparation and cage loading. These measures were taken to minimize stress, preserve animal health and ensure the overall integrity of the animals. Briefly, six mussel cages, each containing 65 individually measured and weighed juvenile blue mussels measuring between 2.5 and 3.5 cm, were deployed in August. The mussel cages were square-shaped (1 m^2) and constructed of 1¼-inch diameter rigid polyvinylchloride (PVC) pipe, glued together to ensure durability. Mussels were held in mussel socks (10-cm diameter plastic mesh with 5-mm holes) attached to the cages and secured with plastic cable tie wraps. The mussel socks held 5 - 10 mussels, each of which was individually separated by constricting the mussel sock with a plastic tie wrap between each mussel but leaving enough space for growth (i.e., 8–10 cm between cable ties). Each mussel was assigned a unique identification number so that measurements of individual growth over the period of exposure could be tracked. Seven mussel socks were tied to the frame of each cage. The cages were moored in approximately 3 to 4 m of water, but the frame of the cage was positioned approximately 1 m below the surface at each station, thus eliminating variability associated with depth.

Evaluation of mussel growth and condition was completed using various physical measurements. Prior to deployment and following retrieval, measurements of shell length, width and height, weight (whole animal wet weight [WAWW]) and volume were conducted on each individual mussel. Length, WAWW and volume were measured using digital vernier calipers, an electronic balance, and graduated cylinder, respectively. At the time of retrieval, following these measurements, mussels were opened using a scalpel and the soma/gonad was removed using surgical tweezers. By definition, the soma tissue includes all mussel soft tissue minus the mantle/gonad, and because reproductive tissue development was minimal at the time of collection, the soft tissues are referred to as soma herein. Internal organs were also inspected for any abnormalities and if present, a description of the abnormality was recorded. Soma/gonad tissues and dry shells were weighed to the nearest 0.001 g using an electronic balance (wet soma and shell weight). Soma dry weights were obtained by taking the dissected tissue and placing in a drying oven at 70 ± 5 °C for 72 hours, followed by weighing at the end of the drying period.

Mussel tissue metal concentrations were evaluated before and after the exposure period to determine metal accumulation. Background tissue metal analyses were conducted on ten pre-exposure composite tissue samples, with soma tissue from five mussels included in each composite sample. Upon retrieval following the period of exposure, soma tissues from a sub-sample of five individual mussels were submitted to RPC laboratories for assessment of tissue metal concentrations with data provided in wet- and dry-weight formats.

4.3.3 Data Analysis

Endpoints used for the shellfish survey included survival and differences in length, WAWW, shell volume and dry soma weight (i.e., growth), condition (weight-at-length relationships), as well as tissue metal concentrations. These endpoints were summarized by separately calculating the mean, standard deviation, standard error, minimum, maximum and sample size by study area. Area differences in mean shell length, width and height, whole animal wet weight, dry soma weight and condition were compared using ANOVA or Analysis-of-Covariance (ANCOVA), as appropriate. All ANOVA and ANCOVA comparisons were evaluated at an alpha level of 0.10 consistent with standard EEM practice (Environment Canada 2012). Blue mussel tissue metal concentrations were compared between the smelter-exposed and reference area cages.

4.4 Fish Population Survey

The objective of the 2014 EEM fish population (fish) survey was to evaluate any smelter-related effects on the health (i.e., age structure, growth, reproduction) of a marine fish species in the vicinity of the smelter on the Baie des Chaleurs. The Brunswick Smelter EEM fish population survey employed a control-impact sampling design focused on comparing fish health endpoints between a near-field, smelter-influenced exposure area (smelter-exposed) and a reference area located up-current, near Little Belledune Point (Figure 4.1). The fish population survey targeted Atlantic tomcod (*Microgadus tomcod*), which is a relatively small-bodied, sedentary marine benthic-feeding fish species. This species was ideal for assessing population-based effects of the smelter operations on fish because individuals have a relatively small home-range size (ensures residency within the area of capture) and benthic invertebrates serve as their primary food source (e.g., linkages can potentially be drawn between sediment contamination and effects to benthic invertebrates and/or the fish population). Twenty sexually mature male and twenty sexually mature female Atlantic tomcod (tomcod) were targeted at each study area (i.e., at both the smelter-exposed area and reference area) for the EEM fish population survey. The fish population survey was conducted in early October 2014, at which time tomcod gonads were sufficiently (re)developed to allow assessment of reproductive health.

4.4.1 Fish Sampling and Processing

Gill nets were used to collect samples for the fish population survey. Information including gear specifications (e.g., mesh size, net length), set duration, sampling depth, GPS latitude-longitude coordinates and habitat descriptions were recorded for each gill net set. All captured fish were identified to species and enumerated, with all non-target fish and any immature sentinel fish released alive at the capture location, when possible. This information was used to allow relative comparisons of fish diversity and abundance between study areas.

Sexually mature tomcod were retained separately by study area in coolers packed with ice to ensure that tissues did not deteriorate before processing. All retained tomcod were transported to a dedicated field laboratory for processing as soon as practical (i.e., within hours) following capture. Measurements collected from each fish included total length, measured to the nearest millimeter using a standard measuring board, and weights, measured to the nearest decigram using an electronic balance. Ageing structures (otoliths and pectoral fin rays) were removed from each sacrificed fish, dried, and subsequently submitted to a qualified laboratory for age analysis. Whole gonads and livers were removed from all sexually-mature fish, with each organ then weighed to the nearest milligram (0.001 g) using an analytical balance with a surrounding draft shield. Ovary tissues were sampled from each sexually-mature female, preserved with 10% buffered formalin solution, and submitted to Zeas Inc. for fecundity and egg size determination. During processing, any observed internal abnormalities were recorded.

4.4.2 Data Analysis

All catch data were tabulated, with catch-per-unit-effort (CPUE) calculated for each study area and compared between study areas to evaluate any differences in fish community diversity and relative abundance. Fish measurement endpoints, including fish length, fresh body weight, age, gonad weight and liver weight were summarized by separately calculating the mean, standard deviation, standard error, minimum, maximum and sample size by study area (effluent-exposed and reference) and sex (male and female). These variables were used to evaluate endpoints associated with survival, energy use (growth and reproduction) and energy storage between the smelter-exposed and reference fish populations. All data sets were assessed for normality and equality of variance in order to determine the suitability of parametric statistical procedures. If data significantly violate the assumption of normality following transformation, non-parametric statistics will be applied. For each of the calculated endpoints, statistical differences between smelter-exposed and reference study areas (by fish sex) were made using ANOVA, Mann-Whitney U-tests or ANCOVA as appropriate following general guidance (Environment Canada 2012). An effect on the fish population was evaluated for each of the calculated EEM endpoints, and defined as a statistically significant difference between the effluent-exposed area and the reference area at an alpha level of 0.10 (Environment Canada 2012).

4.5 Avian Receptor ERA Support Survey

Common terns (*Sterna hirundo*) and shorebirds such as the spotted sandpiper (*Actitis macularius*), commonly use the Brunswick Smelter site, the shoreline area east of the smelter, and the offshore environment, as nesting and/or foraging habitat. The objective of the 2014 EEM avian receptor ERA support sampling was to provide quantitative data from which to evaluate potential risks of smelter-related activity on ecological health of piscivorous or invertivorous birds that may use the Brunswick Smelter site to complete important aspects of their life cycle. The avian receptor ERA support survey included three main components: 1) pelagic fish tissue metals evaluation; 2) beach sand metals concentration evaluation; and, 3) shoreline invertebrate tissue metals evaluation.

4.5.1 Fish Tissue Metal Concentration Evaluation

The objective of the pelagic fish tissue metal concentration evaluation was to determine whole body tissue metal concentrations of pelagic fish that are likely to be consumed by common tern. Field sampling for this study component was conducted in early August 2014, corresponding to the seasonal timing in which common tern are foraging near the smelter to provide for their recently hatched chicks. Study areas for the evaluation included the same near-field smelter-exposed area and Little Belledune Point reference area used for the fish population survey (Figure 4-1). Observations of common tern foraging at the Brunswick Smelter site indicated that the birds normally capture fish within approximately 150 – 400 m from shore (see Figure 3-12), and therefore beach seining was used to capture fish at each study area. Two fish species, Atlantic herring (*Clupea harengus*), which is more pelagic in terms of feeding, and sand lance (*Ammodytes* sp.), which is more of a benthic feeder, were abundant at both the smelter-exposed and reference study areas and thus, served as sentinel species for the fish tissue metal concentration evaluation. Measurements of length and weight taken from each herring and sand lance used for the evaluation. The target length of the fish used for sampling was 5 – 10 cm, which is the size normally consumed by common tern. Up to 10 samples for each species were collected at each study area, each representing a composite of from 3 – 12 fish to meet minimum sample volumes to allow reasonable detection limits at the laboratory. Each composite fish tissue sample was packaged separately, frozen, and submitted to RPC laboratories in Fredericton, NB for whole-body tissue analysis to determine total metal concentrations. Data analysis included comparison of tissue metals between the smelter-exposed and reference study areas. In addition, the data were used for modeling of potential effects of metals on a piscivorous avian receptor (e.g., common tern) as part of the marine ERA.

4.5.2 Beach Sand Metal Concentration Evaluation

The objective of the beach sand metal concentration evaluation was to determine metal concentrations of shoreline material that shorebirds may be exposed to near the smelter in order to support the avian receptor ERA. Beach sand samples were collected at 21 smelter-exposed area stations, corresponding to the intertidal area of same areas targeted for deployment of caged mussels, and incorporating some long standing stations used for Environmental Effects Monitoring by Glencore over the past several decades (i.e., Stations 1E, 2E, and 3E; Figure 4-1).

Six reference stations, located at Little Belledune Point were used to evaluate differences in beach sand metal concentrations. Beach sand sampling was undertaken concurrent with, and at the same locations as, shoreline invertebrate tissue sampling (see below) in early October, 2014.

At each station, replicate beach sand samples were collected at three heights within the intertidal zone, including near the low and high tide marks and approximately at the mid-tide level. Intertidal level of each replicate sample was determined by measuring the difference between the water line and sampling location using a string-line level and measuring tape, with tide tables then used to calculate the sampling height within the intertidal zone. At each replicate beach sand station, a 15 cm^2 imprint was created using a wooden template, and a stainless steel spoon was then used to collect the surficial three centimeters of beach sand into a white tub. Once beach sand from all three replicates had been placed into the tub, the sample was homogenized and subsequently dispensed into a labelled 1,000 mL sealable plastic bag. Additional supporting beach sand observations recorded at each station included sediment texture and colour, any unusual odour, and any smelter-related material (e.g., slag particles) on or in the sediment. Sample quality control (QC) included the collection of field (split-sample) duplicates on a minimum of 10% of the total number of beach sand samples. Following program completion, beach sand samples were shipped to RPC (Fredericton, NB) for analysis of total metals using standard methods. At the laboratory, standard QC measures were applied to ensure analysis accuracy and precision achieved acceptable criteria. Beach sand chemistry data was assessed statistically against reference data, and spatially, relative to soil quality guidelines (for determination of possible COCs for avian receptor modelling). The metals identified as potential COCs were included in modeling of potential effects of metals on a shorebird receptor as part of the marine ERA.

In addition, bioaccessibility testing of beach sand samples was undertaken, as beach sand is ingested by shorebirds in their foraging, and metals within the sand will likely not be 100% available upon ingestion. Protocols for bioaccessibility testing for avian species have been developed and used in lead contaminated sites previously (e.g., Bennett et al, 2007; Kaufman et al, 2007), and a protocol developed by the Environmental Sciences Group, Royal Military College of Canada, Kingston, ON was employed in the current study.

4.5.3 Shoreline Invertebrate Tissue Metal Concentration Evaluation

The objective of the shoreline invertebrate tissue metal concentration evaluation was to provide whole body tissue metal concentrations of shoreline invertebrates that are likely to be consumed by shoreline wading birds (such as spotted sandpiper) to support the avian receptor ERA. This evaluation focused on the collection of invertebrates likely to be consumed by shorebirds in the smelter vicinity, including various crustaceans (e.g., amphipods, decapods) and polychaete worms. Shoreline invertebrate tissue samples were collected at 17 of the 21 smelter-exposed stations used for beach sand sampling, as well as the same six reference stations used for beach sand sampling (Figure 4-1). Field sampling for this study component was conducted in early October 2014, at the same time as beach sand sampling.

Shoreline invertebrate samples were collected using kick-and-sweep sampling of beach areas near the waterline near the time of low tide. The kick-and-sweep samples were collected using a triangular kick net (36 cm base; 510 cm^2 aperture) outfitted with 400 µm mesh using standard methods (e.g., Environment Canada 2010). During sampling, beach sand, detritus and invertebrates were disturbed using the sampler's feet, after which the net was passed through the disturbed area to collect the displaced material. This material was placed into a white tub and shoreline invertebrates were picked free of the debris by eye to create a composite invertebrate tissue sample. Benthic invertebrates selected for use as part of the composite sample were identified to taxonomic group and qualitatively assessed as to the relative proportion that each taxonomic group contributed to the sample. Once a suitable mass of invertebrate tissue was acquired, the composite shoreline invertebrate tissue sample was placed in a polyethylene bag, put on ice, and later frozen. Frozen samples will be shipped to RPC (Fredericton, NB) where samples were analyzed for total metals, with results provided in mg/kg dry-weight (dw) units and moisture content reported to allow conversion to a wet-weight (ww) basis, if required. Shoreline invertebrate tissue metals data were examined for spatial patterns with distance from the smelter, with additional statistical analysis conducted among areas for key metals. In addition, the data were used for modeling of potential effects of metals on a shorebird receptor as part of the marine ERA.

4.5.4 Common Tern Salvage Sampling CWS Permit SS2791

As part of the assessment of potential risk for the common tern, a salvage permit was obtained from CWS to collect salvage chicks and eggs which have been rejected from nests during the nesting period of 2014. Natural mortalities occur, and the purpose of this project is to salvage natural mortalities, and measure metal levels in internal organs (liver and kidney), or in dead eggs, to gather information/data related to systemic exposure levels. The chick samples were collected with limited to no disturbance to nests, and placed in plastic vials and frozen. Eggs found outside of nests were collected, rinsed in de-ionized water (to remove dust or dirt), opened and contents emptied into a plastic vial or container, labelled and frozen. The samples were transported to RPC Analytical Laboratory in Fredericton NB, for weighing, dissection of liver and kidney, and trace metals analysis of these internal organs, or egg contents (no shell, as it may contain adhered lead particles). Percent moisture of tissues was measured, where there was adequate tissue.

Data were interpreted based on available literature from other sites, as well as tissue residue compilations, such as Beyer and Meador (2011).

4.5.5 Observational Shoreline Avian Survey

A walking observational survey of the shoreline along Belledune Point was conducted periodically through July and August to gather additional information related to species foraging in the marine environment. Where possible, observations related to nests, egg counts, or presence and number of fledglings, were gathered through distance observations.

4.6 Supporting Water Quality Assessment

Additional environmental information used to support the benthic invertebrate community, caged mussel and fish population surveys during the EEM biological field program included water quality assessment. The Brunswick Smelter EEM water quality assessment included *in-situ* (field) water quality measures and water sample collection for laboratory analysis. *In-situ* water temperature, dissolved oxygen, pH and salinity measurements were collected from all benthic invertebrate, caged mussel and fish population survey study areas as part of vertical profiles and/or as a supporting spot measures. One *in-situ* water quality vertical profile was conducted at 1 m intervals at each of the four benthic invertebrate community study areas. In addition, each *in-situ* measures was assessed at the surface (i.e., 30 cm below water surface) and at the bottom (i.e., approximately 30 cm above the sediment-water interface) of the water column at each benthic invertebrate community station, at each caged mussel station during deployment and retrieval of the cages, and at each fish population sampling area during the field fish collections. Additional supporting observations regarding water colour and clarity, together with Secchi depth measurement, were recorded at all vertical profile and benthic stations. Vertical profile data were plotted and assessed for any thermal, dissolved oxygen and/or salinity differences among study areas. *In-situ* water quality data collected near the bottom of the water column at benthic and caged mussel stations were compared statistically compared between test site and reference study areas using appropriate tests and following any applicable data transformation to satisfy statistical test assumptions. All vertical profile and benthic station dissolved oxygen and pH data were also compared to applicable federal guidelines for the protection of marine life (i.e., CCME 2014).

Water samples for chemical analysis were collected at each caged mussel station during the summer and fall field survey. Two water samples were collected from approximately mid-column at each station using a horizontally-oriented β-bottle, at each sampling interval. Water samples were preserved as required, maintained cool, and shipped to RPC (Fredericton, NB) for analysis of nutrients (e.g., total phosphorus and total nitrogen) and total metals (including arsenic, cadmium, copper, iron, lead, nickel and zinc) using standard analytical procedures. Quality assurance and quality control (QA/QC) for water sampling included the collection and analysis of field duplicates (on 10% of samples), as well as assessment of laboratory duplicates, spike recoveries and blank analyses. Water chemistry data were compared among test sites and reference areas, and to applicable federal water quality guidelines (CCME 2014).

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APPENDIX B

ANALYTICAL RESULTS

Report ID: 180551-IAS
Report Date: 17-Dec-14
Date Received: 12-Nov-14

CERTIFICATE OF ANALYSIS

for
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Attention: Christine Moore

Project #: MINNOW 2539

Location: New Brunswick

Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-30	180551-30 Dup	180551-31
Client Sample ID:			FPO-1	Lab Duplicate	FPO-2
Date Sampled:			9-Oct-14	9-Oct-14	9-Oct-14
Analytes	**Units**	**RL**			
Carbon - Total Organic	%	0.1	1.3	1.3	0.7

This report relates only to the sample(s) and information provided to the laboratory.

RL = Reporting Limit

Ross Kean

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Inorganic Analytical Chemistry

Peter Crowhurst, B.Sc., C.Chem
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Attention: Christine Moore

Project #: MINNOW 2539

Location: New Brunswick

Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-32	180551-33	180551-34
Client Sample ID: Date Sampled:			FPO-3 7-Oct-14	FPO-4 6-Oct-14	FPO-5 6-Oct-14
Analytes	**Units**	**RL**			
Carbon - Total Organic	%	0.1	0.2	< 0.1	0.1

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Project #: MINNOW 2539

Location: New Brunswick

Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-35	180551-36	180551-37
Client Sample ID:			FE-1	FE-2	FE-3
Date Sampled:			9-Oct-14	10-Oct-14	6-Oct-14
Analytes	**Units**	**RL**			
Carbon - Total Organic	%	0.1	0.3	0.4	0.5

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Location: New Brunswick

Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-38	180551-39	180551-40
Client Sample ID: Date Sampled:			FE-4 6-Oct-14	FE-5 6-Oct-14	RS-1 7-Oct-14
Analytes	**Units**	**RL**			
Carbon - Total Organic	%	0.1	0.4	0.3	0.4

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Location: New Brunswick

Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-40 Dup	180551-41	180551-42
Client Sample ID:			Lab Duplicate	RS-2	RS-3
Date Sampled:			7-Oct-14	8-Oct-14	9-Oct-14
Analytes	**Units**	**RL**			
Carbon - Total Organic	%	0.1	0.4	0.6	0.5

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Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-43	180551-44	180551-45
Client Sample ID: Date Sampled:			RS-4 9-Oct-14	RS-5 9-Oct-14	RD-1 9-Oct-14
Analytes	**Units**	**RL**			
Carbon - Total Organic	%	0.1	0.4	0.6	0.4

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Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-46	180551-47	180551-48
Client Sample ID:			RD-2	RD-3	RD-4
Date Sampled:			9-Oct-14	9-Oct-14	9-Oct-14
Analytes	**Units**	**RL**			
Carbon - Total Organic	%	0.1	0.5	0.3	0.4

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Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-49	180551-50	180551-50 Dup
Client Sample ID:			RD-5	BD-1	Lab Duplicate
Date Sampled:			9-Oct-14	6-Oct-14	6-Oct-14
Analytes	**Units**	**RL**			
Carbon - Total Organic	%	0.1	0.4	0.4	0.4

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Location: New Brunswick

Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-51
Client Sample ID: Date Sampled:			BD-2 6-Oct-14
Analytes	**Units**	**RL**	
Carbon - Total Organic	%	0.1	< 0.1

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Attention: Christine Moore

Project #: MINNOW 2539

Location: New Brunswick

Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-30	180551-31	180551-32
Client Sample ID: Date Sampled:			FPO-1 9-Oct-14	FPO-2 9-Oct-14	FPO-3 7-Oct-14
Analytes	**Units**	**RL**			
PHI -2 (4mm)	% Finer	0.1	97.7	88.1	76.2
PHI -1 (2 mm)	% Finer	0.1	95.6	84.2	62.8
PHI 0 (1 mm)	% Finer	0.1	94.3	81.6	51.1
PHI 1 (0.5 mm)	% Finer	0.1	93.3	79.1	44.8
PHI 2 (0.25 mm)	% Finer	0.1	91.8	75.6	32.6
PHI 3 (0.125 mm)	% Finer	0.1	75.6	51.8	13.6
PHI 4 (62.5 µm)	% Finer	0.1	27.5	14.5	8.3
PHI 5 (31.25 µm)	% Finer	0.1	19.3	9.6	7.1
PHI 6 (15.6 µm)	% Finer	0.1	15.2	7.2	3.4
PHI 7 (7.8 µm)	% Finer	0.1	10.1	4.1	0.4
PHI 8 (3.9 µm)	% Finer	0.1	4.3	1.7	0.3
PHI 9 (1.9 µm)	% Finer	0.1	1.3	0.5	< 0.1
Gravel	%	0.1	4.4	15.8	37.2
Sand	%	0.1	68.1	69.7	54.5
Silt	%	0.1	23.1	12.8	8.0
Clay	%	0.1	4.3	1.7	0.3

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Project #: MINNOW 2539

Location: New Brunswick

Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-33	180551-34	180551-35
Client Sample ID:			FPO-4	FPO-5	FE-1
Date Sampled:			6-Oct-14	6-Oct-14	9-Oct-14
Analytes	**Units**	**RL**			
PHI -2 (4mm)	% Finer	0.1	97.1	100.	91.7
PHI -1 (2 mm)	% Finer	0.1	95.3	100.	83.8
PHI 0 (1 mm)	% Finer	0.1	92.6	99.7	77.0
PHI 1 (0.5 mm)	% Finer	0.1	90.0	97.9	71.6
PHI 2 (0.25 mm)	% Finer	0.1	81.5	43.4	66.2
PHI 3 (0.125 mm)	% Finer	0.1	63.3	4.1	19.4
PHI 4 (62.5 µm)	% Finer	0.1	43.3	0.6	1.9
PHI 5 (31.25 µm)	% Finer	0.1	34.4	1.2	1.4
PHI 6 (15.6 µm)	% Finer	0.1	5.6	1.1	1.3
PHI 7 (7.8 µm)	% Finer	0.1	0.6	1.3	1.2
PHI 8 (3.9 µm)	% Finer	0.1	0.5	1.1	1.1
PHI 9 (1.9 µm)	% Finer	0.1	< 0.1	0.2	0.7
Gravel	%	0.1	4.7	< 0.1	16.2
Sand	%	0.1	52.1	99.4	81.8
Silt	%	0.1	42.8	< 0.1	0.8
Clay	%	0.1	0.5	1.1	1.1

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Attention: Christine Moore

Project #: MINNOW 2539

Location: New Brunswick

Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-36	180551-37	180551-38
Client Sample ID: Date Sampled:			FE-2 10-Oct-14	FE-3 6-Oct-14	FE-4 6-Oct-14
Analytes	**Units**	**RL**			
PHI -2 (4mm)	% Finer	0.1	97.7	99.0	100.
PHI -1 (2 mm)	% Finer	0.1	95.0	98.3	100.
PHI 0 (1 mm)	% Finer	0.1	92.7	97.3	99.8
PHI 1 (0.5 mm)	% Finer	0.1	90.5	96.2	99.0
PHI 2 (0.25 mm)	% Finer	0.1	85.6	87.7	79.4
PHI 3 (0.125 mm)	% Finer	0.1	21.1	18.6	15.1
PHI 4 (62.5 µm)	% Finer	0.1	2.3	3.2	2.3
PHI 5 (31.25 µm)	% Finer	0.1	1.8	2.7	1.8
PHI 6 (15.6 µm)	% Finer	0.1	1.4	2.2	1.6
PHI 7 (7.8 µm)	% Finer	0.1	1.2	1.8	1.4
PHI 8 (3.9 µm)	% Finer	0.1	1.3	1.7	1.3
PHI 9 (1.9 µm)	% Finer	0.1	1.0	1.3	0.9
Gravel	%	0.1	5.0	1.7	< 0.1
Sand	%	0.1	92.7	95.1	97.7
Silt	%	0.1	1.1	1.5	1.0
Clay	%	0.1	1.3	1.7	1.3

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Location: New Brunswick

Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-39	180551-40	180551-41
Client Sample ID:			FE-5	RS-1	RS-2
Date Sampled:			6-Oct-14	7-Oct-14	8-Oct-14
Analytes	**Units**	**RL**			
PHI -2 (4mm)	% Finer	0.1	100.	98.8	98.7
PHI -1 (2 mm)	% Finer	0.1	98.7	98.3	97.3
PHI 0 (1 mm)	% Finer	0.1	96.7	97.4	93.7
PHI 1 (0.5 mm)	% Finer	0.1	94.9	95.9	90.0
PHI 2 (0.25 mm)	% Finer	0.1	71.4	92.3	86.1
PHI 3 (0.125 mm)	% Finer	0.1	7.3	45.5	24.8
PHI 4 (62.5 µm)	% Finer	0.1	1.4	2.4	5.4
PHI 5 (31.25 µm)	% Finer	0.1	1.2	1.8	4.1
PHI 6 (15.6 µm)	% Finer	0.1	1.1	1.4	3.3
PHI 7 (7.8 µm)	% Finer	0.1	1.1	1.2	2.5
PHI 8 (3.9 µm)	% Finer	0.1	1.0	1.2	2.1
PHI 9 (1.9 µm)	% Finer	0.1	0.6	1.0	1.8
Gravel	%	0.1	1.3	1.7	2.7
Sand	%	0.1	97.4	95.9	91.9
Silt	%	0.1	0.4	1.2	3.2
Clay	%	0.1	1.0	1.2	2.1

Report ID: 180551-IAS
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Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-42	180551-43	180551-44
Client Sample ID:			RS-3	RS-4	RS-5
Date Sampled:			9-Oct-14	9-Oct-14	9-Oct-14
Analytes	**Units**	**RL**			
PHI -2 (4mm)	% Finer	0.1	99.4	100.	100.
PHI -1 (2 mm)	% Finer	0.1	97.1	100.	100.
PHI 0 (1 mm)	% Finer	0.1	94.0	99.5	99.7
PHI 1 (0.5 mm)	% Finer	0.1	91.5	98.7	99.1
PHI 2 (0.25 mm)	% Finer	0.1	88.2	96.9	97.6
PHI 3 (0.125 mm)	% Finer	0.1	29.0	29.5	38.9
PHI 4 (62.5 µm)	% Finer	0.1	5.3	3.4	5.3
PHI 5 (31.25 µm)	% Finer	0.1	3.9	2.7	4.1
PHI 6 (15.6 µm)	% Finer	0.1	3.2	2.3	3.3
PHI 7 (7.8 µm)	% Finer	0.1	2.4	1.9	2.5
PHI 8 (3.9 µm)	% Finer	0.1	2.4	1.8	2.4
PHI 9 (1.9 µm)	% Finer	0.1	1.5	1.2	1.8
Gravel	%	0.1	2.9	< 0.1	< 0.1
Sand	%	0.1	91.8	96.6	94.7
Silt	%	0.1	2.9	1.7	2.9
Clay	%	0.1	2.4	1.8	2.4

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Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-45	180551-46	180551-47
Client Sample ID:			RD-1	RD-2	RD-3
Date Sampled:			9-Oct-14	9-Oct-14	9-Oct-14
Analytes	**Units**	**RL**			
PHI -2 (4mm)	% Finer	0.1	99.6	97.9	97.7
PHI -1 (2 mm)	% Finer	0.1	98.3	90.7	96.3
PHI 0 (1 mm)	% Finer	0.1	96.9	81.2	94.1
PHI 1 (0.5 mm)	% Finer	0.1	94.1	73.5	90.6
PHI 2 (0.25 mm)	% Finer	0.1	87.6	69.4	83.1
PHI 3 (0.125 mm)	% Finer	0.1	10.1	16.1	9.3
PHI 4 (62.5 µm)	% Finer	0.1	3.7	6.8	2.9
PHI 5 (31.25 µm)	% Finer	0.1	3.1	5.8	2.4
PHI 6 (15.6 µm)	% Finer	0.1	2.5	5.0	1.9
PHI 7 (7.8 µm)	% Finer	0.1	2.1	3.8	1.8
PHI 8 (3.9 µm)	% Finer	0.1	2.0	3.3	1.8
PHI 9 (1.9 µm)	% Finer	0.1	1.7	1.5	1.5
Gravel	%	0.1	1.7	9.3	3.7
Sand	%	0.1	94.6	83.9	93.4
Silt	%	0.1	1.7	3.5	1.1
Clay	%	0.1	2.0	3.3	1.8

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Location: New Brunswick

Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-48	180551-49
Client Sample ID: Date Sampled:			RD-4 9-Oct-14	RD-5 9-Oct-14
Analytes	**Units**	**RL**		
PHI -2 (4mm)	% Finer	0.1	95.3	64.1
PHI -1 (2 mm)	% Finer	0.1	87.8	43.5
PHI 0 (1 mm)	% Finer	0.1	80.1	22.4
PHI 1 (0.5 mm)	% Finer	0.1	74.3	9.1
PHI 2 (0.25 mm)	% Finer	0.1	70.3	5.9
PHI 3 (0.125 mm)	% Finer	0.1	13.8	3.9
PHI 4 (62.5 µm)	% Finer	0.1	5.2	3.2
PHI 5 (31.25 µm)	% Finer	0.1	4.2	2.8
PHI 6 (15.6 µm)	% Finer	0.1	3.6	2.4
PHI 7 (7.8 µm)	% Finer	0.1	2.7	1.6
PHI 8 (3.9 µm)	% Finer	0.1	2.5	1.5
PHI 9 (1.9 µm)	% Finer	0.1	1.8	1.0
Gravel	%	0.1	12.2	56.5
Sand	%	0.1	82.6	40.3
Silt	%	0.1	2.7	1.7
Clay	%	0.1	2.5	1.5

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Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-01	180551-01 Dup	180551-02
Client Sample ID:			SBS-1	Lab Duplicate	SBS-2
Date Sampled:			8-Oct-14	8-Oct-14	8-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	13300	13200	13700
Antimony	mg/kg	0.1	5.9	2.8	12.3
Arsenic	mg/kg	1	150	83	400
Barium	mg/kg	1	75	46	209
Beryllium	mg/kg	0.1	0.5	0.5	0.6
Bismuth	mg/kg	1	1	< 1	5
Boron	mg/kg	1	8	7	12
Cadmium	mg/kg	0.01	7.80	3.63	19.4
Calcium	mg/kg	50	13800	11000	33600
Chromium	mg/kg	1	37	41	51
Cobalt	mg/kg	0.1	37.1	25.4	83.5
Copper	mg/kg	1	298	194	926
Iron	mg/kg	20	46700	34200	96600
Lead	mg/kg	0.1	3260	1760	9330
Lithium	mg/kg	0.1	19.0	19.6	16.7
Magnesium	mg/kg	10	11400	10800	9440
Manganese	mg/kg	1	446	353	586
Mercury	mg/kg	0.01	< 0.01	< 0.01	0.01
Molybdenum	mg/kg	0.1	3.8	2.6	12.1
Nickel	mg/kg	1	33	38	31
Potassium	mg/kg	20	1240	1200	1310
Rubidium	mg/kg	0.1	7.3	6.8	7.0
Selenium	mg/kg	1	1	< 1	4
Silver	mg/kg	0.1	0.2	0.2	1.1
Sodium	mg/kg	50	1280	1230	1820
Strontium	mg/kg	1	27	26	59
Tellurium	mg/kg	0.1	0.1	< 0.1	0.4
Thallium	mg/kg	0.1	2.0	2.2	3.5
Tin	mg/kg	1	54	26	164
Uranium	mg/kg	0.1	0.6	0.6	1.0
Vanadium	mg/kg	1	48	44	53
Zinc	mg/kg	1	11400	6400	35600

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Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-03	180551-04	180551-05
Client Sample ID: Date Sampled:			SBS-3 8-Oct-14	SBS-4 8-Oct-14	SBS-5 12-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	13600	14800	15200
Antimony	mg/kg	0.1	10.9	4.2	11.9
Arsenic	mg/kg	1	284	96	325
Barium	mg/kg	1	165	38	196
Beryllium	mg/kg	0.1	0.6	0.5	0.7
Bismuth	mg/kg	1	5	2	5
Boron	mg/kg	1	10	6	12
Cadmium	mg/kg	0.01	12.5	7.46	19.5
Calcium	mg/kg	50	28200	8810	35900
Chromium	mg/kg	1	48	57	50
Cobalt	mg/kg	0.1	68.6	25.1	89.9
Copper	mg/kg	1	783	168	999
Iron	mg/kg	20	84000	36300	102000
Lead	mg/kg	0.1	7300	1830	8730
Lithium	mg/kg	0.1	17.4	20.4	18.8
Magnesium	mg/kg	10	10100	12800	10900
Manganese	mg/kg	1	597	403	577
Mercury	mg/kg	0.01	0.01	0.02	0.03
Molybdenum	mg/kg	0.1	10.3	1.9	13.7
Nickel	mg/kg	1	25	38	29
Potassium	mg/kg	20	1260	1280	1470
Rubidium	mg/kg	0.1	6.3	7.6	7.0
Selenium	mg/kg	1	3	< 1	4
Silver	mg/kg	0.1	1.5	1.1	2.0
Sodium	mg/kg	50	1620	1680	1800
Strontium	mg/kg	1	53	22	61
Tellurium	mg/kg	0.1	0.2	< 0.1	0.4
Thallium	mg/kg	0.1	3.2	33.0	13.8
Tin	mg/kg	1	119	20	146
Uranium	mg/kg	0.1	0.9	0.5	1.0
Vanadium	mg/kg	1	50	54	52
Zinc	mg/kg	1	28400	5570	36700

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Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-06	180551-07	180551-08
Client Sample ID: Date Sampled:			SBS-6 12-Oct-14	SBS-7 12-Oct-14	SBS-8 12-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	12500	15200	12100
Antimony	mg/kg	0.1	8.9	3.1	0.1
Arsenic	mg/kg	1	207	76	11
Barium	mg/kg	1	131	46	20
Beryllium	mg/kg	0.1	0.5	0.5	0.4
Bismuth	mg/kg	1	30	4	< 1
Boron	mg/kg	1	10	6	5
Cadmium	mg/kg	0.01	10.9	5.32	0.33
Calcium	mg/kg	50	34100	18500	27000
Chromium	mg/kg	1	40	40	34
Cobalt	mg/kg	0.1	56.8	30.8	11.0
Copper	mg/kg	1	857	248	12
Iron	mg/kg	20	68600	41700	18300
Lead	mg/kg	0.1	19600	1910	64.9
Lithium	mg/kg	0.1	16.1	20.7	16.0
Magnesium	mg/kg	10	9310	12900	11100
Manganese	mg/kg	1	490	456	301
Mercury	mg/kg	0.01	0.02	0.01	< 0.01
Molybdenum	mg/kg	0.1	7.4	2.9	0.2
Nickel	mg/kg	1	25	36	30
Potassium	mg/kg	20	1200	920	740
Rubidium	mg/kg	0.1	6.4	4.7	3.8
Selenium	mg/kg	1	2	< 1	< 1
Silver	mg/kg	0.1	0.9	0.5	< 0.1
Sodium	mg/kg	50	2050	1540	1880
Strontium	mg/kg	1	47	32	40
Tellurium	mg/kg	0.1	0.9	0.2	< 0.1
Thallium	mg/kg	0.1	6.0	3.5	0.7
Tin	mg/kg	1	97	29	< 1
Uranium	mg/kg	0.1	0.7	0.4	0.3
Vanadium	mg/kg	1	47	61	47
Zinc	mg/kg	1	22900	7100	109

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Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-09	180551-10	180551-11
Client Sample ID: Date Sampled:			SBS-9 12-Oct-14	SBS-10 12-Oct-14	SBS-11 12-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	14000	16200	14500
Antimony	mg/kg	0.1	< 0.1	< 0.1	0.2
Arsenic	mg/kg	1	16	14	25
Barium	mg/kg	1	35	19	15
Beryllium	mg/kg	0.1	0.4	0.4	0.4
Bismuth	mg/kg	1	< 1	< 1	< 1
Boron	mg/kg	1	5	4	5
Cadmium	mg/kg	0.01	0.24	0.23	0.28
Calcium	mg/kg	50	22200	16600	25200
Chromium	mg/kg	1	41	53	51
Cobalt	mg/kg	0.1	13.2	15.1	13.3
Copper	mg/kg	1	17	18	17
Iron	mg/kg	20	22800	24900	23200
Lead	mg/kg	0.1	59.6	45.5	90.2
Lithium	mg/kg	0.1	16.3	19.1	18.1
Magnesium	mg/kg	10	12800	15400	13400
Manganese	mg/kg	1	352	426	377
Mercury	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Molybdenum	mg/kg	0.1	< 0.1	0.1	0.2
Nickel	mg/kg	1	34	43	41
Potassium	mg/kg	20	730	890	780
Rubidium	mg/kg	0.1	3.8	4.8	4.2
Selenium	mg/kg	1	< 1	< 1	< 1
Silver	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Sodium	mg/kg	50	1640	1830	1720
Strontium	mg/kg	1	32	33	40
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	0.5	0.6	0.5
Tin	mg/kg	1	< 1	< 1	< 1
Uranium	mg/kg	0.1	0.3	0.3	0.3
Vanadium	mg/kg	1	52	60	54
Zinc	mg/kg	1	101	110	246

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Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-11 Dup	180551-12	180551-13
Client Sample ID:			Lab Duplicate	SBS-12	SBS-13
Date Sampled:			12-Oct-14	12-Oct-14	12-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	14300	15000	14000
Antimony	mg/kg	0.1	< 0.1	0.1	0.1
Arsenic	mg/kg	1	13	13	20
Barium	mg/kg	1	20	15	11
Beryllium	mg/kg	0.1	0.4	0.4	0.4
Bismuth	mg/kg	1	< 1	< 1	< 1
Boron	mg/kg	1	4	5	4
Cadmium	mg/kg	0.01	0.24	0.27	0.47
Calcium	mg/kg	50	19500	17000	32100
Chromium	mg/kg	1	50	37	40
Cobalt	mg/kg	0.1	12.8	14.0	12.3
Copper	mg/kg	1	13	14	14
Iron	mg/kg	20	21400	24500	20300
Lead	mg/kg	0.1	57.9	51.2	45.2
Lithium	mg/kg	0.1	16.7	19.0	16.2
Magnesium	mg/kg	10	12900	13600	12300
Manganese	mg/kg	1	353	373	362
Mercury	mg/kg	0.01	< 0.01	0.01	< 0.01
Molybdenum	mg/kg	0.1	0.1	0.2	0.1
Nickel	mg/kg	1	36	35	35
Potassium	mg/kg	20	750	800	860
Rubidium	mg/kg	0.1	4.3	4.3	5.1
Selenium	mg/kg	1	< 1	< 1	< 1
Silver	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Sodium	mg/kg	50	1540	1410	1890
Strontium	mg/kg	1	33	36	41
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	0.6	0.5	0.9
Tin	mg/kg	1	< 1	< 1	< 1
Uranium	mg/kg	0.1	0.3	0.3	0.3
Vanadium	mg/kg	1	49	63	46
Zinc	mg/kg	1	99	87	83

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Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-14	180551-15	180551-16
Client Sample ID:			SBS-14	SBS-15	SBS-16
Date Sampled:			12-Oct-14	12-Oct-14	12-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	14800	18500	15200
Antimony	mg/kg	0.1	0.1	< 0.1	0.1
Arsenic	mg/kg	1	13	16	13
Barium	mg/kg	1	15	39	85
Beryllium	mg/kg	0.1	0.4	0.4	0.4
Bismuth	mg/kg	1	< 1	< 1	< 1
Boron	mg/kg	1	4	5	6
Cadmium	mg/kg	0.01	0.27	0.28	0.78
Calcium	mg/kg	50	27800	20400	25600
Chromium	mg/kg	1	48	62	46
Cobalt	mg/kg	0.1	13.9	17.2	16.0
Copper	mg/kg	1	12	14	22
Iron	mg/kg	20	21400	27100	23400
Lead	mg/kg	0.1	37.3	34.7	89.9
Lithium	mg/kg	0.1	19.0	20.5	18.3
Magnesium	mg/kg	10	13900	17000	14200
Manganese	mg/kg	1	341	434	373
Mercury	mg/kg	0.01	< 0.01	0.01	0.01
Molybdenum	mg/kg	0.1	0.1	0.1	0.1
Nickel	mg/kg	1	36	45	39
Potassium	mg/kg	20	750	740	840
Rubidium	mg/kg	0.1	4.3	3.8	4.5
Selenium	mg/kg	1	< 1	< 1	< 1
Silver	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Sodium	mg/kg	50	1930	1960	1840
Strontium	mg/kg	1	38	29	52
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	0.5	0.5	0.7
Tin	mg/kg	1	< 1	< 1	< 1
Uranium	mg/kg	0.1	0.2	0.2	0.3
Vanadium	mg/kg	1	48	70	55
Zinc	mg/kg	1	77	92	263

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CERTIFICATE OF ANALYSIS

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Attention: Christine Moore

Project #: MINNOW 2539

Location: New Brunswick

Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-17	180551-18	180551-19
Client Sample ID: Date Sampled:			SBS-17 12-Oct-14	SBS-18 12-Oct-14	SBS-19 12-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	14200	16000	15500
Antimony	mg/kg	0.1	0.4	< 0.1	0.2
Arsenic	mg/kg	1	28	12	22
Barium	mg/kg	1	251	26	52
Beryllium	mg/kg	0.1	0.4	0.4	0.3
Bismuth	mg/kg	1	< 1	< 1	< 1
Boron	mg/kg	1	7	8	14
Cadmium	mg/kg	0.01	0.51	0.45	1.35
Calcium	mg/kg	50	21600	31400	34100
Chromium	mg/kg	1	49	59	51
Cobalt	mg/kg	0.1	14.9	15.7	14.6
Copper	mg/kg	1	28	27	24
Iron	mg/kg	20	26400	24800	23700
Lead	mg/kg	0.1	165.	47.1	112.
Lithium	mg/kg	0.1	15.5	19.0	17.0
Magnesium	mg/kg	10	12300	14900	14600
Manganese	mg/kg	1	387	388	407
Mercury	mg/kg	0.01	0.02	< 0.01	0.02
Molybdenum	mg/kg	0.1	0.3	< 0.1	0.2
Nickel	mg/kg	1	34	42	40
Potassium	mg/kg	20	620	690	820
Rubidium	mg/kg	0.1	3.3	3.7	3.9
Selenium	mg/kg	1	< 1	< 1	< 1
Silver	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Sodium	mg/kg	50	1540	1290	2760
Strontium	mg/kg	1	49	65	64
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	0.4	0.5	0.8
Tin	mg/kg	1	< 1	< 1	< 1
Uranium	mg/kg	0.1	0.3	0.3	0.3
Vanadium	mg/kg	1	74	60	54
Zinc	mg/kg	1	564	110	178

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Project #: MINNOW 2539

Location: New Brunswick

Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-20	180551-21	180551-21 Dup
Client Sample ID:			SBS-20	SBS-21	Lab Duplicate
Date Sampled:			12-Oct-14	12-Oct-14	12-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	17600	16100	16400
Antimony	mg/kg	0.1	0.1	0.1	0.1
Arsenic	mg/kg	1	21	27	15
Barium	mg/kg	1	15	27	21
Beryllium	mg/kg	0.1	0.4	0.4	0.4
Bismuth	mg/kg	1	< 1	< 1	< 1
Boron	mg/kg	1	5	6	7
Cadmium	mg/kg	0.01	0.39	0.35	0.33
Calcium	mg/kg	50	21800	37100	34400
Chromium	mg/kg	1	50	50	56
Cobalt	mg/kg	0.1	18.1	15.6	15.7
Copper	mg/kg	1	19	16	15
Iron	mg/kg	20	26300	25400	25200
Lead	mg/kg	0.1	67.9	52.5	42.5
Lithium	mg/kg	0.1	20.6	18.6	19.1
Magnesium	mg/kg	10	17100	14800	15000
Manganese	mg/kg	1	458	410	466
Mercury	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Molybdenum	mg/kg	0.1	0.1	0.1	0.1
Nickel	mg/kg	1	43	40	44
Potassium	mg/kg	20	750	820	710
Rubidium	mg/kg	0.1	3.8	4.1	3.7
Selenium	mg/kg	1	< 1	< 1	< 1
Silver	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Sodium	mg/kg	50	1550	1760	1710
Strontium	mg/kg	1	37	45	38
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	0.3	0.4	0.4
Tin	mg/kg	1	< 1	< 1	< 1
Uranium	mg/kg	0.1	0.3	0.3	0.3
Vanadium	mg/kg	1	61	63	58
Zinc	mg/kg	1	226	98	85

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Project #: MINNOW 2539

Location: New Brunswick

Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-22	180551-23	180551-24
Client Sample ID:			RBS-1	RBS-2	RBS-3
Date Sampled:			13-Oct-14	13-Oct-14	13-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	5750	7500	8630
Antimony	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Arsenic	mg/kg	1	3	2	4
Barium	mg/kg	1	17	9	12
Beryllium	mg/kg	0.1	0.4	0.4	0.5
Bismuth	mg/kg	1	< 1	< 1	< 1
Boron	mg/kg	1	3	3	3
Cadmium	mg/kg	0.01	0.06	0.09	0.04
Calcium	mg/kg	50	29700	16300	10200
Chromium	mg/kg	1	11	17	18
Cobalt	mg/kg	0.1	5.2	6.0	5.9
Copper	mg/kg	1	6	5	9
Iron	mg/kg	20	9410	10800	13500
Lead	mg/kg	0.1	5.1	5.2	6.2
Lithium	mg/kg	0.1	9.4	12.0	16.0
Magnesium	mg/kg	10	3460	5470	6540
Manganese	mg/kg	1	279	246	245
Mercury	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Molybdenum	mg/kg	0.1	0.2	0.1	0.2
Nickel	mg/kg	1	13	17	20
Potassium	mg/kg	20	700	890	1090
Rubidium	mg/kg	0.1	4.0	4.8	6.5
Selenium	mg/kg	1	< 1	< 1	< 1
Silver	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Sodium	mg/kg	50	1350	1950	1270
Strontium	mg/kg	1	29	25	12
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Tin	mg/kg	1	< 1	< 1	< 1
Uranium	mg/kg	0.1	0.3	0.3	0.3
Vanadium	mg/kg	1	20	19	23
Zinc	mg/kg	1	21	29	34

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Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-25	180551-26	180551-27
Client Sample ID:			RBS-4	RBS-5	RBS-6
Date Sampled:			13-Oct-14	13-Oct-14	13-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	7760	9270	8320
Antimony	mg/kg	0.1	< 0.1	0.1	< 0.1
Arsenic	mg/kg	1	3	5	3
Barium	mg/kg	1	10	10	11
Beryllium	mg/kg	0.1	0.4	0.4	0.4
Bismuth	mg/kg	1	< 1	< 1	< 1
Boron	mg/kg	1	3	3	3
Cadmium	mg/kg	0.01	0.05	0.04	0.04
Calcium	mg/kg	50	14800	6690	6790
Chromium	mg/kg	1	15	18	18
Cobalt	mg/kg	0.1	6.0	7.3	6.0
Copper	mg/kg	1	7	8	6
Iron	mg/kg	20	11800	14100	12500
Lead	mg/kg	0.1	7.1	6.7	6.4
Lithium	mg/kg	0.1	13.9	16.5	15.2
Magnesium	mg/kg	10	5760	6930	6140
Manganese	mg/kg	1	229	260	224
Mercury	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Molybdenum	mg/kg	0.1	0.2	0.2	0.1
Nickel	mg/kg	1	17	21	19
Potassium	mg/kg	20	900	990	1040
Rubidium	mg/kg	0.1	5.5	6.4	6.5
Selenium	mg/kg	1	< 1	< 1	< 1
Silver	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Sodium	mg/kg	50	1200	1440	1270
Strontium	mg/kg	1	14	10	11
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Tin	mg/kg	1	< 1	< 1	< 1
Uranium	mg/kg	0.1	0.3	0.5	0.3
Vanadium	mg/kg	1	20	26	24
Zinc	mg/kg	1	36	36	32

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Location: New Brunswick

Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-28	180551-29	180551-30
Client Sample ID: Date Sampled:			DUP-1 13-Oct-14	DUP-2 13-Oct-14	FPO-1 9-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	6670	13600	13900
Antimony	mg/kg	0.1	0.2	12.3	0.1
Arsenic	mg/kg	1	2	328	7
Barium	mg/kg	1	8	161	69
Beryllium	mg/kg	0.1	0.4	0.6	0.7
Bismuth	mg/kg	1	< 1	10	< 1
Boron	mg/kg	1	4	14	17
Cadmium	mg/kg	0.01	0.04	20.8	0.83
Calcium	mg/kg	50	16500	29800	19900
Chromium	mg/kg	1	11	47	31
Cobalt	mg/kg	0.1	5.3	76.9	10.4
Copper	mg/kg	1	5	876	16
Iron	mg/kg	20	10800	89400	20400
Lead	mg/kg	0.1	5.0	9270	82.9
Lithium	mg/kg	0.1	11.0	16.9	22.7
Magnesium	mg/kg	10	4270	9330	9310
Manganese	mg/kg	1	205	559	294
Mercury	mg/kg	0.01	< 0.01	0.03	-
Molybdenum	mg/kg	0.1	0.2	11.4	1.2
Nickel	mg/kg	1	13	34	33
Potassium	mg/kg	20	810	1460	1940
Rubidium	mg/kg	0.1	4.2	7.7	9.9
Selenium	mg/kg	1	< 1	3	< 1
Silver	mg/kg	0.1	< 0.1	1.4	0.2
Sodium	mg/kg	50	1780	1660	5230
Strontium	mg/kg	1	18	52	34
Tellurium	mg/kg	0.1	< 0.1	0.4	< 0.1
Thallium	mg/kg	0.1	< 0.1	13.2	0.4
Tin	mg/kg	1	< 1	127	< 1
Uranium	mg/kg	0.1	0.3	1.0	3.1
Vanadium	mg/kg	1	16	47	37
Zinc	mg/kg	1	23	34100	124

Report ID: 180551-IAS
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Project #: MINNOW 2539

Location: New Brunswick

Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-31	180551-31 Dup	180551-32
Client Sample ID: Date Sampled:			FPO-2 9-Oct-14	Lab Duplicate 9-Oct-14	FPO-3 7-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	10200	10300	5180
Antimony	mg/kg	0.1	0.2	0.2	1.1
Arsenic	mg/kg	1	5	5	8
Barium	mg/kg	1	54	63	35
Beryllium	mg/kg	0.1	0.5	0.5	0.4
Bismuth	mg/kg	1	< 1	< 1	< 1
Boron	mg/kg	1	12	11	5
Cadmium	mg/kg	0.01	0.82	0.81	0.70
Calcium	mg/kg	50	17300	17200	58500
Chromium	mg/kg	1	23	23	19
Cobalt	mg/kg	0.1	6.7	6.7	3.5
Copper	mg/kg	1	13	10	21
Iron	mg/kg	20	12600	12600	5970
Lead	mg/kg	0.1	42.5	40.2	192.
Lithium	mg/kg	0.1	14.6	14.7	4.8
Magnesium	mg/kg	10	6040	6110	2100
Manganese	mg/kg	1	203	208	72
Mercury	mg/kg	0.01	-	-	-
Molybdenum	mg/kg	0.1	0.8	0.8	1.1
Nickel	mg/kg	1	21	21	8
Potassium	mg/kg	20	1500	1530	940
Rubidium	mg/kg	0.1	7.6	7.8	4.3
Selenium	mg/kg	1	< 1	< 1	< 1
Silver	mg/kg	0.1	< 0.1	< 0.1	0.1
Sodium	mg/kg	50	3700	3750	2610
Strontium	mg/kg	1	64	62	219
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	0.4	0.3	0.3
Tin	mg/kg	1	< 1	< 1	3
Uranium	mg/kg	0.1	18.5	16.7	70.8
Vanadium	mg/kg	1	24	24	14
Zinc	mg/kg	1	74	76	556

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Location: New Brunswick

Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-33	180551-34	180551-35
Client Sample ID:			FPO-4	FPO-5	FE-1
Date Sampled:			6-Oct-14	6-Oct-14	9-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	2950	1530	10500
Antimony	mg/kg	0.1	0.6	0.5	0.4
Arsenic	mg/kg	1	1	2	15
Barium	mg/kg	1	54	12	183
Beryllium	mg/kg	0.1	0.1	0.2	0.4
Bismuth	mg/kg	1	< 1	< 1	2
Boron	mg/kg	1	2	3	6
Cadmium	mg/kg	0.01	0.11	0.43	1.94
Calcium	mg/kg	50	158000	16400	9160
Chromium	mg/kg	1	4	7	35
Cobalt	mg/kg	0.1	0.5	0.9	10.4
Copper	mg/kg	1	5	5	30
Iron	mg/kg	20	710	2060	17500
Lead	mg/kg	0.1	13.8	66.3	336.
Lithium	mg/kg	0.1	0.4	1.4	14.8
Magnesium	mg/kg	10	510	860	8750
Manganese	mg/kg	1	8	40	243
Mercury	mg/kg	0.01	-	-	-
Molybdenum	mg/kg	0.1	0.3	0.6	0.3
Nickel	mg/kg	1	2	2	29
Potassium	mg/kg	20	350	360	1180
Rubidium	mg/kg	0.1	0.9	1.4	6.4
Selenium	mg/kg	1	< 1	< 1	< 1
Silver	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Sodium	mg/kg	50	4040	1990	1870
Strontium	mg/kg	1	504	65	21
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	0.2	< 0.1	1.7
Tin	mg/kg	1	< 1	< 1	2
Uranium	mg/kg	0.1	21.3	9.8	0.6
Vanadium	mg/kg	1	2	8	38
Zinc	mg/kg	1	30	108	593

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Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-36	180551-37	180551-38
Client Sample ID:			FE-2	FE-3	FE-4
Date Sampled:			10-Oct-14	6-Oct-14	6-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	9850	10100	10200
Antimony	mg/kg	0.1	0.2	0.4	0.6
Arsenic	mg/kg	1	12	19	24
Barium	mg/kg	1	150	133	42
Beryllium	mg/kg	0.1	0.4	0.4	0.3
Bismuth	mg/kg	1	< 1	< 1	2
Boron	mg/kg	1	7	8	7
Cadmium	mg/kg	0.01	1.47	2.02	2.64
Calcium	mg/kg	50	7860	12000	10600
Chromium	mg/kg	1	31	34	34
Cobalt	mg/kg	0.1	9.4	10.9	11.8
Copper	mg/kg	1	20	37	56
Iron	mg/kg	20	16000	17500	18100
Lead	mg/kg	0.1	206.	374.	594.
Lithium	mg/kg	0.1	13.6	14.6	14.2
Magnesium	mg/kg	10	8150	8610	8670
Manganese	mg/kg	1	220	249	239
Mercury	mg/kg	0.01	-	-	-
Molybdenum	mg/kg	0.1	0.2	0.3	0.3
Nickel	mg/kg	1	27	29	29
Potassium	mg/kg	20	1060	1040	960
Rubidium	mg/kg	0.1	5.6	5.5	5.2
Selenium	mg/kg	1	< 1	< 1	< 1
Silver	mg/kg	0.1	< 0.1	< 0.1	0.2
Sodium	mg/kg	50	2410	2430	1850
Strontium	mg/kg	1	19	24	18
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	1.5	1.6	3.1
Tin	mg/kg	1	< 1	3	3
Uranium	mg/kg	0.1	0.5	0.4	0.4
Vanadium	mg/kg	1	36	35	35
Zinc	mg/kg	1	326	844	1250

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Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-39	180551-40	180551-41
Client Sample ID: Date Sampled:			FE-5 6-Oct-14	RS-1 7-Oct-14	RS-2 8-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	10200	11400	11300
Antimony	mg/kg	0.1	1.0	< 0.1	< 0.1
Arsenic	mg/kg	1	34	4	4
Barium	mg/kg	1	128	56	118
Beryllium	mg/kg	0.1	0.4	0.6	0.6
Bismuth	mg/kg	1	4	< 1	< 1
Boron	mg/kg	1	7	5	7
Cadmium	mg/kg	0.01	2.63	0.37	0.32
Calcium	mg/kg	50	11300	31400	24800
Chromium	mg/kg	1	34	25	26
Cobalt	mg/kg	0.1	13.4	9.4	9.5
Copper	mg/kg	1	77	8	9
Iron	mg/kg	20	20000	16800	17600
Lead	mg/kg	0.1	860.	20.2	19.7
Lithium	mg/kg	0.1	13.8	19.9	20.4
Magnesium	mg/kg	10	8590	8190	8310
Manganese	mg/kg	1	249	345	305
Mercury	mg/kg	0.01	-	-	-
Molybdenum	mg/kg	0.1	0.4	0.2	0.3
Nickel	mg/kg	1	29	28	28
Potassium	mg/kg	20	940	1290	1320
Rubidium	mg/kg	0.1	5.1	7.4	7.6
Selenium	mg/kg	1	< 1	< 1	< 1
Silver	mg/kg	0.1	0.3	< 0.1	< 0.1
Sodium	mg/kg	50	2090	2080	2330
Strontium	mg/kg	1	20	25	25
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	2.5	0.3	0.3
Tin	mg/kg	1	7	< 1	< 1
Uranium	mg/kg	0.1	0.5	0.5	0.7
Vanadium	mg/kg	1	39	31	32
Zinc	mg/kg	1	1840	55	53

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Attention: Christine Moore

Project #: MINNOW 2539

Location: New Brunswick

Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-41 Dup	180551-42	180551-43
Client Sample ID:			Lab Duplicate	RS-3	RS-4
Date Sampled:			8-Oct-14	9-Oct-14	9-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	11300	11300	11500
Antimony	mg/kg	0.1	0.1	0.1	0.1
Arsenic	mg/kg	1	5	5	4
Barium	mg/kg	1	107	116	127
Beryllium	mg/kg	0.1	0.6	0.6	0.7
Bismuth	mg/kg	1	< 1	< 1	< 1
Boron	mg/kg	1	7	7	6
Cadmium	mg/kg	0.01	0.34	0.35	0.38
Calcium	mg/kg	50	24400	26100	30000
Chromium	mg/kg	1	25	25	26
Cobalt	mg/kg	0.1	9.5	9.4	9.8
Copper	mg/kg	1	9	9	9
Iron	mg/kg	20	17700	17500	18000
Lead	mg/kg	0.1	20.2	19.3	19.2
Lithium	mg/kg	0.1	20.1	19.6	20.0
Magnesium	mg/kg	10	8330	8250	8430
Manganese	mg/kg	1	311	318	337
Mercury	mg/kg	0.01	-	-	-
Molybdenum	mg/kg	0.1	0.3	0.7	0.3
Nickel	mg/kg	1	28	28	29
Potassium	mg/kg	20	1390	1330	1300
Rubidium	mg/kg	0.1	8.2	7.5	7.3
Selenium	mg/kg	1	< 1	< 1	< 1
Silver	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Sodium	mg/kg	50	2550	2610	1870
Strontium	mg/kg	1	24	24	25
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	0.3	0.3	0.3
Tin	mg/kg	1	< 1	< 1	< 1
Uranium	mg/kg	0.1	0.7	0.7	0.8
Vanadium	mg/kg	1	33	33	34
Zinc	mg/kg	1	55	53	56

Report ID: 180551-IAS
Report Date: 17-Dec-14
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Attention: Christine Moore

Project #: MINNOW 2539

Location: New Brunswick

Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-44	180551-45	180551-46
Client Sample ID:			RS-5	RD-1	RD-2
Date Sampled:			9-Oct-14	9-Oct-14	9-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	11500	9430	10500
Antimony	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Arsenic	mg/kg	1	5	6	6
Barium	mg/kg	1	76	35	78
Beryllium	mg/kg	0.1	0.6	0.5	0.6
Bismuth	mg/kg	1	< 1	< 1	< 1
Boron	mg/kg	1	7	7	8
Cadmium	mg/kg	0.01	0.35	0.16	0.29
Calcium	mg/kg	50	29100	5370	6470
Chromium	mg/kg	1	26	22	24
Cobalt	mg/kg	0.1	9.5	7.7	8.5
Copper	mg/kg	1	9	7	9
Iron	mg/kg	20	17700	14400	15900
Lead	mg/kg	0.1	17.6	22.6	26.6
Lithium	mg/kg	0.1	19.9	16.4	18.2
Magnesium	mg/kg	10	8510	7060	7740
Manganese	mg/kg	1	328	216	232
Mercury	mg/kg	0.01	-	-	-
Molybdenum	mg/kg	0.1	0.3	0.2	0.4
Nickel	mg/kg	1	27	23	26
Potassium	mg/kg	20	1370	1270	1420
Rubidium	mg/kg	0.1	7.7	7.2	8.0
Selenium	mg/kg	1	< 1	< 1	< 1
Silver	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Sodium	mg/kg	50	2890	2350	3090
Strontium	mg/kg	1	25	14	17
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	0.3	0.3	0.3
Tin	mg/kg	1	< 1	< 1	< 1
Uranium	mg/kg	0.1	0.6	0.5	0.7
Vanadium	mg/kg	1	33	29	31
Zinc	mg/kg	1	53	42	54

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Attention: Christine Moore

Project #: MINNOW 2539

Location: New Brunswick

Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-47	180551-48	180551-49
Client Sample ID: Date Sampled:			RD-3 9-Oct-14	RD-4 9-Oct-14	RD-5 9-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	9200	10400	9440
Antimony	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Arsenic	mg/kg	1	6	5	6
Barium	mg/kg	1	21	83	17
Beryllium	mg/kg	0.1	0.5	0.6	0.5
Bismuth	mg/kg	1	< 1	< 1	< 1
Boron	mg/kg	1	6	7	6
Cadmium	mg/kg	0.01	0.18	0.29	0.13
Calcium	mg/kg	50	5510	6390	2880
Chromium	mg/kg	1	22	24	20
Cobalt	mg/kg	0.1	7.6	8.6	7.5
Copper	mg/kg	1	8	8	8
Iron	mg/kg	20	13800	15900	16400
Lead	mg/kg	0.1	26.1	24.2	14.8
Lithium	mg/kg	0.1	16.0	18.1	17.3
Magnesium	mg/kg	10	6930	7870	7290
Manganese	mg/kg	1	211	232	370
Mercury	mg/kg	0.01	-	-	-
Molybdenum	mg/kg	0.1	0.2	0.3	0.3
Nickel	mg/kg	1	23	26	23
Potassium	mg/kg	20	1230	1380	1060
Rubidium	mg/kg	0.1	6.9	7.9	6.1
Selenium	mg/kg	1	< 1	< 1	< 1
Silver	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Sodium	mg/kg	50	2460	2280	2480
Strontium	mg/kg	1	13	17	11
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	0.3	0.4	0.2
Tin	mg/kg	1	< 1	< 1	< 1
Uranium	mg/kg	0.1	0.5	0.7	0.6
Vanadium	mg/kg	1	28	33	31
Zinc	mg/kg	1	53	51	47

Attention: Christine Moore

Project #: MINNOW 2539

Location: New Brunswick

Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-50	180551-51	180551-51 Dup
Client Sample ID:			BD-1	BD-2	Lab Duplicate
Date Sampled:			6-Oct-14	6-Oct-14	6-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	10000	3100	2990
Antimony	mg/kg	0.1	0.6	0.4	0.4
Arsenic	mg/kg	1	22	1	< 1
Barium	mg/kg	1	56	58	57
Beryllium	mg/kg	0.1	0.4	< 0.1	< 0.1
Bismuth	mg/kg	1	< 1	< 1	< 1
Boron	mg/kg	1	6	2	2
Cadmium	mg/kg	0.01	2.62	0.11	0.09
Calcium	mg/kg	50	11100	154000	154000
Chromium	mg/kg	1	34	3	3
Cobalt	mg/kg	0.1	11.5	0.5	0.5
Copper	mg/kg	1	55	4	4
Iron	mg/kg	20	18000	660	620
Lead	mg/kg	0.1	575.	8.5	9.0
Lithium	mg/kg	0.1	14.3	0.5	0.5
Magnesium	mg/kg	10	8620	530	510
Manganese	mg/kg	1	237	8	8
Mercury	mg/kg	0.01	-	-	-
Molybdenum	mg/kg	0.1	0.3	0.3	0.3
Nickel	mg/kg	1	28	2	2
Potassium	mg/kg	20	950	370	340
Rubidium	mg/kg	0.1	5.1	1.0	0.8
Selenium	mg/kg	1	< 1	< 1	< 1
Silver	mg/kg	0.1	0.2	< 0.1	< 0.1
Sodium	mg/kg	50	2040	4140	4280
Strontium	mg/kg	1	20	501	497
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	3.1	0.2	0.2
Tin	mg/kg	1	3	< 1	< 1
Uranium	mg/kg	0.1	0.4	23.1	20.5
Vanadium	mg/kg	1	34	1	1
Zinc	mg/kg	1	1240	9	10

Report ID: 180551-IAS
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Attention: Christine Moore

Project #: MINNOW 2539

Location: New Brunswick

Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-52	180551-53	180551-54
Client Sample ID:			SST2-1	SST2-2	SST2-3
Date Sampled:			10-Oct-14	10-Oct-14	10-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	9700	9980	9480
Antimony	mg/kg	0.1	0.2	0.2	0.1
Arsenic	mg/kg	1	10	9	10
Barium	mg/kg	1	228	55	37
Beryllium	mg/kg	0.1	0.4	0.4	0.4
Bismuth	mg/kg	1	< 1	< 1	< 1
Boron	mg/kg	1	6	6	6
Cadmium	mg/kg	0.01	1.57	0.70	0.79
Calcium	mg/kg	50	6120	7280	6000
Chromium	mg/kg	1	30	30	31
Cobalt	mg/kg	0.1	9.3	8.9	9.1
Copper	mg/kg	1	16	15	21
Iron	mg/kg	20	15500	15200	14900
Lead	mg/kg	0.1	162.	116.	147.
Lithium	mg/kg	0.1	13.7	14.5	13.8
Magnesium	mg/kg	10	8230	8280	8070
Manganese	mg/kg	1	217	229	223
Mercury	mg/kg	0.01	-	-	-
Molybdenum	mg/kg	0.1	0.2	0.4	0.3
Nickel	mg/kg	1	28	28	27
Potassium	mg/kg	20	1010	1070	1040
Rubidium	mg/kg	0.1	5.5	5.8	5.6
Selenium	mg/kg	1	< 1	< 1	< 1
Silver	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Sodium	mg/kg	50	2650	2610	2190
Strontium	mg/kg	1	19	17	16
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	1.7	0.8	0.9
Tin	mg/kg	1	< 1	< 1	< 1
Uranium	mg/kg	0.1	0.6	0.6	0.6
Vanadium	mg/kg	1	37	34	34
Zinc	mg/kg	1	238	182	227

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Attention: Christine Moore

Project #: MINNOW 2539

Location: New Brunswick

Analysis of Sand and Sediment Samples

RPC Sample ID:			180551-55	180551-56
Client Sample ID:			SST2-4	SST2-5
Date Sampled:			10-Oct-14	10-Oct-14
Analytes	**Units**	**RL**		
Aluminum	mg/kg	1	9590	9370
Antimony	mg/kg	0.1	0.1	< 0.1
Arsenic	mg/kg	1	9	8
Barium	mg/kg	1	102	74
Beryllium	mg/kg	0.1	0.3	0.4
Bismuth	mg/kg	1	< 1	< 1
Boron	mg/kg	1	6	5
Cadmium	mg/kg	0.01	0.76	0.70
Calcium	mg/kg	50	5700	5360
Chromium	mg/kg	1	30	29
Cobalt	mg/kg	0.1	8.7	8.6
Copper	mg/kg	1	13	12
Iron	mg/kg	20	14700	14700
Lead	mg/kg	0.1	117.	98.1
Lithium	mg/kg	0.1	13.4	13.1
Magnesium	mg/kg	10	7940	7890
Manganese	mg/kg	1	220	218
Mercury	mg/kg	0.01	-	-
Molybdenum	mg/kg	0.1	0.2	0.1
Nickel	mg/kg	1	27	27
Potassium	mg/kg	20	1010	970
Rubidium	mg/kg	0.1	5.5	5.2
Selenium	mg/kg	1	< 1	< 1
Silver	mg/kg	0.1	< 0.1	< 0.1
Sodium	mg/kg	50	2170	2320
Strontium	mg/kg	1	16	16
Tellurium	mg/kg	0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	0.9	0.8
Tin	mg/kg	1	< 1	< 1
Uranium	mg/kg	0.1	0.6	0.4
Vanadium	mg/kg	1	34	34
Zinc	mg/kg	1	139	101

General Report Comments

Samples were air dried and sieved at 2 mm. A portion of each was digested according to EPA Method 3050B.
The resulting solutions were analyzed for trace elements by ICP-MS.
A portion each sample was dried and sieved at 2 mm. Total and Inorganic Carbon were determined using
combustion/acid evolution infrared methods. Total Organic Carbon is calculated as the difference.
Note: The poor replication of trace metals results for the sand samples is believed to be a function of sample heterogeneity.

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Project #: MINNOW 2539
Location: New Brunswick
QA/QC Report

RPC Sample ID:			CRM035430	CRM035431	CRM035432
Type:			CRM NIST 2709a	CRM NIST 2709a	CRM NIST 2709a
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	24900	25000	24700
Antimony	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Arsenic	mg/kg	1	8	9	8
Barium	mg/kg	1	417	425	422
Beryllium	mg/kg	0.1	0.8	0.8	0.8
Bismuth	mg/kg	1	< 1	< 1	< 1
Boron	mg/kg	1	36	36	35
Cadmium	mg/kg	0.01	0.35	0.34	0.35
Calcium	mg/kg	50	13700	14000	14000
Chromium	mg/kg	1	70	71	71
Cobalt	mg/kg	0.1	11.2	11.3	11.4
Copper	mg/kg	1	29	29	30
Iron	mg/kg	20	27500	27800	28000
Lead	mg/kg	0.1	10.9	10.9	10.9
Lithium	mg/kg	0.1	35.3	35.4	35.1
Magnesium	mg/kg	10	12100	12200	12100
Manganese	mg/kg	1	449	452	453
Mercury	mg/kg	0.01	0.84	0.80	0.86
Molybdenum	mg/kg	0.1	0.6	0.6	0.6
Nickel	mg/kg	1	71	73	73
Potassium	mg/kg	20	3670	3740	3670
Rubidium	mg/kg	0.1	32.0	32.2	31.9
Selenium	mg/kg	1	< 1	1	< 1
Silver	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Sodium	mg/kg	50	540	540	540
Strontium	mg/kg	1	104	105	106
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	0.2	0.2	0.2
Tin	mg/kg	1	< 1	< 1	< 1
Uranium	mg/kg	0.1	1.7	1.7	1.7
Vanadium	mg/kg	1	65	66	66
Zinc	mg/kg	1	87	88	89

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Project #: MINNOW 2539

Location: New Brunswick

QA/QC Report

RPC Sample ID:			CRM035433	CRM035434	CRM035435
Type:			CRM NIST 2709a	CRM NIST 2709a	CRM NIST 2709a
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	23700	23900	24000
Antimony	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Arsenic	mg/kg	1	9	8	9
Barium	mg/kg	1	419	418	422
Beryllium	mg/kg	0.1	0.7	0.7	0.7
Bismuth	mg/kg	1	< 1	< 1	< 1
Boron	mg/kg	1	33	34	35
Cadmium	mg/kg	0.01	0.34	0.33	0.36
Calcium	mg/kg	50	13500	13600	13900
Chromium	mg/kg	1	69	70	71
Cobalt	mg/kg	0.1	11.2	11.5	11.6
Copper	mg/kg	1	29	30	30
Iron	mg/kg	20	27600	27800	28200
Lead	mg/kg	0.1	11.0	10.9	11.0
Lithium	mg/kg	0.1	34.7	34.6	34.9
Magnesium	mg/kg	10	11900	12000	12200
Manganese	mg/kg	1	456	459	462
Mercury	mg/kg	0.01	-	-	-
Molybdenum	mg/kg	0.1	0.5	0.5	0.6
Nickel	mg/kg	1	71	73	73
Potassium	mg/kg	20	3500	3520	3580
Rubidium	mg/kg	0.1	30.9	31.3	32.0
Selenium	mg/kg	1	< 1	< 1	< 1
Silver	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Sodium	mg/kg	50	540	540	540
Strontium	mg/kg	1	103	104	105
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	0.2	0.2	0.2
Tin	mg/kg	1	< 1	< 1	< 1
Uranium	mg/kg	0.1	1.7	1.7	1.7
Vanadium	mg/kg	1	63	63	65
Zinc	mg/kg	1	89	90	90

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Project #: MINNOW 2539
Location: New Brunswick
QA/QC Report

RPC Sample ID:			RB022161	RB022162	RB022163
Type:			Blank	Blank	Blank
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	< 1	< 1	< 1
Antimony	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Arsenic	mg/kg	1	< 1	< 1	< 1
Barium	mg/kg	1	< 1	< 1	< 1
Beryllium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Bismuth	mg/kg	1	< 1	< 1	< 1
Boron	mg/kg	1	< 1	< 1	< 1
Cadmium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Calcium	mg/kg	50	< 50	< 50	< 50
Chromium	mg/kg	1	< 1	< 1	< 1
Cobalt	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Copper	mg/kg	1	< 1	< 1	< 1
Iron	mg/kg	20	< 20	< 20	< 20
Lead	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Lithium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Magnesium	mg/kg	10	< 10	< 10	< 10
Manganese	mg/kg	1	< 1	< 1	< 1
Mercury	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Molybdenum	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Nickel	mg/kg	1	< 1	< 1	< 1
Potassium	mg/kg	20	< 20	< 20	< 20
Rubidium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Selenium	mg/kg	1	< 1	< 1	< 1
Silver	mg/kg	0.1	0.1	< 0.1	< 0.1
Sodium	mg/kg	50	< 50	< 50	< 50
Strontium	mg/kg	1	< 1	< 1	< 1
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Tin	mg/kg	1	4	4	4
Uranium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Vanadium	mg/kg	1	< 1	< 1	< 1
Zinc	mg/kg	1	< 1	< 1	< 1

CERTIFICATE OF ANALYSIS

for
Intrinsik Environmental
Sciences Inc
5121 Sackville Street, Suite 506
Halifax, NS B3J 1K1

Project #: MINNOW 2539
Location: New Brunswick
QA/QC Report

RPC Sample ID:			RB022164	RB022165	RB022166
Type:			Blank	Blank	Blank
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	1	< 1	< 1
Antimony	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Arsenic	mg/kg	1	< 1	< 1	< 1
Barium	mg/kg	1	< 1	< 1	< 1
Beryllium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Bismuth	mg/kg	1	< 1	< 1	< 1
Boron	mg/kg	1	< 1	< 1	< 1
Cadmium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Calcium	mg/kg	50	< 50	< 50	< 50
Chromium	mg/kg	1	< 1	< 1	< 1
Cobalt	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Copper	mg/kg	1	< 1	< 1	< 1
Iron	mg/kg	20	< 20	< 20	< 20
Lead	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Lithium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Magnesium	mg/kg	10	< 10	< 10	< 10
Manganese	mg/kg	1	< 1	< 1	< 1
Mercury	mg/kg	0.01	-	-	-
Molybdenum	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Nickel	mg/kg	1	< 1	< 1	< 1
Potassium	mg/kg	20	< 20	< 20	< 20
Rubidium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Selenium	mg/kg	1	< 1	< 1	< 1
Silver	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Sodium	mg/kg	50	< 50	< 50	< 50
Strontium	mg/kg	1	< 1	< 1	< 1
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Tin	mg/kg	1	< 1	< 1	1
Uranium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Vanadium	mg/kg	1	< 1	< 1	< 1
Zinc	mg/kg	1	< 1	< 1	< 1

Your Project #: MB4J0804
Your C.O.C. #: 08398645

Attention: SUB CONTRACTOR
MAXXAM ANALYTICS
CAMPOBELLO
6740 CAMPOBELLO ROAD
MISSISSAUGA, ON
CANADA L5N 2L8

Report Date: 2014/10/21
Report #: R1668072
Version: 1

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B493348
Received: 2014/10/16, 08:45

Sample Matrix: Sea Water
Samples Received: 7

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Hardness (calculated as CaCO3)	7	N/A	2014/10/21	BBY7SOP-00002	EPA 6020a R1 m
Na, K, Ca, Mg, S by CRC ICPMS (diss.)	7	N/A	2014/10/21	BBY7SOP-00002	EPA 6020A R1 m
Elements by ICPMS (dissolved) - Seawater	7	N/A	2014/10/21	BBY7SOP-00002	EPA 6020A R1 m
Nitrogen (Total)	7	2014/10/18	2014/10/20	BBY6SOP-00016	SM 22 4500-N C m
Filter and HNO3 Preserve for Metals	7	N/A	2014/10/17	BBY7 WI-00004	BCMOE Reqs 08/14

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Shanaz Akbar, Project Manager
Email: SAkbar@maxxam.ca
Phone# (604) 734 7276

==
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 CHEMICAL ANALYSES OF SEA WATER

Maxxam ID		KW5348	KW5349	KW5350	KW5351	KW5352	KW5353		
Sampling Date		2014/10/09	2014/10/09	2014/10/09	2014/10/09	2014/10/09	2014/10/09		
COC Number		08398645	08398645	08398645	08398645	08398645	08398645		
	UNITS	**S1-02 (XZ2095)**	**S2-02 (XZ2096)**	**S3-02 (XZ2097)**	**S4-02 (XZ2098)**	**R1-02 (XZ2099)**	**R2-02 (XZ2100)**	**RDL**	**QC Batch**
Calculated Parameters									
Filter and HNO3 Preservation	N/A	LAB	LAB	LAB	LAB	LAB	LAB	N/A	7682029
Misc. Inorganics									
Dissolved Hardness (CaCO3)	mg/L	4870	5090	4900	5100	5210	4890	0.50	7680250
Nutrients									
Total Nitrogen (N)	mg/L	0.139	0.171	0.151	0.161	0.179	0.152	0.020	7684497

RDL = Reportable Detection Limit

Maxxam ID		KW5354		
Sampling Date		2014/10/09		
COC Number		08398645		
	UNITS	**D2-02 (XZ2101)**	**RDL**	**QC Batch**
Calculated Parameters				
Filter and HNO3 Preservation	N/A	LAB	N/A	7682029
Misc. Inorganics				
Dissolved Hardness (CaCO3)	mg/L	4940	0.50	7680250
Nutrients				
Total Nitrogen (N)	mg/L	0.223	0.020	7684497

RDL = Reportable Detection Limit

ELEMENTS BY ATOMIC SPECTROSCOPY (SEA WATER)

Maxxam ID		KW5348	KW5349	KW5350	KW5351	KW5352	KW5353		
Sampling Date		2014/10/09	2014/10/09	2014/10/09	2014/10/09	2014/10/09	2014/10/09		
COC Number		08398645	08398645	08398645	08398645	08398645	08398645		
	UNITS	**S1-02 (XZ2095)**	**S2-02 (XZ2096)**	**S3-02 (XZ2097)**	**S4-02 (XZ2098)**	**R1-02 (XZ2099)**	**R2-02 (XZ2100)**	**RDL**	**QC Batch**
Dissolved Metals by ICPMS									
Dissolved Aluminum (Al)	ug/L	56	59	58	57	59	54	10	7684846
Dissolved Antimony (Sb)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	7684846
Dissolved Arsenic (As)	ug/L	1.42	1.73	1.70	1.57	1.40	1.51	0.50	7684846
Dissolved Barium (Ba)	ug/L	6.4	6.9	7.4	7.8	3.3	5.4	1.0	7684846
Dissolved Beryllium (Be)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	7684846
Dissolved Bismuth (Bi)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	7684846
Dissolved Boron (B)	ug/L	3480	3410	3280	3270	3540	3280	50	7684846
Dissolved Cadmium (Cd)	ug/L	0.159	0.256	0.149	0.228	0.054	0.077	0.050	7684846
Dissolved Chromium (Cr)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	7684846
Dissolved Cobalt (Co)	ug/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.10	7684846
Dissolved Copper (Cu)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	7684846
Dissolved Iron (Fe)	ug/L	2.7	2.5	3.4	<2.0	3.5	2.6	2.0	7684846
Dissolved Lead (Pb)	ug/L	0.57	1.07	0.57	0.81	<0.10	<0.10	0.10	7684846
Dissolved Lithium (Li)	ug/L	158	156	163	163	162	156	20	7684846
Dissolved Manganese (Mn)	ug/L	2.65	3.91	2.70	3.31	1.76	2.98	0.50	7684846
Dissolved Molybdenum (Mo)	ug/L	9.9	9.8	9.8	9.9	9.9	11.5	1.0	7684846
Dissolved Nickel (Ni)	ug/L	0.39	0.49	0.68	0.31	0.29	0.44	0.20	7684846
Dissolved Phosphorus (P)	ug/L	<50	<50	<50	<50	<50	<50	50	7684846
Dissolved Selenium (Se)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	7684846
Dissolved Silicon (Si)	ug/L	105	107	108	124	<100	<100	100	7684846
Dissolved Silver (Ag)	ug/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.050	7684846
Dissolved Strontium (Sr)	ug/L	6770	6530	6830	6930	7010	6540	10	7684846
Dissolved Thallium (Tl)	ug/L	0.75	3.44	1.00	1.84	0.16	0.12	0.10	7684846
Dissolved Tin (Sn)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	7684846
Dissolved Titanium (Ti)	ug/L	<10	<10	<10	<10	<10	<10	10	7684846
Dissolved Uranium (U)	ug/L	2.68	2.59	2.75	2.66	2.74	2.63	0.050	7684846
Dissolved Vanadium (V)	ug/L	<10	<10	<10	<10	<10	<10	10	7684846
Dissolved Zinc (Zn)	ug/L	3.7	5.4	4.0	5.2	1.6	1.6	1.0	7684846
Dissolved Calcium (Ca)	mg/L	355	358	348	364	369	344	1.0	7681364
Dissolved Magnesium (Mg)	mg/L	967	1020	979	1020	1040	979	1.0	7681364
Dissolved Potassium (K)	mg/L	324	339	322	340	343	319	1.0	7681364
Dissolved Sodium (Na)	mg/L	8090	8690	8180	8610	8690	8000	1.0	7681364

RDL = Reportable Detection Limit

ELEMENTS BY ATOMIC SPECTROSCOPY (SEA WATER)

Maxxam ID		KW5348	KW5349	KW5350	KW5351	KW5352	KW5353		
Sampling Date		2014/10/09	2014/10/09	2014/10/09	2014/10/09	2014/10/09	2014/10/09		
COC Number		08398645	08398645	08398645	08398645	08398645	08398645		
	UNITS	**S1-02 (XZ2095)**	**S2-02 (XZ2096)**	**S3-02 (XZ2097)**	**S4-02 (XZ2098)**	**R1-02 (XZ2099)**	**R2-02 (XZ2100)**	**RDL**	**QC Batch**
Dissolved Sulphur (S)	mg/L	819	878	795	870	866	1050	20	7681364

RDL = Reportable Detection Limit

ELEMENTS BY ATOMIC SPECTROSCOPY (SEA WATER)

Maxxam ID		KW5354		
Sampling Date		2014/10/09		
COC Number		08398645		
	UNITS	**D2-02 (XZ2101)**	**RDL**	**QC Batch**
Dissolved Metals by ICPMS				
Dissolved Aluminum (Al)	ug/L	50	10	7684846
Dissolved Antimony (Sb)	ug/L	<0.50	0.50	7684846
Dissolved Arsenic (As)	ug/L	1.78	0.50	7684846
Dissolved Barium (Ba)	ug/L	8.0	1.0	7684846
Dissolved Beryllium (Be)	ug/L	<1.0	1.0	7684846
Dissolved Bismuth (Bi)	ug/L	<1.0	1.0	7684846
Dissolved Boron (B)	ug/L	3270	50	7684846
Dissolved Cadmium (Cd)	ug/L	0.245	0.050	7684846
Dissolved Chromium (Cr)	ug/L	<0.50	0.50	7684846
Dissolved Cobalt (Co)	ug/L	<0.10	0.10	7684846
Dissolved Copper (Cu)	ug/L	<0.50	0.50	7684846
Dissolved Iron (Fe)	ug/L	3.3	2.0	7684846
Dissolved Lead (Pb)	ug/L	1.10	0.10	7684846
Dissolved Lithium (Li)	ug/L	155	20	7684846
Dissolved Manganese (Mn)	ug/L	3.08	0.50	7684846
Dissolved Molybdenum (Mo)	ug/L	9.2	1.0	7684846
Dissolved Nickel (Ni)	ug/L	0.41	0.20	7684846
Dissolved Phosphorus (P)	ug/L	<50	50	7684846
Dissolved Selenium (Se)	ug/L	<0.50	0.50	7684846
Dissolved Silicon (Si)	ug/L	111	100	7684846
Dissolved Silver (Ag)	ug/L	<0.050	0.050	7684846
Dissolved Strontium (Sr)	ug/L	6710	10	7684846
Dissolved Thallium (Tl)	ug/L	3.30	0.10	7684846
Dissolved Tin (Sn)	ug/L	<1.0	1.0	7684846
Dissolved Titanium (Ti)	ug/L	<10	10	7684846
Dissolved Uranium (U)	ug/L	2.73	0.050	7684846
Dissolved Vanadium (V)	ug/L	<10	10	7684846
Dissolved Zinc (Zn)	ug/L	5.6	1.0	7684846
Dissolved Calcium (Ca)	mg/L	359	1.0	7681364
Dissolved Magnesium (Mg)	mg/L	981	1.0	7681364
Dissolved Potassium (K)	mg/L	335	1.0	7681364
Dissolved Sodium (Na)	mg/L	8320	1.0	7681364

RDL = Reportable Detection Limit

ELEMENTS BY ATOMIC SPECTROSCOPY (SEA WATER)

Maxxam ID		KW5354		
Sampling Date		2014/10/09		
COC Number		08398645		
	UNITS	**D2-02 (XZ2101)**	**RDL**	**QC Batch**
Dissolved Sulphur (S)	mg/L	873	20	7681364

RDL = Reportable Detection Limit

Package 1	2.3°C

Each temperature is the average of up to three cooler temperatures taken at receipt

General Comments

Results relate only to the items tested.

MAXXAM ANALYTICS
Attention: SUB CONTRACTOR
Client Project #: MB4J0804
P.O. #:
Site Location:

Quality Assurance Report

Maxxam Job Number: VB493348

QA/QC Batch Num	Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	UNITS	QC Limits
7684497	BB3	Matrix Spike	Total Nitrogen (N)	2014/10/20		106	%	80 - 120
		Spiked Blank	Total Nitrogen (N)	2014/10/20		97	%	80 - 120
		Method Blank	Total Nitrogen (N)	2014/10/20	<0.020		mg/L	
		RPD	Total Nitrogen (N)	2014/10/20	1.3		%	20
7684846	GS2	Matrix Spike	Dissolved Aluminum (Al)	2014/10/21		102	%	75 - 125
			Dissolved Antimony (Sb)	2014/10/21		101	%	75 - 125
			Dissolved Arsenic (As)	2014/10/21		104	%	75 - 125
			Dissolved Barium (Ba)	2014/10/21		100	%	75 - 125
			Dissolved Beryllium (Be)	2014/10/21		104	%	75 - 125
			Dissolved Bismuth (Bi)	2014/10/21		89	%	75 - 125
			Dissolved Boron (B)	2014/10/21		NC	%	75 - 125
			Dissolved Cadmium (Cd)	2014/10/21		87	%	75 - 125
			Dissolved Chromium (Cr)	2014/10/21		89	%	75 - 125
			Dissolved Cobalt (Co)	2014/10/21		82	%	75 - 125
			Dissolved Copper (Cu)	2014/10/21		77	%	75 - 125
			Dissolved Iron (Fe)	2014/10/21		87	%	75 - 125
			Dissolved Lead (Pb)	2014/10/21		102	%	75 - 125
			Dissolved Lithium (Li)	2014/10/21		NC	%	75 - 125
			Dissolved Manganese (Mn)	2014/10/21		94	%	75 - 125
			Dissolved Molybdenum (Mo)	2014/10/21		NC	%	75 - 125
			Dissolved Nickel (Ni)	2014/10/21		78	%	75 - 125
			Dissolved Selenium (Se)	2014/10/21		83	%	75 - 125
			Dissolved Silver (Ag)	2014/10/21		88	%	75 - 125
			Dissolved Strontium (Sr)	2014/10/21		NC	%	75 - 125
			Dissolved Thallium (Tl)	2014/10/21		97	%	75 - 125
			Dissolved Tin (Sn)	2014/10/21		96	%	75 - 125
			Dissolved Titanium (Ti)	2014/10/21		103	%	75 - 125
			Dissolved Uranium (U)	2014/10/21		108	%	75 - 125
			Dissolved Vanadium (V)	2014/10/21		94	%	75 - 125
			Dissolved Zinc (Zn)	2014/10/21		73 (1)	%	75 - 125
		Spiked Blank	Dissolved Aluminum (Al)	2014/10/21		103	%	75 - 125
			Dissolved Antimony (Sb)	2014/10/21		98	%	75 - 125
			Dissolved Arsenic (As)	2014/10/21		103	%	75 - 125
			Dissolved Barium (Ba)	2014/10/21		96	%	75 - 125
			Dissolved Beryllium (Be)	2014/10/21		95	%	75 - 125
			Dissolved Bismuth (Bi)	2014/10/21		100	%	75 - 125
			Dissolved Boron (B)	2014/10/21		101	%	75 - 125
			Dissolved Cadmium (Cd)	2014/10/21		98	%	75 - 125
			Dissolved Chromium (Cr)	2014/10/21		102	%	75 - 125
			Dissolved Cobalt (Co)	2014/10/21		100	%	75 - 125
			Dissolved Copper (Cu)	2014/10/21		103	%	75 - 125
			Dissolved Iron (Fe)	2014/10/21		107	%	75 - 125
			Dissolved Lead (Pb)	2014/10/21		106	%	75 - 125
			Dissolved Lithium (Li)	2014/10/21		103	%	75 - 125
			Dissolved Manganese (Mn)	2014/10/21		101	%	75 - 125
			Dissolved Molybdenum (Mo)	2014/10/21		95	%	75 - 125
			Dissolved Nickel (Ni)	2014/10/21		105	%	75 - 125
			Dissolved Selenium (Se)	2014/10/21		91	%	75 - 125
			Dissolved Silver (Ag)	2014/10/21		77	%	75 - 125
			Dissolved Strontium (Sr)	2014/10/21		103	%	75 - 125
			Dissolved Thallium (Tl)	2014/10/21		87	%	75 - 125
			Dissolved Tin (Sn)	2014/10/21		97	%	75 - 125
			Dissolved Titanium (Ti)	2014/10/21		102	%	75 - 125
			Dissolved Uranium (U)	2014/10/21		102	%	75 - 125
			Dissolved Vanadium (V)	2014/10/21		102	%	75 - 125

Quality Assurance Report (Continued)

Maxxam Job Number: VB493348

QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	UNITS	QC Limits
7684846 GS2	Spiked Blank	Dissolved Zinc (Zn)	2014/10/21		102	%	75 - 125
	Method Blank	Dissolved Aluminum (Al)	2014/10/21	<10		ug/L	
		Dissolved Antimony (Sb)	2014/10/21	<0.50		ug/L	
		Dissolved Arsenic (As)	2014/10/21	<0.50		ug/L	
		Dissolved Barium (Ba)	2014/10/21	<1.0		ug/L	
		Dissolved Beryllium (Be)	2014/10/21	<1.0		ug/L	
		Dissolved Bismuth (Bi)	2014/10/21	<1.0		ug/L	
		Dissolved Boron (B)	2014/10/21	<50		ug/L	
		Dissolved Cadmium (Cd)	2014/10/21	<0.050		ug/L	
		Dissolved Chromium (Cr)	2014/10/21	<0.50		ug/L	
		Dissolved Cobalt (Co)	2014/10/21	<0.10		ug/L	
		Dissolved Copper (Cu)	2014/10/21	<0.50		ug/L	
		Dissolved Iron (Fe)	2014/10/21	<2.0		ug/L	
		Dissolved Lead (Pb)	2014/10/21	<0.10		ug/L	
		Dissolved Lithium (Li)	2014/10/21	<20		ug/L	
		Dissolved Manganese (Mn)	2014/10/21	<0.50		ug/L	
		Dissolved Molybdenum (Mo)	2014/10/21	<1.0		ug/L	
		Dissolved Nickel (Ni)	2014/10/21	<0.20		ug/L	
		Dissolved Phosphorus (P)	2014/10/21	<50		ug/L	
		Dissolved Selenium (Se)	2014/10/21	<0.50		ug/L	
		Dissolved Silicon (Si)	2014/10/21	<100		ug/L	
		Dissolved Silver (Ag)	2014/10/21	<0.050		ug/L	
		Dissolved Strontium (Sr)	2014/10/21	<10		ug/L	
		Dissolved Thallium (Tl)	2014/10/21	<0.10		ug/L	
		Dissolved Tin (Sn)	2014/10/21	<1.0		ug/L	
		Dissolved Titanium (Ti)	2014/10/21	<10		ug/L	
		Dissolved Uranium (U)	2014/10/21	<0.050		ug/L	
		Dissolved Vanadium (V)	2014/10/21	<10		ug/L	
		Dissolved Zinc (Zn)	2014/10/21	<1.0		ug/L	
	RPD	Dissolved Aluminum (Al)	2014/10/21	14.3		%	25
		Dissolved Antimony (Sb)	2014/10/21	NC		%	25
		Dissolved Arsenic (As)	2014/10/21	NC		%	25
		Dissolved Barium (Ba)	2014/10/21	8.6		%	25
		Dissolved Beryllium (Be)	2014/10/21	NC		%	25
		Dissolved Bismuth (Bi)	2014/10/21	NC		%	25
		Dissolved Boron (B)	2014/10/21	8.6		%	25
		Dissolved Cadmium (Cd)	2014/10/21	NC		%	25
		Dissolved Chromium (Cr)	2014/10/21	NC		%	25
		Dissolved Cobalt (Co)	2014/10/21	NC		%	25
		Dissolved Copper (Cu)	2014/10/21	NC		%	25
		Dissolved Iron (Fe)	2014/10/21	NC		%	25
		Dissolved Lead (Pb)	2014/10/21	NC		%	25
		Dissolved Lithium (Li)	2014/10/21	1.1		%	25
		Dissolved Manganese (Mn)	2014/10/21	1.3		%	25
		Dissolved Molybdenum (Mo)	2014/10/21	6.9		%	25
		Dissolved Nickel (Ni)	2014/10/21	NC		%	25
		Dissolved Phosphorus (P)	2014/10/21	NC		%	25
		Dissolved Selenium (Se)	2014/10/21	NC		%	25
		Dissolved Silicon (Si)	2014/10/21	NC		%	25
		Dissolved Silver (Ag)	2014/10/21	NC		%	25
		Dissolved Strontium (Sr)	2014/10/21	0.5		%	25
		Dissolved Thallium (Tl)	2014/10/21	NC		%	25
		Dissolved Tin (Sn)	2014/10/21	NC		%	25
		Dissolved Titanium (Ti)	2014/10/21	NC		%	25
		Dissolved Uranium (U)	2014/10/21	4.7		%	25

Quality Assurance Report (Continued)

Maxxam Job Number: VB493348

QA/QC Batch Num	Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	UNITS	QC Limits
7684846	GS2	RPD	Dissolved Vanadium (V)	2014/10/21	NC		%	25
			Dissolved Zinc (Zn)	2014/10/21	NC		%	25

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 sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.
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 too small to permit a reliable recovery calculation (matrix spike concentration was less than 2x that of the native sample concentration).
NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (one or both samples < 5x RDL).
(1) Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.

Validation Signature Page

Maxxam Job #: B493348

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Rob Reinert, Data Validation Coordinator

Your Project #: 2539
Your C.O.C. #: B 136801

Attention: Paul LePage
Minnow Environmental
2 Lamb St
Georgetown, ON
CANADA L7G 3M9

Report Date: 2014/08/18
Report #: R3125109
Version: 1

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B4E0789
Received: 2014/08/07, 09:49

Sample Matrix: Sea Water
Samples Received: 10

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Phosphorus Total Colourimetry	10	2014/08/15	2014/08/18	ATL SOP 00057	EPA 365.1 R2 m

Remarks:

Reporting results to two significant figures at the RDL is to permit statistical evaluation and is not intended to be an indication of analytical precision.

* 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 Ext:289

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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: 1

Maxxam Job #: B4E0789
Report Date: 2014/08/18

Minnow Environmental
Client Project #: 2539

Sampler Initials: PL

RESULTS OF ANALYSES OF SEA WATER

Maxxam ID		XA1074	XA1075	XA1076	XA1077	XA1078	XA1079	XA1080	XA1081	XA1082	XA1083		
Sampling Date		2014/08/04	2014/08/05	2014/08/04	2014/08/05	2014/08/04	2014/08/05	2014/08/04	2014/08/05	2014/08/04	2014/08/05		
	Units	**D1**	**D2**	**S1-01**	**S1-02**	**S2-01**	**S2-02**	**S3-01**	**S3-02**	**S4-01**	**S4-02**	**RDL**	**QC Batch**
Inorganics													
Total Phosphorus	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.020	3712287

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Package 1	8.7°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 Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits
3712287	Total Phosphorus	2014/08/18	NC	80 - 120	108	80 - 120	ND, RDL=0.020	mg/L	2.9	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.
Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.
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 too small to permit a reliable recovery calculation (matrix spike concentration was less than 2x that of the native sample concentration).

Validation Signature Page

Maxxam Job #: B4E0789

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

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 136801

Page 1 of 1

This column for lab use only:

Client Code 767

Maxxam Job # B4E0789

Cooler ID	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp
			9	7	10	

Integrity YES [✓ NO]

Integrity / Checklist by SM

Labelled by

Location / Bin # 42

B4E0789

INVOICE INFORMATION:

Company Name: Minnow Environmental
Contact Name: Paul LePage
Address: 2 Lamb Str
Georgetown, ON Postal Code L7G 3M9
Email: plepage@minnow.ca
Ph: 905 873-3371 Fax:

REPORT INFORMATION (if differs from invoice):

Company Name:
Contact Name:
Address:
Postal Code
Email:
Ph: Fax:

PO #
Project # / Phase # 2539
Project Name / Site Location
Quote B44763
Site #
Task Order #
Sampled by PL/LB

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

Lab filtration required for sea water dissolved metals analysis

*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			Metals Soil					Hydrocarbons						Total Phosphorus	Total Nitrogen	Sea Water Dissolved Metals by Dilution	
									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	D1	Sea water	4-Aug	3		Y																	✓	✓	✓	
2	D2		5 Aug	3		Y																	✓	✓	✓	
3	S1-01		4 Aug	3		Y																	✓	✓	✓	
4	S1-02		5 Aug	3		Y																	✓	✓	✓	
5	S2-01		4 Aug	3		Y																	✓	✓	✓	
6	S2-02		5 Aug	3		Y																	✓	✓	✓	
7	S3-01		4 Aug	3		Y																	✓	✓	✓	
8	S3-02		5 Aug	3		Y																	✓	✓	✓	
9	S4-01		4 Aug	3		Y																	✓	✓	✓	
10	S4-02		5 Aug	3		Y																	✓	✓	✓	

RELINQUISHED BY: (Signature/Print)	Date	Time	RECEIVED BY: (Signature/Print)	Date	Time
P. LePage c/o Purolator	Aug 6th		Sara Mason SARA MASON	AUG 7	

White: Maxxam Yellow : Mail Pink: Client

Your Project #: DB4E0789
Site Location: 2539
Your C.O.C. #: 08395791

Attention: BEDFORD CLIENT SERVICE

MAXXAM ANALYTICS
200 BLUEWATER ROAD, SUITE 105
BEDFORD, NS
CANADA B4B 1G9

Report Date: 2014/08/15
Report #: R1622648
Version: 1

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B469319
Received: 2014/08/12, 09:00

Sample Matrix: Sea Water
Samples Received: 10

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Hardness (calculated as CaCO3)	10	N/A	2014/08/15	BBY7SOP-00002	EPA 6020a R1 m
Na, K, Ca, Mg, S by CRC ICPMS (diss.)	10	N/A	2014/08/15	BBY7SOP-00002	EPA 6020A R1 m
Elements by ICPMS (dissolved) - Seawater	10	N/A	2014/08/15	BBY7SOP-00002	EPA 6020A R1 m
Nitrogen (Total)	10	2014/08/14	2014/08/14	BBY6SOP-00016	SM 22 4500-N C m
Filter and HNO3 Preserve for Metals	10	N/A	2014/08/13	BBY6WI-00001	EPA 200.2

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Shanaz Akbar, Project Manager
Email: SAkbar@maxxam.ca
Phone# (604) 734 7276

==

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Total cover pages: 1

RESULTS OF CHEMICAL ANALYSES OF SEA WATER

Maxxam ID		KH9745	KH9746	KH9747	KH9748	KH9749	KH9750		
Sampling Date		2014/08/04	2014/08/05	2014/08/04	2014/08/05	2014/08/04	2014/08/05		
COC Number		08395791	08395791	08395791	08395791	08395791	08395791		
	UNITS	**D1 (XA1074)**	**D2 (XA1075)**	**S1-01 (XA1076)**	**S1-02 (XA1077)**	**S2-01 (XA1078)**	**S2-02 (XA1079)**	**RDL**	**QC Batch**
Calculated Parameters									
Filter and HNO3 Preservation	N/A	LAB	LAB	LAB	LAB	LAB	LAB	N/A	7598188
Misc. Inorganics									
Dissolved Hardness (CaCO3)	mg/L	4480	4380	4450	4380	4490	4450	0.50	7596832
Nutrients									
Total Nitrogen (N)	mg/L	0.190	0.203	0.226	0.285	0.209	0.235	0.020	7600211

RDL = Reportable Detection Limit

Maxxam ID		KH9751	KH9752	KH9753	KH9754		
Sampling Date		2014/08/04	2014/08/05	2014/08/04	2014/08/05		
COC Number		08395791	08395791	08395791	08395791		
	UNITS	**S3-01 (XA1080)**	**S3-02 (XA1081)**	**S4-01 (XA1082)**	**S4-02 (XA1083)**	**RDL**	**QC Batch**
Calculated Parameters							
Filter and HNO3 Preservation	N/A	LAB	LAB	LAB	LAB	N/A	7598188
Misc. Inorganics							
Dissolved Hardness (CaCO3)	mg/L	4190	4460	4420	4380	0.50	7596832
Nutrients							
Total Nitrogen (N)	mg/L	0.174	0.261	0.238	0.216	0.020	7600211

RDL = Reportable Detection Limit

ELEMENTS BY ATOMIC SPECTROSCOPY (SEA WATER)

Maxxam ID		KH9745	KH9745	KH9746	KH9747	KH9748	KH9749		
Sampling Date		2014/08/04	2014/08/04	2014/08/05	2014/08/04	2014/08/05	2014/08/04		
COC Number		08395791	08395791	08395791	08395791	08395791	08395791		
	UNITS	**D1 (XA1074)**	**D1 (XA1074) Lab-Dup**	**D2 (XA1075)**	**S1-01 (XA1076)**	**S1-02 (XA1077)**	**S2-01 (XA1078)**	**RDL**	**QC Batch**
Dissolved Metals by ICPMS									
Dissolved Aluminum (Al)	ug/L	16	18	15	15	14	14	10	7602307
Dissolved Antimony (Sb)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	7602307
Dissolved Arsenic (As)	ug/L	1.36	1.40	1.88	1.37	2.27	1.38	0.50	7602307
Dissolved Barium (Ba)	ug/L	10.4	10.4	11.3	11.0	11.2	10.2	1.0	7602307
Dissolved Beryllium (Be)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	7602307
Dissolved Bismuth (Bi)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	7602307
Dissolved Boron (B)	ug/L	3320	3250	3190	3320	3260	3290	50	7602307
Dissolved Cadmium (Cd)	ug/L	0.115	0.099	0.974	0.077	0.989	0.075	0.050	7602307
Dissolved Chromium (Cr)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	7602307
Dissolved Cobalt (Co)	ug/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.10	7602307
Dissolved Copper (Cu)	ug/L	0.62	0.52	0.72	0.68	0.62	0.60	0.50	7602307
Dissolved Iron (Fe)	ug/L	2.3	<2.0	2.4	2.4	<2.0	<2.0	2.0	7602307
Dissolved Lead (Pb)	ug/L	0.51	0.52	1.60	0.24	1.52	0.30	0.10	7602307
Dissolved Lithium (Li)	ug/L	132	132	132	138	127	134	20	7602307
Dissolved Manganese (Mn)	ug/L	2.19	2.29	6.00	1.14	5.73	1.47	0.50	7602307
Dissolved Molybdenum (Mo)	ug/L	8.9	9.0	9.1	9.3	8.4	9.1	1.0	7602307
Dissolved Nickel (Ni)	ug/L	0.49	0.76	0.46	0.63	0.42	0.39	0.20	7602307
Dissolved Phosphorus (P)	ug/L	<50	<50	<50	<50	<50	<50	50	7602307
Dissolved Selenium (Se)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	7602307
Dissolved Silicon (Si)	ug/L	144	137	187	160	201	156	100	7602307
Dissolved Silver (Ag)	ug/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.050	7602307
Dissolved Strontium (Sr)	ug/L	5950	6010	6010	6220	5790	6020	10	7602307
Dissolved Thallium (Tl)	ug/L	0.28	0.30	3.07	0.27	3.30	0.23	0.10	7602307
Dissolved Tin (Sn)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	7602307
Dissolved Titanium (Ti)	ug/L	<10	<10	<10	<10	<10	<10	10	7602307
Dissolved Uranium (U)	ug/L	2.34	2.46	2.47	2.52	2.39	2.42	0.050	7602307
Dissolved Vanadium (V)	ug/L	<10	<10	<10	<10	<10	<10	10	7602307
Dissolved Zinc (Zn)	ug/L	3.0	3.2	7.4	2.4	8.4	1.4	1.0	7602307
Dissolved Calcium (Ca)	mg/L	362	N/A	319	327	327	323	1.0	7597740
Dissolved Magnesium (Mg)	mg/L	868	N/A	870	883	866	896	1.0	7597740
Dissolved Potassium (K)	mg/L	272	N/A	288	293	282	294	1.0	7597740
Dissolved Sodium (Na)	mg/L	7340	N/A	7150	7300	7000	7250	1.0	7597740

N/A = Not Applicable
RDL = Reportable Detection Limit

ELEMENTS BY ATOMIC SPECTROSCOPY (SEA WATER)

Maxxam ID		KH9745	KH9745	KH9746	KH9747	KH9748	KH9749		
Sampling Date		2014/08/04	2014/08/04	2014/08/05	2014/08/04	2014/08/05	2014/08/04		
COC Number		08395791	08395791	08395791	08395791	08395791	08395791		
	UNITS	**D1 (XA1074)**	**D1 (XA1074) Lab-Dup**	**D2 (XA1075)**	**S1-01 (XA1076)**	**S1-02 (XA1077)**	**S2-01 (XA1078)**	**RDL**	**QC Batch**
Dissolved Sulphur (S)	mg/L	650	N/A	713	752	742	748	20	7597740

N/A = Not Applicable
RDL = Reportable Detection Limit

ELEMENTS BY ATOMIC SPECTROSCOPY (SEA WATER)

Maxxam ID		KH9750	KH9751	KH9752	KH9753	KH9754		
Sampling Date		2014/08/05	2014/08/04	2014/08/05	2014/08/04	2014/08/05		
COC Number		08395791	08395791	08395791	08395791	08395791		
	UNITS	**S2-02 (XA1079)**	**S3-01 (XA1080)**	**S3-02 (XA1081)**	**S4-01 (XA1082)**	**S4-02 (XA1083)**	**RDL**	**QC Batch**
Dissolved Metals by ICPMS								
Dissolved Aluminum (Al)	ug/L	15	15	19	13	15	10	7602307
Dissolved Antimony (Sb)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	7602307
Dissolved Arsenic (As)	ug/L	1.46	1.50	1.79	1.40	1.45	0.50	7602307
Dissolved Barium (Ba)	ug/L	10.4	10.1	11.1	10.3	10.4	1.0	7602307
Dissolved Beryllium (Be)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	7602307
Dissolved Bismuth (Bi)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	7602307
Dissolved Boron (B)	ug/L	3470	3360	3450	3290	3380	50	7602307
Dissolved Cadmium (Cd)	ug/L	0.152	0.113	0.123	0.058	0.065	0.050	7602307
Dissolved Chromium (Cr)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	7602307
Dissolved Cobalt (Co)	ug/L	<0.10	<0.10	<0.10	<0.10	<0.10	0.10	7602307
Dissolved Copper (Cu)	ug/L	0.90	0.80	2.49	<0.50	0.68	0.50	7602307
Dissolved Iron (Fe)	ug/L	<2.0	2.4	4.4	<2.0	<2.0	2.0	7602307
Dissolved Lead (Pb)	ug/L	0.63	0.51	1.03	0.27	0.40	0.10	7602307
Dissolved Lithium (Li)	ug/L	130	127	132	135	135	20	7602307
Dissolved Manganese (Mn)	ug/L	2.75	1.98	4.05	1.58	3.11	0.50	7602307
Dissolved Molybdenum (Mo)	ug/L	9.2	8.5	8.8	8.7	8.8	1.0	7602307
Dissolved Nickel (Ni)	ug/L	0.33	0.50	0.48	0.46	0.29	0.20	7602307
Dissolved Phosphorus (P)	ug/L	<50	<50	<50	<50	<50	50	7602307
Dissolved Selenium (Se)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	7602307
Dissolved Silicon (Si)	ug/L	138	149	152	155	140	100	7602307
Dissolved Silver (Ag)	ug/L	<0.050	<0.050	<0.050	<0.050	<0.050	0.050	7602307
Dissolved Strontium (Sr)	ug/L	5980	5760	6250	6140	6120	10	7602307
Dissolved Thallium (Tl)	ug/L	0.70	0.30	0.29	0.11	<0.10	0.10	7602307
Dissolved Tin (Sn)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	7602307
Dissolved Titanium (Ti)	ug/L	<10	<10	<10	<10	<10	10	7602307
Dissolved Uranium (U)	ug/L	2.38	2.38	2.47	2.54	2.41	0.050	7602307
Dissolved Vanadium (V)	ug/L	<10	<10	<10	<10	<10	10	7602307
Dissolved Zinc (Zn)	ug/L	2.8	3.1	4.1	1.2	1.9	1.0	7602307
Dissolved Calcium (Ca)	mg/L	327	320	333	304	328	1.0	7597740
Dissolved Magnesium (Mg)	mg/L	882	824	882	888	866	1.0	7597740
Dissolved Potassium (K)	mg/L	294	271	292	296	286	1.0	7597740
Dissolved Sodium (Na)	mg/L	7130	6840	7130	7330	7190	1.0	7597740

RDL = Reportable Detection Limit

ELEMENTS BY ATOMIC SPECTROSCOPY (SEA WATER)

Maxxam ID		KH9750	KH9751	KH9752	KH9753	KH9754		
Sampling Date		2014/08/05	2014/08/04	2014/08/05	2014/08/04	2014/08/05		
COC Number		08395791	08395791	08395791	08395791	08395791		
	UNITS	**S2-02 (XA1079)**	**S3-01 (XA1080)**	**S3-02 (XA1081)**	**S4-01 (XA1082)**	**S4-02 (XA1083)**	**RDL**	**QC Batch**
Dissolved Sulphur (S)	mg/L	774	699	744	747	705	20	7597740

RDL = Reportable Detection Limit

Package 1	5.3°C

Each temperature is the average of up to three cooler temperatures taken at receipt

General Comments

Results relate only to the items tested.

Quality Assurance Report

Maxxam Job Number: VB469319

QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	UNITS	QC Limits
7600211 SC2	Matrix Spike						
	[KH9746-02]	Total Nitrogen (N)	2014/08/14		NC	%	80 - 120
	Spiked Blank	Total Nitrogen (N)	2014/08/14		107	%	80 - 120
	Method Blank	Total Nitrogen (N)	2014/08/14	<0.020		mg/L	
7602307 GS2	Matrix Spike						
	[KH9745-01]	Dissolved Aluminum (Al)	2014/08/15		102	%	75 - 125
		Dissolved Antimony (Sb)	2014/08/15		103	%	75 - 125
		Dissolved Arsenic (As)	2014/08/15		107	%	75 - 125
		Dissolved Barium (Ba)	2014/08/15		102	%	75 - 125
		Dissolved Beryllium (Be)	2014/08/15		109	%	75 - 125
		Dissolved Bismuth (Bi)	2014/08/15		97	%	75 - 125
		Dissolved Boron (B)	2014/08/15		NC	%	75 - 125
		Dissolved Cadmium (Cd)	2014/08/15		97	%	75 - 125
		Dissolved Chromium (Cr)	2014/08/15		93	%	75 - 125
		Dissolved Cobalt (Co)	2014/08/15		88	%	75 - 125
		Dissolved Copper (Cu)	2014/08/15		82	%	75 - 125
		Dissolved Iron (Fe)	2014/08/15		96	%	75 - 125
		Dissolved Lead (Pb)	2014/08/15		101	%	75 - 125
		Dissolved Lithium (Li)	2014/08/15		NC	%	75 - 125
		Dissolved Manganese (Mn)	2014/08/15		98	%	75 - 125
		Dissolved Molybdenum (Mo)	2014/08/15		NC	%	75 - 125
		Dissolved Nickel (Ni)	2014/08/15		86	%	75 - 125
		Dissolved Selenium (Se)	2014/08/15		90	%	75 - 125
		Dissolved Silver (Ag)	2014/08/15		99	%	75 - 125
		Dissolved Strontium (Sr)	2014/08/15		NC	%	75 - 125
		Dissolved Thallium (Tl)	2014/08/15		95	%	75 - 125
		Dissolved Tin (Sn)	2014/08/15		104	%	75 - 125
		Dissolved Titanium (Ti)	2014/08/15		95	%	75 - 125
		Dissolved Uranium (U)	2014/08/15		107	%	75 - 125
		Dissolved Vanadium (V)	2014/08/15		96	%	75 - 125
		Dissolved Zinc (Zn)	2014/08/15		91	%	75 - 125
	Spiked Blank	Dissolved Aluminum (Al)	2014/08/15		105	%	75 - 125
		Dissolved Antimony (Sb)	2014/08/15		102	%	75 - 125
		Dissolved Arsenic (As)	2014/08/15		107	%	75 - 125
		Dissolved Barium (Ba)	2014/08/15		101	%	75 - 125
		Dissolved Beryllium (Be)	2014/08/15		107	%	75 - 125
		Dissolved Bismuth (Bi)	2014/08/15		102	%	75 - 125
		Dissolved Boron (B)	2014/08/15		115	%	75 - 125
		Dissolved Cadmium (Cd)	2014/08/15		100	%	75 - 125
		Dissolved Chromium (Cr)	2014/08/15		98	%	75 - 125
		Dissolved Cobalt (Co)	2014/08/15		97	%	75 - 125
		Dissolved Copper (Cu)	2014/08/15		100	%	75 - 125
		Dissolved Iron (Fe)	2014/08/15		102	%	75 - 125
		Dissolved Lead (Pb)	2014/08/15		101	%	75 - 125
		Dissolved Lithium (Li)	2014/08/15		107	%	75 - 125
		Dissolved Manganese (Mn)	2014/08/15		102	%	75 - 125
		Dissolved Molybdenum (Mo)	2014/08/15		100	%	75 - 125
		Dissolved Nickel (Ni)	2014/08/15		98	%	75 - 125
		Dissolved Selenium (Se)	2014/08/15		96	%	75 - 125
		Dissolved Silver (Ag)	2014/08/15		96	%	75 - 125
		Dissolved Strontium (Sr)	2014/08/15		103	%	75 - 125
		Dissolved Thallium (Tl)	2014/08/15		100	%	75 - 125
		Dissolved Tin (Sn)	2014/08/15		100	%	75 - 125
		Dissolved Titanium (Ti)	2014/08/15		107	%	75 - 125
		Dissolved Uranium (U)	2014/08/15		99	%	75 - 125

Quality Assurance Report (Continued)

Maxxam Job Number: VB469319

QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	UNITS	QC Limits
7602307 GS2	Spiked Blank	Dissolved Vanadium (V)	2014/08/15		99	%	75 - 125
		Dissolved Zinc (Zn)	2014/08/15		104	%	75 - 125
	Method Blank	Dissolved Aluminum (Al)	2014/08/15	<10		ug/L	
		Dissolved Antimony (Sb)	2014/08/15	<0.50		ug/L	
		Dissolved Arsenic (As)	2014/08/15	<0.50		ug/L	
		Dissolved Barium (Ba)	2014/08/15	<1.0		ug/L	
		Dissolved Beryllium (Be)	2014/08/15	<1.0		ug/L	
		Dissolved Bismuth (Bi)	2014/08/15	<1.0		ug/L	
		Dissolved Boron (B)	2014/08/15	<50		ug/L	
		Dissolved Cadmium (Cd)	2014/08/15	<0.050		ug/L	
		Dissolved Chromium (Cr)	2014/08/15	<0.50		ug/L	
		Dissolved Cobalt (Co)	2014/08/15	<0.10		ug/L	
		Dissolved Copper (Cu)	2014/08/15	<0.50		ug/L	
		Dissolved Iron (Fe)	2014/08/15	<2.0		ug/L	
		Dissolved Lead (Pb)	2014/08/15	<0.10		ug/L	
		Dissolved Lithium (Li)	2014/08/15	<20		ug/L	
		Dissolved Manganese (Mn)	2014/08/15	<0.50		ug/L	
		Dissolved Molybdenum (Mo)	2014/08/15	<1.0		ug/L	
		Dissolved Nickel (Ni)	2014/08/15	<0.20		ug/L	
		Dissolved Phosphorus (P)	2014/08/15	<50		ug/L	
		Dissolved Selenium (Se)	2014/08/15	<0.50		ug/L	
		Dissolved Silicon (Si)	2014/08/15	<100		ug/L	
		Dissolved Silver (Ag)	2014/08/15	<0.050		ug/L	
		Dissolved Strontium (Sr)	2014/08/15	<10		ug/L	
		Dissolved Thallium (Tl)	2014/08/15	<0.10		ug/L	
		Dissolved Tin (Sn)	2014/08/15	<1.0		ug/L	
		Dissolved Titanium (Ti)	2014/08/15	<10		ug/L	
		Dissolved Uranium (U)	2014/08/15	<0.050		ug/L	
		Dissolved Vanadium (V)	2014/08/15	<10		ug/L	
		Dissolved Zinc (Zn)	2014/08/15	<1.0		ug/L	
	RPD [KH9745-01]	Dissolved Aluminum (Al)	2014/08/15	NC		%	25
		Dissolved Antimony (Sb)	2014/08/15	NC		%	25
		Dissolved Arsenic (As)	2014/08/15	NC		%	25
		Dissolved Barium (Ba)	2014/08/15	0.3		%	25
		Dissolved Beryllium (Be)	2014/08/15	NC		%	25
		Dissolved Bismuth (Bi)	2014/08/15	NC		%	25
		Dissolved Boron (B)	2014/08/15	2.2		%	25
		Dissolved Cadmium (Cd)	2014/08/15	NC		%	25
		Dissolved Chromium (Cr)	2014/08/15	NC		%	25
		Dissolved Cobalt (Co)	2014/08/15	NC		%	25
		Dissolved Copper (Cu)	2014/08/15	NC		%	25
		Dissolved Iron (Fe)	2014/08/15	NC		%	25
		Dissolved Lead (Pb)	2014/08/15	2.0		%	25
		Dissolved Lithium (Li)	2014/08/15	0.04		%	25
		Dissolved Manganese (Mn)	2014/08/15	NC		%	25
		Dissolved Molybdenum (Mo)	2014/08/15	1.9		%	25
		Dissolved Nickel (Ni)	2014/08/15	NC		%	25
		Dissolved Phosphorus (P)	2014/08/15	NC		%	25
		Dissolved Selenium (Se)	2014/08/15	NC		%	25
		Dissolved Silicon (Si)	2014/08/15	NC		%	25
		Dissolved Silver (Ag)	2014/08/15	NC		%	25
		Dissolved Strontium (Sr)	2014/08/15	1.0		%	25
		Dissolved Thallium (Tl)	2014/08/15	NC		%	25
		Dissolved Tin (Sn)	2014/08/15	NC		%	25
		Dissolved Titanium (Ti)	2014/08/15	NC		%	25

Quality Assurance Report (Continued)

Maxxam Job Number: VB469319

QA/QC Batch Num	Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	UNITS	QC Limits
7602307	GS2	RPD [KH9745-01]	Dissolved Uranium (U)	2014/08/15	5.0		%	25
			Dissolved Vanadium (V)	2014/08/15	NC		%	25
			Dissolved Zinc (Zn)	2014/08/15	NC		%	25

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 sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.
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 too small to permit a reliable recovery calculation (matrix spike concentration was less than 2x that of the native sample concentration).
NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (one or both samples < 5x RDL).

Validation Signature Page

Maxxam Job #: B469319

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Rob Reinert, Data Validation Coordinator

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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 #: 2539
Your C.O.C. #: B 136802

Attention: Paul LePage
Minnow Environmental
2 Lamb St
Georgetown, ON
CANADA L7G 3M9

Report Date: 2014/08/20
Report #: R3127076
Version: 1

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B4E1932
Received: 2014/08/08, 10:34

Sample Matrix: Sea Water
Samples Received: 6

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Phosphorus Total Colourimetry	6	2014/08/15	2014/08/18	ATL SOP 00057	EPA 365.1 R2 m

Remarks:

Reporting results to two significant figures at the RDL is to permit statistical evaluation and is not intended to be an indication of analytical precision.

* 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 Ext:289

==
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Total cover pages: 1

RESULTS OF ANALYSES OF SEA WATER

Maxxam ID		XA6337	XA6338		XA6339	XA6340	XA6341	XA6342		
Sampling Date		2014/08/06	2014/08/06		2014/08/06	2014/08/06	2014/08/06	2014/08/06		
	Units	**D3**	**D4**	**QC Batch**	**R1-01**	**R1-02**	**R2-01**	**R2-02**	**RDL**	**QC Batch**
Inorganics										
Total Phosphorus	mg/L	ND	ND	3712287	ND	ND	ND	ND	0.020	3712292

ND = Not detected
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Package 1	1.3°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 Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits
3712287	Total Phosphorus	2014/08/18	NC	80 - 120	108	80 - 120	ND, RDL=0.020	mg/L	2.9	25
3712292	Total Phosphorus	2014/08/18	116	80 - 120	108	80 - 120	ND, RDL=0.020	mg/L	1.1	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 sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

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 too small to permit a reliable recovery calculation (matrix spike concentration was less than 2x that of the native sample concentration).

Validation Signature Page

Maxxam Job #: B4E1932

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
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 136802 Page 1 of 1

This column for lab use only:

Client Code

Maxxam Job # B4E1932

Cooler ID	Seal Present	Seal Intact	Temp 1	Temp 2	Temp 3	Average Temp
			2	1	1	

Integrity YES [✓ NO]

Integrity / Checklist by

Labelled by

Location / Bin #

INVOICE INFORMATION:

Company Name: MINNOW ENVIRONMENTAL
Contact Name: PAUL LePAGE
Address: 2 LAMB STR.
GEORGETOWN, ON Postal Code L7G 3M9
Email: plapage@minnow.ca
Ph: 905.873.3371 Fax:

REPORT INFORMATION (if differs from invoice):

Company Name:
Contact Name:
Address:
Postal Code
Email:
Ph: Fax:

PO #
Project # / Phase # 2539
Project Name / Site Location
Quote B44763
Site #
Task Order #
Sampled by PL/LB

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

Lab filtration required for sea water dissolved metals analysis

*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	Total Phosphorus	Total Nitrogen	Sea water dissolved metals by dilution		
1	D3	Sea water	6-Aug	3		Y																	✓	✓	✓		
2	D4	〃	〃	3		Y																	✓	✓	✓		
3	R1-01	〃	〃	3		Y																	✓	✓	✓		
4	R1-02	〃	〃	3		Y																	✓	✓	✓		
5	R2-01	〃	〃	3		Y																	✓	✓	✓		
6	R2-02	〃	〃	3		Y																	✓	✓	✓		
7																											
8																											
9																											

2014 AUG 8 10:34

B4E1932

RELINQUISHED BY: (Signature/Print)	Date	Time	RECEIVED BY: (Signature/Print)	Date	Time
P. LePage c/o Purolator	Aug 7th		Iesha Baribault IESHA BARIBAULT		

Your Project #: DB4E1932
Site Location: 2539
Your C.O.C. #: 08395789

Attention: BEDFORD CLIENT SERVICE

MAXXAM ANALYTICS
200 BLUEWATER ROAD, SUITE 105
BEDFORD, NS
CANADA B4B 1G9

Report Date: 2014/08/19
Report #: R1624232
Version: 1

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B469303

Received: 2014/08/12, 09:00

Sample Matrix: Sea Water
Samples Received: 6

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Hardness (calculated as CaCO3)	6	N/A	2014/08/19	BBY7SOP-00002	EPA 6020a R1 m
Na, K, Ca, Mg, S by CRC ICPMS (diss.)	6	N/A	2014/08/19	BBY7SOP-00002	EPA 6020A R1 m
Elements by ICPMS (dissolved) - Seawater	6	N/A	2014/08/19	BBY7SOP-00002	EPA 6020A R1 m
Nitrogen (Total)	6	2014/08/13	2014/08/14	BBY6SOP-00016	SM 22 4500-N C m
Filter and HNO3 Preserve for Metals	6	N/A	2014/08/13	BBY6WI-00001	EPA 200.2

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Shanaz Akbar, Project Manager
Email: SAkbar@maxxam.ca
Phone# (604) 734 7276

==
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Total cover pages: 1

RESULTS OF CHEMICAL ANALYSES OF SEA WATER

Maxxam ID		KH9667	KH9668	KH9669	KH9670	KH9671	KH9672		
Sampling Date		2014/08/06	2014/08/06	2014/08/06	2014/08/06	2014/08/06	2014/08/06		
COC Number		08395789	08395789	08395789	08395789	08395789	08395789		
	UNITS	**D3 (XA6337)**	**D4 (XA6338)**	**R1-01 (XA6339)**	**R1-02 (XA6340)**	**R2-01 (XA6341)**	**R2-02 (XA6342)**	**RDL**	**QC Batch**

Calculated Parameters									
Filter and HNO3 Preservation	N/A	LAB	LAB	LAB	LAB	LAB	LAB	N/A	7598188
Misc. Inorganics									
Dissolved Hardness (CaCO3)	mg/L	4520	4460	4540	4350	4500	4560	0.50	7596832
Nutrients									
Total Nitrogen (N)	mg/L	0.228	0.202	0.243	0.221	0.282	0.266	0.020	7598443

RDL = Reportable Detection Limit

ELEMENTS BY ATOMIC SPECTROSCOPY (SEA WATER)

Maxxam ID		KH9667	KH9667	KH9668	KH9669	KH9670	KH9671		
Sampling Date		2014/08/06	2014/08/06	2014/08/06	2014/08/06	2014/08/06	2014/08/06		
COC Number		08395789	08395789	08395789	08395789	08395789	08395789		
	UNITS	**D3 (XA6337)**	**D3 (XA6337) Lab-Dup**	**D4 (XA6338)**	**R1-01 (XA6339)**	**R1-02 (XA6340)**	**R2-01 (XA6341)**	**RDL**	**QC Batch**
Dissolved Metals by ICPMS									
Dissolved Aluminum (Al)	ug/L	10	<10	<10	<10	<10	<10	10	7604526
Dissolved Antimony (Sb)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	7604526
Dissolved Arsenic (As)	ug/L	1.23	1.26	1.30	1.30	1.28	1.25	0.50	7604526
Dissolved Barium (Ba)	ug/L	10.8	10.3	10.2	10.4	11.6	11.1	1.0	7604526
Dissolved Beryllium (Be)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	7604526
Dissolved Bismuth (Bi)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	7604526
Dissolved Boron (B)	ug/L	3160	3210	3210	3200	3200	3190	50	7604526
Dissolved Cadmium (Cd)	ug/L	0.052	0.053	0.061	0.055	0.061	0.058	0.050	7604526
Dissolved Chromium (Cr)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	7604526
Dissolved Cobalt (Co)	ug/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.10	7604526
Dissolved Copper (Cu)	ug/L	0.62	0.59	<0.50	<0.50	0.96	0.93	0.50	7604526
Dissolved Iron (Fe)	ug/L	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	2.0	7604526
Dissolved Lead (Pb)	ug/L	0.15	0.13	<0.10	<0.10	<0.10	<0.10	0.10	7604526
Dissolved Lithium (Li)	ug/L	124	121	122	120	122	120	20	7604526
Dissolved Manganese (Mn)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	7604526
Dissolved Molybdenum (Mo)	ug/L	8.8	9.8	9.2	9.3	9.6	9.7	1.0	7604526
Dissolved Nickel (Ni)	ug/L	0.44	0.41	0.44	1.03	<0.20	0.53	0.20	7604526
Dissolved Phosphorus (P)	ug/L	<50	<50	<50	<50	<50	<50	50	7604526
Dissolved Selenium (Se)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	7604526
Dissolved Silicon (Si)	ug/L	183	193	198	188	198	199	100	7604526
Dissolved Silver (Ag)	ug/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.050	7604526
Dissolved Strontium (Sr)	ug/L	6360	6360	6260	6270	6250	6370	10	7604526
Dissolved Thallium (Tl)	ug/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.10	7604526
Dissolved Tin (Sn)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	7604526
Dissolved Titanium (Ti)	ug/L	<10	<10	<10	<10	<10	<10	10	7604526
Dissolved Uranium (U)	ug/L	2.27	2.21	2.26	2.25	2.17	2.29	0.050	7604526
Dissolved Vanadium (V)	ug/L	<10	<10	<10	<10	<10	<10	10	7604526
Dissolved Zinc (Zn)	ug/L	<1.0	1.1	<1.0	<1.0	<1.0	<1.0	1.0	7604526
Dissolved Calcium (Ca)	mg/L	321	N/A	331	328	325	322	1.0	7597740
Dissolved Magnesium (Mg)	mg/L	903	N/A	882	904	861	897	1.0	7597740
Dissolved Potassium (K)	mg/L	294	N/A	289	299	290	297	1.0	7597740
Dissolved Sodium (Na)	mg/L	7340	N/A	7230	7340	7170	7100	1.0	7597740

N/A = Not Applicable
RDL = Reportable Detection Limit

ELEMENTS BY ATOMIC SPECTROSCOPY (SEA WATER)

Maxxam ID		KH9667	KH9667	KH9668	KH9669	KH9670	KH9671		
Sampling Date		2014/08/06	2014/08/06	2014/08/06	2014/08/06	2014/08/06	2014/08/06		
COC Number		08395789	08395789	08395789	08395789	08395789	08395789		
	UNITS	**D3 (XA6337)**	**D3 (XA6337) Lab-Dup**	**D4 (XA6338)**	**R1-01 (XA6339)**	**R1-02 (XA6340)**	**R2-01 (XA6341)**	**RDL**	**QC Batch**
Dissolved Sulphur (S)	mg/L	744	N/A	754	767	737	742	20	7597740

N/A = Not Applicable
RDL = Reportable Detection Limit

ELEMENTS BY ATOMIC SPECTROSCOPY (SEA WATER)

Maxxam ID		KH9672		
Sampling Date		2014/08/06		
COC Number		08395789		
	UNITS	**R2-02 (XA6342)**	**RDL**	**QC Batch**
Dissolved Metals by ICPMS				
Dissolved Aluminum (Al)	ug/L	<10	10	7604526
Dissolved Antimony (Sb)	ug/L	<0.50	0.50	7604526
Dissolved Arsenic (As)	ug/L	1.33	0.50	7604526
Dissolved Barium (Ba)	ug/L	10.6	1.0	7604526
Dissolved Beryllium (Be)	ug/L	<1.0	1.0	7604526
Dissolved Bismuth (Bi)	ug/L	<1.0	1.0	7604526
Dissolved Boron (B)	ug/L	3230	50	7604526
Dissolved Cadmium (Cd)	ug/L	0.061	0.050	7604526
Dissolved Chromium (Cr)	ug/L	<0.50	0.50	7604526
Dissolved Cobalt (Co)	ug/L	<0.10	0.10	7604526
Dissolved Copper (Cu)	ug/L	0.83	0.50	7604526
Dissolved Iron (Fe)	ug/L	<2.0	2.0	7604526
Dissolved Lead (Pb)	ug/L	<0.10	0.10	7604526
Dissolved Lithium (Li)	ug/L	121	20	7604526
Dissolved Manganese (Mn)	ug/L	0.79	0.50	7604526
Dissolved Molybdenum (Mo)	ug/L	9.1	1.0	7604526
Dissolved Nickel (Ni)	ug/L	0.25	0.20	7604526
Dissolved Phosphorus (P)	ug/L	<50	50	7604526
Dissolved Selenium (Se)	ug/L	<0.50	0.50	7604526
Dissolved Silicon (Si)	ug/L	197	100	7604526
Dissolved Silver (Ag)	ug/L	<0.050	0.050	7604526
Dissolved Strontium (Sr)	ug/L	6270	10	7604526
Dissolved Thallium (Tl)	ug/L	<0.10	0.10	7604526
Dissolved Tin (Sn)	ug/L	<1.0	1.0	7604526
Dissolved Titanium (Ti)	ug/L	<10	10	7604526
Dissolved Uranium (U)	ug/L	2.33	0.050	7604526
Dissolved Vanadium (V)	ug/L	<10	10	7604526
Dissolved Zinc (Zn)	ug/L	<1.0	1.0	7604526
Dissolved Calcium (Ca)	mg/L	325	1.0	7597740
Dissolved Magnesium (Mg)	mg/L	910	1.0	7597740
Dissolved Potassium (K)	mg/L	302	1.0	7597740
Dissolved Sodium (Na)	mg/L	7280	1.0	7597740

RDL = Reportable Detection Limit

ELEMENTS BY ATOMIC SPECTROSCOPY (SEA WATER)

Maxxam ID		KH9672		
Sampling Date		2014/08/06		
COC Number		08395789		
	UNITS	**R2-02 (XA6342)**	**RDL**	**QC Batch**
Dissolved Sulphur (S)	mg/L	785	20	7597740

RDL = Reportable Detection Limit

Package 1	5.3°C

Each temperature is the average of up to three cooler temperatures taken at receipt

General Comments

Results relate only to the items tested.

MAXXAM ANALYTICS
Attention: BEDFORD CLIENT SERVICE
Client Project #: DB4E1932
P.O. #:
Site Location: 2539

Quality Assurance Report

Maxxam Job Number: VB469303

QA/QC Batch Num	Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	UNITS	QC Limits
7598443	SC2	Matrix Spike	Total Nitrogen (N)	2014/08/14		95	%	80 - 120
		Spiked Blank	Total Nitrogen (N)	2014/08/14		95	%	80 - 120
		Method Blank	Total Nitrogen (N)	2014/08/14	<0.020		mg/L	
		RPD	Total Nitrogen (N)	2014/08/14	1.1		%	20
7604526	GS2	Matrix Spike						
		[KH9667-01]	Dissolved Aluminum (Al)	2014/08/19		94	%	75 - 125
			Dissolved Antimony (Sb)	2014/08/19		102	%	75 - 125
			Dissolved Arsenic (As)	2014/08/19		99	%	75 - 125
			Dissolved Barium (Ba)	2014/08/19		97	%	75 - 125
			Dissolved Beryllium (Be)	2014/08/19		90	%	75 - 125
			Dissolved Bismuth (Bi)	2014/08/19		91	%	75 - 125
			Dissolved Boron (B)	2014/08/19		NC	%	75 - 125
			Dissolved Cadmium (Cd)	2014/08/19		97	%	75 - 125
			Dissolved Chromium (Cr)	2014/08/19		89	%	75 - 125
			Dissolved Cobalt (Co)	2014/08/19		81	%	75 - 125
			Dissolved Copper (Cu)	2014/08/19		77	%	75 - 125
			Dissolved Iron (Fe)	2014/08/19		90	%	75 - 125
			Dissolved Lead (Pb)	2014/08/19		91	%	75 - 125
			Dissolved Lithium (Li)	2014/08/19		NC	%	75 - 125
			Dissolved Manganese (Mn)	2014/08/19		94	%	75 - 125
			Dissolved Molybdenum (Mo)	2014/08/19		NC	%	75 - 125
			Dissolved Nickel (Ni)	2014/08/19		78	%	75 - 125
			Dissolved Selenium (Se)	2014/08/19		86	%	75 - 125
			Dissolved Silver (Ag)	2014/08/19		99	%	75 - 125
			Dissolved Strontium (Sr)	2014/08/19		NC	%	75 - 125
			Dissolved Thallium (Tl)	2014/08/19		92	%	75 - 125
			Dissolved Tin (Sn)	2014/08/19		99	%	75 - 125
			Dissolved Titanium (Ti)	2014/08/19		100	%	75 - 125
			Dissolved Uranium (U)	2014/08/19		96	%	75 - 125
			Dissolved Vanadium (V)	2014/08/19		91	%	75 - 125
			Dissolved Zinc (Zn)	2014/08/19		81	%	75 - 125
		Spiked Blank	Dissolved Aluminum (Al)	2014/08/19		99	%	75 - 125
			Dissolved Antimony (Sb)	2014/08/19		101	%	75 - 125
			Dissolved Arsenic (As)	2014/08/19		98	%	75 - 125
			Dissolved Barium (Ba)	2014/08/19		98	%	75 - 125
			Dissolved Beryllium (Be)	2014/08/19		95	%	75 - 125
			Dissolved Bismuth (Bi)	2014/08/19		103	%	75 - 125
			Dissolved Boron (B)	2014/08/19		102	%	75 - 125
			Dissolved Cadmium (Cd)	2014/08/19		100	%	75 - 125
			Dissolved Chromium (Cr)	2014/08/19		94	%	75 - 125
			Dissolved Cobalt (Co)	2014/08/19		92	%	75 - 125
			Dissolved Copper (Cu)	2014/08/19		91	%	75 - 125
			Dissolved Iron (Fe)	2014/08/19		99	%	75 - 125
			Dissolved Lead (Pb)	2014/08/19		97	%	75 - 125
			Dissolved Lithium (Li)	2014/08/19		93	%	75 - 125
			Dissolved Manganese (Mn)	2014/08/19		95	%	75 - 125
			Dissolved Molybdenum (Mo)	2014/08/19		99	%	75 - 125
			Dissolved Nickel (Ni)	2014/08/19		91	%	75 - 125
			Dissolved Selenium (Se)	2014/08/19		92	%	75 - 125
			Dissolved Silver (Ag)	2014/08/19		100	%	75 - 125
			Dissolved Strontium (Sr)	2014/08/19		96	%	75 - 125
			Dissolved Thallium (Tl)	2014/08/19		96	%	75 - 125
			Dissolved Tin (Sn)	2014/08/19		99	%	75 - 125
			Dissolved Titanium (Ti)	2014/08/19		98	%	75 - 125
			Dissolved Uranium (U)	2014/08/19		96	%	75 - 125

Quality Assurance Report (Continued)

Maxxam Job Number: VB469303

QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	UNITS	QC Limits
7604526 GS2	Spiked Blank	Dissolved Vanadium (V)	2014/08/19		91	%	75 - 125
		Dissolved Zinc (Zn)	2014/08/19		94	%	75 - 125
	Method Blank	Dissolved Aluminum (Al)	2014/08/19	<10		ug/L	
		Dissolved Antimony (Sb)	2014/08/19	<0.50		ug/L	
		Dissolved Arsenic (As)	2014/08/19	<0.50		ug/L	
		Dissolved Barium (Ba)	2014/08/19	<1.0		ug/L	
		Dissolved Beryllium (Be)	2014/08/19	<1.0		ug/L	
		Dissolved Bismuth (Bi)	2014/08/19	<1.0		ug/L	
		Dissolved Boron (B)	2014/08/19	<50		ug/L	
		Dissolved Cadmium (Cd)	2014/08/19	<0.050		ug/L	
		Dissolved Chromium (Cr)	2014/08/19	<0.50		ug/L	
		Dissolved Cobalt (Co)	2014/08/19	<0.10		ug/L	
		Dissolved Copper (Cu)	2014/08/19	<0.50		ug/L	
		Dissolved Iron (Fe)	2014/08/19	<2.0		ug/L	
		Dissolved Lead (Pb)	2014/08/19	<0.10		ug/L	
		Dissolved Lithium (Li)	2014/08/19	<20		ug/L	
		Dissolved Manganese (Mn)	2014/08/19	<0.50		ug/L	
		Dissolved Molybdenum (Mo)	2014/08/19	<1.0		ug/L	
		Dissolved Nickel (Ni)	2014/08/19	<0.20		ug/L	
		Dissolved Phosphorus (P)	2014/08/19	<50		ug/L	
		Dissolved Selenium (Se)	2014/08/19	<0.50		ug/L	
		Dissolved Silicon (Si)	2014/08/19	<100		ug/L	
		Dissolved Silver (Ag)	2014/08/19	<0.050		ug/L	
		Dissolved Strontium (Sr)	2014/08/19	<10		ug/L	
		Dissolved Thallium (Tl)	2014/08/19	<0.10		ug/L	
		Dissolved Tin (Sn)	2014/08/19	<1.0		ug/L	
		Dissolved Titanium (Ti)	2014/08/19	<10		ug/L	
		Dissolved Uranium (U)	2014/08/19	<0.050		ug/L	
		Dissolved Vanadium (V)	2014/08/19	<10		ug/L	
		Dissolved Zinc (Zn)	2014/08/19	<1.0		ug/L	
	RPD [KH9667-01]	Dissolved Aluminum (Al)	2014/08/19	NC		%	25
		Dissolved Antimony (Sb)	2014/08/19	NC		%	25
		Dissolved Arsenic (As)	2014/08/19	NC		%	25
		Dissolved Barium (Ba)	2014/08/19	4.1		%	25
		Dissolved Beryllium (Be)	2014/08/19	NC		%	25
		Dissolved Bismuth (Bi)	2014/08/19	NC		%	25
		Dissolved Boron (B)	2014/08/19	1.6		%	25
		Dissolved Cadmium (Cd)	2014/08/19	NC		%	25
		Dissolved Chromium (Cr)	2014/08/19	NC		%	25
		Dissolved Cobalt (Co)	2014/08/19	NC		%	25
		Dissolved Copper (Cu)	2014/08/19	NC		%	25
		Dissolved Iron (Fe)	2014/08/19	NC		%	25
		Dissolved Lead (Pb)	2014/08/19	NC		%	25
		Dissolved Lithium (Li)	2014/08/19	2.3		%	25
		Dissolved Manganese (Mn)	2014/08/19	NC		%	25
		Dissolved Molybdenum (Mo)	2014/08/19	10.6		%	25
		Dissolved Nickel (Ni)	2014/08/19	NC		%	25
		Dissolved Phosphorus (P)	2014/08/19	NC		%	25
		Dissolved Selenium (Se)	2014/08/19	NC		%	25
		Dissolved Silicon (Si)	2014/08/19	NC		%	25
		Dissolved Silver (Ag)	2014/08/19	NC		%	25
		Dissolved Strontium (Sr)	2014/08/19	0.008		%	25
		Dissolved Thallium (Tl)	2014/08/19	NC		%	25
		Dissolved Tin (Sn)	2014/08/19	NC		%	25
		Dissolved Titanium (Ti)	2014/08/19	NC		%	25

Quality Assurance Report (Continued)

Maxxam Job Number: VB469303

QA/QC Batch Num	Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	UNITS	QC Limits
7604526	GS2	RPD [KH9667-01]	Dissolved Uranium (U)	2014/08/19	2.9		%	25
			Dissolved Vanadium (V)	2014/08/19	NC		%	25
			Dissolved Zinc (Zn)	2014/08/19	NC		%	25

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 sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.
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 too small to permit a reliable recovery calculation (matrix spike concentration was less than 2x that of the native sample concentration).
NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (one or both samples < 5x RDL).

Validation Signature Page

Maxxam Job #: B469303

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Rob Reinert, Data Validation Coordinator

==
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 #: DB4I8824
Site Location: 2539
Your C.O.C. #: 08398548

Attention: BEDFORD CLIENT SERVICE

MAXXAM ANALYTICS
200 BLUEWATER ROAD, SUITE 105
BEDFORD, NS
CANADA B4B 1G9

Report Date: 2014/10/21
Report #: R1668079
Version: 1

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B492103
Received: 2014/10/11, 12:40

Sample Matrix: Sea Water
Samples Received: 7

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Hardness (calculated as CaCO3)	7	N/A	2014/10/21	BBY7SOP-00002	EPA 6020a R1 m
Na, K, Ca, Mg, S by CRC ICPMS (diss.)	7	N/A	2014/10/21	BBY7SOP-00002	EPA 6020A R1 m
Elements by ICPMS (dissolved) - Seawater	7	N/A	2014/10/21	BBY7SOP-00002	EPA 6020A R1 m
Nitrogen (Total)	7	2014/10/15	2014/10/15	BBY6SOP-00016	SM 22 4500-N C m
Filter and HNO3 Preserve for Metals	7	N/A	2014/10/15	BBY7 WI-00004	BCMOE Reqs 08/14

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Shanaz Akbar, Project Manager
Email: SAkbar@maxxam.ca
Phone# (604) 734 7276

==

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 CHEMICAL ANALYSES OF SEA WATER

Maxxam ID		KV8536	KV8537	KV8537	KV8538	KV8539	KV8540		
Sampling Date		2014/10/07	2014/10/07	2014/10/07	2014/10/07	2014/10/07	2014/10/07		
COC Number		08398548	08398548	08398548	08398548	08398548	08398548		
	UNITS	**S1-01 (XY1058)**	**S2-01 (XY1059)**	**S2-01 (XY1059) Lab-Dup**	**S3-01 (XY1060)**	**S4-01 (XY1061)**	**D1-01 (XY1062)**	**RDL**	**QC Batch**
Calculated Parameters									
Filter and HNO3 Preservation	N/A	LAB	LAB	N/A	LAB	LAB	LAB	N/A	7678820
Misc. Inorganics									
Dissolved Hardness (CaCO3)	mg/L	5160	4970	N/A	5090	4840	5020	0.50	7675900
Nutrients									
Total Nitrogen (N)	mg/L	0.143	0.136	0.142	0.186	0.160	0.135	0.020	7678998

N/A = Not Applicable
RDL = Reportable Detection Limit

Maxxam ID		KV8541	KV8542		
Sampling Date		2014/10/07	2014/10/07		
COC Number		08398548	08398548		
	UNITS	**R1-01 (XY1063)**	**R2-01 (XY1064)**	**RDL**	**QC Batch**
Calculated Parameters					
Filter and HNO3 Preservation	N/A	LAB	LAB	N/A	7678820
Misc. Inorganics					
Dissolved Hardness (CaCO3)	mg/L	5030	4980	0.50	7675900
Nutrients					
Total Nitrogen (N)	mg/L	0.162	0.182	0.020	7678998

RDL = Reportable Detection Limit

ELEMENTS BY ATOMIC SPECTROSCOPY (SEA WATER)

Maxxam ID		KV8536	KV8536	KV8537	KV8538	KV8539	KV8540		
Sampling Date		2014/10/07	2014/10/07	2014/10/07	2014/10/07	2014/10/07	2014/10/07		
COC Number		08398548	08398548	08398548	08398548	08398548	08398548		
	UNITS	**S1-01 (XY1058)**	**S1-01 (XY1058) Lab-Dup**	**S2-01 (XY1059)**	**S3-01 (XY1060)**	**S4-01 (XY1061)**	**D1-01 (XY1062)**	**RDL**	**QC Batch**
Dissolved Metals by ICPMS									
Dissolved Aluminum (Al)	ug/L	64	55	58	59	59	58	10	7684846
Dissolved Antimony (Sb)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	7684846
Dissolved Arsenic (As)	ug/L	1.65	1.49	1.46	1.62	1.68	1.68	0.50	7684846
Dissolved Barium (Ba)	ug/L	8.0	7.3	7.2	6.8	7.9	7.2	1.0	7684846
Dissolved Beryllium (Be)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	7684846
Dissolved Bismuth (Bi)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	7684846
Dissolved Boron (B)	ug/L	3560	3260	3490	3400	3500	3250	50	7684846
Dissolved Cadmium (Cd)	ug/L	0.118	0.112	0.175	0.122	0.100	0.114	0.050	7684846
Dissolved Chromium (Cr)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	7684846
Dissolved Cobalt (Co)	ug/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.10	7684846
Dissolved Copper (Cu)	ug/L	<0.50	<0.50	1.10	<0.50	<0.50	<0.50	0.50	7684846
Dissolved Iron (Fe)	ug/L	3.1	2.4	2.7	3.4	5.5	15.4	2.0	7684846
Dissolved Lead (Pb)	ug/L	0.50	0.47	0.64	0.43	0.48	0.41	0.10	7684846
Dissolved Lithium (Li)	ug/L	161	163	160	160	157	160	20	7684846
Dissolved Manganese (Mn)	ug/L	4.15	4.10	4.33	4.20	3.98	3.88	0.50	7684846
Dissolved Molybdenum (Mo)	ug/L	10.2	9.5	9.7	9.5	9.1	10.1	1.0	7684846
Dissolved Nickel (Ni)	ug/L	0.72	0.58	0.30	0.39	1.95	0.96	0.20	7684846
Dissolved Phosphorus (P)	ug/L	<50	<50	<50	<50	<50	<50	50	7684846
Dissolved Selenium (Se)	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.50	7684846
Dissolved Silicon (Si)	ug/L	<100	<100	<100	<100	<100	<100	100	7684846
Dissolved Silver (Ag)	ug/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.050	7684846
Dissolved Strontium (Sr)	ug/L	6750	6790	6640	6850	6550	6690	10	7684846
Dissolved Thallium (Tl)	ug/L	0.36	0.31	0.56	0.39	0.31	0.35	0.10	7684846
Dissolved Tin (Sn)	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0	7684846
Dissolved Titanium (Ti)	ug/L	<10	<10	<10	<10	<10	<10	10	7684846
Dissolved Uranium (U)	ug/L	2.88	2.75	2.78	2.75	2.74	2.68	0.050	7684846
Dissolved Vanadium (V)	ug/L	<10	<10	<10	<10	<10	<10	10	7684846
Dissolved Zinc (Zn)	ug/L	4.9 (1)	3.9	4.0	3.3	3.1	3.3	1.0	7684846
Dissolved Calcium (Ca)	mg/L	353	N/A	351	361	355	353	1.0	7676358
Dissolved Magnesium (Mg)	mg/L	1040	N/A	994	1020	960	1010	1.0	7676358

N/A = Not Applicable
RDL = Reportable Detection Limit
(1) Matrix Spike outside acceptance criteria (10% of analytes failure allowed)

ELEMENTS BY ATOMIC SPECTROSCOPY (SEA WATER)

Maxxam ID		KV8536	KV8536	KV8537	KV8538	KV8539	KV8540		
Sampling Date		2014/10/07	2014/10/07	2014/10/07	2014/10/07	2014/10/07	2014/10/07		
COC Number		08398548	08398548	08398548	08398548	08398548	08398548		
	UNITS	**S1-01 (XY1058)**	**S1-01 (XY1058) Lab-Dup**	**S2-01 (XY1059)**	**S3-01 (XY1060)**	**S4-01 (XY1061)**	**D1-01 (XY1062)**	**RDL**	**QC Batch**
Dissolved Potassium (K)	mg/L	333	N/A	334	337	324	334	1.0	7676358
Dissolved Sodium (Na)	mg/L	8670	N/A	8300	8640	8300	8680	1.0	7676358
Dissolved Sulphur (S)	mg/L	866	N/A	834	858	854	859	20	7676358

N/A = Not Applicable
RDL = Reportable Detection Limit

ELEMENTS BY ATOMIC SPECTROSCOPY (SEA WATER)

Maxxam ID		KV8541	KV8542		
Sampling Date		2014/10/07	2014/10/07		
COC Number		08398548	08398548		
	UNITS	**R1-01 (XY1063)**	**R2-01 (XY1064)**	**RDL**	**QC Batch**
Dissolved Metals by ICPMS					
Dissolved Aluminum (Al)	ug/L	59	59	10	7684846
Dissolved Antimony (Sb)	ug/L	<0.50	<0.50	0.50	7684846
Dissolved Arsenic (As)	ug/L	1.61	1.27	0.50	7684846
Dissolved Barium (Ba)	ug/L	4.6	7.4	1.0	7684846
Dissolved Beryllium (Be)	ug/L	<1.0	<1.0	1.0	7684846
Dissolved Bismuth (Bi)	ug/L	<1.0	<1.0	1.0	7684846
Dissolved Boron (B)	ug/L	3410	3450	50	7684846
Dissolved Cadmium (Cd)	ug/L	0.065	0.063	0.050	7684846
Dissolved Chromium (Cr)	ug/L	<0.50	<0.50	0.50	7684846
Dissolved Cobalt (Co)	ug/L	<0.10	<0.10	0.10	7684846
Dissolved Copper (Cu)	ug/L	<0.50	<0.50	0.50	7684846
Dissolved Iron (Fe)	ug/L	3.7	2.7	2.0	7684846
Dissolved Lead (Pb)	ug/L	0.14	0.16	0.10	7684846
Dissolved Lithium (Li)	ug/L	161	159	20	7684846
Dissolved Manganese (Mn)	ug/L	2.33	3.09	0.50	7684846
Dissolved Molybdenum (Mo)	ug/L	10.2	9.7	1.0	7684846
Dissolved Nickel (Ni)	ug/L	1.23	0.29	0.20	7684846
Dissolved Phosphorus (P)	ug/L	<50	<50	50	7684846
Dissolved Selenium (Se)	ug/L	<0.50	<0.50	0.50	7684846
Dissolved Silicon (Si)	ug/L	<100	<100	100	7684846
Dissolved Silver (Ag)	ug/L	<0.050	<0.050	0.050	7684846
Dissolved Strontium (Sr)	ug/L	6690	6690	10	7684846
Dissolved Thallium (Tl)	ug/L	<0.10	<0.10	0.10	7684846
Dissolved Tin (Sn)	ug/L	<1.0	<1.0	1.0	7684846
Dissolved Titanium (Ti)	ug/L	<10	<10	10	7684846
Dissolved Uranium (U)	ug/L	2.72	2.66	0.050	7684846
Dissolved Vanadium (V)	ug/L	<10	<10	10	7684846
Dissolved Zinc (Zn)	ug/L	1.9	1.7	1.0	7684846
Dissolved Calcium (Ca)	mg/L	356	344	1.0	7676358
Dissolved Magnesium (Mg)	mg/L	1010	1000	1.0	7676358
Dissolved Potassium (K)	mg/L	330	330	1.0	7676358
Dissolved Sodium (Na)	mg/L	8380	8150	1.0	7676358

RDL = Reportable Detection Limit

ELEMENTS BY ATOMIC SPECTROSCOPY (SEA WATER)

Maxxam ID		KV8541	KV8542		
Sampling Date		2014/10/07	2014/10/07		
COC Number		08398548	08398548		
	UNITS	**R1-01 (XY1063)**	**R2-01 (XY1064)**	**RDL**	**QC Batch**
Dissolved Sulphur (S)	mg/L	812	847	20	7676358

RDL = Reportable Detection Limit

Package 1	7.3°C

Each temperature is the average of up to three cooler temperatures taken at receipt

General Comments

Results relate only to the items tested.

MAXXAM ANALYTICS
Attention: BEDFORD CLIENT SERVICE
Client Project #: DB4I8824
P.O. #:
Site Location: 2539

Quality Assurance Report

Maxxam Job Number: VB492103

QA/QC Batch Num	Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	UNITS	QC Limits
7678998	CHU	Matrix Spike [KV8537-02]	Total Nitrogen (N)	2014/10/15		92	%	80 - 120
		Spiked Blank	Total Nitrogen (N)	2014/10/15		98	%	80 - 120
		Method Blank	Total Nitrogen (N)	2014/10/15	<0.020		mg/L	
		RPD [KV8537-02]	Total Nitrogen (N)	2014/10/15	3.8		%	20
7684846	GS2	Matrix Spike [KV8536-01]	Dissolved Aluminum (Al)	2014/10/21		102	%	75 - 125
			Dissolved Antimony (Sb)	2014/10/21		101	%	75 - 125
			Dissolved Arsenic (As)	2014/10/21		104	%	75 - 125
			Dissolved Barium (Ba)	2014/10/21		100	%	75 - 125
			Dissolved Beryllium (Be)	2014/10/21		104	%	75 - 125
			Dissolved Bismuth (Bi)	2014/10/21		89	%	75 - 125
			Dissolved Boron (B)	2014/10/21		NC	%	75 - 125
			Dissolved Cadmium (Cd)	2014/10/21		87	%	75 - 125
			Dissolved Chromium (Cr)	2014/10/21		89	%	75 - 125
			Dissolved Cobalt (Co)	2014/10/21		82	%	75 - 125
			Dissolved Copper (Cu)	2014/10/21		77	%	75 - 125
			Dissolved Iron (Fe)	2014/10/21		87	%	75 - 125
			Dissolved Lead (Pb)	2014/10/21		102	%	75 - 125
			Dissolved Lithium (Li)	2014/10/21		NC	%	75 - 125
			Dissolved Manganese (Mn)	2014/10/21		94	%	75 - 125
			Dissolved Molybdenum (Mo)	2014/10/21		NC	%	75 - 125
			Dissolved Nickel (Ni)	2014/10/21		78	%	75 - 125
			Dissolved Selenium (Se)	2014/10/21		83	%	75 - 125
			Dissolved Silver (Ag)	2014/10/21		88	%	75 - 125
			Dissolved Strontium (Sr)	2014/10/21		NC	%	75 - 125
			Dissolved Thallium (Tl)	2014/10/21		97	%	75 - 125
			Dissolved Tin (Sn)	2014/10/21		96	%	75 - 125
			Dissolved Titanium (Ti)	2014/10/21		103	%	75 - 125
			Dissolved Uranium (U)	2014/10/21		108	%	75 - 125
			Dissolved Vanadium (V)	2014/10/21		94	%	75 - 125
			Dissolved Zinc (Zn)	2014/10/21		73 (1)	%	75 - 125
		Spiked Blank	Dissolved Aluminum (Al)	2014/10/21		103	%	75 - 125
			Dissolved Antimony (Sb)	2014/10/21		98	%	75 - 125
			Dissolved Arsenic (As)	2014/10/21		103	%	75 - 125
			Dissolved Barium (Ba)	2014/10/21		96	%	75 - 125
			Dissolved Beryllium (Be)	2014/10/21		95	%	75 - 125
			Dissolved Bismuth (Bi)	2014/10/21		100	%	75 - 125
			Dissolved Boron (B)	2014/10/21		101	%	75 - 125
			Dissolved Cadmium (Cd)	2014/10/21		98	%	75 - 125
			Dissolved Chromium (Cr)	2014/10/21		102	%	75 - 125
			Dissolved Cobalt (Co)	2014/10/21		100	%	75 - 125
			Dissolved Copper (Cu)	2014/10/21		103	%	75 - 125
			Dissolved Iron (Fe)	2014/10/21		107	%	75 - 125
			Dissolved Lead (Pb)	2014/10/21		106	%	75 - 125
			Dissolved Lithium (Li)	2014/10/21		103	%	75 - 125
			Dissolved Manganese (Mn)	2014/10/21		101	%	75 - 125
			Dissolved Molybdenum (Mo)	2014/10/21		95	%	75 - 125
			Dissolved Nickel (Ni)	2014/10/21		105	%	75 - 125
			Dissolved Selenium (Se)	2014/10/21		91	%	75 - 125
			Dissolved Silver (Ag)	2014/10/21		77	%	75 - 125
			Dissolved Strontium (Sr)	2014/10/21		103	%	75 - 125
			Dissolved Thallium (Tl)	2014/10/21		87	%	75 - 125
			Dissolved Tin (Sn)	2014/10/21		97	%	75 - 125
			Dissolved Titanium (Ti)	2014/10/21		102	%	75 - 125

Quality Assurance Report (Continued)

Maxxam Job Number: VB492103

QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	UNITS	QC Limits
7684846 GS2	Spiked Blank	Dissolved Uranium (U)	2014/10/21		102	%	75 - 125
		Dissolved Vanadium (V)	2014/10/21		102	%	75 - 125
		Dissolved Zinc (Zn)	2014/10/21		102	%	75 - 125
	Method Blank	Dissolved Aluminum (Al)	2014/10/21	<10		ug/L	
		Dissolved Antimony (Sb)	2014/10/21	<0.50		ug/L	
		Dissolved Arsenic (As)	2014/10/21	<0.50		ug/L	
		Dissolved Barium (Ba)	2014/10/21	<1.0		ug/L	
		Dissolved Beryllium (Be)	2014/10/21	<1.0		ug/L	
		Dissolved Bismuth (Bi)	2014/10/21	<1.0		ug/L	
		Dissolved Boron (B)	2014/10/21	<50		ug/L	
		Dissolved Cadmium (Cd)	2014/10/21	<0.050		ug/L	
		Dissolved Chromium (Cr)	2014/10/21	<0.50		ug/L	
		Dissolved Cobalt (Co)	2014/10/21	<0.10		ug/L	
		Dissolved Copper (Cu)	2014/10/21	<0.50		ug/L	
		Dissolved Iron (Fe)	2014/10/21	<2.0		ug/L	
		Dissolved Lead (Pb)	2014/10/21	<0.10		ug/L	
		Dissolved Lithium (Li)	2014/10/21	<20		ug/L	
		Dissolved Manganese (Mn)	2014/10/21	<0.50		ug/L	
		Dissolved Molybdenum (Mo)	2014/10/21	<1.0		ug/L	
		Dissolved Nickel (Ni)	2014/10/21	<0.20		ug/L	
		Dissolved Phosphorus (P)	2014/10/21	<50		ug/L	
		Dissolved Selenium (Se)	2014/10/21	<0.50		ug/L	
		Dissolved Silicon (Si)	2014/10/21	<100		ug/L	
		Dissolved Silver (Ag)	2014/10/21	<0.050		ug/L	
		Dissolved Strontium (Sr)	2014/10/21	<10		ug/L	
		Dissolved Thallium (Tl)	2014/10/21	<0.10		ug/L	
		Dissolved Tin (Sn)	2014/10/21	<1.0		ug/L	
		Dissolved Titanium (Ti)	2014/10/21	<10		ug/L	
		Dissolved Uranium (U)	2014/10/21	<0.050		ug/L	
		Dissolved Vanadium (V)	2014/10/21	<10		ug/L	
		Dissolved Zinc (Zn)	2014/10/21	<1.0		ug/L	
	RPD [KV8536-01]	Dissolved Aluminum (Al)	2014/10/21	14.3		%	25
		Dissolved Antimony (Sb)	2014/10/21	NC		%	25
		Dissolved Arsenic (As)	2014/10/21	NC		%	25
		Dissolved Barium (Ba)	2014/10/21	8.6		%	25
		Dissolved Beryllium (Be)	2014/10/21	NC		%	25
		Dissolved Bismuth (Bi)	2014/10/21	NC		%	25
		Dissolved Boron (B)	2014/10/21	8.6		%	25
		Dissolved Cadmium (Cd)	2014/10/21	NC		%	25
		Dissolved Chromium (Cr)	2014/10/21	NC		%	25
		Dissolved Cobalt (Co)	2014/10/21	NC		%	25
		Dissolved Copper (Cu)	2014/10/21	NC		%	25
		Dissolved Iron (Fe)	2014/10/21	NC		%	25
		Dissolved Lead (Pb)	2014/10/21	NC		%	25
		Dissolved Lithium (Li)	2014/10/21	1.1		%	25
		Dissolved Manganese (Mn)	2014/10/21	1.3		%	25
		Dissolved Molybdenum (Mo)	2014/10/21	6.9		%	25
		Dissolved Nickel (Ni)	2014/10/21	NC		%	25
		Dissolved Phosphorus (P)	2014/10/21	NC		%	25
		Dissolved Selenium (Se)	2014/10/21	NC		%	25
		Dissolved Silicon (Si)	2014/10/21	NC		%	25
		Dissolved Silver (Ag)	2014/10/21	NC		%	25
		Dissolved Strontium (Sr)	2014/10/21	0.5		%	25
		Dissolved Thallium (Tl)	2014/10/21	NC		%	25
		Dissolved Tin (Sn)	2014/10/21	NC		%	25

Quality Assurance Report (Continued)

Maxxam Job Number: VB492103

QA/QC Batch Num	Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	UNITS	QC Limits
7684846	GS2	RPD [KV8536-01]	Dissolved Titanium (Ti)	2014/10/21	NC		%	25
			Dissolved Uranium (U)	2014/10/21	4.7		%	25
			Dissolved Vanadium (V)	2014/10/21	NC		%	25
			Dissolved Zinc (Zn)	2014/10/21	NC		%	25

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 sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.
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 too small to permit a reliable recovery calculation (matrix spike concentration was less than 2x that of the native sample concentration).
NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (one or both samples < 5x RDL).
(1) Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.

Validation Signature Page

Maxxam Job #: B492103

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Rob Reinert, Data Validation Coordinator

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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.

Report ID: 180540-IAS
Report Date: 17-Dec-14
Date Received: 12-Nov-14

CERTIFICATE OF ANALYSIS

for
Intrinsik Environmental
Sciences Inc
5121 Sackville Street, Suite 506
Halifax, NS B3J 1K1

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1212
Fax: 506.452.0594
www.rpc.ca

Attention: Christine Moore

Project #: 2539

Location: NB

Analysis of Invertebrate Samples

RPC Sample ID:			180540-01	180540-02	180540-03
Client Sample ID:			SBI-4 Small Invert.	SBI-5	SBI-6 Small Invert.
Date Sampled:			13-Oct-14	13-Oct-14	13-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.1	72.2	142.	108.
Antimony	mg/kg	0.01	0.07	0.10	0.10
Arsenic	mg/kg	0.1	1.1	1.1	1.3
Barium	mg/kg	0.1	22.6	21.9	22.6
Beryllium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Bismuth	mg/kg	0.1	0.1	< 0.1	< 0.1
Boron	mg/kg	0.1	5.7	6.6	6.0
Cadmium	mg/kg	0.001	0.793	0.601	0.424
Calcium	mg/kg	5	15100	16600	15300
Chromium	mg/kg	0.1	0.2	0.3	0.3
Cobalt	mg/kg	0.01	0.08	0.11	0.10
Copper	mg/kg	0.1	15.2	12.5	12.5
Iron	mg/kg	2	95	171	135
Lead	mg/kg	0.01	13.8	21.4	18.6
Lithium	mg/kg	0.01	0.23	0.27	0.25
Magnesium	mg/kg	1	1160	1350	1170
Manganese	mg/kg	0.1	8.9	9.8	8.3
Mercury	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Molybdenum	mg/kg	0.01	0.07	0.06	0.07
Nickel	mg/kg	0.1	0.2	0.2	0.2
Potassium	mg/kg	2	1610	1200	1640
Rubidium	mg/kg	0.01	0.67	0.64	0.75
Selenium	mg/kg	0.1	0.2	0.2	0.3
Silver	mg/kg	0.01	0.67	0.46	0.45
Sodium	mg/kg	5	6650	7110	6370
Strontium	mg/kg	0.1	212.	220.	205.
Tellurium	mg/kg	0.01	< 0.01	< 0.01	0.01
Thallium	mg/kg	0.01	0.55	0.54	0.29
Tin	mg/kg	0.01	0.08	0.15	0.08
Uranium	mg/kg	0.01	0.01	0.01	0.02
Vanadium	mg/kg	0.1	0.3	0.5	0.4
Zinc	mg/kg	0.2	20.4	30.1	32.9

This report relates only to the sample(s) and information provided to the laboratory.

RL = Reporting Limit

Ross Kean

A. Ross Kean, M.Sc.
Department Head
Inorganic Analytical Chemistry

Peter Crowhurst, B.Sc., C.Chem
Analytical Chemist
Inorganic Analytical Chemistry

Report ID: 180540-IAS
Report Date: 17-Dec-14
Date Received: 12-Nov-14

CERTIFICATE OF ANALYSIS

for
Intrinsik Environmental
Sciences Inc
5121 Sackville Street, Suite 506
Halifax, NS B3J 1K1

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1212
Fax: 506.452.0594
www.rpc.ca

Attention: Christine Moore

Project #: 2539

Location: NB

Analysis of Invertebrate Samples

RPC Sample ID:			180540-04	180540-05	180540-06
Client Sample ID:			SBI-7	SBI-8	SBI-9
Date Sampled:			13-Oct-14	12-Oct-14	12-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.1	157.	40.2	65.0
Antimony	mg/kg	0.01	0.10	0.04	0.02
Arsenic	mg/kg	0.1	1.0	0.7	0.8
Barium	mg/kg	0.1	26.5	5.5	3.6
Beryllium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Bismuth	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Boron	mg/kg	0.1	8.7	10.5	7.9
Cadmium	mg/kg	0.001	0.298	0.292	0.134
Calcium	mg/kg	5	18500	16000	15800
Chromium	mg/kg	0.1	0.4	0.2	0.2
Cobalt	mg/kg	0.01	0.08	0.05	0.05
Copper	mg/kg	0.1	6.2	4.2	7.4
Iron	mg/kg	2	156	71	85
Lead	mg/kg	0.01	14.0	6.00	3.64
Lithium	mg/kg	0.01	0.32	0.24	0.22
Magnesium	mg/kg	1	1440	1480	1330
Manganese	mg/kg	0.1	8.9	6.7	7.9
Mercury	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Molybdenum	mg/kg	0.01	0.05	0.05	0.04
Nickel	mg/kg	0.1	0.2	0.1	0.1
Potassium	mg/kg	2	766	591	1060
Rubidium	mg/kg	0.01	0.44	0.22	0.39
Selenium	mg/kg	0.1	0.2	0.2	0.1
Silver	mg/kg	0.01	0.37	0.24	0.22
Sodium	mg/kg	5	7300	8400	7380
Strontium	mg/kg	0.1	253.	213.	200.
Tellurium	mg/kg	0.01	0.01	< 0.01	< 0.01
Thallium	mg/kg	0.01	0.17	0.11	0.05
Tin	mg/kg	0.01	0.10	0.13	0.03
Uranium	mg/kg	0.01	0.01	0.02	< 0.01
Vanadium	mg/kg	0.1	0.5	0.2	0.3
Zinc	mg/kg	0.2	18.8	14.2	10.0

Report ID: 180540-IAS
Report Date: 17-Dec-14
Date Received: 12-Nov-14

CERTIFICATE OF ANALYSIS

for
Intrinsik Environmental
Sciences Inc
5121 Sackville Street, Suite 506
Halifax, NS B3J 1K1

rpc
921 College Hill Rd
Fredericton NB
Canada E3B 6Z9
Tel: 506.452.1212
Fax: 506.452.0594
www.rpc.ca

Attention: Christine Moore

Project #: 2539

Location: NB

Analysis of Invertebrate Samples

RPC Sample ID:			180540-07	180540-08	180540-08 Dup
Client Sample ID:			SBI-10 Small Invert.	SBI-11	Lab Duplicate
Date Sampled:			12-Oct-14	12-Oct-14	12-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.1	83.9	16.1	35.0
Antimony	mg/kg	0.01	0.02	0.01	0.02
Arsenic	mg/kg	0.1	1.2	1.3	1.4
Barium	mg/kg	0.1	2.5	2.0	3.2
Beryllium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Bismuth	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Boron	mg/kg	0.1	5.2	3.4	3.4
Cadmium	mg/kg	0.001	0.200	0.131	0.135
Calcium	mg/kg	5	16900	16900	15700
Chromium	mg/kg	0.1	0.2	< 0.1	< 0.1
Cobalt	mg/kg	0.01	0.05	0.02	0.04
Copper	mg/kg	0.1	8.8	10.4	13.1
Iron	mg/kg	2	82	23	42
Lead	mg/kg	0.01	2.29	1.25	1.72
Lithium	mg/kg	0.01	0.16	0.09	0.11
Magnesium	mg/kg	1	944	804	789
Manganese	mg/kg	0.1	3.3	2.0	2.3
Mercury	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Molybdenum	mg/kg	0.01	0.05	0.05	0.06
Nickel	mg/kg	0.1	0.2	< 0.1	0.1
Potassium	mg/kg	2	2110	2460	2590
Rubidium	mg/kg	0.01	0.84	0.84	0.91
Selenium	mg/kg	0.1	0.3	0.3	0.3
Silver	mg/kg	0.01	0.26	0.22	0.25
Sodium	mg/kg	5	5430	4380	4580
Strontium	mg/kg	0.1	244.	241.	220.
Tellurium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Thallium	mg/kg	0.01	0.07	0.06	0.07
Tin	mg/kg	0.01	0.11	0.18	0.22
Uranium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Vanadium	mg/kg	0.1	0.3	< 0.1	0.1
Zinc	mg/kg	0.2	16.5	10.9	11.6

Report ID: 180540-IAS
Report Date: 17-Dec-14
Date Received: 12-Nov-14

CERTIFICATE OF ANALYSIS

for
Intrinsik Environmental
Sciences Inc
5121 Sackville Street, Suite 506
Halifax, NS B3J 1K1

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Tel: 506.452.1212
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www.rpc.ca

Attention: Christine Moore

Project #: 2539

Location: NB

Analysis of Invertebrate Samples

RPC Sample ID:			180540-09	180540-10	180540-11
Client Sample ID: Date Sampled:			SBI-12 12-Oct-14	SBI-13 12-Oct-14	SBI-14 12-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.1	32.1	81.4	37.6
Antimony	mg/kg	0.01	0.02	0.02	0.02
Arsenic	mg/kg	0.1	1.3	1.1	0.6
Barium	mg/kg	0.1	3.5	3.5	2.4
Beryllium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Bismuth	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Boron	mg/kg	0.1	5.8	6.8	8.7
Cadmium	mg/kg	0.001	0.142	0.205	0.077
Calcium	mg/kg	5	20700	20400	12400
Chromium	mg/kg	0.1	< 0.1	0.3	< 0.1
Cobalt	mg/kg	0.01	0.04	0.05	0.03
Copper	mg/kg	0.1	10.3	10.0	5.0
Iron	mg/kg	2	43	113	46
Lead	mg/kg	0.01	2.86	5.01	3.29
Lithium	mg/kg	0.01	0.18	0.22	0.22
Magnesium	mg/kg	1	1360	1350	1340
Manganese	mg/kg	0.1	6.1	13.2	12.2
Mercury	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Molybdenum	mg/kg	0.01	0.05	0.06	0.03
Nickel	mg/kg	0.1	0.2	0.2	0.1
Potassium	mg/kg	2	1670	1300	775
Rubidium	mg/kg	0.01	0.58	0.52	0.26
Selenium	mg/kg	0.1	0.2	0.2	0.1
Silver	mg/kg	0.01	0.23	0.18	0.16
Sodium	mg/kg	5	6370	5550	7530
Strontium	mg/kg	0.1	268.	265.	162.
Tellurium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Thallium	mg/kg	0.01	0.07	0.07	0.03
Tin	mg/kg	0.01	0.04	0.20	0.16
Uranium	mg/kg	0.01	< 0.01	0.01	< 0.01
Vanadium	mg/kg	0.1	0.2	0.3	0.1
Zinc	mg/kg	0.2	11.8	13.0	7.5

Report ID: 180540-IAS
Report Date: 17-Dec-14
Date Received: 12-Nov-14

CERTIFICATE OF ANALYSIS
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Attention: Christine Moore

Project #: 2539

Location: NB

Analysis of Invertebrate Samples

RPC Sample ID:			180540-12	180540-13	180540-14
Client Sample ID:			SBI-15	SBI-16	SBI-17
Date Sampled:			12-Oct-14	12-Oct-14	12-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.1	44.9	97.1	48.7
Antimony	mg/kg	0.01	0.01	0.03	0.01
Arsenic	mg/kg	0.1	0.6	0.8	0.6
Barium	mg/kg	0.1	2.6	3.0	2.7
Beryllium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Bismuth	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Boron	mg/kg	0.1	9.0	10.0	11.0
Cadmium	mg/kg	0.001	0.086	0.152	0.082
Calcium	mg/kg	5	14000	14800	15800
Chromium	mg/kg	0.1	0.1	0.2	0.1
Cobalt	mg/kg	0.01	0.04	0.06	0.04
Copper	mg/kg	0.1	4.5	5.9	3.4
Iron	mg/kg	2	57	123	58
Lead	mg/kg	0.01	2.85	7.19	3.46
Lithium	mg/kg	0.01	0.24	0.25	0.25
Magnesium	mg/kg	1	1440	1290	1560
Manganese	mg/kg	0.1	9.4	10.5	5.9
Mercury	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Molybdenum	mg/kg	0.01	0.03	0.05	0.04
Nickel	mg/kg	0.1	0.1	0.2	0.1
Potassium	mg/kg	2	744	900	552
Rubidium	mg/kg	0.01	0.28	0.40	0.23
Selenium	mg/kg	0.1	0.1	0.2	0.1
Silver	mg/kg	0.01	0.18	0.20	0.18
Sodium	mg/kg	5	7940	6740	7780
Strontium	mg/kg	0.1	184.	203.	212.
Tellurium	mg/kg	0.01	< 0.01	0.02	< 0.01
Thallium	mg/kg	0.01	0.02	0.05	0.03
Tin	mg/kg	0.01	0.03	0.15	0.12
Uranium	mg/kg	0.01	< 0.01	0.01	0.01
Vanadium	mg/kg	0.1	0.2	0.4	0.2
Zinc	mg/kg	0.2	7.4	9.3	8.0

Report ID: 180540-IAS
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for
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Sciences Inc
5121 Sackville Street, Suite 506
Halifax, NS B3J 1K1

Attention: Christine Moore

Project #: 2539

Location: NB

Analysis of Invertebrate Samples

RPC Sample ID:			180540-15	180540-16	180540-17
Client Sample ID: Date Sampled:			SBI-18 12-Oct-14	SBI-19 12-Oct-14	SBI-20 12-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.1	43.9	115.	60.3
Antimony	mg/kg	0.01	0.01	0.02	0.01
Arsenic	mg/kg	0.1	0.6	1.1	0.6
Barium	mg/kg	0.1	2.6	2.5	2.5
Beryllium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Bismuth	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Boron	mg/kg	0.1	9.4	8.9	10.2
Cadmium	mg/kg	0.001	0.082	0.136	0.066
Calcium	mg/kg	5	13300	16400	13100
Chromium	mg/kg	0.1	0.1	0.3	0.2
Cobalt	mg/kg	0.01	0.04	0.08	0.04
Copper	mg/kg	0.1	3.2	6.7	3.2
Iron	mg/kg	2	63	139	70
Lead	mg/kg	0.01	3.41	5.03	3.32
Lithium	mg/kg	0.01	0.23	0.27	0.27
Magnesium	mg/kg	1	1410	1300	1600
Manganese	mg/kg	0.1	22.0	6.5	11.0
Mercury	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Molybdenum	mg/kg	0.01	0.04	0.06	0.03
Nickel	mg/kg	0.1	0.1	0.3	0.1
Potassium	mg/kg	2	581	1190	564
Rubidium	mg/kg	0.01	0.22	0.55	0.25
Selenium	mg/kg	0.1	0.1	0.3	0.1
Silver	mg/kg	0.01	0.16	0.19	0.15
Sodium	mg/kg	5	7060	7360	8440
Strontium	mg/kg	0.1	180.	227.	179.
Tellurium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Thallium	mg/kg	0.01	0.02	0.06	0.02
Tin	mg/kg	0.01	0.05	0.09	0.09
Uranium	mg/kg	0.01	0.01	0.01	0.01
Vanadium	mg/kg	0.1	0.2	0.4	0.2
Zinc	mg/kg	0.2	7.7	11.9	6.8

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Attention: Christine Moore

Project #: 2539

Location: NB

Analysis of Invertebrate Samples

RPC Sample ID:			180540-18	180540-19	180540-19 Dup
Client Sample ID: Date Sampled:			SBI-21 Small Invert. 12-Oct-14	RBI-1 13-Oct-14	Lab Duplicate 13-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.1	82.1	232.	218.
Antimony	mg/kg	0.01	0.02	0.01	< 0.01
Arsenic	mg/kg	0.1	1.4	0.6	0.6
Barium	mg/kg	0.1	2.8	42.8	50.3
Beryllium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Bismuth	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Boron	mg/kg	0.1	6.8	9.7	10.1
Cadmium	mg/kg	0.001	0.110	0.029	0.026
Calcium	mg/kg	5	18900	14000	13200
Chromium	mg/kg	0.1	0.2	0.4	0.4
Cobalt	mg/kg	0.01	0.08	0.10	0.09
Copper	mg/kg	0.1	10.1	2.4	2.0
Iron	mg/kg	2	94	226	215
Lead	mg/kg	0.01	3.01	0.41	0.42
Lithium	mg/kg	0.01	0.23	0.35	0.34
Magnesium	mg/kg	1	1480	1360	1280
Manganese	mg/kg	0.1	9.1	10.6	9.8
Mercury	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Molybdenum	mg/kg	0.01	0.07	0.06	0.05
Nickel	mg/kg	0.1	0.2	0.3	0.3
Potassium	mg/kg	2	1890	764	776
Rubidium	mg/kg	0.01	0.74	0.57	0.55
Selenium	mg/kg	0.1	0.3	0.1	0.1
Silver	mg/kg	0.01	0.26	0.03	0.02
Sodium	mg/kg	5	5900	6970	6930
Strontium	mg/kg	0.1	260.	213.	203.
Tellurium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Thallium	mg/kg	0.01	0.04	< 0.01	< 0.01
Tin	mg/kg	0.01	0.05	0.02	0.02
Uranium	mg/kg	0.01	< 0.01	0.02	0.02
Vanadium	mg/kg	0.1	0.3	0.6	0.6
Zinc	mg/kg	0.2	13.2	6.8	6.0

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Attention: Christine Moore

Project #: 2539

Location: NB

Analysis of Invertebrate Samples

RPC Sample ID:			180540-20	180540-21	180540-22
Client Sample ID: Date Sampled:			RBI-2 13-Oct-14	RBI-3 13-Oct-14	RBI-4 13-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.1	99.9	79.4	82.7
Antimony	mg/kg	0.01	< 0.01	0.01	< 0.01
Arsenic	mg/kg	0.1	0.8	0.8	0.7
Barium	mg/kg	0.1	23.6	10.1	26.0
Beryllium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Bismuth	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Boron	mg/kg	0.1	7.4	7.2	9.5
Cadmium	mg/kg	0.001	0.066	0.037	0.032
Calcium	mg/kg	5	15700	16100	13800
Chromium	mg/kg	0.1	0.2	0.2	0.2
Cobalt	mg/kg	0.01	0.05	0.05	0.04
Copper	mg/kg	0.1	4.4	5.6	3.1
Iron	mg/kg	2	119	97	96
Lead	mg/kg	0.01	0.30	0.80	0.30
Lithium	mg/kg	0.01	0.21	0.22	0.22
Magnesium	mg/kg	1	1150	1250	1230
Manganese	mg/kg	0.1	5.4	6.2	6.2
Mercury	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Molybdenum	mg/kg	0.01	0.06	0.06	0.05
Nickel	mg/kg	0.1	0.2	0.2	0.2
Potassium	mg/kg	2	1510	1580	919
Rubidium	mg/kg	0.01	0.67	0.68	0.43
Selenium	mg/kg	0.1	0.2	0.1	0.1
Silver	mg/kg	0.01	0.06	0.07	0.05
Sodium	mg/kg	5	6030	6730	7070
Strontium	mg/kg	0.1	228.	218.	206.
Tellurium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Thallium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Tin	mg/kg	0.01	0.05	0.09	0.03
Uranium	mg/kg	0.01	0.02	0.02	0.02
Vanadium	mg/kg	0.1	0.3	0.3	0.3
Zinc	mg/kg	0.2	10.6	8.6	7.2

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Attention: Christine Moore

Project #: 2539

Location: NB

Analysis of Invertebrate Samples

RPC Sample ID:			180540-23	180540-24	180540-25
Client Sample ID:			RBI-5	RBI-6	SBI-4 Large Invert.
Date Sampled:			13-Oct-14	13-Oct-14	13-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.1	124.	185.	55.7
Antimony	mg/kg	0.01	< 0.01	0.02	0.13
Arsenic	mg/kg	0.1	0.7	0.6	3.6
Barium	mg/kg	0.1	31.7	38.2	14.4
Beryllium	mg/kg	0.01	< 0.01	< 0.01	< 0.02
Bismuth	mg/kg	0.1	< 0.1	< 0.1	< 0.2
Boron	mg/kg	0.1	9.7	8.9	14.2
Cadmium	mg/kg	0.001	0.046	0.050	2.30
Calcium	mg/kg	5	15500	12200	49500
Chromium	mg/kg	0.1	0.3	0.4	< 0.2
Cobalt	mg/kg	0.01	0.07	0.08	0.15
Copper	mg/kg	0.1	3.2	2.0	49.2
Iron	mg/kg	2	161	202	92
Lead	mg/kg	0.01	0.53	0.76	32.4
Lithium	mg/kg	0.01	0.25	0.25	0.32
Magnesium	mg/kg	1	1270	887	3040
Manganese	mg/kg	0.1	6.2	8.3	8.7
Mercury	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Molybdenum	mg/kg	0.01	0.06	0.06	0.15
Nickel	mg/kg	0.1	0.2	0.3	0.3
Potassium	mg/kg	2	827	592	4260
Rubidium	mg/kg	0.01	0.47	0.47	1.82
Selenium	mg/kg	0.1	0.2	0.2	0.7
Silver	mg/kg	0.01	0.05	0.04	2.44
Sodium	mg/kg	5	6640	3770	16000
Strontium	mg/kg	0.1	224.	186.	733.
Tellurium	mg/kg	0.01	< 0.01	< 0.01	< 0.02
Thallium	mg/kg	0.01	< 0.01	< 0.01	1.72
Tin	mg/kg	0.01	0.03	0.05	0.34
Uranium	mg/kg	0.01	0.03	0.02	< 0.02
Vanadium	mg/kg	0.1	0.5	0.6	0.3
Zinc	mg/kg	0.2	7.2	6.0	59.9

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Attention: Christine Moore

Project #: 2539

Location: NB

Analysis of Invertebrate Samples

RPC Sample ID:			180540-26	180540-27	180540-28
Client Sample ID:			SBI-6 Large Invert.	SBI-10 Large Invert.	SBI-21 Large Invert.
Date Sampled:			13-Oct-14	13-Oct-14	13-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.1	116.	430.	135.
Antimony	mg/kg	0.01	0.15	0.14	0.03
Arsenic	mg/kg	0.1	2.9	3.1	3.3
Barium	mg/kg	0.1	12.0	20.5	6.0
Beryllium	mg/kg	0.01	< 0.02	< 0.02	< 0.02
Bismuth	mg/kg	0.1	< 0.2	< 0.2	< 0.2
Boron	mg/kg	0.1	13.3	19.8	12.0
Cadmium	mg/kg	0.001	0.777	0.810	0.245
Calcium	mg/kg	5	43200	53400	44200
Chromium	mg/kg	0.1	0.4	0.9	0.6
Cobalt	mg/kg	0.01	0.18	0.27	0.15
Copper	mg/kg	0.1	30.3	22.4	25.6
Iron	mg/kg	2	190	545	184
Lead	mg/kg	0.01	37.5	22.3	4.57
Lithium	mg/kg	0.01	0.34	0.78	0.39
Magnesium	mg/kg	1	2660	3720	2990
Manganese	mg/kg	0.1	13.5	21.5	10.6
Mercury	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Molybdenum	mg/kg	0.01	0.14	0.19	0.15
Nickel	mg/kg	0.1	0.4	0.7	0.4
Potassium	mg/kg	2	3910	5320	4900
Rubidium	mg/kg	0.01	1.58	2.49	1.84
Selenium	mg/kg	0.1	0.7	0.7	0.7
Silver	mg/kg	0.01	0.75	1.05	0.47
Sodium	mg/kg	5	14400	14300	14900
Strontium	mg/kg	0.1	579.	722.	644.
Tellurium	mg/kg	0.01	< 0.02	0.02	< 0.02
Thallium	mg/kg	0.01	0.57	0.35	0.09
Tin	mg/kg	0.01	0.12	0.84	0.07
Uranium	mg/kg	0.01	0.02	0.04	< 0.02
Vanadium	mg/kg	0.1	0.7	1.5	0.6
Zinc	mg/kg	0.2	56.3	45.5	33.3

General Report Comments

Samples were homogenized and portions were prepared by Microwave Assisted Digestion in nitric acid (SOP 4.M26).
The resulting solutions were analyzed for trace elements by ICP-MS (SOP 4.M01).
Mercury was analysed by Cold Vapour AAS (SOP 4.M52 & SOP 4.M53).
Results are reported on an "as received" (wet weight) basis.

Note concerning 180540-1, 180540-3, 180540-7 & 180540-18
These samples contained both small and large invertebrates.
The large invertebrates were separated out and became samples 180540-25 to 28.

Project #: 2539
Location: NB
QA/QC Report

RPC Sample ID:			CRM035844	CRM035845	CRM035846
Type:			CRM DOLT-4	CRM DOLT-4	CRM DOLT-4
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.1	65.5	84.7	80.3
Antimony	mg/kg	0.01	0.03	0.02	0.02
Arsenic	mg/kg	0.1	9.1	9.2	8.7
Barium	mg/kg	0.1	0.3	0.3	0.3
Beryllium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Bismuth	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Boron	mg/kg	0.1	0.6	0.6	0.8
Cadmium	mg/kg	0.001	24.7	25.2	24.1
Calcium	mg/kg	5	639	644	651
Chromium	mg/kg	0.1	1.3	1.5	1.3
Cobalt	mg/kg	0.01	0.22	0.23	0.22
Copper	mg/kg	0.1	31.6	31.6	31.3
Iron	mg/kg	2	1770	1790	1780
Lead	mg/kg	0.01	0.17	0.18	0.15
Lithium	mg/kg	0.01	0.08	0.08	0.08
Magnesium	mg/kg	1	1380	1380	1370
Manganese	mg/kg	0.1	9.5	9.8	9.6
Mercury	mg/kg	0.01	2.44	2.48	2.49
Molybdenum	mg/kg	0.01	1.14	1.14	1.12
Nickel	mg/kg	0.1	1.0	1.0	1.0
Potassium	mg/kg	2	9460	9390	9400
Rubidium	mg/kg	0.01	3.26	3.29	3.29
Selenium	mg/kg	0.1	9.0	9.1	8.3
Silver	mg/kg	0.01	0.74	0.79	0.78
Sodium	mg/kg	5	6840	6810	6830
Strontium	mg/kg	0.1	5.3	5.3	5.4
Tellurium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Thallium	mg/kg	0.01	0.02	0.02	0.02
Tin	mg/kg	0.01	0.17	0.17	0.18
Uranium	mg/kg	0.01	0.06	0.06	0.06
Vanadium	mg/kg	0.1	0.6	0.6	0.5
Zinc	mg/kg	0.2	108.	110.	103.

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Project #: 2539
Location: NB
QA/QC Report

RPC Sample ID:			RB022398	RB022399	RB022400
Type:			Blank	Blank	Blank
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.1	< 0.1	< 0.1	0.1
Antimony	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Arsenic	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Barium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Beryllium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Bismuth	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Boron	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Cadmium	mg/kg	0.001	< 0.001	< 0.001	< 0.001
Calcium	mg/kg	5	< 5	< 5	< 5
Chromium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Cobalt	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Copper	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Iron	mg/kg	2	< 2	< 2	< 2
Lead	mg/kg	0.01	< 0.01	< 0.01	0.01
Lithium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Magnesium	mg/kg	1	< 1	< 1	< 1
Manganese	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Mercury	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Molybdenum	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Nickel	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Potassium	mg/kg	2	< 2	< 2	3
Rubidium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Selenium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Silver	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Sodium	mg/kg	5	< 5	< 5	< 5
Strontium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Tellurium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Thallium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Tin	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Uranium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Vanadium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Zinc	mg/kg	0.2	< 0.2	< 0.2	0.3

Report ID: 178331-IAS
Report Date: 31-Oct-14
Date Received: 30-Sep-14

CERTIFICATE OF ANALYSIS

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Attention: Christine Moore

Project #: 2539

Location: NB

Analysis of Samples

RPC Sample ID:			178331-01	178331-02	178331-03
Client Sample ID:			BM-TO-01	BM-TO-02	BM-TO-03
Date Sampled:			6-Aug-14	6-Aug-14	6-Aug-14
Analytes	**Units**	**RL**			
Moisture	%	0.01	79.6	84.1	82.1

This report relates only to the sample(s) and information provided to the laboratory.

RL = Reporting Limit

Ross Kean

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Peter Crowhurst, B.Sc., C.Chem
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Analysis of Samples

RPC Sample ID:			178331-04	178331-05	178331-06
Client Sample ID: Date Sampled:			BM-TO-04 6-Aug-14	BM-TO-05 6-Aug-14	BM-TO-06 6-Aug-14
Analytes	**Units**	**RL**			
Moisture	%	0.01	81.5	81.8	82.6

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Analysis of Samples

RPC Sample ID:			178331-07	178331-08	178331-09
Client Sample ID: Date Sampled:			BM-TO-07 6-Aug-14	BM-TO-08 6-Aug-14	BM-TO-09 6-Aug-14
Analytes	**Units**	**RL**			
Moisture	%	0.01	81.8	83.3	82.3

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Analysis of Samples

RPC Sample ID:			178331-10	178331-11	178331-12
Client Sample ID:			BM-TO-10	EXP-AH-01	EXP-AH-02
Date Sampled:			6-Aug-14	9-Aug-14	9-Aug-14
Analytes	**Units**	**RL**			
Moisture	%	0.01	81.9	81.2	79.6

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Location: NB

Analysis of Samples

RPC Sample ID:			178331-13	178331-14	178331-15
Client Sample ID:			EXP-AH-03	EXP-AH-04	EXP-AH-05
Date Sampled:			9-Aug-14	9-Aug-14	9-Aug-14
Analytes	**Units**	**RL**			
Moisture	%	0.01	78.9	80.2	80.1

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Analysis of Samples

RPC Sample ID:			178331-16	178331-17	178331-18
Client Sample ID:			EXP-AH-06	EXP-AH-07	EXP-AH-08
Date Sampled:			9-Aug-14	9-Aug-14	9-Aug-14
Analytes	**Units**	**RL**			
Moisture	%	0.01	80.4	80.5	80.2

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Analysis of Samples

RPC Sample ID:			178331-19	178331-20	178331-21
Client Sample ID: Date Sampled:			EXP-AH-09 9-Aug-14	EXP-AH-10 9-Aug-14	EXP-SL-01 9-Aug-14
Analytes	**Units**	**RL**			
Moisture	%	0.01	79.9	79.1	75.7

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Analysis of Samples

RPC Sample ID:			178331-22	178331-23	178331-24
Client Sample ID: Date Sampled:			EXP-SL-02 9-Aug-14	EXP-SL-03 9-Aug-14	EXP-SL-04 9-Aug-14
Analytes	**Units**	**RL**			
Moisture	%	0.01	78.2	77.3	77.9

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Location: NB

Analysis of Samples

RPC Sample ID:			178331-25	178331-26	178331-27
Client Sample ID: Date Sampled:			EXP-SL-05 9-Aug-14	EXP-SL-06 9-Aug-14	REF-AH-01 9-Aug-14
Analytes	**Units**	**RL**			
Moisture	%	0.01	77.8	77.6	76.3

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Analysis of Samples

RPC Sample ID:			178331-28	178331-29	178331-30
Client Sample ID: Date Sampled:			REF-AH-02 9-Aug-14	REF-AH-03 9-Aug-14	REF-AH-04 9-Aug-14
Analytes	**Units**	**RL**			
Moisture	%	0.01	76.2	76.5	78.9

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Analysis of Samples

RPC Sample ID:			178331-31	178331-32	178331-33
Client Sample ID: Date Sampled:			REF-AH-05 9-Aug-14	REF-SL-01 9-Aug-14	REF-SL-02 9-Aug-14
Analytes	**Units**	**RL**			
Moisture	%	0.01	73.9	76.7	75.8

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Analysis of Samples

RPC Sample ID:			178331-34	178331-35	178331-36
Client Sample ID: Date Sampled:			REF-SL-03 9-Aug-14	REF-SL-04 9-Aug-14	REF-SL-05 9-Aug-14
Analytes	**Units**	**RL**			
Moisture	%	0.01	74.3	75.4	74.3

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Analysis of Samples

RPC Sample ID:			178331-37	178331-38	178331-39
Client Sample ID:			REF-SL-06	REF-SL-07	REF-SL-08
Date Sampled:			9-Aug-14	9-Aug-14	9-Aug-14
Analytes	**Units**	**RL**			
Moisture	%	0.01	73.6	75.8	74.8

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Location: NB

Analysis of Samples

RPC Sample ID:			178331-40	178331-41
Client Sample ID:			REF-SL-09	REF-SL-10
Date Sampled:			9-Aug-14	9-Aug-14
Analytes	**Units**	**RL**		
Moisture	%	0.01	75.6	73.5

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Location: NB

Analysis of Samples

RPC Sample ID:			178331-01	178331-02	178331-03
Client Sample ID:			BM-TO-01	BM-TO-02	BM-TO-03
Date Sampled:			6-Aug-14	6-Aug-14	6-Aug-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.5	76.6	35.7	41.6
Antimony	mg/kg	0.005	0.010	0.006	0.005
Arsenic	mg/kg	0.05	1.58	1.35	1.61
Barium	mg/kg	0.05	0.61	0.26	0.28
Beryllium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Bismuth	mg/kg	0.05	0.07	< 0.05	< 0.05
Boron	mg/kg	0.05	5.18	4.37	5.28
Cadmium	mg/kg	0.0005	0.280	0.317	0.267
Calcium	mg/kg	5	739	619	670
Chromium	mg/kg	0.05	0.28	0.16	0.17
Cobalt	mg/kg	0.005	0.107	0.095	0.109
Copper	mg/kg	0.05	1.64	1.52	1.60
Iron	mg/kg	1	76	45	47
Lead	mg/kg	0.005	0.350	0.238	0.363
Lithium	mg/kg	0.005	0.115	0.078	0.084
Magnesium	mg/kg	1	602	555	547
Manganese	mg/kg	0.05	3.52	2.96	3.31
Mercury	mg/kg	0.01	-	-	-
Molybdenum	mg/kg	0.005	0.139	0.111	0.188
Nickel	mg/kg	0.05	0.39	0.34	0.42
Potassium	mg/kg	1	1980	1810	2010
Rubidium	mg/kg	0.005	1.08	0.920	0.972
Selenium	mg/kg	0.05	0.80	0.71	0.73
Silver	mg/kg	0.005	0.024	0.024	0.021
Sodium	mg/kg	5	2700	2530	2910
Strontium	mg/kg	0.05	5.28	4.56	4.61
Tellurium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Thallium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Tin	mg/kg	0.005	0.074	0.008	0.017
Uranium	mg/kg	0.005	0.050	0.040	0.071
Vanadium	mg/kg	0.05	0.32	0.20	0.39
Zinc	mg/kg	0.5	20.4	14.5	17.8

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Attention: Christine Moore

Project #: 2539

Location: NB

Analysis of Samples

RPC Sample ID:			178331-04	178331-05	178331-06
Client Sample ID:			BM-TO-04	BM-TO-05	BM-TO-06
Date Sampled:			6-Aug-14	6-Aug-14	6-Aug-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.5	25.2	25.7	77.6
Antimony	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Arsenic	mg/kg	0.05	1.37	1.31	1.39
Barium	mg/kg	0.05	0.24	0.22	0.46
Beryllium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Bismuth	mg/kg	0.05	< 0.05	< 0.05	< 0.05
Boron	mg/kg	0.05	5.03	4.66	5.44
Cadmium	mg/kg	0.0005	0.268	0.260	0.282
Calcium	mg/kg	5	606	2460	671
Chromium	mg/kg	0.05	0.13	0.14	0.23
Cobalt	mg/kg	0.005	0.084	0.086	0.122
Copper	mg/kg	0.05	1.47	1.26	1.43
Iron	mg/kg	1	34	35	73
Lead	mg/kg	0.005	0.211	0.305	0.325
Lithium	mg/kg	0.005	0.076	0.073	0.114
Magnesium	mg/kg	1	545	504	531
Manganese	mg/kg	0.05	2.92	2.41	3.34
Mercury	mg/kg	0.01	-	-	-
Molybdenum	mg/kg	0.005	0.116	0.104	0.129
Nickel	mg/kg	0.05	0.29	0.31	0.41
Potassium	mg/kg	1	2010	1820	2020
Rubidium	mg/kg	0.005	0.968	0.927	1.02
Selenium	mg/kg	0.05	0.60	0.59	0.66
Silver	mg/kg	0.005	0.023	0.023	0.027
Sodium	mg/kg	5	3010	2640	2780
Strontium	mg/kg	0.05	4.58	8.90	4.59
Tellurium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Thallium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Tin	mg/kg	0.005	0.006	0.010	0.009
Uranium	mg/kg	0.005	0.043	0.043	0.055
Vanadium	mg/kg	0.05	0.20	0.20	0.35
Zinc	mg/kg	0.5	13.9	19.0	16.1

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Attention: Christine Moore

Project #: 2539

Location: NB

Analysis of Samples

RPC Sample ID:			178331-06 Dup	178331-07	178331-08
Client Sample ID:			Lab Duplicate	BM-TO-07	BM-TO-08
Date Sampled:			6-Aug-14	6-Aug-14	6-Aug-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.5	78.2	49.9	99.0
Antimony	mg/kg	0.005	0.010	< 0.005	< 0.005
Arsenic	mg/kg	0.05	1.41	1.50	1.40
Barium	mg/kg	0.05	0.46	0.32	0.57
Beryllium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Bismuth	mg/kg	0.05	< 0.05	< 0.05	< 0.05
Boron	mg/kg	0.05	5.25	4.24	4.33
Cadmium	mg/kg	0.0005	0.276	0.252	0.305
Calcium	mg/kg	5	709	784	925
Chromium	mg/kg	0.05	0.24	0.16	0.24
Cobalt	mg/kg	0.005	0.120	0.087	0.126
Copper	mg/kg	0.05	1.48	1.50	1.49
Iron	mg/kg	1	73	52	91
Lead	mg/kg	0.005	0.289	0.251	0.364
Lithium	mg/kg	0.005	0.113	0.088	0.120
Magnesium	mg/kg	1	543	537	491
Manganese	mg/kg	0.05	3.55	2.83	3.75
Mercury	mg/kg	0.01	-	-	-
Molybdenum	mg/kg	0.005	0.103	0.100	0.146
Nickel	mg/kg	0.05	0.41	0.30	0.45
Potassium	mg/kg	1	2020	2040	1860
Rubidium	mg/kg	0.005	1.02	0.992	1.00
Selenium	mg/kg	0.05	0.64	0.72	0.66
Silver	mg/kg	0.005	0.030	0.018	0.024
Sodium	mg/kg	5	2750	2490	2200
Strontium	mg/kg	0.05	4.78	5.21	6.94
Tellurium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Thallium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Tin	mg/kg	0.005	0.035	0.009	0.009
Uranium	mg/kg	0.005	0.038	0.033	0.056
Vanadium	mg/kg	0.05	0.28	0.23	0.40
Zinc	mg/kg	0.5	14.9	18.3	19.9

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Attention: Christine Moore

Project #: 2539

Location: NB

Analysis of Samples

RPC Sample ID:			178331-09	178331-10	178331-11
Client Sample ID: Date Sampled:			BM-TO-09 6-Aug-14	BM-TO-10 6-Aug-14	EXP-AH-01 9-Aug-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.5	59.5	45.3	9.3
Antimony	mg/kg	0.005	0.005	< 0.005	0.015
Arsenic	mg/kg	0.05	1.33	1.62	0.49
Barium	mg/kg	0.05	0.34	0.28	0.15
Beryllium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Bismuth	mg/kg	0.05	< 0.05	< 0.05	0.06
Boron	mg/kg	0.05	4.87	5.04	2.08
Cadmium	mg/kg	0.0005	0.284	0.287	0.109
Calcium	mg/kg	5	824	722	5640
Chromium	mg/kg	0.05	0.19	0.16	< 0.05
Cobalt	mg/kg	0.005	0.095	0.110	0.012
Copper	mg/kg	0.05	1.43	1.53	1.02
Iron	mg/kg	1	59	50	25
Lead	mg/kg	0.005	0.418	0.284	1.61
Lithium	mg/kg	0.005	0.103	0.090	0.066
Magnesium	mg/kg	1	551	565	655
Manganese	mg/kg	0.05	2.77	2.75	2.27
Mercury	mg/kg	0.01	-	-	< 0.01
Molybdenum	mg/kg	0.005	0.088	0.134	0.019
Nickel	mg/kg	0.05	0.34	0.38	0.07
Potassium	mg/kg	1	2100	2120	3070
Rubidium	mg/kg	0.005	1.02	1.07	0.675
Selenium	mg/kg	0.05	0.72	0.72	0.46
Silver	mg/kg	0.005	0.026	0.027	0.020
Sodium	mg/kg	5	2970	3100	3220
Strontium	mg/kg	0.05	5.15	5.52	17.4
Tellurium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Thallium	mg/kg	0.005	< 0.005	< 0.005	0.254
Tin	mg/kg	0.005	0.006	0.008	0.017
Uranium	mg/kg	0.005	0.021	0.038	0.005
Vanadium	mg/kg	0.05	0.20	0.27	< 0.05
Zinc	mg/kg	0.5	14.6	18.6	24.7

Report ID: 178331-IAS
Report Date: 31-Oct-14
Date Received: 30-Sep-14

CERTIFICATE OF ANALYSIS

for
Intrinsik Environmental
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Halifax, NS B3J 1K1

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Canada E3B 6Z9
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Fax: 506.452.0594
www.rpc.ca

Attention: Christine Moore

Project #: 2539

Location: NB

Analysis of Samples

RPC Sample ID:			178331-12	178331-13	178331-14
Client Sample ID: Date Sampled:			EXP-AH-02 9-Aug-14	EXP-AH-03 9-Aug-14	EXP-AH-04 9-Aug-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.5	13.6	3.4	3.6
Antimony	mg/kg	0.005	0.008	0.008	0.006
Arsenic	mg/kg	0.05	0.50	0.61	0.53
Barium	mg/kg	0.05	0.11	0.14	0.10
Beryllium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Bismuth	mg/kg	0.05	< 0.05	< 0.05	< 0.05
Boron	mg/kg	0.05	2.07	2.02	2.03
Cadmium	mg/kg	0.0005	0.0911	0.0866	0.0827
Calcium	mg/kg	5	5700	6490	6850
Chromium	mg/kg	0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/kg	0.005	0.014	0.009	0.009
Copper	mg/kg	0.05	0.97	0.89	0.83
Iron	mg/kg	1	29	20	20
Lead	mg/kg	0.005	1.26	1.02	1.09
Lithium	mg/kg	0.005	0.063	0.059	0.059
Magnesium	mg/kg	1	690	750	728
Manganese	mg/kg	0.05	2.05	2.28	2.38
Mercury	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Molybdenum	mg/kg	0.005	0.017	0.017	0.018
Nickel	mg/kg	0.05	0.08	0.08	0.08
Potassium	mg/kg	1	3020	3440	3340
Rubidium	mg/kg	0.005	0.692	0.798	0.728
Selenium	mg/kg	0.05	0.47	0.47	0.48
Silver	mg/kg	0.005	0.018	0.013	0.013
Sodium	mg/kg	5	3110	3140	3170
Strontium	mg/kg	0.05	17.5	20.3	20.3
Tellurium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Thallium	mg/kg	0.005	0.263	0.358	0.286
Tin	mg/kg	0.005	0.005	0.008	0.013
Uranium	mg/kg	0.005	< 0.005	0.005	< 0.005
Vanadium	mg/kg	0.05	0.08	< 0.05	< 0.05
Zinc	mg/kg	0.5	23.5	27.2	25.4

Report ID: 178331-IAS
Report Date: 31-Oct-14
Date Received: 30-Sep-14

CERTIFICATE OF ANALYSIS

for
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Attention: Christine Moore

Project #: 2539

Location: NB

Analysis of Samples

RPC Sample ID:			178331-15	178331-16	178331-17
Client Sample ID: Date Sampled:			EXP-AH-05 9-Aug-14	EXP-AH-06 9-Aug-14	EXP-AH-07 9-Aug-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.5	5.4	7.0	14.1
Antimony	mg/kg	0.005	0.006	0.010	0.007
Arsenic	mg/kg	0.05	0.51	0.53	0.53
Barium	mg/kg	0.05	0.12	0.12	0.12
Beryllium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Bismuth	mg/kg	0.05	< 0.05	< 0.05	< 0.05
Boron	mg/kg	0.05	1.91	1.87	1.97
Cadmium	mg/kg	0.0005	0.0910	0.0793	0.0834
Calcium	mg/kg	5	6330	5630	5480
Chromium	mg/kg	0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/kg	0.005	0.011	0.010	0.017
Copper	mg/kg	0.05	0.86	0.82	0.92
Iron	mg/kg	1	21	22	38
Lead	mg/kg	0.005	1.28	1.27	1.44
Lithium	mg/kg	0.005	0.056	0.057	0.076
Magnesium	mg/kg	1	706	696	694
Manganese	mg/kg	0.05	2.10	1.82	1.96
Mercury	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Molybdenum	mg/kg	0.005	0.016	0.016	0.017
Nickel	mg/kg	0.05	0.08	0.07	0.09
Potassium	mg/kg	1	3360	3540	3320
Rubidium	mg/kg	0.005	0.749	0.794	0.723
Selenium	mg/kg	0.05	0.48	0.49	0.45
Silver	mg/kg	0.005	0.017	0.016	0.014
Sodium	mg/kg	5	2950	3060	3100
Strontium	mg/kg	0.05	18.6	16.9	16.3
Tellurium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Thallium	mg/kg	0.005	0.353	0.342	0.291
Tin	mg/kg	0.005	0.008	0.013	0.013
Uranium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Vanadium	mg/kg	0.05	< 0.05	< 0.05	0.07
Zinc	mg/kg	0.5	24.8	23.3	24.3

Report ID: 178331-IAS
Report Date: 31-Oct-14
Date Received: 30-Sep-14

CERTIFICATE OF ANALYSIS

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Attention: Christine Moore

Project #: 2539

Location: NB

Analysis of Samples

RPC Sample ID:			178331-18	178331-18 Dup	178331-19
Client Sample ID: Date Sampled:			EXP-AH-08 9-Aug-14	Lab Duplicate 9-Aug-14	EXP-AH-09 9-Aug-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.5	45.1	4.7	5.5
Antimony	mg/kg	0.005	0.006	0.006	0.012
Arsenic	mg/kg	0.05	0.55	0.52	0.56
Barium	mg/kg	0.05	0.21	0.10	0.12
Beryllium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Bismuth	mg/kg	0.05	< 0.05	< 0.05	< 0.05
Boron	mg/kg	0.05	1.86	1.85	1.62
Cadmium	mg/kg	0.0005	0.0716	0.0737	0.0750
Calcium	mg/kg	5	5880	6250	6120
Chromium	mg/kg	0.05	0.11	< 0.05	< 0.05
Cobalt	mg/kg	0.005	0.030	0.010	0.016
Copper	mg/kg	0.05	0.88	0.82	0.89
Iron	mg/kg	1	71	20	31
Lead	mg/kg	0.005	1.11	0.868	1.71
Lithium	mg/kg	0.005	0.102	0.058	0.054
Magnesium	mg/kg	1	731	725	692
Manganese	mg/kg	0.05	3.11	2.49	2.15
Mercury	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Molybdenum	mg/kg	0.005	0.016	0.014	0.017
Nickel	mg/kg	0.05	0.11	0.07	0.08
Potassium	mg/kg	1	3630	3650	3670
Rubidium	mg/kg	0.005	0.828	0.787	0.791
Selenium	mg/kg	0.05	0.46	0.45	0.49
Silver	mg/kg	0.005	0.012	0.013	0.012
Sodium	mg/kg	5	3080	3110	2960
Strontium	mg/kg	0.05	16.8	17.8	16.2
Tellurium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Thallium	mg/kg	0.005	0.262	0.262	0.253
Tin	mg/kg	0.005	0.009	0.008	0.040
Uranium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Vanadium	mg/kg	0.05	0.21	< 0.05	< 0.05
Zinc	mg/kg	0.5	22.6	23.6	25.8

Report ID: 178331-IAS
Report Date: 31-Oct-14
Date Received: 30-Sep-14

CERTIFICATE OF ANALYSIS

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Attention: Christine Moore

Project #: 2539

Location: NB

Analysis of Samples

RPC Sample ID:			178331-20	178331-21	178331-22
Client Sample ID:			EXP-AH-10	EXP-SL-01	EXP-SL-02
Date Sampled:			9-Aug-14	9-Aug-14	9-Aug-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.5	2.5	2.8	19.0
Antimony	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Arsenic	mg/kg	0.05	0.52	0.69	0.62
Barium	mg/kg	0.05	0.08	0.17	0.16
Beryllium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Bismuth	mg/kg	0.05	< 0.05	< 0.05	< 0.05
Boron	mg/kg	0.05	1.66	1.09	1.05
Cadmium	mg/kg	0.0005	0.0624	0.0728	0.0939
Calcium	mg/kg	5	6000	7160	5920
Chromium	mg/kg	0.05	< 0.05	< 0.05	0.06
Cobalt	mg/kg	0.005	0.008	0.013	0.018
Copper	mg/kg	0.05	0.80	0.94	0.95
Iron	mg/kg	1	19	21	35
Lead	mg/kg	0.005	0.769	0.936	1.20
Lithium	mg/kg	0.005	0.052	0.066	0.056
Magnesium	mg/kg	1	667	570	573
Manganese	mg/kg	0.05	2.50	2.96	2.70
Mercury	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Molybdenum	mg/kg	0.005	0.014	0.011	0.012
Nickel	mg/kg	0.05	0.07	0.08	0.11
Potassium	mg/kg	1	3680	3620	3610
Rubidium	mg/kg	0.005	0.774	0.897	0.943
Selenium	mg/kg	0.05	0.49	0.62	0.56
Silver	mg/kg	0.005	0.010	0.006	0.008
Sodium	mg/kg	5	2940	2290	2210
Strontium	mg/kg	0.05	16.2	23.4	22.0
Tellurium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Thallium	mg/kg	0.005	0.239	0.386	0.467
Tin	mg/kg	0.005	0.023	0.018	0.056
Uranium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Vanadium	mg/kg	0.05	< 0.05	< 0.05	0.06
Zinc	mg/kg	0.5	22.2	33.7	31.7

CERTIFICATE OF ANALYSIS

for
Intrinsik Environmental
Sciences Inc
5121 Sackville Street, Suite 506
Halifax, NS B3J 1K1

Attention: Christine Moore

Project #: 2539

Location: NB

Analysis of Samples

RPC Sample ID:			178331-23	178331-24	178331-25
Client Sample ID: Date Sampled:			EXP-SL-03 9-Aug-14	EXP-SL-04 9-Aug-14	EXP-SL-05 9-Aug-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.5	22.1	60.0	159.
Antimony	mg/kg	0.005	0.222	0.092	0.355
Arsenic	mg/kg	0.05	1.72	0.90	2.74
Barium	mg/kg	0.05	0.80	0.71	1.65
Beryllium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Bismuth	mg/kg	0.05	< 0.05	< 0.05	< 0.05
Boron	mg/kg	0.05	1.07	1.07	1.19
Cadmium	mg/kg	0.0005	0.200	0.0990	0.205
Calcium	mg/kg	5	6600	6510	6280
Chromium	mg/kg	0.05	0.16	0.19	0.53
Cobalt	mg/kg	0.005	0.285	0.163	0.618
Copper	mg/kg	0.05	5.43	3.41	6.16
Iron	mg/kg	1	360	305	718
Lead	mg/kg	0.005	29.8	10.7	53.8
Lithium	mg/kg	0.005	0.070	0.106	0.170
Magnesium	mg/kg	1	589	597	627
Manganese	mg/kg	0.05	3.65	3.77	6.03
Mercury	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Molybdenum	mg/kg	0.005	0.078	0.075	0.085
Nickel	mg/kg	0.05	0.07	0.12	0.19
Potassium	mg/kg	1	3700	3720	3720
Rubidium	mg/kg	0.005	0.966	1.03	1.11
Selenium	mg/kg	0.05	0.57	0.55	0.60
Silver	mg/kg	0.005	0.020	0.022	0.023
Sodium	mg/kg	5	2200	2260	2300
Strontium	mg/kg	0.05	22.5	23.8	22.8
Tellurium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Thallium	mg/kg	0.005	0.347	0.420	0.549
Tin	mg/kg	0.005	0.972	0.283	2.05
Uranium	mg/kg	0.005	< 0.005	0.005	0.009
Vanadium	mg/kg	0.05	0.07	0.17	0.81
Zinc	mg/kg	0.5	156.	100.	248.

Report ID: 178331-IAS
Report Date: 31-Oct-14
Date Received: 30-Sep-14

CERTIFICATE OF ANALYSIS

for
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Attention: Christine Moore

Project #: 2539

Location: NB

Analysis of Samples

RPC Sample ID:			178331-26	178331-27	178331-28
Client Sample ID: Date Sampled:			EXP-SL-06 9-Aug-14	REF-AH-01 9-Aug-14	REF-AH-02 9-Aug-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.5	265.	1.6	1.4
Antimony	mg/kg	0.005	0.375	< 0.005	< 0.005
Arsenic	mg/kg	0.05	3.30	0.55	0.57
Barium	mg/kg	0.05	2.24	0.06	0.07
Beryllium	mg/kg	0.005	0.007	< 0.005	< 0.005
Bismuth	mg/kg	0.05	< 0.05	< 0.05	< 0.05
Boron	mg/kg	0.05	1.21	0.96	1.13
Cadmium	mg/kg	0.0005	0.129	0.0438	0.0836
Calcium	mg/kg	5	5870	5390	6580
Chromium	mg/kg	0.05	0.78	< 0.05	< 0.05
Cobalt	mg/kg	0.005	0.895	0.007	0.008
Copper	mg/kg	0.05	8.56	0.79	0.79
Iron	mg/kg	1	1030	15	19
Lead	mg/kg	0.005	59.7	0.072	0.134
Lithium	mg/kg	0.005	0.310	0.042	0.038
Magnesium	mg/kg	1	694	565	619
Manganese	mg/kg	0.05	8.32	1.41	2.90
Mercury	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Molybdenum	mg/kg	0.005	0.249	0.016	0.016
Nickel	mg/kg	0.05	0.47	0.06	0.07
Potassium	mg/kg	1	3690	3800	3880
Rubidium	mg/kg	0.005	1.17	0.788	0.808
Selenium	mg/kg	0.05	0.58	0.39	0.44
Silver	mg/kg	0.005	0.050	< 0.005	< 0.005
Sodium	mg/kg	5	2250	2080	2180
Strontium	mg/kg	0.05	20.8	11.8	16.1
Tellurium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Thallium	mg/kg	0.005	0.519	< 0.005	< 0.005
Tin	mg/kg	0.005	1.73	0.017	0.006
Uranium	mg/kg	0.005	0.012	< 0.005	< 0.005
Vanadium	mg/kg	0.05	0.92	< 0.05	< 0.05
Zinc	mg/kg	0.5	299.	25.2	25.4

Report ID: 178331-IAS
Report Date: 31-Oct-14
Date Received: 30-Sep-14

CERTIFICATE OF ANALYSIS

for
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Attention: Christine Moore
Project #: 2539
Location: NB

Analysis of Samples

RPC Sample ID:			178331-29	178331-30	178331-30 Dup
Client Sample ID:			REF-AH-03	REF-AH-04	Lab Duplicate
Date Sampled:			9-Aug-14	9-Aug-14	9-Aug-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.5	0.9	3.0	2.4
Antimony	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Arsenic	mg/kg	0.05	0.40	0.54	0.49
Barium	mg/kg	0.05	< 0.05	0.07	0.06
Beryllium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Bismuth	mg/kg	0.05	< 0.05	< 0.05	< 0.05
Boron	mg/kg	0.05	0.60	1.31	1.26
Cadmium	mg/kg	0.0005	0.0443	0.0950	0.0855
Calcium	mg/kg	5	3460	6100	6380
Chromium	mg/kg	0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/kg	0.005	< 0.005	0.008	0.007
Copper	mg/kg	0.05	0.54	0.76	0.76
Iron	mg/kg	1	12	21	18
Lead	mg/kg	0.005	0.057	0.170	0.150
Lithium	mg/kg	0.005	0.024	0.043	0.043
Magnesium	mg/kg	1	369	623	627
Manganese	mg/kg	0.05	1.19	2.72	2.46
Mercury	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Molybdenum	mg/kg	0.005	0.010	0.018	0.016
Nickel	mg/kg	0.05	< 0.05	0.07	0.07
Potassium	mg/kg	1	2670	3000	3010
Rubidium	mg/kg	0.005	0.539	0.630	0.630
Selenium	mg/kg	0.05	0.32	0.44	0.40
Silver	mg/kg	0.005	< 0.005	0.005	< 0.005
Sodium	mg/kg	5	1300	2400	2420
Strontium	mg/kg	0.05	8.06	15.5	15.9
Tellurium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Thallium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Tin	mg/kg	0.005	< 0.005	0.005	0.007
Uranium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Vanadium	mg/kg	0.05	< 0.05	< 0.05	< 0.05
Zinc	mg/kg	0.5	15.7	24.3	22.8

Report ID: 178331-IAS
Report Date: 31-Oct-14
Date Received: 30-Sep-14

CERTIFICATE OF ANALYSIS

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Attention: Christine Moore

Project #: 2539

Location: NB

Analysis of Samples

RPC Sample ID:			178331-31	178331-32	178331-33
Client Sample ID: Date Sampled:			REF-AH-05 9-Aug-14	REF-SL-01 9-Aug-14	REF-SL-02 9-Aug-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.5	3.3	1.8	1.6
Antimony	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Arsenic	mg/kg	0.05	0.60	0.72	0.79
Barium	mg/kg	0.05	0.06	0.15	0.13
Beryllium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Bismuth	mg/kg	0.05	< 0.05	< 0.05	< 0.05
Boron	mg/kg	0.05	1.06	0.94	0.90
Cadmium	mg/kg	0.0005	0.0624	0.0825	0.0814
Calcium	mg/kg	5	7480	5670	5700
Chromium	mg/kg	0.05	< 0.05	< 0.05	< 0.05
Cobalt	mg/kg	0.005	0.007	0.007	0.008
Copper	mg/kg	0.05	0.89	0.74	0.74
Iron	mg/kg	1	20	18	18
Lead	mg/kg	0.005	0.045	0.036	0.021
Lithium	mg/kg	0.005	0.042	0.057	0.053
Magnesium	mg/kg	1	600	543	532
Manganese	mg/kg	0.05	2.61	2.75	2.58
Mercury	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Molybdenum	mg/kg	0.005	0.016	0.016	0.014
Nickel	mg/kg	0.05	0.07	0.06	0.06
Potassium	mg/kg	1	3600	3870	3780
Rubidium	mg/kg	0.005	0.752	0.995	0.980
Selenium	mg/kg	0.05	0.50	0.52	0.59
Silver	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Sodium	mg/kg	5	2130	2080	2040
Strontium	mg/kg	0.05	15.2	18.6	18.3
Tellurium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Thallium	mg/kg	0.005	< 0.005	0.007	< 0.005
Tin	mg/kg	0.005	< 0.005	0.015	0.006
Uranium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Vanadium	mg/kg	0.05	< 0.05	< 0.05	< 0.05
Zinc	mg/kg	0.5	29.4	29.3	29.6

Report ID: 178331-IAS
Report Date: 31-Oct-14
Date Received: 30-Sep-14

CERTIFICATE OF ANALYSIS

for
Intrinsik Environmental
Sciences Inc
5121 Sackville Street, Suite 506
Halifax, NS B3J 1K1

rpc
921 College Hill Rd
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Canada E3B 6Z9
Tel: 506.452.1212
Fax: 506.452.0594
www.rpc.ca

Attention: Christine Moore

Project #: 2539

Location: NB

Analysis of Samples

RPC Sample ID:			178331-34	178331-35	178331-36
Client Sample ID: Date Sampled:			REF-SL-03 9-Aug-14	REF-SL-04 9-Aug-14	REF-SL-05 9-Aug-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.5	1.7	1.6	1.4
Antimony	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Arsenic	mg/kg	0.05	0.79	0.64	0.86
Barium	mg/kg	0.05	0.22	0.26	0.17
Beryllium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Bismuth	mg/kg	0.05	< 0.05	0.05	< 0.05
Boron	mg/kg	0.05	0.84	0.84	0.74
Cadmium	mg/kg	0.0005	0.0545	0.0363	0.0735
Calcium	mg/kg	5	6670	6240	5050
Chromium	mg/kg	0.05	0.05	< 0.05	< 0.05
Cobalt	mg/kg	0.005	0.007	0.008	0.007
Copper	mg/kg	0.05	0.65	0.64	0.71
Iron	mg/kg	1	23	23	17
Lead	mg/kg	0.005	0.031	0.039	0.019
Lithium	mg/kg	0.005	0.062	0.059	0.045
Magnesium	mg/kg	1	528	501	490
Manganese	mg/kg	0.05	3.47	1.84	2.58
Mercury	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Molybdenum	mg/kg	0.005	0.016	0.014	0.013
Nickel	mg/kg	0.05	0.07	0.06	0.05
Potassium	mg/kg	1	3840	3620	3730
Rubidium	mg/kg	0.005	0.911	0.774	0.937
Selenium	mg/kg	0.05	0.61	0.58	0.55
Silver	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Sodium	mg/kg	5	1810	1900	1570
Strontium	mg/kg	0.05	21.6	20.5	16.2
Tellurium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Thallium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Tin	mg/kg	0.005	0.024	0.010	< 0.005
Uranium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Vanadium	mg/kg	0.05	< 0.05	< 0.05	< 0.05
Zinc	mg/kg	0.5	38.0	31.7	30.9

Report ID: 178331-IAS
Report Date: 31-Oct-14
Date Received: 30-Sep-14

CERTIFICATE OF ANALYSIS

for
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Tel: 506.452.1212
Fax: 506.452.0594
www.rpc.ca

Attention: Christine Moore

Project #: 2539

Location: NB

Analysis of Samples

RPC Sample ID:			178331-37	178331-38	178331-39
Client Sample ID:			REF-SL-06	REF-SL-07	REF-SL-08
Date Sampled:			9-Aug-14	9-Aug-14	9-Aug-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.5	2.3	2.3	2.3
Antimony	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Arsenic	mg/kg	0.05	1.12	0.65	0.81
Barium	mg/kg	0.05	0.16	0.11	0.10
Beryllium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Bismuth	mg/kg	0.05	< 0.05	< 0.05	< 0.05
Boron	mg/kg	0.05	0.61	0.63	0.71
Cadmium	mg/kg	0.0005	0.0896	0.102	0.0680
Calcium	mg/kg	5	4260	4820	4270
Chromium	mg/kg	0.05	0.05	< 0.05	< 0.05
Cobalt	mg/kg	0.005	0.008	0.008	0.008
Copper	mg/kg	0.05	0.77	0.74	0.73
Iron	mg/kg	1	18	18	16
Lead	mg/kg	0.005	0.024	0.026	0.021
Lithium	mg/kg	0.005	0.068	0.042	0.050
Magnesium	mg/kg	1	466	460	491
Manganese	mg/kg	0.05	2.97	2.23	2.31
Mercury	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Molybdenum	mg/kg	0.005	0.018	0.019	0.016
Nickel	mg/kg	0.05	0.05	0.06	0.06
Potassium	mg/kg	1	3850	3900	3820
Rubidium	mg/kg	0.005	0.998	0.990	0.994
Selenium	mg/kg	0.05	0.61	0.61	0.57
Silver	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Sodium	mg/kg	5	1460	1420	1780
Strontium	mg/kg	0.05	13.5	15.9	13.4
Tellurium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Thallium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Tin	mg/kg	0.005	< 0.005	0.012	0.005
Uranium	mg/kg	0.005	0.010	< 0.005	< 0.005
Vanadium	mg/kg	0.05	< 0.05	< 0.05	< 0.05
Zinc	mg/kg	0.5	31.5	27.4	27.0

Report ID: 178331-IAS
Report Date: 31-Oct-14
Date Received: 30-Sep-14

CERTIFICATE OF ANALYSIS

for
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www.rpc.ca

Attention: Christine Moore

Project #: 2539

Location: NB

Analysis of Samples

RPC Sample ID:			178331-40	178331-41	178331-41 Dup
Client Sample ID:			REF-SL-09	REF-SL-10	Lab Duplicate
Date Sampled:			9-Aug-14	9-Aug-14	9-Aug-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.5	2.0	1.5	1.3
Antimony	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Arsenic	mg/kg	0.05	0.71	1.00	1.00
Barium	mg/kg	0.05	0.17	0.15	0.19
Beryllium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Bismuth	mg/kg	0.05	< 0.05	< 0.05	< 0.05
Boron	mg/kg	0.05	1.04	0.73	0.77
Cadmium	mg/kg	0.0005	0.0635	0.0577	0.0574
Calcium	mg/kg	5	6220	3960	6580
Chromium	mg/kg	0.05	< 0.05	< 0.05	0.07
Cobalt	mg/kg	0.005	0.007	0.007	0.006
Copper	mg/kg	0.05	0.77	0.70	0.73
Iron	mg/kg	1	19	16	18
Lead	mg/kg	0.005	0.027	0.016	0.016
Lithium	mg/kg	0.005	0.091	0.051	0.059
Magnesium	mg/kg	1	572	472	529
Manganese	mg/kg	0.05	2.49	1.95	2.69
Mercury	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Molybdenum	mg/kg	0.005	0.015	0.013	0.013
Nickel	mg/kg	0.05	0.07	0.06	0.06
Potassium	mg/kg	1	3450	3880	3920
Rubidium	mg/kg	0.005	0.885	0.967	0.954
Selenium	mg/kg	0.05	0.57	0.54	0.55
Silver	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Sodium	mg/kg	5	2040	1660	1680
Strontium	mg/kg	0.05	20.4	12.8	20.9
Tellurium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Thallium	mg/kg	0.005	< 0.005	< 0.005	< 0.005
Tin	mg/kg	0.005	0.021	0.008	0.008
Uranium	mg/kg	0.005	0.006	< 0.005	< 0.005
Vanadium	mg/kg	0.05	< 0.05	< 0.05	< 0.05
Zinc	mg/kg	0.5	29.1	25.9	29.2

General Report Comments

Portions of the samples were prepared by Microwave Assisted Digestion in nitric acid.
The resulting solutions were analyzed for trace elements by ICP-MS.
Mercury was analysed by Cold Vapour AAS.

CERTIFICATE OF ANALYSIS
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Project #: 2539
Location: NB
QA/QC Report

RPC Sample ID:			CRM033761	CRM033762	CRM033903
Type:			CRM NIST 2976	CRM NIST 1566b	CRM DORM-4
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.5	150.	127.	1410
Antimony	mg/kg	0.005	0.018	0.013	< 0.01
Arsenic	mg/kg	0.05	13.3	7.18	6.5
Barium	mg/kg	0.05	0.68	7.40	5.4
Beryllium	mg/kg	0.005	< 0.005	0.008	0.02
Bismuth	mg/kg	0.05	< 0.05	< 0.05	< 0.1
Boron	mg/kg	0.05	27.9	4.96	9.3
Cadmium	mg/kg	0.0005	0.828	2.44	0.316
Calcium	mg/kg	5	7470	782	2380
Chromium	mg/kg	0.05	0.73	0.41	2.0
Cobalt	mg/kg	0.005	0.622	0.343	0.26
Copper	mg/kg	0.05	4.01	67.0	15.2
Iron	mg/kg	1	185	199	347
Lead	mg/kg	0.005	1.23	0.291	0.43
Lithium	mg/kg	0.005	0.714	0.220	1.17
Magnesium	mg/kg	1	4840	1010	924
Manganese	mg/kg	0.05	38.0	18.0	3.0
Mercury	mg/kg	0.01	-	-	0.37
Molybdenum	mg/kg	0.005	0.539	0.181	0.29
Nickel	mg/kg	0.05	0.91	0.95	1.3
Potassium	mg/kg	1	10100	6180	13200
Rubidium	mg/kg	0.005	4.51	3.06	6.04
Selenium	mg/kg	0.05	1.57	1.70	3.1
Silver	mg/kg	0.005	0.008	0.581	0.03
Sodium	mg/kg	5	34400	3080	14600
Strontium	mg/kg	0.05	77.3	6.34	9.8
Tellurium	mg/kg	0.005	< 0.005	< 0.005	< 0.01
Thallium	mg/kg	0.005	0.007	0.005	0.02
Tin	mg/kg	0.005	0.121	0.031	0.07
Uranium	mg/kg	0.005	0.225	0.243	0.06
Vanadium	mg/kg	0.05	0.79	0.56	1.6
Zinc	mg/kg	0.5	141.	1420	52.2

Report ID: 178331-IAS
Report Date: 31-Oct-14
Date Received: 30-Sep-14

CERTIFICATE OF ANALYSIS

for
Intrinsik Environmental
Sciences Inc
5121 Sackville Street, Suite 506
Halifax, NS B3J 1K1

Project #: 2539
Location: NB
QA/QC Report

RPC Sample ID:			CRM033904	CRM033905	RB021229
Type:			CRM DORM-4	CRM DOLT-4	Blank
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.5	1410	72.2	< 0.5
Antimony	mg/kg	0.005	< 0.01	< 0.01	< 0.005
Arsenic	mg/kg	0.05	6.6	9.0	< 0.05
Barium	mg/kg	0.05	5.4	0.2	< 0.05
Beryllium	mg/kg	0.005	0.01	< 0.01	< 0.005
Bismuth	mg/kg	0.05	< 0.1	< 0.1	< 0.05
Boron	mg/kg	0.05	9.2	0.5	< 0.05
Cadmium	mg/kg	0.0005	0.327	24.5	< 0.0005
Calcium	mg/kg	5	2470	664	< 5
Chromium	mg/kg	0.05	2.0	1.3	< 0.05
Cobalt	mg/kg	0.005	0.26	0.23	< 0.005
Copper	mg/kg	0.05	15.2	31.4	< 0.05
Iron	mg/kg	1	376	1780	< 1
Lead	mg/kg	0.005	0.43	0.13	< 0.005
Lithium	mg/kg	0.005	1.20	0.08	< 0.005
Magnesium	mg/kg	1	910	1380	< 1
Manganese	mg/kg	0.05	3.2	9.8	< 0.05
Mercury	mg/kg	0.01	0.36	2.52	< 0.01
Molybdenum	mg/kg	0.005	0.30	1.13	< 0.005
Nickel	mg/kg	0.05	1.4	0.9	< 0.05
Potassium	mg/kg	1	13400	9370	< 1
Rubidium	mg/kg	0.005	6.10	3.31	< 0.005
Selenium	mg/kg	0.05	3.1	7.3	< 0.05
Silver	mg/kg	0.005	0.02	0.85	< 0.005
Sodium	mg/kg	5	14400	6800	< 5
Strontium	mg/kg	0.05	9.9	5.4	< 0.05
Tellurium	mg/kg	0.005	< 0.01	< 0.01	< 0.005
Thallium	mg/kg	0.005	< 0.01	0.01	< 0.005
Tin	mg/kg	0.005	0.08	0.19	0.008
Uranium	mg/kg	0.005	0.06	0.06	< 0.005
Vanadium	mg/kg	0.05	1.6	0.6	< 0.05
Zinc	mg/kg	0.5	52.6	122.	< 0.5

Report ID: 178331-IAS
Report Date: 31-Oct-14
Date Received: 30-Sep-14

CERTIFICATE OF ANALYSIS

for
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Project #: 2539
Location: NB
QA/QC Report

RPC Sample ID:			RB021308	RB021309
Type:			Blank	Blank
Analytes	**Units**	**RL**		
Aluminum	mg/kg	0.5	< 0.5	< 0.5
Antimony	mg/kg	0.005	< 0.005	< 0.005
Arsenic	mg/kg	0.05	< 0.05	< 0.05
Barium	mg/kg	0.05	< 0.05	< 0.05
Beryllium	mg/kg	0.005	< 0.005	< 0.005
Bismuth	mg/kg	0.05	< 0.05	< 0.05
Boron	mg/kg	0.05	< 0.05	< 0.05
Cadmium	mg/kg	0.0005	< 0.0005	< 0.0005
Calcium	mg/kg	5	< 5	< 5
Chromium	mg/kg	0.05	< 0.05	< 0.05
Cobalt	mg/kg	0.005	< 0.005	< 0.005
Copper	mg/kg	0.05	< 0.05	< 0.05
Iron	mg/kg	1	< 1	< 1
Lead	mg/kg	0.005	< 0.005	< 0.005
Lithium	mg/kg	0.005	< 0.005	< 0.005
Magnesium	mg/kg	1	< 1	< 1
Manganese	mg/kg	0.05	< 0.05	< 0.05
Mercury	mg/kg	0.01	< 0.01	< 0.01
Molybdenum	mg/kg	0.005	< 0.005	< 0.005
Nickel	mg/kg	0.05	< 0.05	< 0.05
Potassium	mg/kg	1	< 1	< 1
Rubidium	mg/kg	0.005	< 0.005	< 0.005
Selenium	mg/kg	0.05	< 0.05	< 0.05
Silver	mg/kg	0.005	< 0.005	< 0.005
Sodium	mg/kg	5	< 5	< 5
Strontium	mg/kg	0.05	< 0.05	< 0.05
Tellurium	mg/kg	0.005	< 0.005	< 0.005
Thallium	mg/kg	0.005	< 0.005	< 0.005
Tin	mg/kg	0.005	< 0.005	< 0.005
Uranium	mg/kg	0.005	< 0.005	< 0.005
Vanadium	mg/kg	0.05	< 0.05	< 0.05
Zinc	mg/kg	0.5	< 0.5	< 0.5

Report ID: 183502-IAS
Report Date: 20-Feb-15
Date Received: 22-Jan-15

CERTIFICATE OF ANALYSIS

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Attention: Christine Moore

Project #: 2539

Location: Chaleur Bay

Analysis of Samples

RPC Sample ID:			183502-01	183502-01 Dup	183502-02
Client Sample ID:			R1-M5-4	Lab Duplicate	R1-M6-7
Date Sampled:			11-Oct-14	11-Oct-14	11-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	374	301	433
Antimony	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Arsenic	mg/kg	1	12	12	7
Barium	mg/kg	1	14	21	6
Beryllium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Bismuth	mg/kg	1	< 1	< 1	< 1
Boron	mg/kg	1	18	16	21
Cadmium	mg/kg	0.01	1.30	1.22	1.38
Calcium	mg/kg	50	3640	3450	3310
Chromium	mg/kg	1	< 1	< 1	1
Cobalt	mg/kg	0.1	0.4	0.4	0.4
Copper	mg/kg	1	5	5	7
Iron	mg/kg	20	340	290	410
Lead	mg/kg	0.1	3.3	3.2	1.7
Lithium	mg/kg	0.1	0.6	0.5	0.7
Magnesium	mg/kg	10	2300	2060	3110
Manganese	mg/kg	1	13	12	16
Molybdenum	mg/kg	0.1	0.5	0.5	0.3
Nickel	mg/kg	1	2	2	2
Potassium	mg/kg	20	10400	9570	10400
Rubidium	mg/kg	0.1	5.4	5.0	4.8
Selenium	mg/kg	1	3	3	3
Silver	mg/kg	0.1	0.1	0.1	< 0.1
Sodium	mg/kg	50	13000	12000	19400
Strontium	mg/kg	1	25	22	31
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Tin	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Uranium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Vanadium	mg/kg	1	3	3	2
Zinc	mg/kg	1	81	80	75

This report relates only to the sample(s) and information provided to the laboratory.

RL = Reporting Limit

Ross Kean

A. Ross Kean, M.Sc.
Department Head
Inorganic Analytical Chemistry

Peter Crowhurst, B.Sc., C.Chem
Analytical Chemist
Inorganic Analytical Chemistry

Report ID: 183502-IAS
Report Date: 20-Feb-15
Date Received: 22-Jan-15

CERTIFICATE OF ANALYSIS

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Attention: Christine Moore
Project #: 2539
Location: Chaleur Bay

Analysis of Samples

RPC Sample ID:			183502-03	183502-04	183502-05
Client Sample ID:			R1-M7-1	R1-M4-7	R1-M3-5
Date Sampled:			11-Oct-14	11-Oct-14	11-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	122	693	132
Antimony	mg/kg	0.1	< 0.1	< 0.1	0.1
Arsenic	mg/kg	1	6	8	11
Barium	mg/kg	1	3	6	14
Beryllium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Bismuth	mg/kg	1	< 1	< 1	< 1
Boron	mg/kg	1	18	30	18
Cadmium	mg/kg	0.01	0.56	2.15	1.04
Calcium	mg/kg	50	1280	5150	1550
Chromium	mg/kg	1	< 1	2	< 1
Cobalt	mg/kg	0.1	0.2	0.6	0.4
Copper	mg/kg	1	4	9	6
Iron	mg/kg	20	130	650	160
Lead	mg/kg	0.1	1.1	2.7	1.7
Lithium	mg/kg	0.1	0.4	1.2	0.4
Magnesium	mg/kg	10	2760	4830	2460
Manganese	mg/kg	1	5	23	9
Molybdenum	mg/kg	0.1	0.2	0.6	0.5
Nickel	mg/kg	1	< 1	2	1
Potassium	mg/kg	20	10600	13300	9470
Rubidium	mg/kg	0.1	4.3	6.1	4.4
Selenium	mg/kg	1	2	4	3
Silver	mg/kg	0.1	< 0.1	0.1	< 0.1
Sodium	mg/kg	50	19700	32400	15100
Strontium	mg/kg	1	16	47	19
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Tin	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Uranium	mg/kg	0.1	< 0.1	0.3	0.1
Vanadium	mg/kg	1	< 1	3	2
Zinc	mg/kg	1	32	146	81

Report ID: 183502-IAS
Report Date: 20-Feb-15
Date Received: 22-Jan-15

CERTIFICATE OF ANALYSIS

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Attention: Christine Moore

Project #: 2539

Location: Chaleur Bay

Analysis of Samples

RPC Sample ID:			183502-06	183502-07	183502-08
Client Sample ID:			R2-M3-7	R2-M2-6	R2-M6-4
Date Sampled:			11-Oct-14	11-Oct-14	11-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	175	516	130
Antimony	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Arsenic	mg/kg	1	7	11	5
Barium	mg/kg	1	6	17	2
Beryllium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Bismuth	mg/kg	1	< 1	< 1	< 1
Boron	mg/kg	1	20	19	20
Cadmium	mg/kg	0.01	1.00	1.66	0.88
Calcium	mg/kg	50	2080	1660	1560
Chromium	mg/kg	1	< 1	1	< 1
Cobalt	mg/kg	0.1	0.2	0.5	0.2
Copper	mg/kg	1	5	6	7
Iron	mg/kg	20	180	480	150
Lead	mg/kg	0.1	1.5	2.8	1.3
Lithium	mg/kg	0.1	0.5	0.7	0.4
Magnesium	mg/kg	10	2740	2640	2770
Manganese	mg/kg	1	8	14	7
Molybdenum	mg/kg	0.1	0.3	0.5	0.3
Nickel	mg/kg	1	< 1	2	< 1
Potassium	mg/kg	20	9490	10700	9640
Rubidium	mg/kg	0.1	4.3	5.4	3.9
Selenium	mg/kg	1	2	3	3
Silver	mg/kg	0.1	< 0.1	< 0.1	0.1
Sodium	mg/kg	50	17700	15800	16900
Strontium	mg/kg	1	22	19	18
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Tin	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Uranium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Vanadium	mg/kg	1	1	3	< 1
Zinc	mg/kg	1	54	104	48

Report ID: 183502-IAS
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CERTIFICATE OF ANALYSIS

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Attention: Christine Moore

Project #: 2539

Location: Chaleur Bay

Analysis of Samples

RPC Sample ID:			183502-09	183502-10	183502-10 Dup
Client Sample ID:			R2-M4-5	R2-M1-8	Lab Duplicate
Date Sampled:			11-Oct-14	11-Oct-14	11-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	179	225	267
Antimony	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Arsenic	mg/kg	1	8	9	8
Barium	mg/kg	1	4	4	4
Beryllium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Bismuth	mg/kg	1	< 1	< 1	< 1
Boron	mg/kg	1	23	19	20
Cadmium	mg/kg	0.01	1.83	1.19	1.20
Calcium	mg/kg	50	2380	2160	2490
Chromium	mg/kg	1	< 1	< 1	< 1
Cobalt	mg/kg	0.1	0.4	0.3	0.3
Copper	mg/kg	1	6	5	5
Iron	mg/kg	20	200	240	260
Lead	mg/kg	0.1	1.7	2.3	2.2
Lithium	mg/kg	0.1	0.6	0.5	0.5
Magnesium	mg/kg	10	3760	2700	2730
Manganese	mg/kg	1	8	8	8
Molybdenum	mg/kg	0.1	0.3	0.4	0.4
Nickel	mg/kg	1	1	1	1
Potassium	mg/kg	20	12000	10600	10400
Rubidium	mg/kg	0.1	5.2	4.4	4.5
Selenium	mg/kg	1	4	3	3
Silver	mg/kg	0.1	0.1	< 0.1	< 0.1
Sodium	mg/kg	50	27400	17400	17500
Strontium	mg/kg	1	28	21	21
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Tin	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Uranium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Vanadium	mg/kg	1	1	1	1
Zinc	mg/kg	1	125	43	41

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Project #: 2539

Location: Chaleur Bay

Analysis of Samples

RPC Sample ID:			183502-11	183502-12	183502-13
Client Sample ID:			S1-M6-5	S1-M3-2	S1-M1-11
Date Sampled:			11-Oct-14	11-Oct-14	11-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	193	109	278
Antimony	mg/kg	0.1	< 0.1	< 0.1	0.1
Arsenic	mg/kg	1	15	9	8
Barium	mg/kg	1	10	5	7
Beryllium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Bismuth	mg/kg	1	< 1	< 1	< 1
Boron	mg/kg	1	21	20	20
Cadmium	mg/kg	0.01	3.43	2.25	2.93
Calcium	mg/kg	50	2670	2070	4220
Chromium	mg/kg	1	< 1	< 1	< 1
Cobalt	mg/kg	0.1	0.4	0.2	0.3
Copper	mg/kg	1	7	5	6
Iron	mg/kg	20	210	140	280
Lead	mg/kg	0.1	62.0	32.6	54.4
Lithium	mg/kg	0.1	0.5	0.4	0.6
Magnesium	mg/kg	10	3160	2830	3120
Manganese	mg/kg	1	10	7	10
Molybdenum	mg/kg	0.1	0.5	0.4	0.4
Nickel	mg/kg	1	1	< 1	1
Potassium	mg/kg	20	11500	11400	12600
Rubidium	mg/kg	0.1	5.4	4.5	5.2
Selenium	mg/kg	1	5	3	3
Silver	mg/kg	0.1	0.1	0.1	0.2
Sodium	mg/kg	50	21600	17200	18600
Strontium	mg/kg	1	25	19	27
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Tin	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Uranium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Vanadium	mg/kg	1	1	< 1	1
Zinc	mg/kg	1	152	99	100

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Attention: Christine Moore

Project #: 2539

Location: Chaleur Bay

Analysis of Samples

RPC Sample ID:			183502-14	183502-15	183502-16
Client Sample ID:			S1-M6-6	S1-M5-8	S2-M7-1
Date Sampled:			11-Oct-14	11-Oct-14	11-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	348	314	356
Antimony	mg/kg	0.1	< 0.1	0.1	0.2
Arsenic	mg/kg	1	9	10	10
Barium	mg/kg	1	8	13	6
Beryllium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Bismuth	mg/kg	1	< 1	< 1	< 1
Boron	mg/kg	1	21	21	25
Cadmium	mg/kg	0.01	5.42	4.58	5.59
Calcium	mg/kg	50	2060	2170	5800
Chromium	mg/kg	1	1	1	1
Cobalt	mg/kg	0.1	0.5	0.5	0.7
Copper	mg/kg	1	8	9	10
Iron	mg/kg	20	350	350	480
Lead	mg/kg	0.1	105.	62.8	69.0
Lithium	mg/kg	0.1	0.6	0.6	0.8
Magnesium	mg/kg	10	2940	2840	3980
Manganese	mg/kg	1	12	13	17
Molybdenum	mg/kg	0.1	0.5	0.6	0.6
Nickel	mg/kg	1	2	2	3
Potassium	mg/kg	20	11400	10800	12800
Rubidium	mg/kg	0.1	5.3	4.9	5.7
Selenium	mg/kg	1	5	4	5
Silver	mg/kg	0.1	0.1	0.1	0.2
Sodium	mg/kg	50	17600	18500	26400
Strontium	mg/kg	1	21	23	38
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Tin	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Uranium	mg/kg	0.1	< 0.1	0.1	0.1
Vanadium	mg/kg	1	2	2	2
Zinc	mg/kg	1	210	183	124

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Location: Chaleur Bay

Analysis of Samples

RPC Sample ID:			183502-17	183502-18	183502-18 Dup
Client Sample ID:			S2-M6-12	S2-M1-4	Lab Duplicate
Date Sampled:			11-Oct-14	11-Oct-14	11-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	287	133	217
Antimony	mg/kg	0.1	0.3	0.1	0.1
Arsenic	mg/kg	1	11	8	8
Barium	mg/kg	1	9	2	3
Beryllium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Bismuth	mg/kg	1	< 1	< 1	< 1
Boron	mg/kg	1	22	19	20
Cadmium	mg/kg	0.01	3.63	4.33	4.84
Calcium	mg/kg	50	2450	2010	2460
Chromium	mg/kg	1	1	< 1	1
Cobalt	mg/kg	0.1	0.6	0.3	0.3
Copper	mg/kg	1	9	7	7
Iron	mg/kg	20	380	200	280
Lead	mg/kg	0.1	54.4	98.9	108.
Lithium	mg/kg	0.1	0.7	0.4	0.5
Magnesium	mg/kg	10	3410	2600	2780
Manganese	mg/kg	1	14	12	15
Molybdenum	mg/kg	0.1	0.5	0.3	0.4
Nickel	mg/kg	1	2	< 1	< 1
Potassium	mg/kg	20	11200	10500	9940
Rubidium	mg/kg	0.1	5.0	4.2	4.3
Selenium	mg/kg	1	5	4	4
Silver	mg/kg	0.1	0.2	0.1	0.2
Sodium	mg/kg	50	23800	16700	16800
Strontium	mg/kg	1	25	20	22
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Tin	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Uranium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Vanadium	mg/kg	1	3	1	2
Zinc	mg/kg	1	115	202	227

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Analysis of Samples

RPC Sample ID:			183502-19	183502-20	183502-21
Client Sample ID:			S2-M2-4	S2-M5-11	S3-M4-4
Date Sampled:			11-Oct-14	11-Oct-14	11-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	176	730	798
Antimony	mg/kg	0.1	0.1	0.2	0.2
Arsenic	mg/kg	1	12	9	14
Barium	mg/kg	1	9	8	14
Beryllium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Bismuth	mg/kg	1	< 1	< 1	< 1
Boron	mg/kg	1	23	25	21
Cadmium	mg/kg	0.01	3.65	1.97	3.28
Calcium	mg/kg	50	12300	2630	12000
Chromium	mg/kg	1	< 1	2	2
Cobalt	mg/kg	0.1	0.4	0.5	0.8
Copper	mg/kg	1	8	8	9
Iron	mg/kg	20	260	760	870
Lead	mg/kg	0.1	45.6	32.3	64.1
Lithium	mg/kg	0.1	0.6	1.1	1.1
Magnesium	mg/kg	10	3260	3640	2870
Manganese	mg/kg	1	13	27	29
Molybdenum	mg/kg	0.1	0.5	0.5	0.7
Nickel	mg/kg	1	2	2	3
Potassium	mg/kg	20	12600	11800	11900
Rubidium	mg/kg	0.1	5.4	5.8	6.4
Selenium	mg/kg	1	4	4	5
Silver	mg/kg	0.1	0.1	0.1	0.1
Sodium	mg/kg	50	21300	22300	17200
Strontium	mg/kg	1	61	26	55
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	< 0.1	< 0.1	0.1
Tin	mg/kg	0.1	< 0.1	0.1	0.1
Uranium	mg/kg	0.1	< 0.1	0.1	0.1
Vanadium	mg/kg	1	2	3	4
Zinc	mg/kg	1	109	62	132

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Project #: 2539

Location: Chaleur Bay

Analysis of Samples

RPC Sample ID:			183502-22	183502-23	183502-24
Client Sample ID:			S3-M7-2	S3-M2-9	S3-M5-8
Date Sampled:			11-Oct-14	11-Oct-14	11-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	102	470	174
Antimony	mg/kg	0.1	< 0.1	0.2	0.1
Arsenic	mg/kg	1	14	11	10
Barium	mg/kg	1	2	6	7
Beryllium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Bismuth	mg/kg	1	< 1	< 1	< 1
Boron	mg/kg	1	22	26	22
Cadmium	mg/kg	0.01	3.52	5.06	3.03
Calcium	mg/kg	50	4220	3020	2500
Chromium	mg/kg	1	< 1	2	< 1
Cobalt	mg/kg	0.1	0.3	0.7	0.4
Copper	mg/kg	1	8	9	9
Iron	mg/kg	20	170	580	240
Lead	mg/kg	0.1	45.2	66.8	50.7
Lithium	mg/kg	0.1	0.6	0.9	0.6
Magnesium	mg/kg	10	3860	4360	3430
Manganese	mg/kg	1	13	21	12
Molybdenum	mg/kg	0.1	0.4	0.6	0.5
Nickel	mg/kg	1	< 1	4	2
Potassium	mg/kg	20	13000	12900	12400
Rubidium	mg/kg	0.1	5.3	5.8	5.4
Selenium	mg/kg	1	6	5	4
Silver	mg/kg	0.1	0.3	0.1	0.1
Sodium	mg/kg	50	26600	30500	23800
Strontium	mg/kg	1	41	38	27
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Tin	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Uranium	mg/kg	0.1	< 0.1	0.2	< 0.1
Vanadium	mg/kg	1	< 1	3	2
Zinc	mg/kg	1	210	161	108

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Project #: 2539

Location: Chaleur Bay

Analysis of Samples

RPC Sample ID:			183502-25	183502-26	183502-27
Client Sample ID: Date Sampled:			S3-M2-11 11-Oct-14	S4-M5-1 11-Oct-14	S4-M4-10 11-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	99	178	237
Antimony	mg/kg	0.1	0.1	0.1	0.1
Arsenic	mg/kg	1	10	10	9
Barium	mg/kg	1	6	4	8
Beryllium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Bismuth	mg/kg	1	< 1	< 1	< 1
Boron	mg/kg	1	24	28	22
Cadmium	mg/kg	0.01	2.54	5.21	4.29
Calcium	mg/kg	50	2550	2410	2630
Chromium	mg/kg	1	< 1	1	1
Cobalt	mg/kg	0.1	0.5	0.5	0.5
Copper	mg/kg	1	7	10	8
Iron	mg/kg	20	160	270	320
Lead	mg/kg	0.1	35.6	75.3	71.5
Lithium	mg/kg	0.1	0.5	0.7	0.7
Magnesium	mg/kg	10	3730	4200	3750
Manganese	mg/kg	1	12	17	12
Molybdenum	mg/kg	0.1	0.4	0.4	0.6
Nickel	mg/kg	1	2	2	2
Potassium	mg/kg	20	12400	15300	11300
Rubidium	mg/kg	0.1	5.1	5.8	5.0
Selenium	mg/kg	1	5	5	4
Silver	mg/kg	0.1	< 0.1	< 0.1	0.3
Sodium	mg/kg	50	25100	29200	25600
Strontium	mg/kg	1	30	32	27
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	< 0.1	0.2	0.2
Tin	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Uranium	mg/kg	0.1	< 0.1	< 0.1	0.1
Vanadium	mg/kg	1	2	2	2
Zinc	mg/kg	1	92	198	170

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Location: Chaleur Bay

Analysis of Samples

RPC Sample ID:			183502-28	183502-29	183502-30
Client Sample ID:			S4-M2-4	S4-M6-11	S4-M1-1
Date Sampled:			11-Oct-14	11-Oct-14	11-Oct-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	311	68	274
Antimony	mg/kg	0.1	0.2	0.1	0.2
Arsenic	mg/kg	1	11	10	10
Barium	mg/kg	1	9	6	8
Beryllium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Bismuth	mg/kg	1	< 1	< 1	< 1
Boron	mg/kg	1	25	25	21
Cadmium	mg/kg	0.01	4.21	5.81	3.38
Calcium	mg/kg	50	4330	2810	3410
Chromium	mg/kg	1	1	< 1	1
Cobalt	mg/kg	0.1	0.5	0.9	0.5
Copper	mg/kg	1	10	7	9
Iron	mg/kg	20	390	140	350
Lead	mg/kg	0.1	83.1	100.	81.2
Lithium	mg/kg	0.1	0.7	0.5	0.6
Magnesium	mg/kg	10	3850	3750	3220
Manganese	mg/kg	1	12	8	15
Molybdenum	mg/kg	0.1	0.6	0.6	0.5
Nickel	mg/kg	1	2	4	2
Potassium	mg/kg	20	12700	13200	10800
Rubidium	mg/kg	0.1	5.8	5.9	4.9
Selenium	mg/kg	1	5	5	4
Silver	mg/kg	0.1	0.1	0.2	0.2
Sodium	mg/kg	50	26200	25700	21000
Strontium	mg/kg	1	37	35	30
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	0.2	0.3	0.2
Tin	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Uranium	mg/kg	0.1	< 0.1	0.1	< 0.1
Vanadium	mg/kg	1	2	2	2
Zinc	mg/kg	1	176	232	129

General Report Comments

Portions of the samples were prepared by Microwave Assisted Digestion in nitric acid (SOP 4.M26).
The resulting solutions were analyzed for trace elements by ICP-MS and ICP-ES.
Samples were identified as "Dry Mussel". Results are reported on an "as received" basis.

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Project #: 2539
Location: Chaleur Bay
QA/QC Report

RPC Sample ID:			CRM037288	CRM037289	CRM037290
Type:			CRM NIST 2976	CRM NIST 2976	CRM NIST 2976
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	144	140	138
Antimony	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Arsenic	mg/kg	1	13	14	14
Barium	mg/kg	1	< 1	< 1	< 1
Beryllium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Bismuth	mg/kg	1	< 1	< 1	< 1
Boron	mg/kg	1	28	28	28
Cadmium	mg/kg	0.01	0.85	0.83	0.81
Calcium	mg/kg	50	8150	7710	7830
Chromium	mg/kg	1	< 1	< 1	< 1
Cobalt	mg/kg	0.1	0.6	0.6	0.6
Copper	mg/kg	1	4	4	4
Iron	mg/kg	20	170	170	170
Lead	mg/kg	0.1	1.2	1.1	1.1
Lithium	mg/kg	0.1	0.7	0.7	0.7
Magnesium	mg/kg	10	4860	4840	4970
Manganese	mg/kg	1	38	37	38
Molybdenum	mg/kg	0.1	0.5	0.5	0.5
Nickel	mg/kg	1	< 1	< 1	< 1
Potassium	mg/kg	20	9690	9750	9720
Rubidium	mg/kg	0.1	4.0	4.0	4.2
Selenium	mg/kg	1	2	2	2
Silver	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Sodium	mg/kg	50	35700	35400	36400
Strontium	mg/kg	1	81	79	79
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Tin	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Uranium	mg/kg	0.1	0.2	0.2	0.2
Vanadium	mg/kg	1	< 1	< 1	< 1
Zinc	mg/kg	1	139	138	137

CERTIFICATE OF ANALYSIS

for
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Project #: 2539
Location: Chaleur Bay
QA/QC Report

RPC Sample ID:			RB023315	RB023316	RB023317
Type:			Blank	Blank	Blank
Analytes	**Units**	**RL**			
Aluminum	mg/kg	1	< 1	< 1	< 1
Antimony	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Arsenic	mg/kg	1	< 1	< 1	< 1
Barium	mg/kg	1	< 1	< 1	< 1
Beryllium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Bismuth	mg/kg	1	< 1	< 1	< 1
Boron	mg/kg	1	< 1	< 1	< 1
Cadmium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Calcium	mg/kg	50	< 50	< 50	< 50
Chromium	mg/kg	1	< 1	< 1	< 1
Cobalt	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Copper	mg/kg	1	< 1	< 1	< 1
Iron	mg/kg	20	< 20	< 20	< 20
Lead	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Lithium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Magnesium	mg/kg	10	< 10	< 10	< 10
Manganese	mg/kg	1	< 1	< 1	< 1
Molybdenum	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Nickel	mg/kg	1	< 1	< 1	< 1
Potassium	mg/kg	20	< 20	< 20	< 20
Rubidium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Selenium	mg/kg	1	< 1	< 1	< 1
Silver	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Sodium	mg/kg	50	< 50	< 50	< 50
Strontium	mg/kg	1	< 1	< 1	< 1
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Tin	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Uranium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Vanadium	mg/kg	1	< 1	< 1	< 1
Zinc	mg/kg	1	< 1	< 1	< 1

Report ID: 180119-IAS
Report Date: 19-Dec-14
Date Received: 04-Nov-14

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Attention: Christine Moore

Project #: Not Available

Analysis of Samples

RPC Sample ID:			180119-01	180119-02	180119-03
Client Sample ID:			E-06-23-14-2 1/2 Formed Chick	E-06-23-14-3 Orange Liquid	E-06-23-14-4 Orange Liquid
Date Sampled:			23-Jun-14	23-Jun-14	23-Jun-14
Analytes	**Units**	**RL**			
Moisture	%	0.01	78.3	81.2	79.6

This report relates only to the sample(s) and information provided to the laboratory.

RL = Reporting Limit

Ross Kean

A. Ross Kean, M.Sc.
Department Head
Inorganic Analytical Chemistry

Peter Crowhurst, B.Sc., C.Chem
Analytical Chemist
Inorganic Analytical Chemistry

Report ID: 180119-IAS
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Attention: Christine Moore

Project #: Not Available

Analysis of Samples

RPC Sample ID:			180119-04	180119-05	180119-06
Client Sample ID:			E-06-23-14-5 1/2 Formed Chick	E-06-23-14-6 1/2 Formed Chick	E-06-23-14-7 Formed Chick
Date Sampled:			23-Jun-14	23-Jun-14	23-Jun-14
Analytes	**Units**	**RL**			
Moisture	%	0.01	78.6	74.6	77.2

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Attention: Christine Moore

Project #: Not Available

Analysis of Samples

RPC Sample ID:			180119-07	180119-08	180119-09
Client Sample ID:			E-06-23-14-8 Formed Chick	E-06-23-14-9 Orange Liquid	E-06-23-14-10 Formed Chick
Date Sampled:			23-Jun-14	23-Jun-14	23-Jun-14
Analytes	**Units**	**RL**			
Moisture	%	0.01	73.8	79.5	75.9

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Project #: Not Available

Analysis of Samples

RPC Sample ID:			180119-10	180119-11	180119-12
Client Sample ID:			E-06-23-14-11 Formed Chick	E-06-23-14-12 1/2 Formed Chick	E-07-11-14-14 Orange Liquid
Date Sampled:			23-Jun-14	23-Jun-14	11-Jul-14
Analytes	**Units**	**RL**			
Moisture	%	0.01	80.2	78.5	77.8

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Attention: Christine Moore

Project #: Not Available

Analysis of Samples

RPC Sample ID:			180119-13	180119-14	180119-15
Client Sample ID:			E-07-11-14-15 Orange Liquid	E-07-11-14-16 Orange Liquid	E-07-11-14-17 Orange Liquid
Date Sampled:			11-Jul-14	11-Jul-14	11-Jul-14
Analytes	**Units**	**RL**			
Moisture	%	0.01	77.5	77.3	78.4

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Attention: Christine Moore

Project #: Not Available

Analysis of Samples

RPC Sample ID:			180119-16	180119-17	180119-18
Client Sample ID:			E-07-11-14-18 Orange Liquid	E-07-11-14-19 Orange Liquid	E-07-11-14-20 Formed Chick
Date Sampled:			11-Jul-14	11-Jul-14	11-Jul-14
Analytes	**Units**	**RL**			
Moisture	%	0.01	77.4	79.4	80.5

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Attention: Christine Moore

Project #: Not Available

Analysis of Samples

RPC Sample ID:			180119-28	180119-31	180119-33
Client Sample ID:			C-07-07-14-7 Liver	C-07-11-14-11 Liver	C-07-11-14-14 Liver
Date Sampled:			7-Jul-14	11-Jul-14	11-Jul-14
Analytes	**Units**	**RL**			
Moisture	%	0.01	73.1	73.2	70.3

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Attention: Christine Moore

Project #: Not Available

Analysis of Samples

RPC Sample ID:			180119-34	180119-35	180119-36
Client Sample ID:			C-07-15-14-16 Liver	C-07-17-14-17 Liver	C-07-24-14-21 Liver
Date Sampled:			15-Jul-14	17-Jul-14	24-Jul-14
Analytes	**Units**	**RL**			
Moisture	%	0.01	74.2	73.8	69.8

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Project #: Not Available

Analysis of Samples

RPC Sample ID:			180119-37
Client Sample ID: Date Sampled:			C-07-29-14-22 Liver 29-Jul-14
Analytes	**Units**	**RL**	
Moisture	%	0.01	73.2

Report ID: 180119-IAS
Report Date: 19-Dec-14
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Attention: Christine Moore

Project #: Not Available

Analysis of Samples

RPC Sample ID:			180119-01	180119-01 Dup	180119-02
Client Sample ID:			E-06-23-14-2 1/2 Formed Chick	Lab Duplicate	E-06-23-14-3 Orange Liquid
Date Sampled:			23-Jun-14	23-Jun-14	23-Jun-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Antimony	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Arsenic	mg/kg	0.1	< 0.1	< 0.1	0.1
Barium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Beryllium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Bismuth	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Boron	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Cadmium	mg/kg	0.001	0.007	0.006	0.002
Calcium	mg/kg	5	557	534	469
Chromium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Cobalt	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Copper	mg/kg	0.1	1.0	1.1	0.8
Iron	mg/kg	2	26	26	24
Lead	mg/kg	0.01	0.75	0.72	0.27
Lithium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Magnesium	mg/kg	1	128	125	84
Manganese	mg/kg	0.1	0.5	0.5	0.5
Mercury	mg/kg	0.01	0.08	0.08	0.09
Molybdenum	mg/kg	0.01	0.02	0.01	0.01
Nickel	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Potassium	mg/kg	2	1420	1430	1390
Rubidium	mg/kg	0.01	0.52	0.52	0.41
Selenium	mg/kg	0.1	0.5	0.6	0.7
Silver	mg/kg	0.01	0.02	< 0.01	< 0.01
Sodium	mg/kg	5	1610	1650	1670
Strontium	mg/kg	0.1	1.6	1.6	0.6
Tellurium	mg/kg	0.01	0.05	0.05	0.05
Thallium	mg/kg	0.01	0.33	0.33	0.08
Tin	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Uranium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Vanadium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Zinc	mg/kg	0.2	12.7	12.0	11.3

Report ID: 180119-IAS
Report Date: 19-Dec-14
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Attention: Christine Moore

Project #: Not Available

Analysis of Samples

RPC Sample ID:			180119-03	180119-04	180119-05
Client Sample ID:			E-06-23-14-4 Orange Liquid	E-06-23-14-5 1/2 Formed Chick	E-06-23-14-6 1/2 Formed Chick
Date Sampled:			23-Jun-14	23-Jun-14	23-Jun-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Antimony	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Arsenic	mg/kg	0.1	< 0.1	< 0.1	0.1
Barium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Beryllium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Bismuth	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Boron	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Cadmium	mg/kg	0.001	0.002	0.001	0.004
Calcium	mg/kg	5	532	601	609
Chromium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Cobalt	mg/kg	0.01	< 0.01	< 0.01	0.02
Copper	mg/kg	0.1	0.8	0.8	0.8
Iron	mg/kg	2	25	36	33
Lead	mg/kg	0.01	0.46	0.25	0.44
Lithium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Magnesium	mg/kg	1	122	107	116
Manganese	mg/kg	0.1	0.4	0.6	0.8
Mercury	mg/kg	0.01	0.11	0.05	0.09
Molybdenum	mg/kg	0.01	0.02	0.02	0.02
Nickel	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Potassium	mg/kg	2	1240	1380	1620
Rubidium	mg/kg	0.01	0.45	0.46	0.51
Selenium	mg/kg	0.1	0.6	0.6	0.9
Silver	mg/kg	0.01	0.01	< 0.01	< 0.01
Sodium	mg/kg	5	1610	1740	1870
Strontium	mg/kg	0.1	1.3	2.2	1.6
Tellurium	mg/kg	0.01	0.04	0.01	0.03
Thallium	mg/kg	0.01	0.19	0.21	0.10
Tin	mg/kg	0.01	< 0.01	0.09	< 0.01
Uranium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Vanadium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Zinc	mg/kg	0.2	9.4	14.9	18.0

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Attention: Christine Moore

Project #: Not Available

Analysis of Samples

RPC Sample ID:			180119-06	180119-07	180119-08
Client Sample ID:			E-06-23-14-7 Formed Chick	E-06-23-14-8 Formed Chick	E-06-23-14-9 Orange Liquid
Date Sampled:			23-Jun-14	23-Jun-14	23-Jun-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.1	< 0.1	0.1	< 0.1
Antimony	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Arsenic	mg/kg	0.1	0.2	0.2	0.1
Barium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Beryllium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Bismuth	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Boron	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Cadmium	mg/kg	0.001	0.003	0.002	0.002
Calcium	mg/kg	5	2530	2200	511
Chromium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Cobalt	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Copper	mg/kg	0.1	0.8	0.8	0.8
Iron	mg/kg	2	37	32	30
Lead	mg/kg	0.01	0.17	0.14	0.33
Lithium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Magnesium	mg/kg	1	182	172	91
Manganese	mg/kg	0.1	0.7	0.7	0.6
Mercury	mg/kg	0.01	0.11	0.11	0.07
Molybdenum	mg/kg	0.01	0.02	0.02	0.01
Nickel	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Potassium	mg/kg	2	1810	1960	1340
Rubidium	mg/kg	0.01	0.48	0.53	0.40
Selenium	mg/kg	0.1	0.8	0.8	0.7
Silver	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Sodium	mg/kg	5	1600	1930	1560
Strontium	mg/kg	0.1	3.1	3.7	0.8
Tellurium	mg/kg	0.01	< 0.01	< 0.01	0.06
Thallium	mg/kg	0.01	0.04	0.05	0.10
Tin	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Uranium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Vanadium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Zinc	mg/kg	0.2	20.6	15.8	12.9

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Attention: Christine Moore

Project #: Not Available

Analysis of Samples

RPC Sample ID:			180119-09	180119-10	180119-11
Client Sample ID:			E-06-23-14-10 Formed Chick	E-06-23-14-11 Formed Chick	E-06-23-14-12 1/2 Formed Chick
Date Sampled:			23-Jun-14	23-Jun-14	23-Jun-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Antimony	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Arsenic	mg/kg	0.1	0.1	< 0.1	0.1
Barium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Beryllium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Bismuth	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Boron	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Cadmium	mg/kg	0.001	0.002	0.002	0.002
Calcium	mg/kg	5	1520	546	507
Chromium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Cobalt	mg/kg	0.01	0.01	< 0.01	< 0.01
Copper	mg/kg	0.1	0.7	0.9	0.9
Iron	mg/kg	2	33	28	28
Lead	mg/kg	0.01	0.16	0.32	0.20
Lithium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Magnesium	mg/kg	1	130	85	90
Manganese	mg/kg	0.1	0.7	0.4	0.5
Mercury	mg/kg	0.01	0.09	0.06	0.08
Molybdenum	mg/kg	0.01	0.02	0.01	0.01
Nickel	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Potassium	mg/kg	2	1530	1380	1320
Rubidium	mg/kg	0.01	0.48	0.46	0.43
Selenium	mg/kg	0.1	0.8	0.5	0.6
Silver	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Sodium	mg/kg	5	1610	1610	1520
Strontium	mg/kg	0.1	2.2	1.7	1.4
Tellurium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Thallium	mg/kg	0.01	0.54	0.06	0.06
Tin	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Uranium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Vanadium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Zinc	mg/kg	0.2	14.4	10.3	10.9

Report ID: 180119-IAS
Report Date: 19-Dec-14
Date Received: 04-Nov-14

CERTIFICATE OF ANALYSIS

for
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Attention: Christine Moore
Project #: Not Available

Analysis of Samples

RPC Sample ID:			180119-11 Dup	180119-12	180119-13
Client Sample ID:			Lab Duplicate	E-07-11-14-14 Orange Liquid	E-07-11-14-15 Orange Liquid
Date Sampled:			23-Jun-14	11-Jul-14	11-Jul-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Antimony	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Arsenic	mg/kg	0.1	0.1	0.1	0.1
Barium	mg/kg	0.1	< 0.1	0.1	< 0.1
Beryllium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Bismuth	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Boron	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Cadmium	mg/kg	0.001	0.002	0.009	0.005
Calcium	mg/kg	5	503	864	737
Chromium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Cobalt	mg/kg	0.01	< 0.01	0.01	< 0.01
Copper	mg/kg	0.1	0.9	0.9	0.9
Iron	mg/kg	2	28	30	27
Lead	mg/kg	0.01	0.19	0.53	0.32
Lithium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Magnesium	mg/kg	1	90	126	100
Manganese	mg/kg	0.1	0.5	0.8	0.6
Mercury	mg/kg	0.01	0.08	0.09	0.09
Molybdenum	mg/kg	0.01	0.01	0.02	0.01
Nickel	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Potassium	mg/kg	2	1350	1710	1240
Rubidium	mg/kg	0.01	0.44	0.64	0.35
Selenium	mg/kg	0.1	0.6	0.8	0.6
Silver	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Sodium	mg/kg	5	1560	1680	1600
Strontium	mg/kg	0.1	1.4	2.6	1.3
Tellurium	mg/kg	0.01	< 0.01	0.05	0.02
Thallium	mg/kg	0.01	0.06	0.26	0.09
Tin	mg/kg	0.01	< 0.01	< 0.01	0.07
Uranium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Vanadium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Zinc	mg/kg	0.2	10.7	17.8	13.3

Report ID: 180119-IAS
Report Date: 19-Dec-14
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Attention: Christine Moore

Project #: Not Available

Analysis of Samples

RPC Sample ID:			180119-14	180119-15	180119-16
Client Sample ID: Date Sampled:			E-07-11-14-16 Orange Liquid 11-Jul-14	E-07-11-14-17 Orange Liquid 11-Jul-14	E-07-11-14-18 Orange Liquid 11-Jul-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Antimony	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Arsenic	mg/kg	0.1	0.1	0.1	0.1
Barium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Beryllium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Bismuth	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Boron	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Cadmium	mg/kg	0.001	0.008	0.006	0.015
Calcium	mg/kg	5	615	792	636
Chromium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Cobalt	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Copper	mg/kg	0.1	0.9	0.8	1.0
Iron	mg/kg	2	33	24	32
Lead	mg/kg	0.01	0.25	0.62	0.33
Lithium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Magnesium	mg/kg	1	89	94	88
Manganese	mg/kg	0.1	0.6	0.3	0.5
Mercury	mg/kg	0.01	0.06	0.09	0.07
Molybdenum	mg/kg	0.01	0.02	0.01	0.01
Nickel	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Potassium	mg/kg	2	1210	1340	1200
Rubidium	mg/kg	0.01	0.38	0.42	0.36
Selenium	mg/kg	0.1	0.7	0.5	0.6
Silver	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Sodium	mg/kg	5	1530	1450	1430
Strontium	mg/kg	0.1	2.2	1.6	1.7
Tellurium	mg/kg	0.01	0.02	0.03	0.02
Thallium	mg/kg	0.01	0.32	0.05	0.15
Tin	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Uranium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Vanadium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Zinc	mg/kg	0.2	16.8	12.3	14.1

Report ID: 180119-IAS
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Attention: Christine Moore

Project #: Not Available

Analysis of Samples

RPC Sample ID:			180119-17	180119-18	180119-19
Client Sample ID:			E-07-11-14-19 Orange Liquid	E-07-11-14-20 Formed Chick	C-07-06-14-3 Kidney
Date Sampled:			11-Jul-14	11-Jul-14	6-Jul-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.1	< 0.1	< 0.1	10.2
Antimony	mg/kg	0.01	< 0.01	0.01	0.12
Arsenic	mg/kg	0.1	0.2	0.1	0.5
Barium	mg/kg	0.1	< 0.1	0.1	< 0.1
Beryllium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Bismuth	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Boron	mg/kg	0.1	< 0.1	< 0.1	0.1
Cadmium	mg/kg	0.001	0.003	0.006	0.441
Calcium	mg/kg	5	916	2040	222
Chromium	mg/kg	0.1	< 0.1	< 0.1	0.1
Cobalt	mg/kg	0.01	< 0.01	< 0.01	0.03
Copper	mg/kg	0.1	0.8	0.9	3.1
Iron	mg/kg	2	30	36	58
Lead	mg/kg	0.01	0.30	0.52	7.09
Lithium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Magnesium	mg/kg	1	109	165	194
Manganese	mg/kg	0.1	0.4	1.0	0.8
Mercury	mg/kg	0.01	0.11	0.11	0.06
Molybdenum	mg/kg	0.01	0.02	0.03	0.07
Nickel	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Potassium	mg/kg	2	1540	1660	2510
Rubidium	mg/kg	0.01	0.47	0.65	0.97
Selenium	mg/kg	0.1	0.6	0.7	0.8
Silver	mg/kg	0.01	< 0.01	< 0.01	0.02
Sodium	mg/kg	5	1630	1780	1550
Strontium	mg/kg	0.1	1.2	4.6	0.4
Tellurium	mg/kg	0.01	0.05	0.03	0.05
Thallium	mg/kg	0.01	0.03	0.48	0.32
Tin	mg/kg	0.01	< 0.01	< 0.01	0.04
Uranium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Vanadium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Zinc	mg/kg	0.2	13.9	17.4	21.3

CERTIFICATE OF ANALYSIS

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Attention: Christine Moore

Project #: Not Available

Analysis of Samples

RPC Sample ID:			180119-20	180119-21	180119-22
Client Sample ID:			C-07-07-14-7 Kidney	C-07-11-14-14 Kidney	C-07-15-14-16 Kidney
Date Sampled:			7-Jul-14	11-Jul-14	15-Jul-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.1	6.3	0.9	0.4
Antimony	mg/kg	0.01	1.41	0.23	0.20
Arsenic	mg/kg	0.1	4.8	0.9	0.6
Barium	mg/kg	0.1	0.2	< 0.1	< 0.1
Beryllium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Bismuth	mg/kg	0.1	0.1	< 0.1	< 0.1
Boron	mg/kg	0.1	0.1	0.1	< 0.1
Cadmium	mg/kg	0.001	1.91	0.213	0.379
Calcium	mg/kg	5	352	738	258
Chromium	mg/kg	0.1	0.1	< 0.1	< 0.1
Cobalt	mg/kg	0.01	0.07	0.03	0.02
Copper	mg/kg	0.1	7.2	3.7	3.8
Iron	mg/kg	2	96	63	66
Lead	mg/kg	0.01	28.3	8.31	5.25
Lithium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Magnesium	mg/kg	1	129	342	192
Manganese	mg/kg	0.1	1.5	1.8	1.1
Mercury	mg/kg	0.01	0.09	0.03	0.03
Molybdenum	mg/kg	0.01	0.13	0.16	0.13
Nickel	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Potassium	mg/kg	2	2660	3820	3060
Rubidium	mg/kg	0.01	0.85	1.81	1.14
Selenium	mg/kg	0.1	1.4	1.5	1.6
Silver	mg/kg	0.01	0.05	0.04	0.04
Sodium	mg/kg	5	1530	1640	1470
Strontium	mg/kg	0.1	0.3	0.6	0.7
Tellurium	mg/kg	0.01	0.39	0.26	0.18
Thallium	mg/kg	0.01	3.01	0.19	0.18
Tin	mg/kg	0.01	0.11	0.04	0.02
Uranium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Vanadium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Zinc	mg/kg	0.2	28.4	17.0	23.5

CERTIFICATE OF ANALYSIS

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Attention: Christine Moore

Project #: Not Available

Analysis of Samples

RPC Sample ID:			180119-23	180119-24	180119-25
Client Sample ID:			C-07-15-14-17 Kidney	C-07-24-14-21 Kidney	C-07-06-14-3 Liver
Date Sampled:			15-Jul-14	24-Jul-14	6-Jul-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.1	2.0	0.6	3.9
Antimony	mg/kg	0.01	0.21	2.26	0.19
Arsenic	mg/kg	0.1	0.7	2.3	0.6
Barium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Beryllium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Bismuth	mg/kg	0.1	< 0.1	0.2	< 0.1
Boron	mg/kg	0.1	< 0.1	0.1	< 0.1
Cadmium	mg/kg	0.001	0.214	2.04	0.259
Calcium	mg/kg	5	755	397	311
Chromium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Cobalt	mg/kg	0.01	0.04	0.07	0.03
Copper	mg/kg	0.1	4.0	16.1	4.7
Iron	mg/kg	2	58	151	105
Lead	mg/kg	0.01	3.63	26.9	6.47
Lithium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Magnesium	mg/kg	1	190	348	203
Manganese	mg/kg	0.1	1.0	3.8	1.9
Mercury	mg/kg	0.01	0.02	0.08	0.08
Molybdenum	mg/kg	0.01	0.16	1.03	0.10
Nickel	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Potassium	mg/kg	2	2800	5480	2310
Rubidium	mg/kg	0.01	1.11	3.15	0.88
Selenium	mg/kg	0.1	1.8	3.2	0.6
Silver	mg/kg	0.01	0.03	0.07	0.09
Sodium	mg/kg	5	1460	2220	1460
Strontium	mg/kg	0.1	1.1	0.4	0.4
Tellurium	mg/kg	0.01	0.44	0.46	0.06
Thallium	mg/kg	0.01	0.27	0.71	0.25
Tin	mg/kg	0.01	< 0.01	0.03	0.02
Uranium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Vanadium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Zinc	mg/kg	0.2	22.1	38.7	22.8

Report ID: 180119-IAS
Report Date: 19-Dec-14
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Attention: Christine Moore

Project #: Not Available

Analysis of Samples

RPC Sample ID:			180119-26	180119-27	180119-28
Client Sample ID:			C-07-06-14-5 Liver	C-07-07-14-6 Liver	C-07-07-14-7 Liver
Date Sampled:			6-Jul-14	7-Jul-14	7-Jul-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.1	2.5	7.5	6.7
Antimony	mg/kg	0.01	0.11	0.59	0.87
Arsenic	mg/kg	0.1	0.5	1.3	2.2
Barium	mg/kg	0.1	< 0.1	0.2	< 0.1
Beryllium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Bismuth	mg/kg	0.1	< 0.1	< 0.1	0.1
Boron	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Cadmium	mg/kg	0.001	0.661	0.263	1.64
Calcium	mg/kg	5	257	545	476
Chromium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Cobalt	mg/kg	0.01	0.01	0.04	0.06
Copper	mg/kg	0.1	4.5	5.4	22.3
Iron	mg/kg	2	53	67	107
Lead	mg/kg	0.01	2.16	11.9	20.4
Lithium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Magnesium	mg/kg	1	177	146	163
Manganese	mg/kg	0.1	1.0	1.8	1.8
Mercury	mg/kg	0.01	0.10	0.13	0.12
Molybdenum	mg/kg	0.01	0.06	0.11	0.18
Nickel	mg/kg	0.1	< 0.1	0.1	< 0.1
Potassium	mg/kg	2	1770	2310	2570
Rubidium	mg/kg	0.01	0.60	0.90	0.84
Selenium	mg/kg	0.1	0.6	0.9	1.2
Silver	mg/kg	0.01	0.14	0.10	0.80
Sodium	mg/kg	5	1140	1400	1570
Strontium	mg/kg	0.1	0.6	0.3	0.3
Tellurium	mg/kg	0.01	0.11	0.08	0.40
Thallium	mg/kg	0.01	0.28	0.35	2.00
Tin	mg/kg	0.01	< 0.01	0.08	0.15
Uranium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Vanadium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Zinc	mg/kg	0.2	21.0	27.6	42.8

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Project #: Not Available

Analysis of Samples

RPC Sample ID:			180119-29	180119-29 Dup	180119-30
Client Sample ID:			C-07-07-14-8 Liver	Lab Duplicate	C-07-07-14-9 Liver
Date Sampled:			7-Jul-14	7-Jul-14	7-Jul-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.1	1.5	1.5	20.6
Antimony	mg/kg	0.01	0.06	0.05	0.88
Arsenic	mg/kg	0.1	0.6	0.5	2.0
Barium	mg/kg	0.1	< 0.1	< 0.1	0.2
Beryllium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Bismuth	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Boron	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Cadmium	mg/kg	0.001	0.219	0.226	0.461
Calcium	mg/kg	5	290	385	558
Chromium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Cobalt	mg/kg	0.01	0.04	0.04	0.06
Copper	mg/kg	0.1	8.8	7.8	5.2
Iron	mg/kg	2	100	97	85
Lead	mg/kg	0.01	2.78	2.43	19.4
Lithium	mg/kg	0.01	< 0.01	< 0.01	0.02
Magnesium	mg/kg	1	127	162	140
Manganese	mg/kg	0.1	1.5	1.5	1.5
Mercury	mg/kg	0.01	0.11	0.10	0.09
Molybdenum	mg/kg	0.01	0.13	0.13	0.09
Nickel	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Potassium	mg/kg	2	2660	2660	2310
Rubidium	mg/kg	0.01	0.93	0.92	0.89
Selenium	mg/kg	0.1	0.8	0.8	1.0
Silver	mg/kg	0.01	0.27	0.23	0.27
Sodium	mg/kg	5	1550	1530	1460
Strontium	mg/kg	0.1	0.2	0.2	0.4
Tellurium	mg/kg	0.01	0.08	0.07	0.16
Thallium	mg/kg	0.01	0.28	0.30	0.45
Tin	mg/kg	0.01	0.02	0.02	0.10
Uranium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Vanadium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Zinc	mg/kg	0.2	24.0	25.4	26.5

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Project #: Not Available

Analysis of Samples

RPC Sample ID:			180119-31	180119-31 Dup	180119-32
Client Sample ID:			C-07-11-14-11 Liver	Lab Duplicate	C-07-11-14-12 Liver
Date Sampled:			11-Jul-14	11-Jul-14	11-Jul-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.1	0.5	< 0.1	0.3
Antimony	mg/kg	0.01	0.04	0.03	0.08
Arsenic	mg/kg	0.1	0.4	0.4	0.5
Barium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Beryllium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Bismuth	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Boron	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Cadmium	mg/kg	0.001	0.185	0.147	0.190
Calcium	mg/kg	5	170	159	702
Chromium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Cobalt	mg/kg	0.01	0.02	0.02	0.02
Copper	mg/kg	0.1	5.8	5.1	6.2
Iron	mg/kg	2	127	126	50
Lead	mg/kg	0.01	0.94	0.78	2.20
Lithium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Magnesium	mg/kg	1	246	241	105
Manganese	mg/kg	0.1	2.2	2.2	0.9
Mercury	mg/kg	0.01	0.02	0.02	0.08
Molybdenum	mg/kg	0.01	0.21	0.21	0.13
Nickel	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Potassium	mg/kg	2	2650	2610	3250
Rubidium	mg/kg	0.01	1.01	1.00	1.18
Selenium	mg/kg	0.1	1.1	0.9	0.8
Silver	mg/kg	0.01	0.19	0.13	0.18
Sodium	mg/kg	5	1360	1370	1910
Strontium	mg/kg	0.1	0.4	0.4	1.7
Tellurium	mg/kg	0.01	0.26	0.23	0.13
Thallium	mg/kg	0.01	0.06	0.05	0.10
Tin	mg/kg	0.01	< 0.01	< 0.01	0.01
Uranium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Vanadium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Zinc	mg/kg	0.2	20.6	18.1	21.8

Report ID: 180119-IAS
Report Date: 19-Dec-14
Date Received: 04-Nov-14

CERTIFICATE OF ANALYSIS

for
Intrinsik Environmental
Sciences Inc
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Halifax, NS B3J 1K1

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Fax: 506.452.0594
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Attention: Christine Moore

Project #: Not Available

Analysis of Samples

RPC Sample ID:			180119-33	180119-34	180119-35
Client Sample ID:			C-07-11-14-14 Liver	C-07-15-14-16 Liver	C-07-17-14-17 Liver
Date Sampled:			11-Jul-14	15-Jul-14	17-Jul-14
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.1	0.2	< 0.1	< 0.1
Antimony	mg/kg	0.01	0.21	0.12	0.16
Arsenic	mg/kg	0.1	0.8	0.5	0.6
Barium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Beryllium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Bismuth	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Boron	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Cadmium	mg/kg	0.001	0.096	0.243	0.083
Calcium	mg/kg	5	380	447	513
Chromium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Cobalt	mg/kg	0.01	0.03	0.02	0.03
Copper	mg/kg	0.1	18.4	4.5	4.6
Iron	mg/kg	2	116	97	117
Lead	mg/kg	0.01	1.23	1.19	0.77
Lithium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Magnesium	mg/kg	1	161	195	167
Manganese	mg/kg	0.1	2.5	1.4	1.4
Mercury	mg/kg	0.01	0.03	0.03	0.02
Molybdenum	mg/kg	0.01	0.36	0.24	0.25
Nickel	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Potassium	mg/kg	2	3100	2790	2680
Rubidium	mg/kg	0.01	1.35	1.06	1.06
Selenium	mg/kg	0.1	1.3	1.2	1.0
Silver	mg/kg	0.01	0.79	0.07	0.02
Sodium	mg/kg	5	1340	1350	1380
Strontium	mg/kg	0.1	0.2	0.4	0.8
Tellurium	mg/kg	0.01	0.31	0.14	0.23
Thallium	mg/kg	0.01	0.07	0.04	0.09
Tin	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Uranium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Vanadium	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Zinc	mg/kg	0.2	24.5	25.5	18.4

Report ID: 180119-IAS
Report Date: 19-Dec-14
Date Received: 04-Nov-14

CERTIFICATE OF ANALYSIS

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Attention: Christine Moore

Project #: Not Available

Analysis of Samples

RPC Sample ID:			180119-36	180119-37
Client Sample ID:			C-07-24-14-21 Liver	C-07-29-14-22 Liver
Date Sampled:			24-Jul-14	29-Jul-14
Analytes	**Units**	**RL**		
Aluminum	mg/kg	0.1	0.2	0.5
Antimony	mg/kg	0.01	0.37	1.69
Arsenic	mg/kg	0.1	0.6	3.5
Barium	mg/kg	0.1	< 0.1	< 0.1
Beryllium	mg/kg	0.01	< 0.01	< 0.01
Bismuth	mg/kg	0.1	< 0.1	< 0.1
Boron	mg/kg	0.1	< 0.1	< 0.1
Cadmium	mg/kg	0.001	0.520	1.81
Calcium	mg/kg	5	127	254
Chromium	mg/kg	0.1	< 0.1	< 0.1
Cobalt	mg/kg	0.01	0.05	0.05
Copper	mg/kg	0.1	6.8	22.7
Iron	mg/kg	2	188	647
Lead	mg/kg	0.01	5.31	22.5
Lithium	mg/kg	0.01	< 0.01	< 0.01
Magnesium	mg/kg	1	264	234
Manganese	mg/kg	0.1	7.0	4.7
Mercury	mg/kg	0.01	0.06	0.08
Molybdenum	mg/kg	0.01	0.61	0.56
Nickel	mg/kg	0.1	< 0.1	< 0.1
Potassium	mg/kg	2	3280	3060
Rubidium	mg/kg	0.01	1.88	1.81
Selenium	mg/kg	0.1	1.2	1.8
Silver	mg/kg	0.01	0.04	0.12
Sodium	mg/kg	5	1120	1610
Strontium	mg/kg	0.1	0.2	0.1
Tellurium	mg/kg	0.01	0.19	0.46
Thallium	mg/kg	0.01	0.15	1.28
Tin	mg/kg	0.01	< 0.01	0.03
Uranium	mg/kg	0.01	< 0.01	< 0.01
Vanadium	mg/kg	0.1	< 0.1	< 0.1
Zinc	mg/kg	0.2	50.0	98.4

General Report Comments

180119-1 to 180119-18 (Egg Samples)
The samples were homogenized and portions were prepared by Microwave Assisted Digestion in nitric acid (SOP 4.M26).
The resulting solutions were analyzed for trace elements by ICP-MS (SOP 4.M01).
Mercury was analysed by Cold Vapour AAS (SOP 4.M52 & SOP 4.M53).

180119-19 to 180119-37 (Chick Samples)
The specimens were dissected to remove the liver and kidneys which became discrete analytical samples.
The analytical samples were homogenized and portions were prepared by Microwave Assisted Digestion in nitric acid (SOP 4.M26).
The resulting solutions were analyzed for trace elements by ICP-MS (SOP 4.M01).
Mercury was analysed by Cold Vapour AAS (SOP 4.M52 & SOP 4.M53).

Note: Some of the Chick samples were unsuitable for analysis.

CERTIFICATE OF ANALYSIS

for
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Project #: Not Available

QA/QC Report

RPC Sample ID:			CRM036053	CRM036054	CRM036114
Type:			CRM DOLT-4	CRM DOLT-4	CRM DOLT-4
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.1	76.1	64.7	86.1
Antimony	mg/kg	0.01	0.02	< 0.01	0.01
Arsenic	mg/kg	0.1	8.9	8.9	9.2
Barium	mg/kg	0.1	0.3	0.2	0.5
Beryllium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Bismuth	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Boron	mg/kg	0.1	0.7	0.6	0.5
Cadmium	mg/kg	0.001	23.7	24.0	24.4
Calcium	mg/kg	5	658	639	642
Chromium	mg/kg	0.1	1.3	1.3	1.7
Cobalt	mg/kg	0.01	0.23	0.22	0.24
Copper	mg/kg	0.1	31.5	31.4	32.1
Iron	mg/kg	2	1790	1770	1830
Lead	mg/kg	0.01	0.19	0.14	0.13
Lithium	mg/kg	0.01	0.09	0.08	0.09
Magnesium	mg/kg	1	1430	1400	1410
Manganese	mg/kg	0.1	10.0	9.8	10.0
Mercury	mg/kg	0.01	2.56	2.46	2.62
Molybdenum	mg/kg	0.01	1.16	1.15	1.14
Nickel	mg/kg	0.1	0.9	0.9	1.1
Potassium	mg/kg	2	9720	9650	9620
Rubidium	mg/kg	0.01	3.38	3.39	3.37
Selenium	mg/kg	0.1	8.0	8.1	8.4
Silver	mg/kg	0.01	0.76	0.81	0.80
Sodium	mg/kg	5	6960	6990	6950
Strontium	mg/kg	0.1	5.5	5.4	5.5
Tellurium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Thallium	mg/kg	0.01	0.02	0.02	0.02
Tin	mg/kg	0.01	0.18	0.17	0.18
Uranium	mg/kg	0.01	0.06	0.06	0.06
Vanadium	mg/kg	0.1	0.6	0.5	0.6
Zinc	mg/kg	0.2	114.	114.	113.

CERTIFICATE OF ANALYSIS

for
Intrinsik Environmental
Sciences Inc
5121 Sackville Street, Suite 506
Halifax, NS B3J 1K1

Project #: Not Available

QA/QC Report

RPC Sample ID:			CRM036115	RB022527	RB022528
Type:			CRM DOLT-4	Blank	Blank
Analytes	**Units**	**RL**			
Aluminum	mg/kg	0.1	96.7	< 0.1	< 0.1
Antimony	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Arsenic	mg/kg	0.1	8.9	< 0.1	< 0.1
Barium	mg/kg	0.1	0.3	< 0.1	< 0.1
Beryllium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Bismuth	mg/kg	0.1	< 0.1	< 0.1	< 0.1
Boron	mg/kg	0.1	0.4	< 0.1	< 0.1
Cadmium	mg/kg	0.001	24.4	< 0.001	< 0.001
Calcium	mg/kg	5	655	< 5	< 5
Chromium	mg/kg	0.1	1.4	< 0.1	< 0.1
Cobalt	mg/kg	0.01	0.24	< 0.01	< 0.01
Copper	mg/kg	0.1	32.3	< 0.1	< 0.1
Iron	mg/kg	2	1820	< 2	< 2
Lead	mg/kg	0.01	0.13	< 0.01	< 0.01
Lithium	mg/kg	0.01	0.10	< 0.01	< 0.01
Magnesium	mg/kg	1	1430	< 1	< 1
Manganese	mg/kg	0.1	10.4	< 0.1	< 0.1
Mercury	mg/kg	0.01	2.59	< 0.01	< 0.01
Molybdenum	mg/kg	0.01	1.15	< 0.01	< 0.01
Nickel	mg/kg	0.1	1.1	< 0.1	< 0.1
Potassium	mg/kg	2	9480	< 2	< 2
Rubidium	mg/kg	0.01	3.33	< 0.01	< 0.01
Selenium	mg/kg	0.1	8.0	< 0.1	< 0.1
Silver	mg/kg	0.01	0.84	< 0.01	< 0.01
Sodium	mg/kg	5	6910	< 5	< 5
Strontium	mg/kg	0.1	5.5	< 0.1	< 0.1
Tellurium	mg/kg	0.01	< 0.01	< 0.01	< 0.01
Thallium	mg/kg	0.01	0.02	< 0.01	< 0.01
Tin	mg/kg	0.01	0.19	< 0.01	< 0.01
Uranium	mg/kg	0.01	0.06	< 0.01	< 0.01
Vanadium	mg/kg	0.1	0.7	< 0.1	< 0.1
Zinc	mg/kg	0.2	113.	0.2	< 0.2

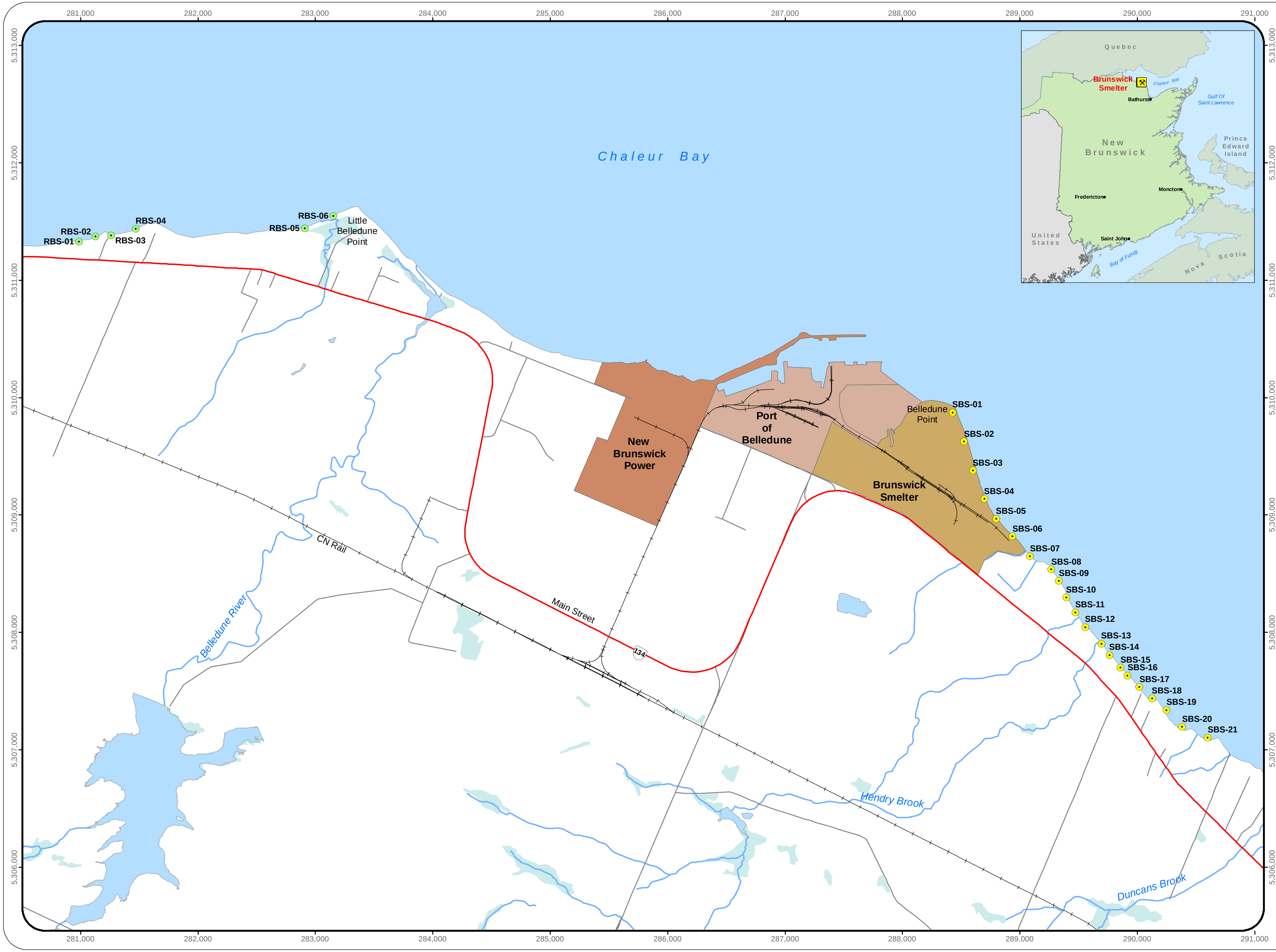
Project #: Not Available

QA/QC Report

RPC Sample ID:			RB022566	RB022567
Type:			Blank	Blank
Analytes	**Units**	**RL**		
Aluminum	mg/kg	0.1	< 0.1	< 0.1
Antimony	mg/kg	0.01	< 0.01	< 0.01
Arsenic	mg/kg	0.1	< 0.1	< 0.1
Barium	mg/kg	0.1	< 0.1	< 0.1
Beryllium	mg/kg	0.01	< 0.01	< 0.01
Bismuth	mg/kg	0.1	< 0.1	< 0.1
Boron	mg/kg	0.1	< 0.1	< 0.1
Cadmium	mg/kg	0.001	< 0.001	< 0.001
Calcium	mg/kg	5	< 5	< 5
Chromium	mg/kg	0.1	< 0.1	< 0.1
Cobalt	mg/kg	0.01	< 0.01	< 0.01
Copper	mg/kg	0.1	< 0.1	< 0.1
Iron	mg/kg	2	< 2	< 2
Lead	mg/kg	0.01	< 0.01	< 0.01
Lithium	mg/kg	0.01	< 0.01	< 0.01
Magnesium	mg/kg	1	< 1	< 1
Manganese	mg/kg	0.1	< 0.1	< 0.1
Mercury	mg/kg	0.01	< 0.01	< 0.01
Molybdenum	mg/kg	0.01	< 0.01	< 0.01
Nickel	mg/kg	0.1	< 0.1	< 0.1
Potassium	mg/kg	2	< 2	< 2
Rubidium	mg/kg	0.01	< 0.01	< 0.01
Selenium	mg/kg	0.1	< 0.1	< 0.1
Silver	mg/kg	0.01	< 0.01	< 0.01
Sodium	mg/kg	5	< 5	< 5
Strontium	mg/kg	0.1	< 0.1	< 0.1
Tellurium	mg/kg	0.01	< 0.01	< 0.01
Thallium	mg/kg	0.01	< 0.01	< 0.01
Tin	mg/kg	0.01	< 0.01	< 0.01
Uranium	mg/kg	0.01	< 0.01	< 0.01
Vanadium	mg/kg	0.1	< 0.1	< 0.1
Zinc	mg/kg	0.2	0.2	0.2

APPENDIX C

SAMPLING LOCATION MAPS



Features

Beach Sand Sampling Locations

- ● Reference Station
- ● Smelter - Exposed Station
- ▨ Brunswick Smelter
- ▨ New Brunswick Power
- ▨ Port of Belledune
- ▨ Waterbody
- ▨ Wetland
- — Watercourse
- — Highway
- — Road
- —+— Railway

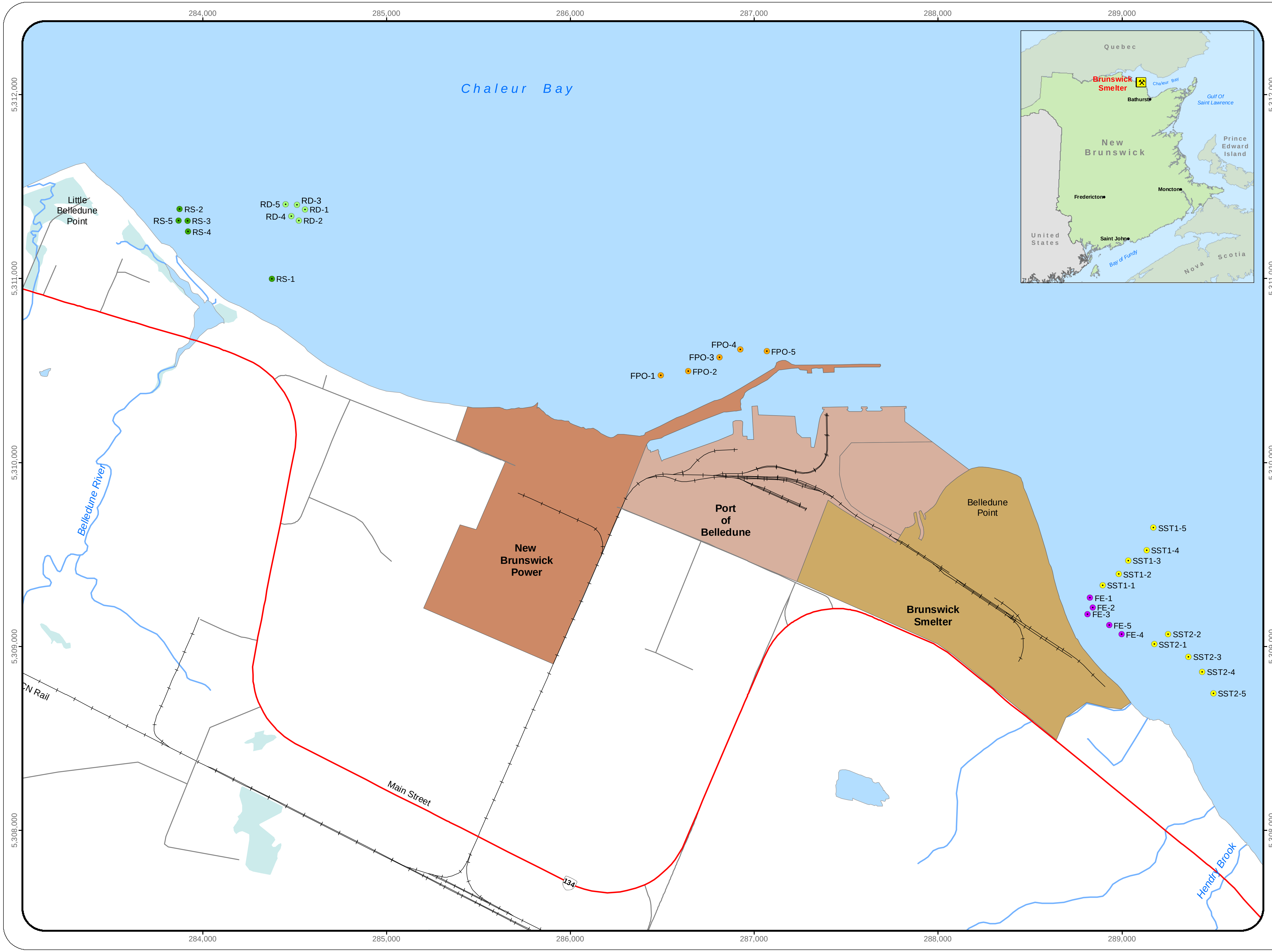
N
W E
S

790 395 0 790
Meters

MAP INFORMATION
Datum: NAD 83 Map Projection: UTM Zone 20N
Data Source:Province of New Brunswick, Service New Brunswick - GoeNB. All rights reserved.
Created By: M.LaPlame
Creation Date: January 2015
Project No.: 2539

Figure 1: Beach Sand Sampling Locations

Created by:
minnow environmental inc.



Features

Benthic and Sediment Sampling Locations

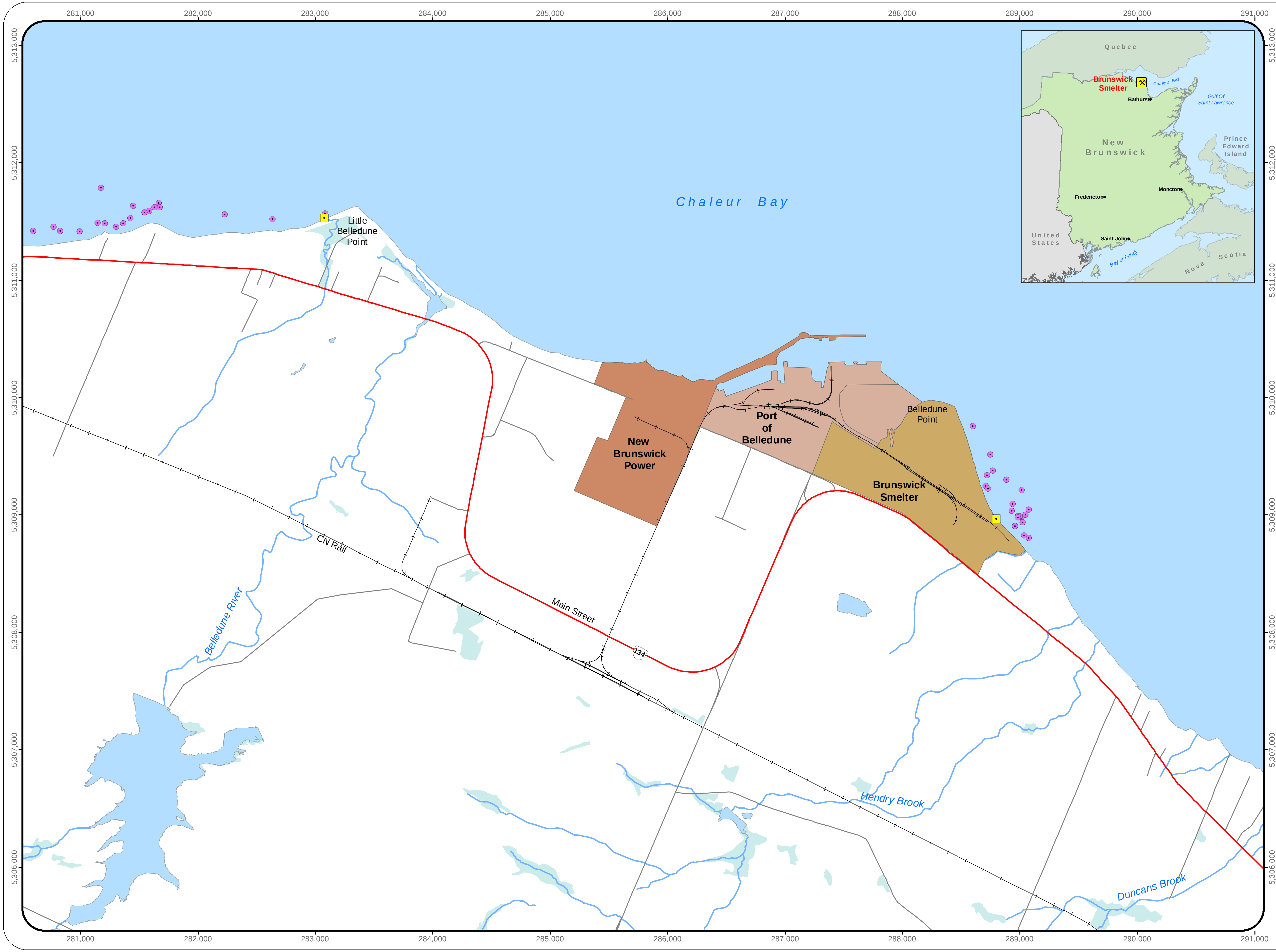
- ● Fertilizer Plant Outfall
- ● Final Effluent
- ● Reference Deep Shallow
- ● Reference Sediment
- ● Smelter Sediment Transect
- ▨ Brunswick Smelter
- ▨ New Brunswick Power
- ▨ Port of Belledune
- ▨ Waterbody
- ▨ Wetland
- — Watercourse
- — Highway
- — Road
- ┼ Railway

MAP INFORMATION
Datum: NAD 83 Map Projection: UTM Zone 20N
Data Source:Province of New Brunswick, Service New Brunswick - GoeNB. All rights reserved.
Created By: M.LaPalme
Creation Date: January 2015
Project No.: 2539

Figure 2: Benthic and Sediment Sampling Locations

Created by:

minnow environmental inc.



Features

Fish Sampling Locations

- ● Gill Net Set Location
- ▪ Siene Netting Location
- ▨ Brunswick Smelter
- ▨ New Brunswick Power
- ▨ Port of Belledune
- ▨ Waterbody
- ▨ Wetland
- — Watercourse
- — Highway
- — Road
- —+— Railway

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790 395 0 790

Meters

MAP INFORMATION
Datum: NAD 83 Map Projection: UTM Zone 20N
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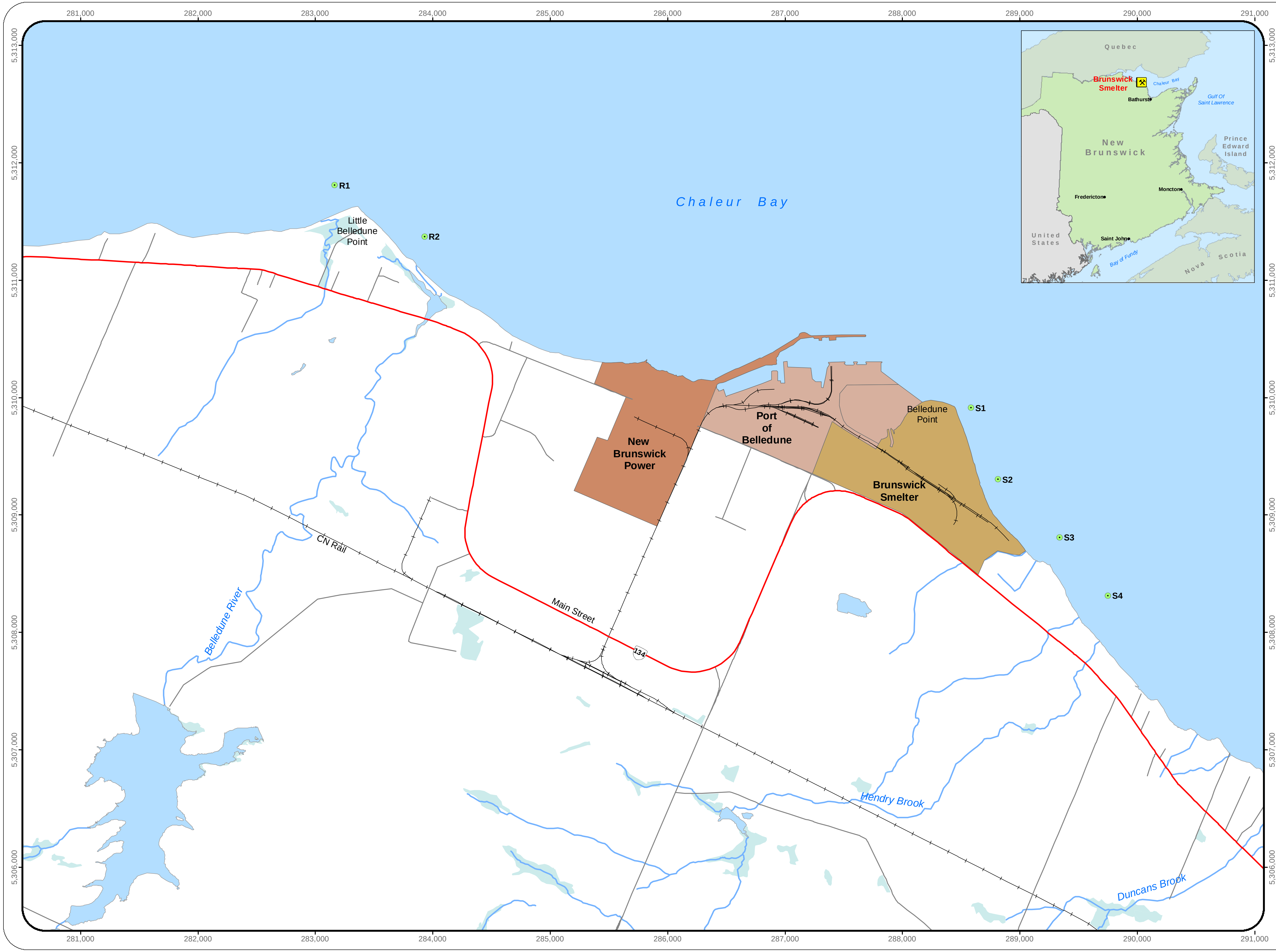
Created By: M.LaPlame
Creation Date: January 2015
Project No.: 2539

Figure 3: Gill and Siene Netting Sampling Locations

Created by:

minnow
environmental inc.



Features

●	Mussel Cage and Water Sampling Locations
▨	Brunswick Smelter
▨	New Brunswick Power
▨	Port of Belledune
▨	Waterbody
▨	Wetland
—	Watercourse
—	Highway
—	Road
┼	Railway

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Creation Date: January 2015
Project No.: 2539

Figure 4: Mussel Cage and Water Sampling Locations

Created by:
minnow environmental inc.

Figure 5 **Sampling Locations for Common Tern Egg and Chicks**

Notes:
Site A = South of lab near fence
Site B = Roof of lab
Site C = Roof of change house;
Site D = Small area north of security near fence
Site E = South side of CRP pond
Site F = South of slag settling pond
Site G = Island inside CRP pond
Site H = North parking lot
Site I = Main office

APPENDIX D
QUALITY ASSURANCE QUALITY CONTROL

D-1.0 RESULTS OF QUALITY ASSURANCE / QUALITY CONTROL (QA/QC) OF DATA

D-1.1 Maxxam Analytics Data (Marine Water)

The percent (%) recoveries provided by Maxxam Analytics for laboratory-spiked samples of marine water were reviewed. Laboratory percent recoveries met control limits (*i.e.*, 75% to 125% for metals or 80-120% for phosphorus and nitrogen) with the exception of a few samples. The laboratory indicated that 10% failure of analytes is allowed and the lab is below this limit. Laboratory duplicate data for marine water were also reviewed and results were within acceptable ranges (*i.e.,* relative percent differences (RPD) were within 25% as per laboratory QA/QC limits). For these samples, the lab indicated that the overall quality control for the analysis met the acceptability criteria. Laboratory QA/QC results provided by Maxxam Analytics are included with the data in Appendix B. Laboratory QA/QC is considered acceptable.

The RPD was also calculated for field duplicates. However, RPDs for some field duplicates were not calculated as the concentration of the samples and/or field duplicates were too low to yield a reliable calculation (*i.e.,* concentration of samples or field duplicates with less than 5 times the reporting detection limit (RDL)). In addition, RPDs were not calculated for non-detect concentrations. The RPD for marine water field duplicates were calculated (See Tables D-1 to D-4). The RPDs of field duplicates were well within the 25% limit, for all of the dissolved hardness ($CaCO_3$) samples. However, all of the total nitrogen duplicate samples collected in fall had RPDs of more than 25%. All the RPDs of field duplicates collected in summer for dissolved metals were within the 25% limit. The RPDs of field duplicates collected in fall were within 25% limit for 89% of the analytes for dissolved metals. No field duplicates were collected for reference water samples.

Given the results of the QA/QC, data are considered acceptable

D-1.2 RPC Data (Beach Sand and Sediment)

The percent (%) recoveries were not provided by RPC for laboratory-spiked samples. As such, laboratory percent recoveries for spiked-samples were not reviewed. RPDs for beach sand and sediment field duplicate samples were calculated to ensure that analyses were within acceptable ranges (*i.e.,* relative percent differences (RPD) were within 30% as per Ontario Ministry of Environment limits).

The RPD was also calculated for field duplicates. However, RPDs for some field duplicates were not calculated as the concentration of the samples and/or field duplicates were too low to yield a reliable calculation (*i.e.,* concentration of samples or field duplicates with less than 5 times the reporting detection limit (RDL)). In addition, RPDs were not calculated for non-detect concentrations. The RPD for beach sand and sediment field duplicates were calculated (See Tables D-5 to D-8). The RPDs of field duplicates were within 30% limit for 70% of analytes for the reference beach sand duplicate samples. The study area beach sand duplicate samples had greater than 90% of analytes with RPDs of more than 30%. This is due to presence of slag within some of these samples, which results in a heterogeneous sample, thereby affecting reproducibility of analytical results. The fertilizer plant out fall (FPO) area sediment duplicate samples yielded RPDs that were within 30% limit for more than 85% of the analytes. The final effluent (FE) area sediment duplicate samples yielded RPDs that were within 30% limit for all of the analytes. Some analytes were more than 25% (or 30%) higher than the original samples while others were more than 25% (or 30%) lower. The differences are likely due to the heterogeneity of the biological samples being analyzed.

Given the nature of the materials, results of the QA/QC, data are considered acceptable.

Table D-1 Relative Percent Differences (RPD) for Marine Water Sample S3-01 and D1

Analyte	S3-01 / D1 Duplicate Concentration (Summer; mg/L)	RPD[a]	S3-01 / D1 Duplicate Concentration (Fall; mg/L)	RPD[a]
Total Phosphorus	<0.02 / <0.20	NC	NA	NC
Dissolved Hardness (CaCO$_3$)	4190 / 4480	6.7	5090 / 5020	1.4
Total Nitrogen	0.174 / 0.190	8.8	0.186 / 0.135	31.8
Dissolved Aluminum	15/ 16	6.5	59 / 58	1.7
Dissolved Antimony	<0.50 / <0.50	NC	<0.50 / <0.50	NC
Dissolved Arsenic	1.50 / 1.36	NC	1.62 / 1.68	3.6
Dissolved Barium	10.1 / 10.4	2.9	6.8 / 7.2	5.7
Dissolved Beryllium	<1.0 / <1.0	NC	<1.0 / <1.0	NC
Dissolved Bismuth	<1.0 / <1.0	NC	<1.0 / <1.0	NC
Dissolved Boron	3360 / 3320	1.2	3400 / 3250	4.5
Dissolved Cadmium	0.113 / 0.115	NC	0.122 / 0.114	6.8
Dissolved Chromium	<0.50 / <0.50	NC	<0.50 / <0.50	NC
Dissolved Cobalt	<0.10 / <0.10	NC	<0.10 / <0.10	NC
Dissolved Copper	0.80 / 0.62	NC	<0.50 / <0.50	NC
Dissolved Iron	2.4 / 2.3	NC	3.4 / 15.4	127.7
Dissolved Lead	0.51 / 0.51	0.0	0.43 / 0.41	4.8
Dissolved Lithium	127 / 132	3.9	160 / 160	0.0
Dissolved Manganese	1.98 / 2.19	NC	4.20 / 3.88	7.9
Dissolved Molybdenum	8.5 / 8.9	4.6	9.5 / 10.1	6.1
Dissolved Nickel	0.50 / 0.49	NC	0.39 / 0.96	84.4
Dissolved Phosphorus	<50 / <50	NC	<50 / <50	NC
Dissolved Selenium	<0.50 / <0.50	NC	<0.50 / <0.50	NC
Dissolved Silicon	149 / 144	3.4	<100 / <100	NC
Dissolved Silver	<0.050 / <0.050	NC	<0.050 / <0.050	NC
Dissolved Strontium	5760 / 5950	3.2	6850 / 6690	2.4
Dissolved Thallium	0.30 / 0.28	NC	0.39 / 0.35	10.8
Dissolved Tin	<1.0 / <1.0	NC	<1.0 / <1.0	NC

Table D-1 Relative Percent Differences (RPD) for Marine Water Sample S3-01 and D1

Analyte	S3-01 / D1 Duplicate Concentration (Summer; mg/L)	RPD[a]	S3-01 / D1 Duplicate Concentration (Fall; mg/L)	RPD[a]
Dissolved Titanium	<10 / <10	NC	<10 / <10	NC
Dissolved Uranium	2.38 / 2.34	1.7	2.75 / 2.68	2.6
Dissolved Vanadium	<10 / <10	NC	<10 / <10	NC
Dissolved Zinc	3.1 / 3.0	NC	3.3 / 3.3	0.0
Dissolved Calcium	320 / 362	12.3	361 / 353	2.2
Dissolved Magnesium	824 / 868	5.2	1020 / 1010	1.0
Dissolved Potassium	271 / 272	0.4	337 / 334	0.9
Dissolved Sodium	6840 / 7340	7.1	8640 / 8680	0.5
Dissolved Sulphur	699 / 650	7.3	858 / 859	0.1

Note:
NC = not calculated as all data were not detected or less than 5x the RDL
[a] Acceptable range is 0 – 25%

Table D-2 Relative Percent Differences (RPD) for Marine Water Sample S1-02 and D2

Analyte	S1-02 / D2 Duplicate Concentration (Summer; mg/L)	RPD[a]	S1-02 / D2 Duplicate Concentration (Fall; mg/L)	RPD[a]
Total Phosphorus	<0.02 / <0.02	NC	NA	NC
Dissolved Hardness ($CaCO_3$)	4380 / 4380	0.0	4870 / 4940	1.4
Total Nitrogen	0.285 / 0.203	33.6	0.139 / 0.223	46.4
Dissolved Aluminum	14 / 15	6.9	56 / 50	11.3
Dissolved Antimony	<0.50 / <0.50	NC	<0.50 / <0.50	NC
Dissolved Arsenic	2.27 / 1.88	NC	1.42 / 1.78	22.5
Dissolved Barium	11.2 / 11.3	0.9	6.4 / 8.0	22.2
Dissolved Beryllium	<1.0 / <1.0	NC	<1.0 / <1.0	NC
Dissolved Bismuth	<1.0 / <1.0	NC	<1.0 / <1.0	NC
Dissolved Boron	3260 / 3190	2.2	3480 / 3270	6.2
Dissolved Cadmium	0.989 / 0.974	NC	0.159 / 0.245	42.6
Dissolved Chromium	<0.50 / <0.50	NC	<0.50 / <0.50	NC
Dissolved Cobalt	<0.10 / <0.10	NC	<0.10 / <0.10	NC
Dissolved Copper	0.62 / 0.72	NC	<0.50 / <0.50	NC
Dissolved Iron	<2.0 / 2.4	NC	2.7 / 3.3	20.0
Dissolved Lead	1.52 / 1.60	5.1	0.57 / 1.10	63.5
Dissolved Lithium	127 / 132	3.9	158 / 155	1.9
Dissolved Manganese	5.73 /6.00	4.6	2.65 / 3.08	15.0
Dissolved Molybdenum	8.4 / 9.1	8.0	9.9 / 9.2	7.3
Dissolved Nickel	0.42 / 0.46	NC	0.39 / 0.41	5.0
Dissolved Phosphorus	<50 / <50	NC	<50 / <50	NC
Dissolved Selenium	<0.50 / <0.50	NC	<0.50 /<0.50	NC
Dissolved Silicon	201 / 187	7.2	105 / 111	5.6
Dissolved Silver	<0.050 / <0.050	NC	<0.050 / <0.050	NC

Table D-2 Relative Percent Differences (RPD) for Marine Water Sample S1-02 and D2

Analyte	S1-02 / D2 Duplicate Concentration (Summer; mg/L)	RPD[a]	S1-02 / D2 Duplicate Concentration (Fall; mg/L)	RPD[a]
Dissolved Strontium	5790 / 6010	3.7	6770 /6710	0.9
Dissolved Thallium	3.30 / 3.07	7.2	0.75 / 3.30	125.9
Dissolved Tin	<1.0 / <1.0	NC	<1.0 / <1.0	NC
Dissolved Titanium	<10 / <10	NC	<10 / <10	NC
Dissolved Uranium	2.39 / 2.47	3.3	2.68 / 2.73	1.8
Dissolved Vanadium	<10 / <10	NC	<10 / <10	NC
Dissolved Zinc	8.4 / 7.4	12.7	3.7 / 5.6	40.9
Dissolved Calcium	327 / 319	2.5	355 / 359	1.1
Dissolved Magnesium	866 / 870	0.5	967 / 981	1.4
Dissolved Potassium	282 / 288	2.1	324 / 335	3.3
Dissolved Sodium	7000 / 7150	2.1	8090 / 8320	2.8
Dissolved Sulphur	742 / 713	4.0	819 / 873	6.4

Note:
NC = not calculated as all data were not detected or less than 5x the RDL
[a] Acceptable range is 0 – 25%

Table D-3 Relative Percent Differences (RPD) for Marine Water Sample R2-01 and D3

Analyte	R2-01 / D3 Duplicate Concentration (Summer; mg/L)	RPD[a]	R2-01 / D3 Duplicate Concentration (Fall; mg/L)	RPD[a]
Total Phosphorus	<0.20 / <0.02	NC	NA	NC
Dissolved Hardness (CaCO$_3$)	4500 / 4520	0.4	NA	NC
Total Nitrogen	0.282 / 0.228	21.2	NA	NC
Dissolved Aluminum	<10 / 10	NC	NA	NC
Dissolved Antimony	<0.5 / <0.5	NC	NA	NC
Dissolved Arsenic	1.25 / 1.23	1.6	NA	NC
Dissolved Barium	11.1 / 10.8	2.7	NA	NC
Dissolved Beryllium	<1 / <1	NC	NA	NC
Dissolved Bismuth	<1 / <1	NC	NA	NC
Dissolved Boron	3190 / 3160	0.9	NA	NC
Dissolved Cadmium	0.058 / 0.052	NC	NA	NC
Dissolved Chromium	<0.5 / <0.5	NC	NA	NC
Dissolved Cobalt	< 0.1 / <0.1	NC	NA	NC
Dissolved Copper	0.93/ 0.62	NC	NA	NC
Dissolved Iron	<2 / <2	NC	NA	NC
Dissolved Lead	<0.1 / 0.15	NC	NA	NC
Dissolved Lithium	120 /124	3.3	NA	NC
Dissolved Manganese	<0.5 / <0.5	NC	NA	NC
Dissolved Molybdenum	9.7 / 8.8	9.7	NA	NC
Dissolved Nickel	0.53 / 0.44	NC	NA	NC
Dissolved Phosphorus	<50 / <50	NC	NA	NC

Table D-3 Relative Percent Differences (RPD) for Marine Water Sample R2-01 and D3

Analyte	R2-01 / D3 Duplicate Concentration (Summer; mg/L)	RPD[a]	R2-01 / D3 Duplicate Concentration (Fall; mg/L)	RPD[a]
Dissolved Selenium	<0.5 / <0.5	NC	NA	NC
Dissolved Silicon	199 / 183	8.4	NA	NC
Dissolved Silver	<0.05 / <0.05	NC	NA	NC
Dissolved Strontium	6370 / 6360	0.2	NA	NC
Dissolved Thallium	<0.1 / <0.1	NC	NA	NC
Dissolved Tin	<1 / <1	NC	NA	NC
Dissolved Titanium	<10 / <10	NC	NA	NC
Dissolved Uranium	2.29 / 2.27	0.9	NA	NC
Dissolved Vanadium	<10 <10	NC	NA	NC
Dissolved Zinc	<1 / <1	NC	NA	NC
Dissolved Calcium	322 / 321	0.3	NA	NC
Dissolved Magnesium	897 / 903	0.7	NA	NC
Dissolved Potassium	297 / 294	1.0	NA	NC
Dissolved Sodium	7100 / 7340	3.3	NA	NC
Dissolved Sulphur	742 / 744	0.3	NA	NC

Note:
NA = not analyzed; NC = not calculated as all data were not detected or less than 5x the RDL
[a] Acceptable range is 0 – 25%

Table D-4 Relative Percent Differences (RPD) for Marine Water Sample R1-02/R1-01 and D4

Analyte	R1-02 / D4 Duplicate Concentration (Summer; mg/L)	RPD[a]	R1-01 / D4 Duplicate Concentration (Fall; mg/L)	RPD[a]
Total Phosphorus	<0.20 / <0.02	NC	NA	NC
Dissolved Hardness ($CaCO_3$)	4350 / 4460	2.5	NA	NC
Total Nitrogen	0.221 / 0.202	9.0	NA	NC
Dissolved Aluminum	<10 / <10	NC	NA	NC
Dissolved Antimony	<0.50 / <0.50	NC	NA	NC
Dissolved Arsenic	1.28 / 1.30	NC	NA	NC
Dissolved Barium	11.6 / 10.2	12.8	NA	NC
Dissolved Beryllium	<1.0 / <1.0	NC	NA	NC
Dissolved Bismuth	<1.0 / <1.0	NC	NA	NC
Dissolved Boron	3200 / 3210	0.3	NA	NC
Dissolved Cadmium	0.061 / 0.061	NC	NA	NC
Dissolved Chromium	<0.50 / <0.50	NC	NA	NC
Dissolved Cobalt	<0.10 / <0.10	NC	NA	NC
Dissolved Copper	0.96 / <0.50	NC	NA	NC
Dissolved Iron	<2.0 / <2.0	NC	NA	NC
Dissolved Lead	<0.10 / <0.10	NC	NA	NC
Dissolved Lithium	122 / 122	0.0	NA	NC
Dissolved Manganese	<0.50 / <0.50	NC	NA	NC
Dissolved Molybdenum	9.6 / 9.2	4.3	NA	NC
Dissolved Nickel	<0.20 / 0.44	75.0	NA	NC
Dissolved Phosphorus	<50 / <50	NC	NA	NC

Table D-4 Relative Percent Differences (RPD) for Marine Water Sample R1-02/R1-01 and D4

Analyte	R1-02 / D4 Duplicate Concentration (Summer; mg/L)	RPD[a]	R1-01 / D4 Duplicate Concentration (Fall; mg/L)	RPD[a]
Dissolved Selenium	<0.50 / <0.50	NC	NA	NC
Dissolved Silicon	198 / 198	0.0	NA	NC
Dissolved Silver	<0.050 / <0.050	NC	NA	NC
Dissolved Strontium	6250 / 6260	0.2	NA	NC
Dissolved Thallium	<0.10 / <0.10	NC	NA	NC
Dissolved Tin	<1.0 / <1.0	NC	NA	NC
Dissolved Titanium	<10 / <10	NC	NA	NC
Dissolved Uranium	2.17 / 2.26	4.1	NA	NC
Dissolved Vanadium	<10 / <10	NC	NA	NC
Dissolved Zinc	<1.0 / <1.0	NC	NA	NC
Dissolved Calcium	325 / 331	1.8	NA	NC
Dissolved Magnesium	861 / 882	2.4	NA	NC
Dissolved Potassium	290 / 289	0.3	NA	NC
Dissolved Sodium	7170 / 7230	0.8	NA	NC
Dissolved Sulphur	737 / 754	2.3	NA	NC

Note:

NA = not analyzed; NC = not calculated as all data were not detected or less than 5x the RDL

[a] Acceptable range is 0 – 25%

Table D-5 Relative Percent Differences (RPD) for Reference Beach Sand Sample RBS-1 and DUP-1

Analyte	RBS-1 Concentration (mg/kg)	DUP-1 Duplicate Sample Concentration (mg/kg)	RPD[a]
Aluminum	5750	6670	14.8
Antimony	<0.1	0.2	NC
Arsenic	3	2	NC
Barium	17	8	72.0
Beryllium	0.4	0.4	NC
Bismuth	<1	<1	NC
Boron	3	4	NC
Cadmium	0.06	0.04	40.0
Calcium	29700	16500	57.1
Chromium	11	11	0.0
Cobalt	5.2	5.3	1.9
Copper	6	5	18.2
Iron	9410	10800	13.8
Lead	5.1	5	2.0
Lithium	9.4	11	15.7
Magnesium	3460	4270	21.0
Manganese	279	205	30.6
Mercury	<0.01	<0.01	NC
Molybdenum	0.2	0.2	NC
Nickel	13	13	0.0
Potassium	700	810	14.6
Rubidium	4	4.2	4.9
Selenium	<1	<1	NC
Silver	<0.1	<0.1	NC
Sodium	1350	1780	27.5
Strontium	29	18	46.8
Tellurium	<0.1	<0.1	NC
Thallium	<0.1	<0.1	NC
Tin	<1	<1	NC
Uranium	0.3	0.3	NC
Vanadium	20	16	22.2
Zinc	21	23	9.1

Note:

NC = not calculated as all data were not detected or less than 5x the RDL

[a] Acceptable range is 0 – 30%

Table D-6 Relative Percent Differences (RPD) for Study Area Beach Sand Sample SBS-5 and DUP-2

Analyte	SBS-5 Concentration (mg/kg)	DUP-2 Duplicate Sample Concentration (mg/kg)	RPD[a]
Aluminum	15200	13600	11.1
Antimony	11.9	12.3	3.3
Arsenic	325	328	0.9
Barium	196	161	19.6
Beryllium	0.7	0.6	15.4
Bismuth	5	10	66.7
Boron	12	14	15.4
Cadmium	19.5	20.8	6.5
Calcium	35900	29800	18.6
Chromium	50	47	6.2
Cobalt	89.9	76.9	15.6
Copper	999	876	13.1
Iron	102000	89400	13.2
Lead	8730	9270	6.0
Lithium	18.8	16.9	10.6
Magnesium	10900	9330	15.5
Manganese	577	559	3.2
Mercury	0.03	0.03	NC
Molybdenum	13.7	11.4	18.3
Nickel	29	34	15.9
Potassium	1470	1460	0.7
Rubidium	7	7.7	9.5
Selenium	4	3	NC
Silver	2	1.4	35.3
Sodium	1800	1660	8.1
Strontium	61	52	15.9
Tellurium	0.4	0.4	0.0
Thallium	13.8	13.2	4.4
Tin	146	127	13.9
Uranium	1	1	0.0
Vanadium	52	47	10.1
Zinc	36700	34100	7.3

Note:

NC = not calculated as all data were not detected or less than 5x the RDL

[a] Acceptable range is 0 – 30%

Table D-7 Relative Percent Differences (RPD) for Fertilizer Plant Outfall Sample FPO-4 and BD-2

Analyte	FPO-4 Concentration (mg/kg)	BD-2 Duplicate Sample Concentration (mg/kg)	RPD[a]
Aluminum	2950	3100	5.0
Antimony	0.6	0.4	NC
Arsenic	1	1	NC
Barium	54	58	7.1
Beryllium	0.1	<0.1	NC
Bismuth	<1	<1	NC
Boron	2	2	NC
Cadmium	0.11	0.11	0.0
Calcium	158000	154000	2.6
Chromium	4	3	NC
Cobalt	0.5	0.5	0.0
Copper	5	4	NC
Iron	710	660	7.3
Lead	13.8	8.5	47.5
Lithium	0.4	0.5	NC
Magnesium	510	530	3.8
Manganese	8	8	0.0
Mercury	NA	NA	NC
Molybdenum	0.3	0.3	NC
Nickel	2	2	NC
Potassium	350	370	5.6
Rubidium	0.9	1	10.5
Selenium	<1	<1	NC
Silver	< 0.1	< 0.1	NC
Sodium	4040	4140	2.4
Strontium	504	501	0.6
Tellurium	<0.1	<0.1	NC
Thallium	0.2	0.2	NC
Tin	<1	<1	NC
Uranium	21.3	23.1	8.1
Vanadium	2	1	NC
Zinc	30	9	107.7

Note:

NA = not analyzed; NC = not calculated as all data were not detected or less than 5x the RDL

[a] Acceptable range is 0 – 30%

Table D-8 Relative Percent Differences (RPD) for Final Effluent Sample FE-4 and BD-1

Analyte	FE-4 Concentration (mg/kg)	BD-1 Duplicate Sample Concentration (mg/kg)	RPD[a]
Aluminum	10200	10000	2.0
Antimony	0.6	0.6	0.0
Arsenic	24	22	8.7
Barium	42	56	28.6
Beryllium	0.3	0.4	NC
Bismuth	2	<1	NC
Boron	7	6	15.4
Cadmium	2.64	2.62	0.8
Calcium	10600	11100	4.6
Chromium	34	34	0.0
Cobalt	11.8	11.5	2.6
Copper	56	55	1.8
Iron	18100	18000	0.6
Lead	594	575	3.3
Lithium	14.2	14.3	0.7
Magnesium	8670	8620	0.6
Manganese	239	237	0.8
Mercury	NA	NA	NC
Molybdenum	0.3	0.3	NC
Nickel	29	28	3.5
Potassium	960	950	1.0
Rubidium	5.2	5.1	1.9
Selenium	<1	<1	NC
Silver	0.2	0.2	NC
Sodium	1850	2040	9.8
Strontium	18	20	10.5
Tellurium	<0.1	<0.1	NC
Thallium	3.1	3.1	0.0
Tin	3	3	NC
Uranium	0.4	0.4	NC
Vanadium	35	34	2.9
Zinc	1250	1240	0.8

Note:

NA = not analyzed; NC = not calculated as all data were not detected or less than 5x the RDL

[a] Acceptable range is 0 – 30%

D 1.3 Certified Reference Material

Several Certified Reference Materials (CRM) were run as part of the analytical program. For tissues, DOLT-4 (dogfish liver CRM for trace metals), and DORM-4 (fish protein CRM for trace metals) were run. Table D-9 and D-10 cite certified values for selected metals, compared to experimental values noted in the laboratory recovery sheets. These recoveries were all considered to be within acceptable ranges. Lead recovery, and, to a lesser extent, zinc recovery was lower in beach sand or sediments, but the data were still considered acceptable for use in the study.

Table D-9 CRM Outcomes for DOLT-4

Element	DOLT-4				
	Certified Level	Experimental Level: Shoreline invertebrates (mean; N = 3)	Experimental Level: Chick and Egg Tissues (mean; N = 4)	Experimental Level: Fish tissue (N = 1)	% Recovery
Cadmium	24.3 +/- 0.8	24.7	24.1	24.5	99.1 -101.6
Lead	0.16 +/- 0.04	0.17	0.15	0.13	81.25 - 106
Zinc	116 +/- 0.12	107	113.5	122	92 - 105

Table D-10 CRM Outcomes for DORM-4

Element	DORM-4				
	Certified Level	Experimental Level (mean; n = 3) (shoreline invertebrates)	Experimental Level (mean; N = 4) Chick and Egg Tissues	Experimental Level (N = 2; mean) Fish tissue	% Recovery
Cadmium	0.306 +/- 0.015	NA	NA	0.322	105
Lead	0.416 +/- 0.053	NA	NA	0.43	103
Zinc	52.2 +/- 3.2	NA	NA	52.4	100

NA = not applicable, as CRM was not run for this tissue

Table D-11 CRM Outcomes for NIST 2709a

Element	Certified Level	Experimental Level (mean; n = 6) beach sand and sediments	% Recovery
Cadmium	0.371 +/- 0.002	0.345	93
Lead	17.3 +/- 0.1	10.9	63
Zinc[a]	103 +/- 4	88.8	86

[a] Zinc certified value is a reference value, rather than a certified value.

APPENDIX E

MINNOW (2015a) BENTHIC COMMUNITY STUDY

Brunswick Smelter 2014 Benthic Monitoring Program

Report Prepared For:
Glencore Canada Corp., Brunswick Smelter
Belledune, NB

Prepared By:
Minnow Environmental Inc.
Georgetown, ON.

March 2015

Brunswick Smelter 2014
Benthic Monitoring Program

Prepared for:

Glencore Canada Corp., Brunswick Smelter

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March 2015

EXECUTIVE SUMMARY

Glencore Canada Corporation (Glencore) operates the Brunswick Smelter complex located in Belledune, New Brunswick. The complex includes a lead smelter and bulk handling facility that were commissioned in 1966. Since 1981, process wastewater from the Brunswick Smelter has been collected and treated at a waste water treatment plant (WWTP) prior to discharge into the Baie des Chaleurs just east of the Port of Belledune. Historically, the Brunswick Smelter complex also included a zinc smelting facility and a fertilizer plant that produced di-ammonium phosphate (DAP) using by-products from the smelting operations. The zinc smelter and fertilizer plant were decommissioned in 1972 and 1996, respectively. Until closure of the fertilizer plant, a gypsum-based slurry, produced as an effluent waste product from the plant, was discharged into the Baie des Chaleurs just north of a breakwater that currently bounds the Port of Belledune.

The Brunswick Smelter has been monitoring the condition of benthic invertebrate communities in the Baie des Chaleurs since 1965. This Benthic Monitoring Program (BMP) has been conducted in order to meet provincial Certificate-of-Approval requirements that, in turn, allow the discharge of treated effluent. To date, a total of 27 benthic monitoring surveys have been conducted at the Brunswick Smelter, with the current monitoring frequency set at every ten years. Although these studies have indicated elevation of some metals in sediment near the lead smelter WWTP discharge in the Baie des Chaleurs, only minor influences to benthic invertebrate community structure have been indicated at this area. Some influences to benthic invertebrate community structure have also been documented near the former Fertilizer Plant Outfall as the result of habitat alteration from the historical discharge of gypsum at this location.

This Brunswick Smelter BMP provides an evaluation of *in-situ* water quality, sediment quality, and benthic invertebrate community conditions at estuarine environments influenced by the current lead smelter effluent and the historical Fertilizer Plant gypsum deposit in 2014. As in previous studies, two areas that have not been influenced by current lead smelter and historical fertilizer plant operations were used as a basis for the evaluation of any chemical or biological smelter-related effects (Shallow- and Deep-Reference areas). The evaluation of environmental conditions also included comparisons to applicable Canadian Sediment Quality Guidelines (CSQG) and temporal evaluation to assess any changes in sediment quality and benthic invertebrate community health over time.

The *in-situ* water quality assessment indicated no effluent-related or gypsum bed-related influences on water temperature, dissolved oxygen, salinity, pH or turbidity at the lead smelter

WWTP discharge area or the historical Fertilizer Plant Outfall area, respectively, at the time of the 2014 field survey.

At the lead smelter Final Effluent discharge area in the Baie des Chaleurs, sediment metal concentrations were elevated compared to reference, with mean lead and zinc concentrations greater than CSQG Probable Effect Levels (PEL) and mean arsenic, cadmium and copper above the CSQG lower (threshold) effect levels (i.e., the Interim Sediment Quality Guidelines [ISQG]) in 2014. The benthic invertebrate community of the Final Effluent area in 2014 showed significantly lower density, diversity and evenness, as well as significant differences in Bray-Curtis Index, compared to reference. However, in some cases, the differences in benthic metrics between areas were not ecologically meaningful (based on comparison to accepted environmental monitoring Critical Effect Sizes [CES]), and no differences in the relative abundance of metal-sensitive groups were indicated between areas, suggesting that any effects associated with sediment metal concentrations at the Final Effluent area were very subtle. Nevertheless, temporal comparisons indicated higher sediment metal concentrations at the Final Effluent area in 2014 compared to the 2004 – 2008 studies, as well as significantly lower benthic invertebrate community density and differences in community structure in 2014 versus these earlier studies. Although these temporal differences in benthic invertebrate community endpoints were subtle (e.g., most benthic indices at the Final Effluent area in 2014 were within historical ranges, and no differences in abundance of metal-sensitive groups were indicated), higher sediment metal concentrations at this area over time suggested a potential causal link. Because lead smelter effluent quantity and quality have remained relatively unchanged since 2006, dredging activity at the Port of Belledune in 2010 and storm event-related erosion of a (former) lead smelter slag pile were identified as the most likely contributors to elevated metal concentrations in sediment near the current lead smelter discharge in 2014 versus the earlier studies. In turn, the higher sediment metal concentrations may have accounted for a greater number of differences in benthic invertebrate community endpoints at this area since 2008.

At the Fertilizer Plant Outfall area, sediment was characterized by high mean concentrations of calcium, strontium and uranium, and minor elevation in mean antimony, lead and zinc concentrations compared to reference, but no metals were above PEL, and only mean lead and zinc concentrations were above ISQG threshold effect levels. The benthic invertebrate community of the Fertilizer Plant Outfall area had significantly lower density and significant differences in Bray-Curtis Index compared to reference in 2014, with the data suggesting that altered physical habitat at the Fertilizer Plant Outfall (i.e., the compact gypsum bed) was the likely cause for these differences. Temporal comparisons indicated no significant change in sediment metal concentrations at the Fertilizer Plant Outfall in 2014 compared to studies conducted from 2004 – 2008. In addition, no substantial changes in benthic invertebrate community endpoints were indicated since 2008 at the Fertilizer Plant Outfall area, perhaps with the exception of a slight improvement in taxonomic richness relative to reference. This suggested slow but continued recovery in habitat conditions and the corresponding benthic invertebrate community health with time at the area affected by gypsum deposits from the former Fertilizer Plant discharge (e.g., through erosion, dissipation and/or burial of the gypsum bed).

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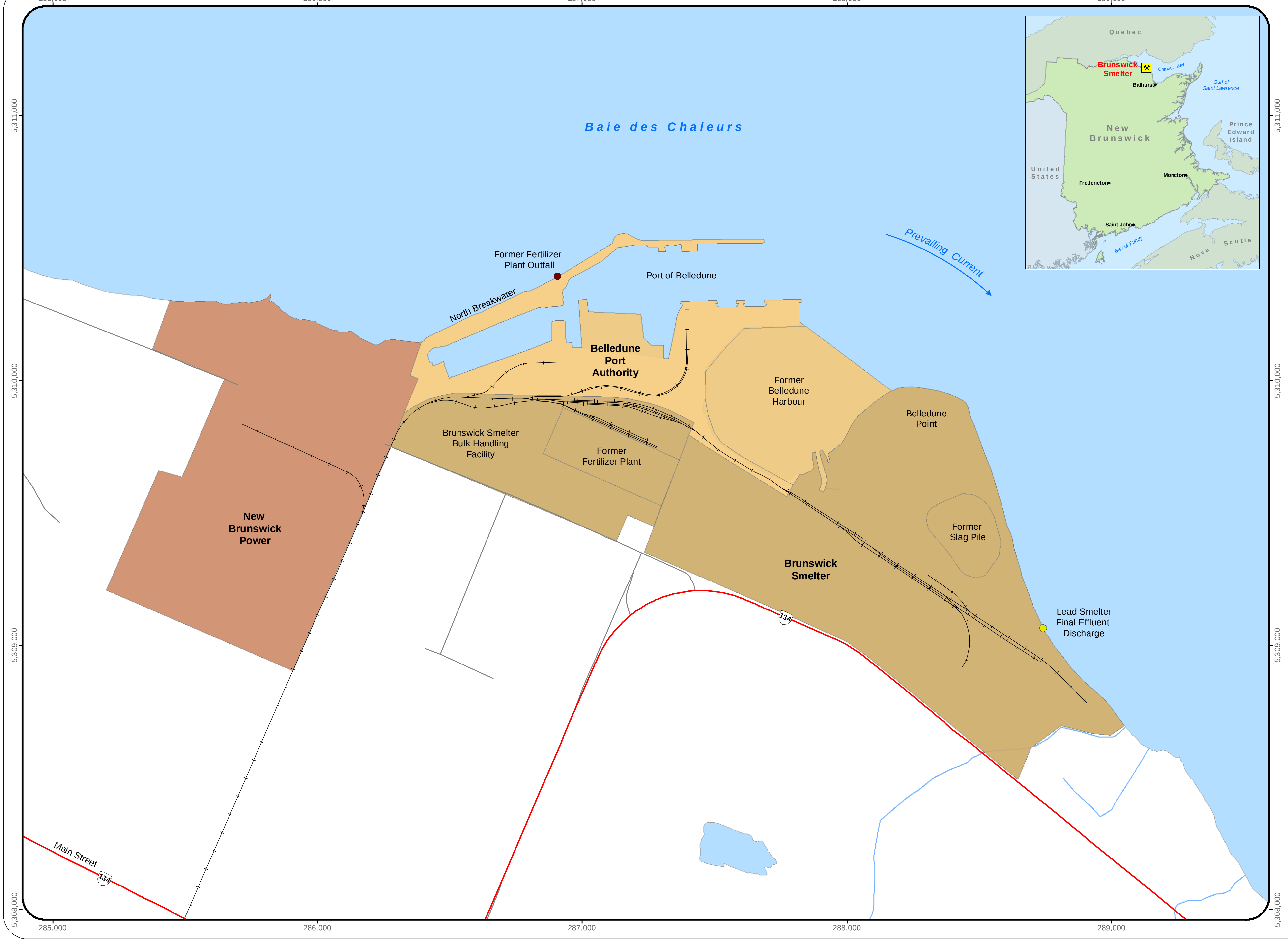
1.0 INTRODUCTION

1.1 Site Description and Study Background

Glencore Canada Corporation (Glencore) operates the Brunswick Smelter complex located in Belledune, New Brunswick. The complex includes a lead smelter and bulk handling facility, and is situated next to a deep-water port (Port of Belledune) on the south shore of the Baie des Chaleurs (Figure 1.1). The lead smelter has operated since 1966, with annual production recently (i.e., 2000 – 2010) ranging from 60,000 to 100,000 tonnes of lead per year (NB DOE 2011). Since 1981, process wastewater from the Brunswick Smelter has been collected and treated at a waste water treatment plant (WWTP) prior to discharge into the Baie des Chaleurs just east of the Port of Belledune (Figure 1.1). In addition to the treated effluent, the Brunswick Smelter complex can be a source of metals to the Baie des Chaleurs via atmospheric stack emissions (that can also include sulphur dioxide and nitrogen oxides), fugitive dust and storm water runoff. The predominant metals of concern from these sources has generally included arsenic, cadmium, lead and zinc (Beak 1999, 2001; Minnow 2005, 2007, 2009). Despite concentrations of some metals being above sediment quality guidelines near the effluent discharge in the Baie des Chaleurs, only minor differences in benthic invertebrate community structure have been shown in the effluent-exposed area compared to reference areas uninfluenced by smelter operations (Minnow 2005, 2007, 2009).

Historically, the Brunswick Smelter complex also included a zinc smelting facility and a fertilizer plant that produced di-ammonium phosphate (DAP) using by-products from the smelting operations. The zinc smelter and fertilizer plant were decommissioned in 1972 and 1996, respectively. Until closure of the fertilizer plant, a gypsum-based slurry, produced as an effluent waste product from the plant, was discharged into the Baie des Chaleurs just north of a breakwater that currently bounds the Port of Belledune (Figure 1.1). Although gypsum (i.e., calcium sulphate) generally exhibits high solubility in seawater, dispersion of the slurry at the outfall location was insufficient to achieve complete gypsum dissolution resulting in the historical development of a relatively insoluble gypsum bed in the vicinity of the discharge. The gypsum bed material has historically showed relatively low concentrations of the smelter-associated metals indicated above (OCG 1989; JWEL 1994, 1995; Beak 1997, 1999, 2001; Minnow 2007, 2009). However, through habitat alteration, the accumulation of gypsum has resulted in differences in benthic community structure (including lower richness) near the fertilizer plant effluent outfall compared to reference areas with natural substrate and/or uninfluenced by any direct industrial discharge (Minnow 2007, 2009). Routine monitoring has indicated that the surface area of the gypsum bed was approximately 50% smaller in 2014



Features

MAP INFORMATION
Datum: NAD 83 Map Projection: UTM Zone 20N
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Figure 1.1: Location of the Brunswick Smelter

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compared to 2002, reflecting a combination of natural erosion, chemical dissipation and burial by naturally transported material (Minnow 2015).

Notably, until 1981, drainage from a smelter slag disposal lagoon had been directed into a harbour (referred to as Belledune Harbour) located directly north of the smelter complex. In 2010, the Belledune Port Authority (BPA) completed a 20.5 ha dredging project to deepen the charted depth of the Port of Belledune by approximately 1 to 3 meters. The dredged material was placed in containment cells constructed within Belledune Harbour, resulting in the complete infilling of inner Belledune Harbour (approximately 31.2 ha). Prior to dredging and infilling of Belledune Harbour by the BPA, routine monitoring studies conducted by the Brunswick Smelter had indicated highly elevated arsenic, cadmium, copper, lead, mercury and zinc concentrations in sediment of Belledune Harbour (Beak 1999; Minnow 2009). In turn, low benthic invertebrate community richness, diversity and evenness together with a general absence of metal-sensitive benthic invertebrates suggested that high sediment metal concentrations were adversely affecting biota of Belledune Harbour (Beak 1999; Minnow 2004, 2005, 2007, 2009).

The Brunswick Smelter has been monitoring the condition of benthic invertebrate communities in the Baie des Chaleurs since 1965. This Benthic Monitoring Program (BMP) has been conducted in order to meet provincial requirements under the Brunswick Smelter Certificate-of-Approval (C-of-A) to discharge treated effluent. To date, a total of 27 benthic monitoring surveys have been conducted at the Brunswick Smelter, with the current monitoring frequency set at every ten years. Consistent with this monitoring frequency, this Brunswick Smelter BMP report documents sediment quality and benthic invertebrate community conditions in 2014 at estuarine environments influenced by the current lead smelter effluent and the historical Fertilizer Plant gypsum deposit.

1.2 2014 Benthic Monitoring Program Objectives

The objectives of the Brunswick Smelter 2014 BMP were to evaluate any current effluent-related effects on sediment quality and benthic invertebrates in the Baie des Chaleurs, to document current sediment quality and benthic invertebrate community conditions at the area historically influenced by the gypsum-based effluent deposit at the Fertilizer Plant outfall, and to compare the 2014 results to previous studies to assess any changes in sediment quality and/or benthic invertebrate community conditions over time.

1.3 Report Organization

The Brunswick Smelter 2014 BMP study included surface water quality monitoring, sediment quality monitoring, and a benthic invertebrate community survey. Station location descriptions and the methods used for sample collection, sample processing and data analyses are presented in Section 2.0. *In-situ* water quality results are provided in Section 3.0. Sediment quality data are presented and compared to reference conditions, applicable sediment quality guidelines and to historical data in Section 4.0. Section 5.0 provides the benthic invertebrate community survey results. The conclusions of the Brunswick Smelter 2014 BMP are provided in Section 6.0. Finally, all references cited in this report are listed in Section 7.0.

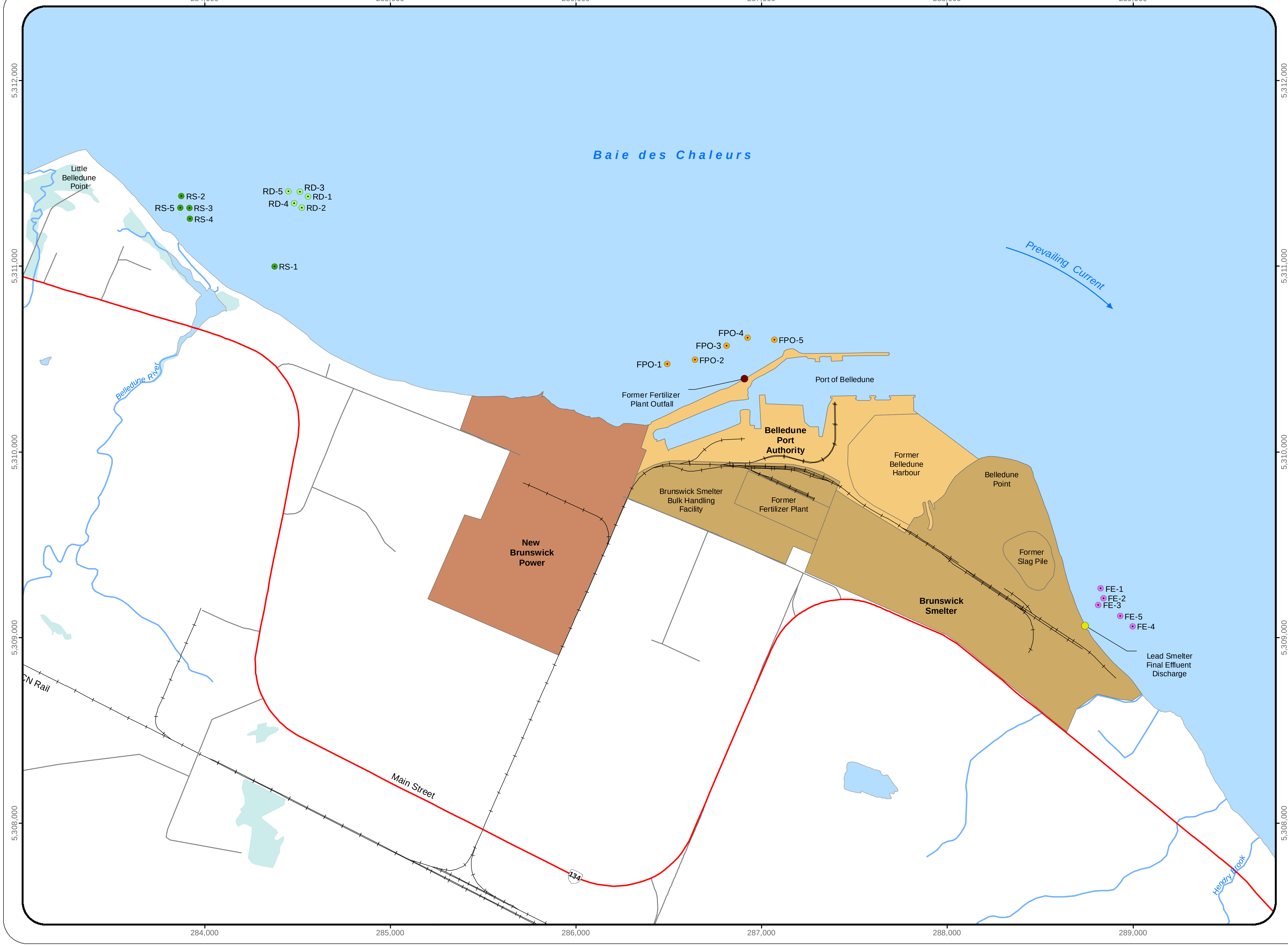
2.0 METHODS

The Brunswick Smelter 2014 Benthic Monitoring Program (BMP) included surface water quality, sediment quality, and benthic invertebrate community monitoring components. Field sampling for these components was conducted October 6th - 10th, 2014. The 2014 study concentrated on four study areas, all of which have been included in the Brunswick Smelter BMP since 2004. These areas included the active lead smelter Final Effluent (FE) receiving waters and the 'recovering' area situated near the historical Fertilizer Plant Outfall (FPO), both of which are located near Belledune Point in the Baie des Chaleurs (Figure 2.1). To minimize biological variability associated with differing depth and substrate features, two reference areas were included in the study: shallow- (RS) and deep- (RD) water reference areas were sampled for comparison to the Final Effluent and Fertilizer Plant Outfall study areas, respectively. Both reference areas are located near Little Belledune Point in the Baie des Chaleurs, which is an area considered to be unaffected by current or historical smelter complex-related influences as a result of prevailing winds and ocean currents (Figure 2.1).

Similar to monitoring programs conducted since 2004, the Brunswick Smelter 2014 BMP employed a Control-Impact approach to evaluate differences between smelter-influenced and respective reference areas. Five stations were sampled at each study area (Table 2.1; Figure 2.1). These stations were situated at approximately the same locations used previously, to the extent possible, to facilitate relevant temporal comparisons. During sampling, water depth at each station was corrected for tide (i.e., converted to chart datum), with target tide-corrected depths of between 2.5 – 3.5 m and 6.5 - 7.5 m used for shallow and deep study area stations, respectively (Table 2.1). Visual evaluation of habitat features (e.g., physical substrate properties) was conducted in the field to assess/confirm comparability among stations and between study areas as a criterion for station inclusion in the 2014 BMP. In the event that depth and/or habitat properties at a historical monitoring station were outside of acceptable criteria, a new station location was established (Table 2.1). All stations were located and/or geo-referenced using a portable Global Positioning System (GPS) unit with coordinates recorded in latitude-longitude decimal minutes and based on 1983 North American Datum (NAD).

2.1 Water Quality Monitoring

Water quality monitoring included *in-situ* water temperature, dissolved oxygen, salinity and pH measurements and evaluation of water clarity at each station. The *in-situ* measurements were taken at the surface and bottom (i.e., approximately 30 cm above the water-sediment interface) of the water column at each station using a calibrated YSI 556 MDS (Multiparameter Display



Benthic Sampling Location

- ● Fertilizer Plant Outfall Station
- ● Final Effluent Station
- ● Deep Reference Station
- ● Shallow Reference Station

Features

- ● Former Fertilizer Plant Outfall
- ● Lead Smelter Final Effluent Discharge
- ▨ Brunswick Smelter
- ▨ New Brunswick Power
- ▨ Port of Belledune
- ▨ Waterbody
- ▨ Wetland
- — Watercourse
- — Highway
- — Road
- ┼ Railway

MAP INFORMATION
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Figure 2.1: Brunswick Smelter 2014 Benthic Monitoring Program Station Locations

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System) meter equipped with a YSI 6820 Sonde (YSI Inc., Yellow Springs, OH). The evaluation of water clarity was based on collection of Secchi depth data at each station. Secchi depth measurement was conducted as outlined by Wetzel and Likens (2000). Notably, Secchi depth readings greater than chart datum depths may have been determined for some Final Effluent and Shallow Reference stations (i.e., stations with tide-corrected depth of 2.5 – 3.5 m) based on time of collection in the tidal cycle.

Analysis of the *in-situ* water quality data included comparison of top and bottom measures to evaluate any differences in water column stratification among areas. *In-situ* water quality measurements collected at the water column bottom and Secchi depth were compared statistically among study areas using Analysis-of-Variance (ANOVA) and *post-hoc* testing. Prior to ANOVA, all data were transformed as required to meet test assumptions of normality and homogeneity of variance. Tukey's Honestly Significant Difference (HSD) and Tamhane's *post-hoc* tests were applied in cases in which normal data with equal and unequal variance, respectively, were encountered. In instances where normality could not be achieved through data transformation, non-parametric Kruskal-Wallis (multiple group comparisons) and/or Mann-Whitney U-test (study area pair-wise comparisons) statistics were used to confirm the statistical results from the ANOVA and *post-hoc* tests using log-transformed data. Similarly, in instances in which variances of normal data could not be homogenized by log transformation, pair-wise comparisons were conducted using Student's t-tests assuming unequal variance to confirm the statistical findings of the ANOVA tests. All statisticnal comparisons were conducted using SPSS Version 12.0 software (SPSS Inc., Chicago, IL). In addition to these comparisons, mean dissolved oxygen and pH data from each study area were compared to applicable Canadian Water Quality Guidelines for the protection of marine life (CWQG; CCME 2015).

2.2 Sediment Quality

Sediment quality was assessed at all Brunswick Smelter BMP stations (Figure 2.1) concurrent with benthic invertebrate community sampling. The sediment quality assessment included evaluation of substrate physical and chemical characteristics. The sediment samples were collected using a stainless steel standard Ponar grab (0.052 m^2 sampling area). At each station, a composite sediment sample was created by collecting the top three centimetres of surficial material from two acceptable Ponar grabs (i.e., full to each edge of the sampler). Each composite sample was thoroughly homogenized in a plastic tub before being spooned directly into a labeled plastic bag and then sealed. Following collection, the sediment samples were placed into a cooler, transported to the smelter and stored in a refrigerator until shipment to

Table 2.1: Brunswick Smelter Benthic Monitoring Program station location and sampling date and depth information, October 2014.

Location		Date Sampled	Coordinates (latitude longitude)	Tide Corrected Depth (m)
Shallow Reference	RS-1[a]	7-Oct-14	47 54.962	3.42
			65 53.160	
	RS-2[a]	8-Oct-14	47 55.156	3.48
			65 53.574	
	RS-3[a]	8-Oct-14	47 55.113	3.45
			65 53.540	
	RS-4[a]	8-Oct-14	47 55.096	2.89
			65 53.524	
	RS-5[a]	8-Oct-14	47 55.122	2.74
			65 53.577	
Final Effluent Outfall	FE-1[a]	9-Oct-14	47 54.115	3.36
			65 49.541	
	FE-2[a]	10-Oct-14	47 54.087	2.93
			65 49.528	
	FE-3[a]	6-Oct-14	47 54.067	2.82
			65 49.548	
	FE-4[b]	6-Oct-14	47 54.012	3.64
			65 49.398	
	FE-5[b]	6-Oct-14	47 54.037	3.14
			65 49.452	
Deep Reference	RD-1[a]	8-Oct-14	47 55.169	7.21
			65 53.026	
	RD-2[a]	8-Oct-14	47 55.136	6.80
			65 53.051	
	RD-3[a]	9-Oct-14	47 55.181	7.25
			65 53.061	
	RD-4[a]	9-Oct-14	47 55.147	6.87
			65 53.086	
	RD-5[a]	9-Oct-14	47 55 181	7.23
			65 53.112	
Fertilizer Plant Outfall	FPO-1[b]	9-Oct-14	47 54.721	6.51
			65 51.447	
	FPO-2[b]	9-Oct-14	47 54.736	6.74
			65 51.329	
	FPO-3[a]	9-Oct-14	47 54.780	6.96
			65 51.194	
	FPO-4[b]	6-Oct-14	47 54.806	6.92
			65 51.104	
	FPO-5[b]	6-Oct-14	47 54.803	6.24
			65 50.990	

[a] Same station location coordinates as in the 2006 and 2008 Brunswick Smelter BMP studies.

[b] New (2014) station coordinates; slight change in station location required to ensure habitat comparability with other like-depth stations.

the Research and Productivity Council (RPC; Fredericton, New Brunswick) for analytical testing. Additional supporting observations recorded at each station included sediment texture and colour, and the presence of algae or plants on or in the sediment. A split-sample field duplicate was taken at each of the Final Effluent (Station FE-4) and Fertilizer Plant Outfall (Station FPO-4) stations for quality assurance/quality control (QA/QC) evaluation (Appendix B). Upon completion of the field program, sediment samples were shipped on ice to RPC for analytical testing. Sample analyses for physical characterization included total organic carbon (TOC) and particle size determinations, and for sediment chemistry included analysis of total metals, all of which were completed using standard analytical methods and with QA/QC checks applied (Appendix B).

Sediment quality data from each smelter complex-influenced area were compared: 1) to reference area data collected at the same relative depth; 2) to sediment quality guidelines for the protection of marine life; and, 3) to historical sediment quality data collected since 2004, as these data had been collected at the same study areas/stations using a similar control-impact approach as in the 2014 study. Sediment physical characteristics (i.e., particle size, TOC) were compared statistically among the four study areas using the same tests, transformations, assumptions and software described above for the *in-situ* water quality comparisons (see Section 2.1). Mean sediment chemistry data from the Final Effluent and Fertilizer Plant Outfall study areas were compared separately to shallow and deep reference areas, respectively, and to applicable marine sediment quality guidelines available from federal (arsenic, cadmium, chromium, copper, lead and zinc metals) and British Columbia (nickel and silver) sources (i.e., CCME 2015; BCMOE 2014). The sediment metal chemistry data were compared to Interim Sediment Quality Guidelines (ISQG) and Probable Effects Levels (PEL), which represent concentrations at which adverse biological effects may become apparent (i.e., threshold effect levels) or that have often been observed, respectively (CCME 2015).

Temporal data analysis included evaluation of plotted data for key sediment chemistry parameters (i.e., parameters with concentrations decidedly higher at the smelter complex-influenced study areas compared to reference and/or with concentrations above any marine sediment quality guidelines) to assess any changes over time. The temporal sediment quality data set (i.e., 2004 – 2014 data) was assessed using Principal Components Analysis (PCA) to assist with evaluation of any general patterns in the data. The PCA was conducted separately for shallow- and deep-water smelter-influenced study area data sets. Principal components scores generated for each station using the correlation matrix from the log-transformed sediment chemistry data set were plotted and compared among study years to evaluate general changes in the magnitude of sediment chemistry differences between each respective smelter-influenced area station and reference. Additional statistical comparisons were conducted for the key sediment chemistry variables (as defined above) using single-factor and two-way factorial ANOVA tests of the 2008 and/or 2014 data to further assess the degree of any observed differences in the sediment chemistry data.

2.3 Benthic Invertebrate Community Survey

Benthic invertebrate community (benthic) samples were collected at all Brunswick Smelter BMP stations (Figure 2.1) using a standard Ponar grab. A single sample, consisting of a composite of three grabs (i.e., 0.156 m^2 sampling area), was collected at each station with care taken to ensure that each grab captured the surface material and was full to each edge, and that substrate characteristics were as comparable as possible within and between like-depth study areas. Any incomplete grabs were discarded. Each acceptable grab was field-sieved using 500-μm mesh with the retained material carefully transferred into a plastic sampling jar containing both external and internal station identification labels. All benthic samples were preserved to a level of 10% buffered formalin in ambient water. Supporting information recorded at each benthic station included substrate description, tide-corrected sampling depth, general habitat notes (e.g., substrate properties, extent and type of aquatic vegetation present, potential confounding influences, etc.), *in-situ* water quality at the sediment-water interface and Secchi depth (see Section 2.1), and any other information considered relevant to the interpretation of the benthic invertebrate community data.

The benthic samples were submitted to Zeas Inc. (Nobleton, ON) for analysis following standard sorting methods that incorporated recommended QA/QC procedures for assessing sub-sampling error and sorting recovery checks (i.e., Environment Canada 2012). Upon arrival at the laboratory, a biological stain was added to each benthic invertebrate community sample to facilitate greater sorting accuracy. The samples were washed free of formalin in a 500 μm sieve and the remaining sample material was then examined under a stereomicroscope at a magnification of at least ten times by a technician. All benthic invertebrates were removed from the sample debris and placed into vials containing a 70% ethanol solution according to major taxonomic groups (e.g., phyla, orders). A senior taxonomist later enumerated and identified the benthic organisms to lowest-practical-level (typically to genus or species) taxonomy using up-to-date taxonomic keys.

Benthic invertebrate communities were assessed based on metrics of mean invertebrate abundance (or “density”; average number of organisms per m^2), mean taxon richness (number of taxa), Simpson’s Diversity and Evenness, Shannon-Weiner Diversity and Evenness, and Bray-Curtis Index of Dissimilarity (Bray-Curtis Index). The Simpson’s and Shannon-Weiner indices were calculated using lowest-practical-level taxonomy according to formula provided by Smith and Wilson (1996), with the Kreb's method used for calculation of Simpson's Evenness. Bray-Curtis Index was also calculated using lowest-practical level taxonomy, but based on formula presented by Environment Canada (2012). Additional comparisons were conducted using the percent composition of dominant/indicator taxa (calculated as the abundance of each respective taxonomic group relative to the total number of organisms in the sample). Dominant/indicator taxonomic groups were defined as those groups representing, on average, greater than 5% of total organism abundance for a study area and/or any groups that have been described as 'tolerant' or 'sensitive' in the scientific literature. Notably, errant polychaetes (Errantia), sedentary polychaetes (Sedentaria), gastropod molluscs (snails) and bivalve molluscs (clams and mussels) generally show relatively high tolerance to environmental stressors including metals, organic contaminants (e.g., hydrocarbons), intermittent hypoxia and/or reducing sediment or water quality conditions (Pearson and Rosenberg 1978, Bryan and Gibbs 1983, Chang et al. 1992). Conversely, amphipod and cumacean crustaceans are widely considered to be highly sensitive to contaminant exposure, including metals, and thus are important indicators of environmental stress (Pearson and Rosenberg 1978, Chang et al. 1992).

Benthic data from each smelter complex-influenced area were compared: 1) to reference area data collected at the same relative tide corrected depth; and, 2) to historical benthic data collected since 2004, as these data had been collected at the same study areas/stations using a similar control-impact approach as in the 2014 study. Differences in benthic indices and community composition data between smelter-influenced and reference areas sharing similar tide-corrected depth were tested separately using pair-wise, single factor ANOVA. Prior to ANOVA, all data were evaluated for normality and homogeneity of variance as described previously. For any non-normal data or normal data with unequal variance following data log (for absolute data) or logit (for proportional data) transformation, non-parametric Mann-Whitney U-tests and Student's T-tests assuming unequal variance were used to confirm the ANOVA test results. All statistical comparisons were conducted using SPSS (Version 12.0) software. An effect on the benthic invertebrate community was defined as a statistically significant difference between the paired smelter-influenced and reference areas at an alpha level of 0.10. For each endpoint showing a significant difference, a magnitude of difference was calculated between study area means for the metric. Because the benthic invertebrate community survey was designed to have sufficient power to detect a difference (effect size) of ± two standard deviations (2 SD), the magnitude of the difference was calculated to reflect the number of reference mean SD (SD_{REF}) using equations provided by Environment Canada (2012). A Critical Effect Size (CES) of $\pm$ 2 SD_{REF} was used to define any ecologically relevant ‘effects’, which is analogous to differences outside of the magnitude of difference that could be expected to occur naturally between two areas that are uninfluenced by any anthropogenic inputs (i.e., between reference areas; see Munkittrick et al. 2009, Environment Canada 2012).

Temporal data analysis was conducted through visual evaluation of plotted benthic indices and dominant community groups (as defined above) for the 2004 – 2014 studies. In addition, qualitative comparison of the magnitude of difference (direction and size) was conducted among studies to assist with the evaluation of any ecologically relevant differences between respective study area pairs (i.e., Final Effluent versus Shallow Reference areas, and Fertilizer Plant Outfall versus Deep Reference areas) over time. Finally, data from the two most recent studies (i.e., 2008 and 2014) were assessed statistically using a two-way factorial ANOVA of respective study area pairs to assist with the determination of relative changes over time.

3.0 WATER QUALITY

Water temperature at the bottom of the water column varied by less than 0.5°C among all shallow-water and deep-water study areas (Figure 3.1). Although bottom water temperature was significantly warmer at the Shallow Reference compared to all other study areas, the small differences in water temperature indicated among study areas was unlikely to be ecologically meaningful. No substantial differences in water temperature were indicated between the surface and bottom of the water column at any study areas, suggesting well mixed water column conditions in the Baie des Chaleurs at depths assessed for the BMP study (Appendix Table A.1). Dissolved oxygen concentrations at the bottom of the water column were high and well above the CWQG minimum limit of 8.0 mg/L at all study areas, with no significant differences shown between the smelter complex-influenced study areas compared to respective reference areas (Figure 3.1; Appendix Table A.3). Salinity at the bottom of the water column was approximately 27 ppt at all study areas (Figure 3.1) indicating strongly polyhaline estuarine conditions (after M^{c}Lusky 1989). Mean pH was also similar among all study areas, with slightly basic values well within the range specified as acceptable under the CWQG indicated at each study area (Figure 3.1). No significant differences in salinity or pH were indicated among areas. In addition, no substantial differences in salinity or pH were shown between the surface and bottom of the water column at any of the study areas which, together with minor differences in water temperature shown between surface and bottom (Appendix Table A.1), suggested that the water column was well mixed at all study areas.

Secchi depth was greater than water depth at the Final Effluent study area and thus, no comparisons to reference were possible for these data. Secchi depth was significantly deeper (i.e., water was clearer) at the Fertilizer Plant Outfall compared to the reference areas (Appendix Table A.3), with the occurrence of slightly lower water clarity at the reference areas likely attributable to influences associated with outlet flow from the Belledune River (see Figure 2.1).

Overall, the incremental differences in bottom water temperature, dissolved oxygen, salinity, pH and turbidity (as indicated by Secchi depth) measures between the smelter complex-influenced study areas and respective shallow- and deep-water reference areas were small and unlikely to be ecologically meaningful. In addition, there was no evidence that water temperature, dissolved oxygen, salinity, pH or turbidity of the Baie des Chaleurs was appreciably influenced in 2014 by the active effluent discharge or the former gypsum-based slurry discharge.

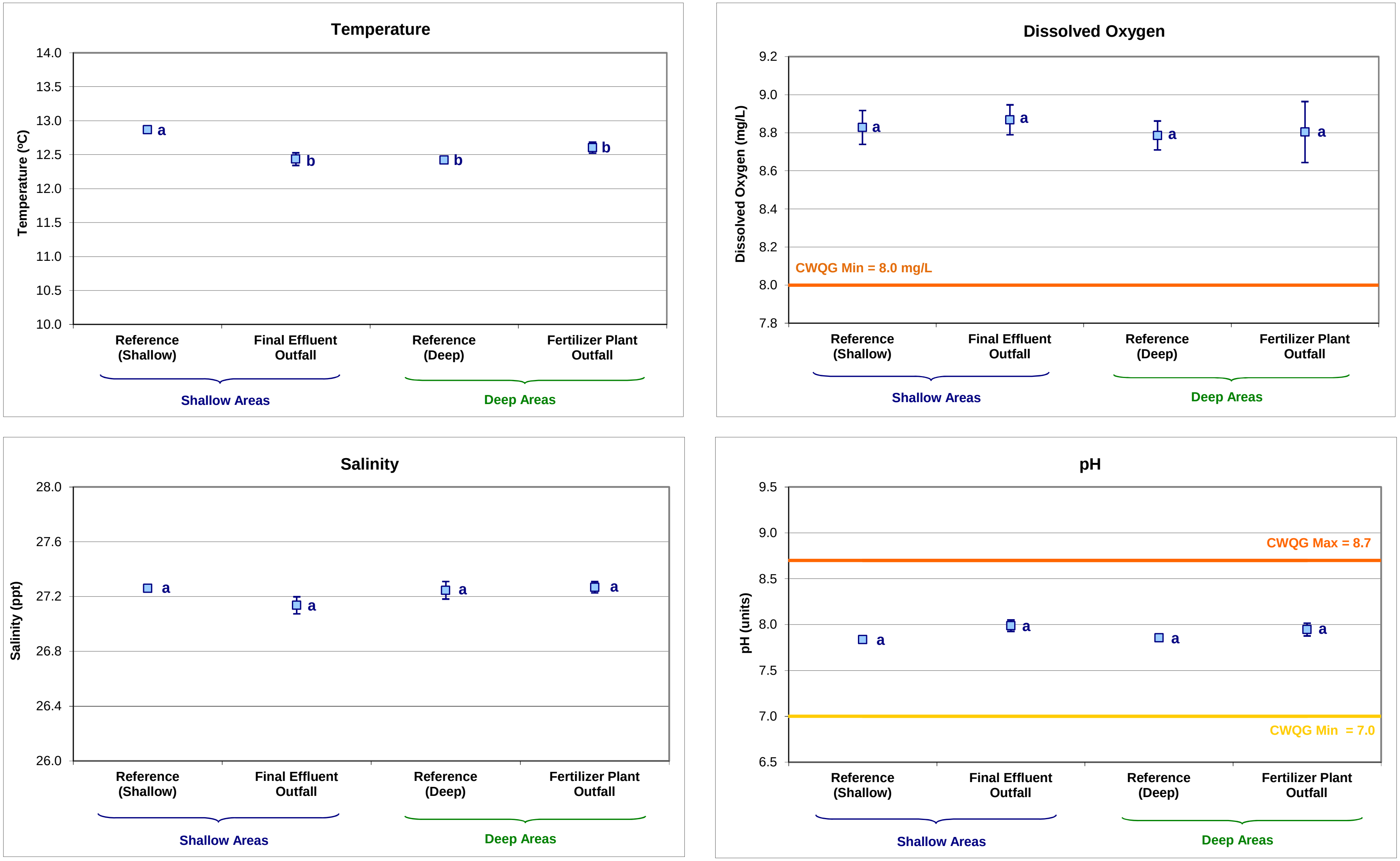


Figure 3.1: Comparison of *in-situ* water quality (mean ± SE, n = 5) at benthic stations for the Brunswick Smelter Benthic Monitoring Program, October 2014. Data points with the same letter do not differ significantly.

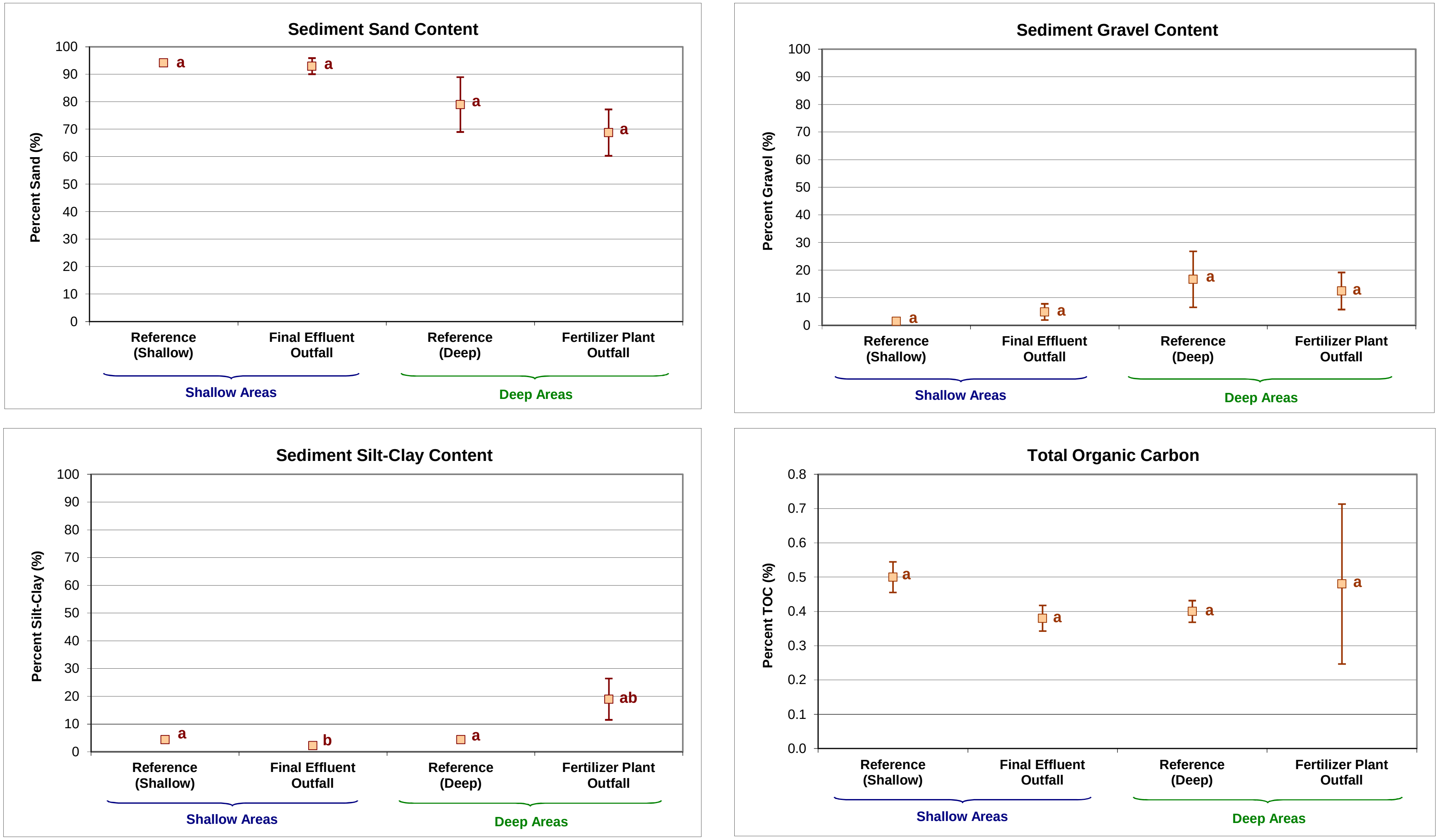
4.0 SEDIMENT QUALITY

4.1 Final Effluent (FE) Study Area

4.1.1 Existing Substrate Features and Chemistry

Substrate at the Final Effluent study area was uniform brown and comprised mainly of sand-sized particles with low total organic carbon (TOC) content (Figure 4.1). No significant differences in particle size or TOC content were indicated between the Final Effluent and Shallow Reference (RS) study areas with the exception of a slightly lower silt-clay particle size fraction at the Final Effluent area (Figure 4.1). Minimal sediment anoxia was apparent at the Final Effluent study area, whereas at the Shallow Reference, dark grey sediment approximately 2 – 3 cm below the sediment-water interface suggested the occurrence of anoxic sediment conditions below the sediment surface (Appendix Table B.1). Although sediment TOC was slightly lower at the Final Effluent compared to Shallow Reference areas, the mean incremental difference between areas was small (i.e., 0.1%; Figure 4.1). Therefore, TOC content was unlikely to contribute substantially to differences in sediment anoxia between study areas. Rather, differences in the occurrence of substrate anoxia between the Final Effluent and Shallow Reference may have been related to differences in sediment compactness, with naturally lower compactness at the Final Effluent study area potentially facilitating oxygen diffusion more deeply into the substrate than at the reference area.

Sediment metal concentrations were elevated at the Final Effluent area compared to the Shallow Reference area, with antimony, arsenic, cadmium, copper, lead, thallium and zinc concentrations elevated by the highest factors (i.e., greater than approximately five-fold higher) at the active lead smelter effluent discharge (Table 4.1; Appendix Table B.2). Of the metals with established sediment quality guidelines, only average concentrations of lead and zinc were above Probable Effect Levels (PEL) at the Final Effluent study area (Table 4.1). Mean arsenic, cadmium and copper concentrations were above Interim Sediment Quality Guideline (ISQG) threshold effect levels at the Final Effluent study area (Table 4.1). Notably, mean concentrations of all metals were below threshold sediment quality guidelines at both reference areas (Table 4.1), suggesting naturally low concentrations of metals in sediment of the Baie des Chaleurs near Little Belledune Point. Overall, some elevation in sediment metal concentrations was apparent near the active lead smelter Final Effluent discharge, but only lead and zinc were above guideline effect levels, on average, at concentrations that were likely to affect sediment-dwelling biota.



Sediment Sand Content

Sediment Gravel Content

Sediment Silt-Clay Content

Total Organic Carbon

Figure 4.1: Comparison of physical-chemical sediment quality (mean ± SE, n = 5) at benthic stations for the Brunswick Smelter Benthic Monitoring Program, October 2014. Data points with the same letter do not differ significantly.

Table 4.1: Summary of mean physical and chemical sediment quality data (n = 5), Brunswick Smelter Benthic Monitoring Program, October 2014.

Parameter	Units	Method Detection Limit	Guideline[a]		Shallow-Water Study Areas		Deep-Water Study Areas	
			ISQG	PEL	Reference (Shallow)	Final Effluent Outfall	Reference (Deep)	Fertilizer Plant Outfall
Gravel	%	0.1	-	-	1.5	4.9	16.7	12.4
Sand	%	0.1	-	-	94.2	92.9	79.0	68.8
Silt	%	0.1	-	-	2.4	1.0	2.1	17.4
Clay	%	0.1			2.0	1.3	2.2	1.6
Total Organic Carbon	%	0.1	-	-	0.5	0.4	0.4	0.5
Aluminum	mg/kg	1	-	-	11,400	10,150	9,794	6,775
Antimony	mg/kg	0.1	-	-	0.1	0.5	< 0.1	0.5
Arsenic	mg/kg	1	7.2	41.6	5	21	6	5
Barium	mg/kg	1	-	-	98	129	47	46
Beryllium	mg/kg	0.1	-	-	0.6	0.4	0.5	0.4
Bismuth	mg/kg	1	-	-	< 1	2	< 1	< 1
Boron	mg/kg	1	-	-	6	7	7	8
Cadmium	mg/kg	0.1	0.7	4.2	0.36	2.14	0.21	0.58
Calcium	mg/kg	50	-	-	28,240	10,234	5,324	53,477
Chromium	mg/kg	1	52.3	161	26	34	22	17
Cobalt	mg/kg	0.1	-	-	9.5	11.2	8.0	4.4
Copper	mg/kg	1	18.7	109	9	44	8	12
Iron	mg/kg	20	-	-	17,530	17,810	15,280	8,339
Lead	mg/kg	0.1	30.2	113	19	472	23	79
Lithium	mg/kg	0.1	-	-	19.9	14.2	17.2	8.8
Magnesium	mg/kg	10	-	-	8,340	8,549	7,378	3,772
Manganese	mg/kg	1	-	-	327	240	252	124
Molybdenum	mg/kg	0.1	-	-	0.4	0.3	0.3	0.8
Nickel	mg/kg	1	30	50	28	29	24	13
Potassium	mg/kg	20	-	-	1,329	1,035	1,272	1,022
Rubidium	mg/kg	0.1	-	-	7.6	5.6	7.2	4.8
Selenium	mg/kg	1	-	-	< 1	< 1	< 1	< 1
Silver	mg/kg	0.1	1.0	2.2	< 0.1	0.2	< 0.1	0.1
Sodium	mg/kg	50	-	-	2,378	2,149	2,532	3,542
Strontium	mg/kg	1	-	-	25	21	14	176
Tellurium	mg/kg	0.1	-	-	< 0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	-	-	0.3	2.1	0.3	0.3
Uranium	mg/kg	0.1	-	-	0.7	0.5	0.6	24.6
Vanadium	mg/kg	1	-	-	33	37	30	17
Zinc	mg/kg	1	124	272	54	970	49	176

[a] Canadian Sediment Quality Guidelines (CSQG; CCME 1998) for the protection of marine life, including Interim Sediment Quality Guidelines (ISQG) and Probable Effect Level (PEL), with the exception of nickel and silver, which are from the British Columbia Ministry of Environment (2014)

🟦 Indicates mean value is above the CSQG (CCME 1998) or BCMOE (2014) ISQG.

🟩 Indicates value is above the CSQG (CCME 1998) or BCMOE (2014) PEL.

4.1.2 Temporal Comparison of Sediment Chemistry

Temporal comparison of the sediment chemistry data indicated higher mean antimony, arsenic, cadmium, copper, lead, and zinc concentrations in sediment at the Final Effluent discharge area in 2014 compared to previous benthic monitoring studies (Figure 4.2). Comparisons to sediment quality guidelines indicated that lead and zinc were well above PEL, and arsenic, cadmium and copper well above ISQG, in 2014 compared to previous studies in which concentrations of these metals were generally at their respective guideline levels (Figure 4.2). With the exception of antimony, statistical comparisons indicated that concentrations of these metals in sediment at the Final Effluent area were significantly higher in 2014 compared to 2008 (single factor ANOVA; Appendix Table B.6). Significantly higher concentrations of these metals were also indicated at the Final Effluent area when taking into account changes in sediment metal concentrations at the Shallow Reference area (i.e., two-way ANOVA; Appendix Table B.7). In addition, Principal Components Analysis (PCA) indicated greater divergence in sediment metal concentrations between the Final Effluent discharge area and the Shallow Reference area in 2014 compared to studies conducted from 2004 – 2008 based on Principal Component Axis 1 (PC Axis-1) scores, which largely reflected concentrations of arsenic, cadmium, copper, lead, thallium and zinc (Appendix Figure B.1). Notably, relatively minor changes in concentrations of key smelter-related metals had been shown over time at the Final Effluent discharge area in studies conducted previous to 2014 (Figure 4.2; Minnow 2009). Collectively, these data suggested higher concentrations of key smelter-related metals in 2014 compared to previous studies.

Three hypotheses for the cause of higher metal concentrations in sediment at the Final Effluent study area in 2014 compared to previous studies include: 1) changes in lead smelter effluent quantity and/or quality since the previous (2008) study; 2) inadvertent metal contamination resulting from the dredging of the Port of Belledune by BPA in 2010; and, 3) shoreline erosion of the former lead smelter slag pile area since the previous (2008) study. Review of lead smelter effluent quantity and quality indicated no substantial changes in volume of effluent or concentrations of key smelter-related metals in lead smelter effluent between 2008 and 2014 (Appendix Tables A.4 and A.5). This suggested that typical Brunswick Smelter operations did not contribute substantially to any changes in sediment metal concentrations at the Final Effluent discharge area.

During the 2010 dredging of the Port of Belledune, prevailing currents in the Baie des Chaleurs may have resulted in the lateral transport of any metal-contaminated sediment from the dredging operation to the current lead smelter Final Effluent discharge area, resulting in higher metal concentrations at this area in 2014 compared to 2008. In part, this is supported by the

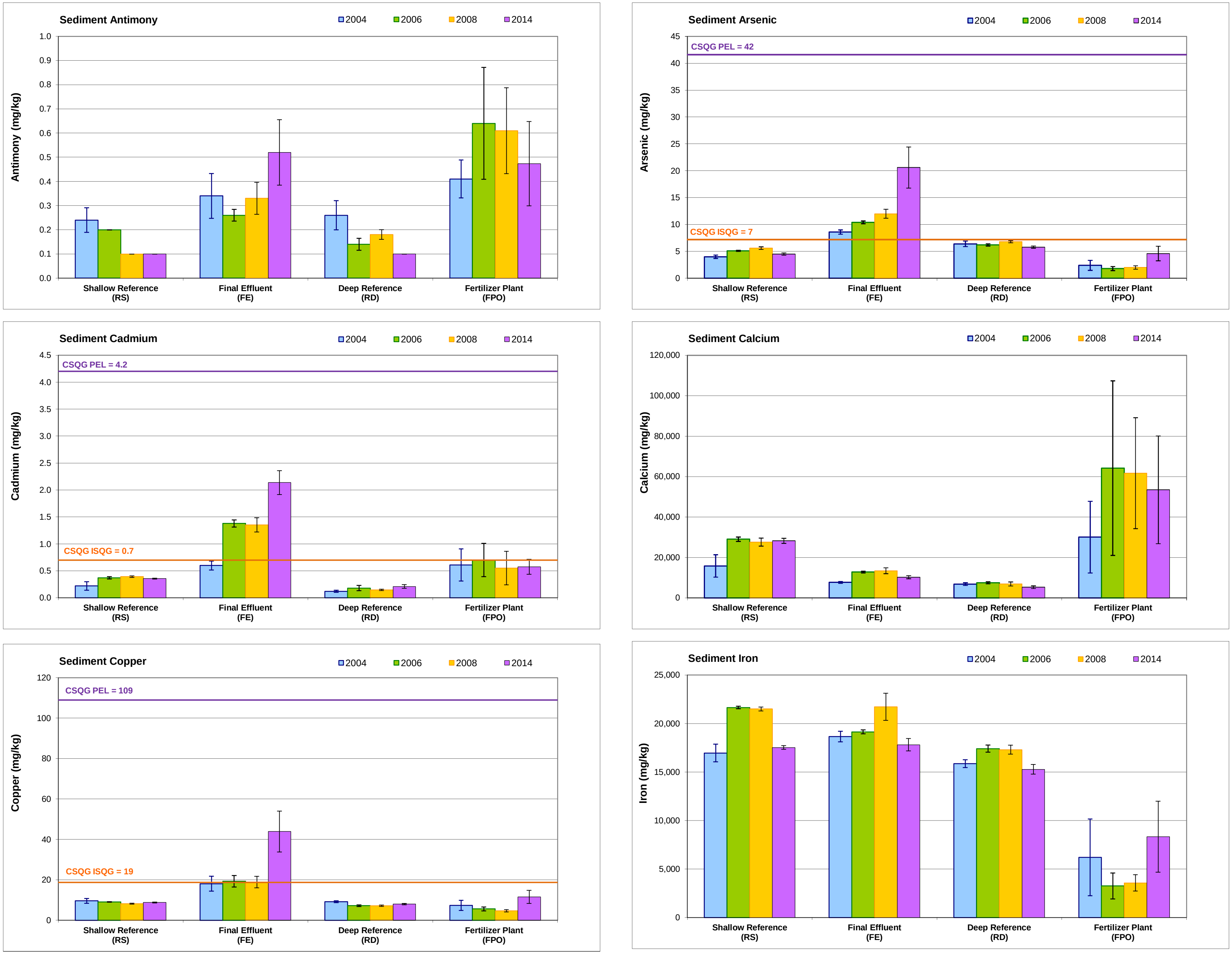


Figure 4.2: Temporal comparison of sediment metal concentrations at the effluent-exposed area, fertilizer plant outfall and respective reference areas (mean ± SE; n = 5) since the onset of a control-impact monitoring approach at the Brunswick Smelter, 2004 - 2014.

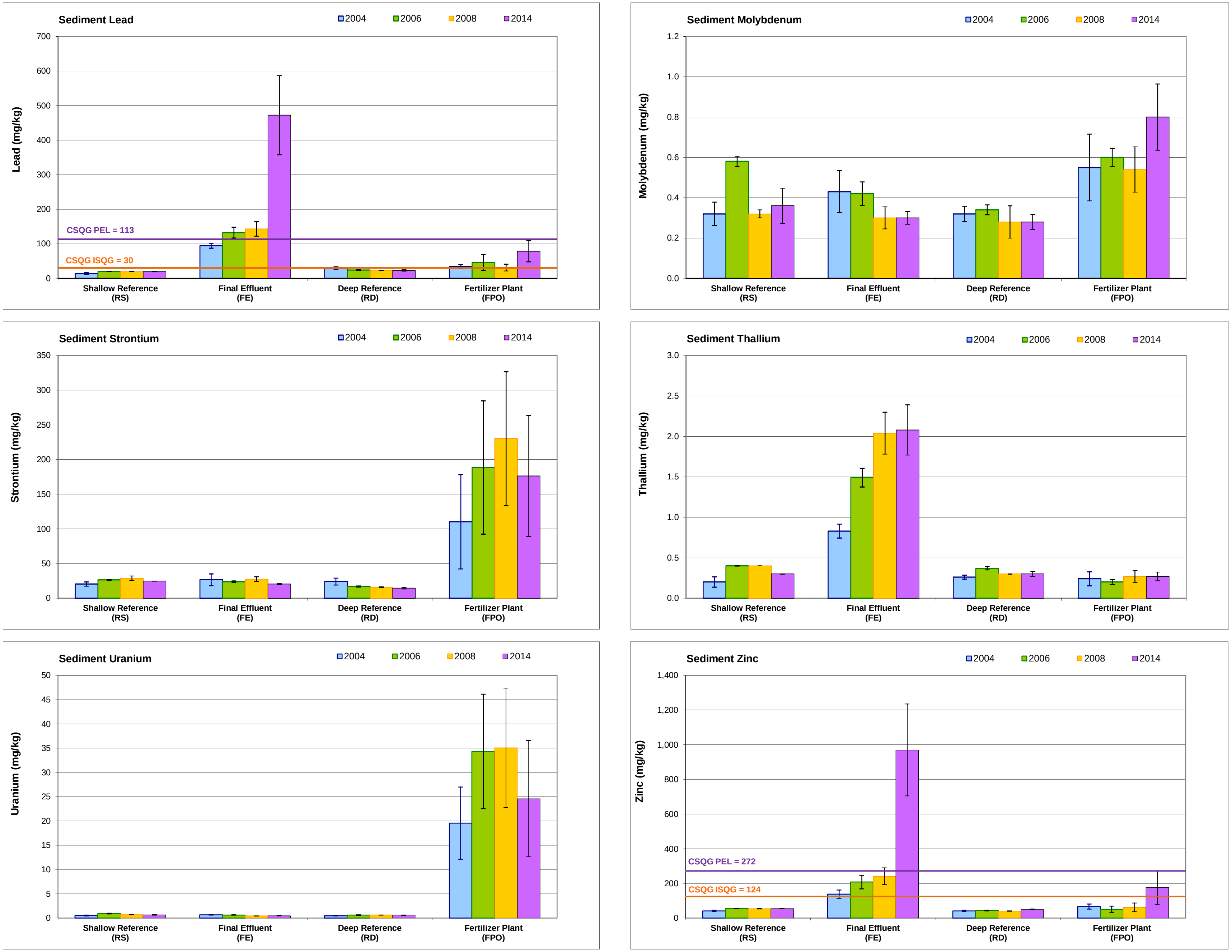


Figure 4.2: Temporal comparison of sediment metal concentrations at the effluent-exposed area, fertilizer plant outfall and respective reference areas (mean ± SE; n = 5) since the onset of a control-impact monitoring approach at the Brunswick Smelter, 2004 - 2014.

fact that sediment of Belledune Harbour and the Port of Belledune was known to have very high concentrations of the same metals shown to be elevated at the Final Effluent area in 2014 (see Minnow 2005, 2007, 2009). The Brunswick Smelter had historically stored slag (a by-product of the smelting process that can be high in metal oxides) in a large pile on Belledune Point immediately adjacent to the Baie des Chaleurs shoreline (see Figure 2.1). A significant storm event occurred in December 2010 that resulted in the breach of a protective armouring wall for the slag pile and subsequent erosion of approximately 5 – 10 linear meters of material from the slag pile. Slag deposits as deep as approximately 20 cm had accumulated on the Baie des Chaleurs shoreline within about 200 m of either direction of the slag pile as a result of this storm event. Some of this material likely was also deposited in the Baie des Chaleurs at the Final Effluent discharge study area which, in turn, likely contributed to higher sediment metal concentrations at this area in 2014 compared to the previous studies.

Therefore, effluent quantity and quality have remained relatively consistent since 2006 and thus, were not likely to contribute substantially to higher metal concentrations at the Final Effluent study area in 2014 compared to the previous 2008 study. Rather, dredging activities at the Port of Belledune in 2010 and slag pile erosion associated with a December 2010 storm event were likely the key contributors of elevated metal concentrations in sediment near the current lead smelter discharge in the Baie des Chaleurs in 2014 compared to previous studies.

4.2 Fertilizer Plant Outfall (FPO) Study Area

4.2.1 Existing Substrate Features and Chemistry

Substrate properties at the Fertilizer Plant Outfall study area were highly variable, ranging from natural sand, silty-sand and gravel-sand mixtures with or without gypsum present (Appendix Table B.1). The gypsum deposits generally formed a semi-compact to compact base on which the natural material indicated above overlaid. No significant differences in substrate particle size or TOC content were indicated between the Fertilizer Plant Outfall area and Deep Reference area, despite a slightly higher proportion of substrate in the silt-clay size fraction at the Fertilizer Plant Outfall area (Figure 4.1). The presence of gypsum in field-collected sediment samples was often apparent visibly (as white-coloured material) and/or by (metallic) odour, and was represented by the ‘silt-clay’ component in the particle size analyses.

Metal concentrations in sediment of the Fertilizer Plant Outfall were generally comparable to the Deep Reference area with the exceptions of calcium, strontium and uranium, which on average were an order of magnitude higher (i.e., ≥ ten-fold higher), and antimony, cadmium, lead, molybdenum and zinc, which on average were two- to five-fold higher, at the Fertilizer

Plant Outfall area (Table 4.1; Appendix Table B.5). However, of those metals with established sediment quality guidelines, none were above PEL, and only mean lead and zinc concentrations were above ISQG threshold effect levels at the Fertilizer Plant Outfall area (Table 4.1). Sediment metal concentrations at the Fertilizer Plant Outfall exhibited greater within-area variability than at the other Baie des Chaleurs study areas (Appendix Table B.3), likely reflecting various levels of recovery to natural substrate of the historical gypsum bed (e.g., through erosion, dissipation, and/or burial of the gypsum bed) among sampling stations. Overall, high calcium, strontium and uranium concentrations, coupled with minor elevation in other metals including antimony, lead and zinc, characterized the sediment of the Fertilizer Plant Outfall compared to reference. However, only lead and zinc were above threshold effect guidelines at the Fertilizer Plant Outfall area, suggesting limited potential for biological effects at the area affected by the historical plant discharge.

4.2.2 Temporal Comparison of Sediment Chemistry

Temporal comparison of the Fertilizer Plant Outfall area sediment chemistry data indicated slightly higher mean arsenic, copper, lead, molybdenum and zinc concentrations in 2014 compared to the 2004 – 2008 benthic monitoring studies (Figure 4.2). However, sediment metal concentrations remained well below PEL at the Fertilizer Plant Outfall in 2014 (Figure 4.2). Moreover, metal concentration differences at the Fertilizer Plant Outfall area between 2014 and 2008 were not significant, even when data from the Deep Reference were taken into account (Appendix Tables B.9 and B.10). Evaluation of temporal changes using PCA did not indicate any definitive directional differences in sediment metal concentrations over time at the Fertilizer Plant Outfall area (Appendix Figure B.2). Similar to the results indicated for individual studies, the PCA suggested high variability in sediment quality at the Fertilizer Plant Outfall area among studies. This is consistent with changes in sediment quality resulting from variable erosion, dissipation and/or burial of the gypsum bed as the system recovers to a more natural physical state over time. Overall, no significant changes in sediment metal concentrations were apparent at the Fertilizer Plant Outfall in 2014 compared to studies conducted from 2004 - 2008, with high variability in sediment metals of this area suggesting a variable state of habitat recovery within the area affected by the former gypsum bed deposit.

5.0 BENTHIC INVERTEBRATE COMMUNITY SURVEY

5.1 Final Effluent (FE) Study Area

5.1.1 Existing Conditions

Benthic invertebrate community density at the Final Effluent area was significantly lower than at the Shallow Reference, but the magnitude of difference between areas was less than the critical effect size (CES) of ±2 SD_{REF}, suggesting that the difference in density between areas was not ecologically significant (Figure 5.1; Table 5.1). No significant difference in taxonomic richness was indicated between the Final Effluent and Shallow Reference areas (Figure 5.1). However, Simpson's and Shannon-Weiner diversity and evenness indices were relatively low at the Final Effluent area, suggesting that the benthic invertebrate community was dominated by few taxa. Diversity and evenness at the Final Effluent area were significantly lower than at the Shallow Reference at an ecologically relevant magnitude of difference (Table 5.1). Although a significant difference in Bray-Curtis Index was indicated between the Final Effluent and Shallow Reference area, the magnitude of difference was not at an ecologically meaningful level (Figure 5.1; Table 5.1). Collectively, comparisons of the indices above suggested that benthic invertebrate community density and structure differed between the Final Effluent and Shallow Reference areas.

Comparison of the benthic invertebrate community structure indicated significantly lower relative abundance of errant polychaetes and gastropod molluscs, but significantly higher relative abundance of bivalve molluscs, at the Final Effluent area compared to the Shallow Reference area (Figure 5.2; Table 5.1). Because these groups show relatively high tolerance to environmental stressors including metals (Pearson and Rosenberg 1978, Bryan and Gibbs 1983, Chang et al. 1992), the differential direction of response among these groups between the Final Effluent and Shallow Reference areas suggested that effects associated with metals, if any, were minor. No significant difference in the relative abundance of metal-sensitive crustaceans was indicated between the Final Effluent and Shallow Reference study areas (Figure 5.2; Table 5.1), further suggesting that any effects associated with sediment metal concentrations on benthic community assemblage at the Final Effluent area were minor.

5.1.2 Temporal Comparisons

Temporal comparisons of the benthic invertebrate community data indicated that a greater number of indices differed significantly between the Final Effluent area and the Shallow Reference area in 2014 compared to the previous three studies (Table 5.2). Two-way factorial analysis of the benthic endpoints indicated that only the relative change in organism density,

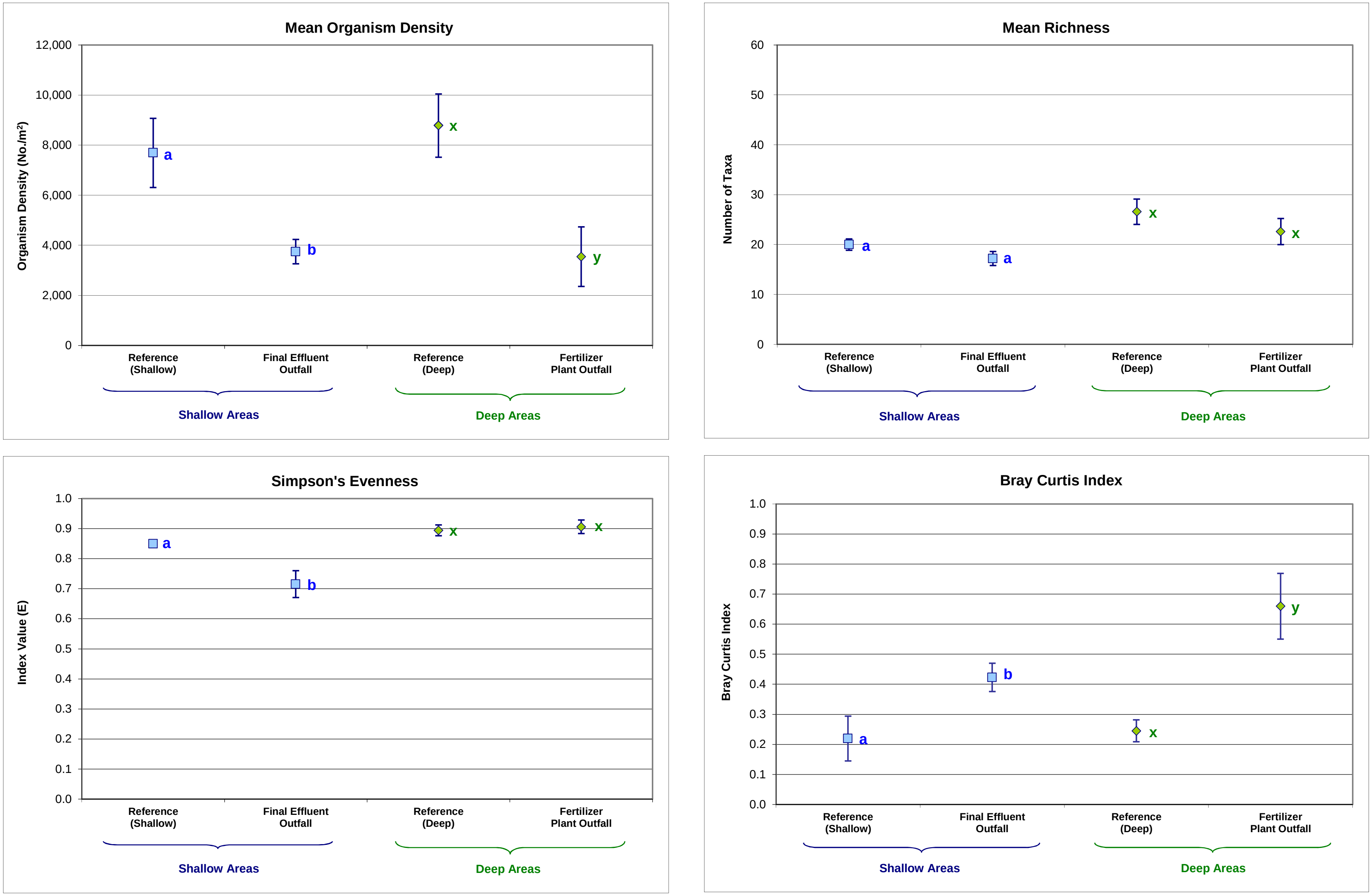


Figure 5.1: Comparison of benthic invertebrate community richness, density, Simpson's Evenness and Bray-Curtis Index (mean ± SE, n = 5), Brunswick Smelter Benthic Monitoring Program, October 2014. Data points with the same letter for a,b and x,y pairings applicable to shallow and deep study area comparisons, respectively, do not differ signficantly.

Table 5.1: Benthic invertebrate community statistical comparison results between final effluent-exposed (FE) and shallow reference (R study areas, Brunswick Smelter Benthic Monitoring Program, October 2014.

Metric	Statistical Test Results				Summary Statistics					
	Significant Difference Between Areas?	*p*-value	Statistical Analysis[a]	Magnitude of Difference [b] (No. of SD)	Area	Mean	Standard Deviation	Standard Error	Minimum	Maximum
Density (Individuals/m^2)	YES	0.027	α	-1.3	Shallow Reference	7,692	3,080	1,377	2,671	10,851
					Final Effluent Area	3,750	1,082	484	2,070	4,996
Richness (Number of Taxa)	NO	0.158	α	-	Shallow Reference	20.0	2.5	1.1	18.0	24.0
					Final Effluent Area	17.2	3.1	1.4	12.0	20.0
Simpson's Diversity	YES	0.018	β	-6.2	Shallow Reference	0.806	0.022	0.010	0.778	0.833
					Final Effluent Area	0.673	0.099	0.044	0.545	0.772
Simpson's Evenness (E)	YES	0.020	β	-5.0	Shallow Reference	0.849	0.027	0.012	0.812	0.882
					Final Effluent Area	0.715	0.100	0.045	0.577	0.812
Shannon-Weiner Diversity (H')	YES	0.018	β	-4.6	Shallow Reference	2.940	0.139	0.062	2.724	3.051
					Final Effluent Area	2.304	0.461	0.206	1.738	2.731
Shannon-Weiner Evenness (J')	YES	0.028	α	-2.8	Shallow Reference	0.682	0.043	0.019	0.627	0.732
					Final Effluent Area	0.562	0.091	0.041	0.455	0.668
Bray-Curtis Index	YES	0.050	α	1.2	Shallow Reference	0.219	0.167	0.075	0.086	0.509
					Final Effluent Area	0.423	0.105	0.047	0.340	0.598
Errantia (%)	YES	0.036	γ	-1.0	Shallow Reference	12.0%	6.9%	3.1%	7.4%	24.2%
					Final Effluent Area	5.4%	2.6%	1.2%	2.3%	8.3%
Sedentaria (%)	NO	0.313	δ	-	Shallow Reference	32.1%	7.2%	3.2%	26.3%	42.8%
					Final Effluent Area	26.2%	12.2%	5.4%	11.6%	41.8%
Metal-Sensitive Crustaceans (%)	NO	0.852	δ	-	Shallow Reference	3.6%	1.2%	0.5%	2.1%	5.0%
					Final Effluent Area	4.0%	2.1%	0.9%	2.3%	7.2%
Gastropoda (%)	YES	0.087	δ	-0.7	Shallow Reference	4.6%	3.6%	1.6%	1.6%	10.7%
					Final Effluent Area	2.1%	2.9%	1.3%	0.3%	7.2%
Bivalvia (%)	YES	0.057	δ	2.5	Shallow Reference	45.8%	6.2%	2.8%	39.4%	52.5%
					Final Effluent Area	61.5%	13.8%	6.2%	45.1%	81.5%

[a] Data analysis included: α - data untransformed, single factor ANOVA test; β - data untransformed, single factor ANOVA test results confirmed using t-test assuming unequal variance; γ - data logit trar single factor ANOVA test results confirmed using Mann-Whitney U-test; and, δ - data logit transformed, single-factor ANOVA test conducted.

[b] Magnitude calculated by comparing the difference between the reference area and effluent-exposed area means divided by the reference area standard deviation.

▨ Highlighted values indicates significant difference between study areas based on ANOVA p-value less than 0.10.

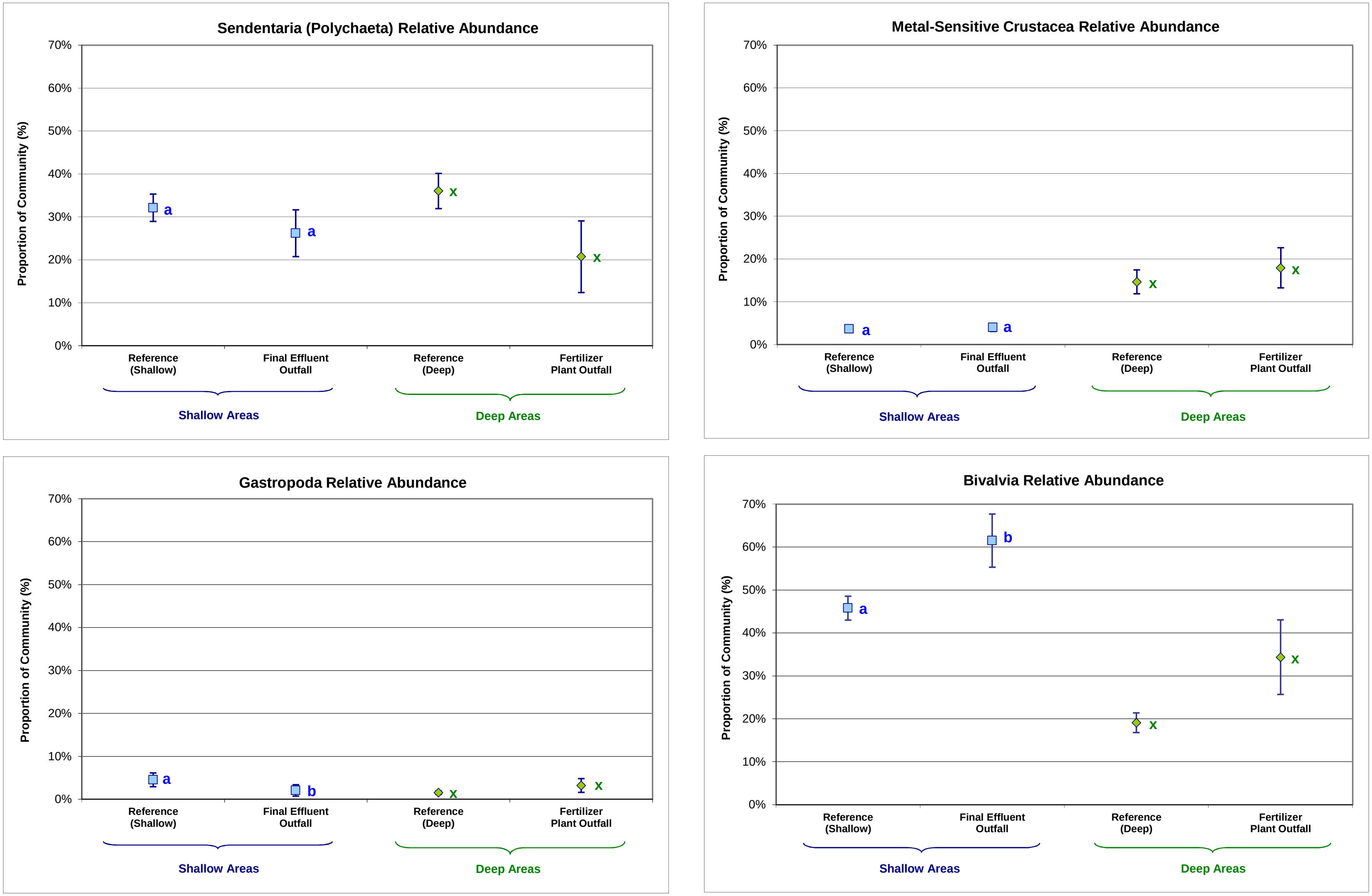


Figure 5.2: Comparison of benthic invertebrate community dominant group relative abundance (mean ± SE, n = 5), Brunswick Smelter Benthic Monitoring Program, October 2014. Data points with the same letter for a,b and x,y pairings applicable to shallow and deep study area comparisons, respectively, do not differ signficantly.

Table 5.2: Temporal comparison of key benthic invertebrate community metrics for the Final Effluent (FE) and Fertilizer Plant Outfall (FPO) study areas versus respective reference study areas, Brunswick Smelter Benthic Monitoring Program, 2004 - 2014.

Endpoint	**Statistically Significant Differences Observed?***							
	Final Effluent (FE) versus Shallow Reference (RS)				Fertilizer Plant Outfall (FPO) versus Deep Reference (RD)			
	2004	2006	2008	2014	2004	2006	2008	2014
Density (organisms/m^2)	No	No	No	**Yes (-1.3)**	No	No	No	**Yes (-1.9)**
Richness	**Yes (+1.2)**	No	No	No	**Yes (-4.2)**	**Yes (-2.4)**	**Yes (-3.1)**	No
Simpson's Evenness	No	No	No	**Yes (-5.0)**	No	No	No	No
Shannon-Weiner Diversity	No	No	No	**Yes (-4.6)**	No	No	No	No
Bray-Curtis Index	-	**Yes (+1.0)**	**Yes (+5.3)**	**Yes (+1.2)**	-	**Yes (+6.2)**	**Yes (+7.9)**	**Yes (-5.1)**
Sedentaria (% of community)	No	**Yes (+1.5)**	**Yes (-3.1)**	No	**Yes (+1.9)**	No	No	No
Metal-Sensitive Crustacea (% of community)	No	**Yes (-2.7)**	No	No	No	No	No	No
Gastropoda (% of community)	No	No	No	**Yes (-0.7)**	No	No	**Yes (+8.1)**	No
Bivalvia (% of community)	No	No	No	**Yes (+2.5)**	No	No	No	No

* Magnitude of difference (in brackets) expressed as number of standard deviations (SD) from the reference mean.

Shannon-Weiner Diversity and Evenness, and gastropod abundance differed significantly at the Final Effluent area in 2014 compared to 2008 taking changes at the Shallow Reference area into account (Figures 5.3 and 5.4; Appendix Table C.3). For each of these endpoints, values at the Final Effluent area were consistently lower than at the Shallow Reference area. Because no differences were indicated between the Final Effluent area and reference for these metrics in the 2004 - 2008 benthic monitoring studies (Table 5.2), these results suggested subtle changes in benthic invertebrate community structure since 2008. It is noteworthy that these subtle temporal changes in community structure at the Final Effluent area were coincident with higher sediment metal concentrations at this area over the same time period (Section 4.1), suggesting a potential causal link. However, Final Effluent area benthic invertebrate community metrics in 2014 were generally within ranges observed from 2004 – 2008 (Figure 5.3). In addition, no consistent direction of change was evident for any benthic indices or community structure endpoints at the Final Effluent area over time with the exception of taxonomic richness, which appeared to have decreased more recently (Figures 5.3 and 5.4). Overall, changes in benthic invertebrate community density and structure were evident at the Final Effluent area since 2008 that may be associated with higher sediment metal concentrations at this area over the same time period. However, the indicated changes were subtle, and most benthic endpoints at the Final Effluent area in 2014 were within historical ranges, suggesting that any changes over time may have reflected natural temporal and/or seasonal variability in benthic invertebrate community features between separate Baie des Chaleurs sampling areas.

5.2 Fertilizer Plant Outfall (FPO) Study Area

5.2.1 Existing Conditions

Benthic invertebrate density was significantly lower at the Fertilizer Plant Outfall area compared to the Deep Reference area, with the difference between areas near the ecologically meaningful magnitude of ±2 SD_{REF} (Figure 5.1; Table 5.3). However, taxonomic richness and indices of diversity and evenness did not differ significantly between the Fertilizer Plant Outfall area and reference (Figure 5.1; Table 5.3). Moreover, because Shannon-Weiner Diversity (SWD) greater than 3.0 units generally indicate an unimpaired benthic invertebrate community (Washington 1984), a mean SWD of 3.4 at the Fertilizer Plant Outfall area suggested a relatively healthy benthic invertebrate community at this area. Evenness indices at the Fertilizer Plant Outfall area were also high, indicating a relatively even distribution of taxa across groups and suggesting a well-balanced benthic invertebrate community structure. Although Bray-Curtis Index differed significantly between the Fertilizer Plant Outfall and Deep

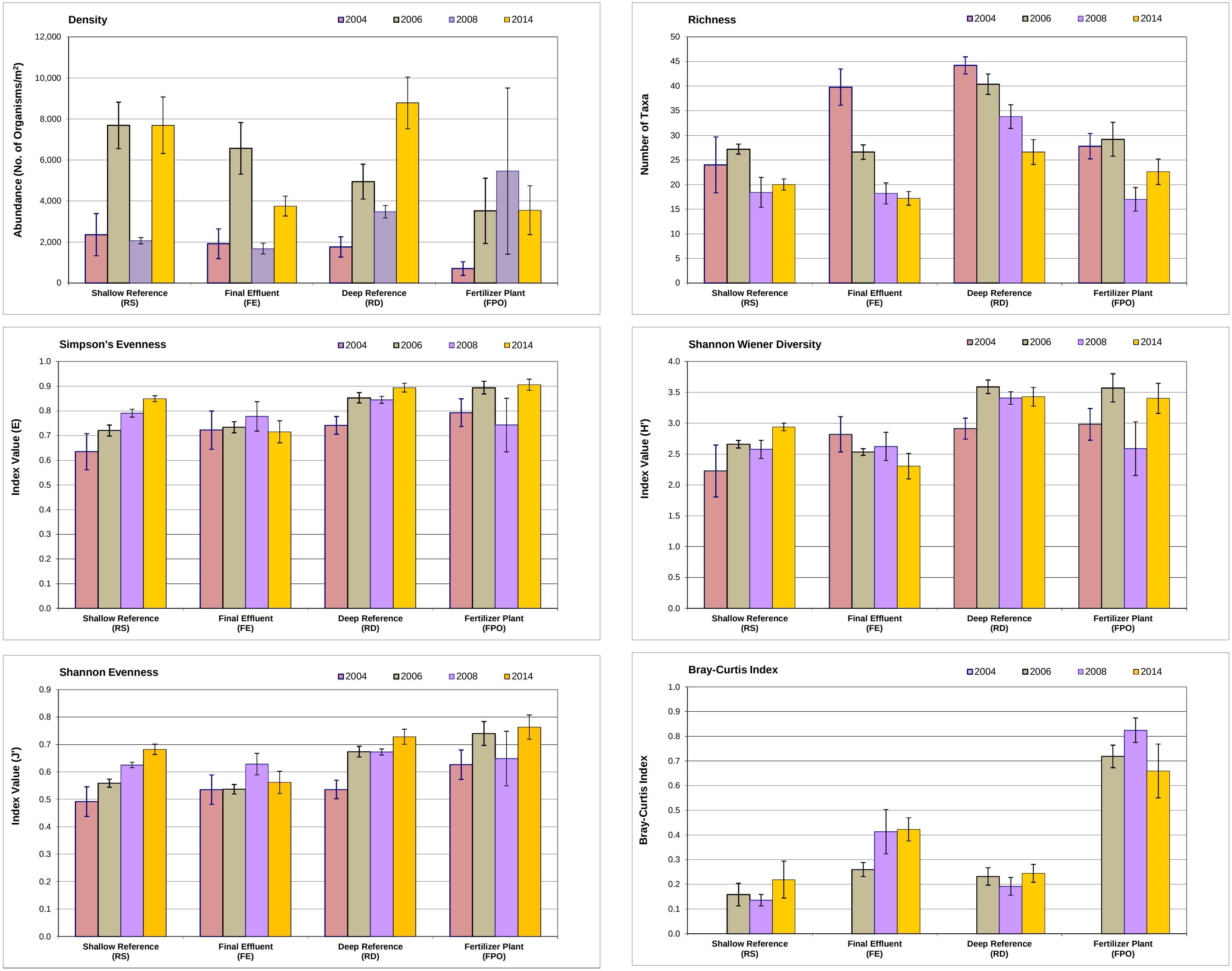
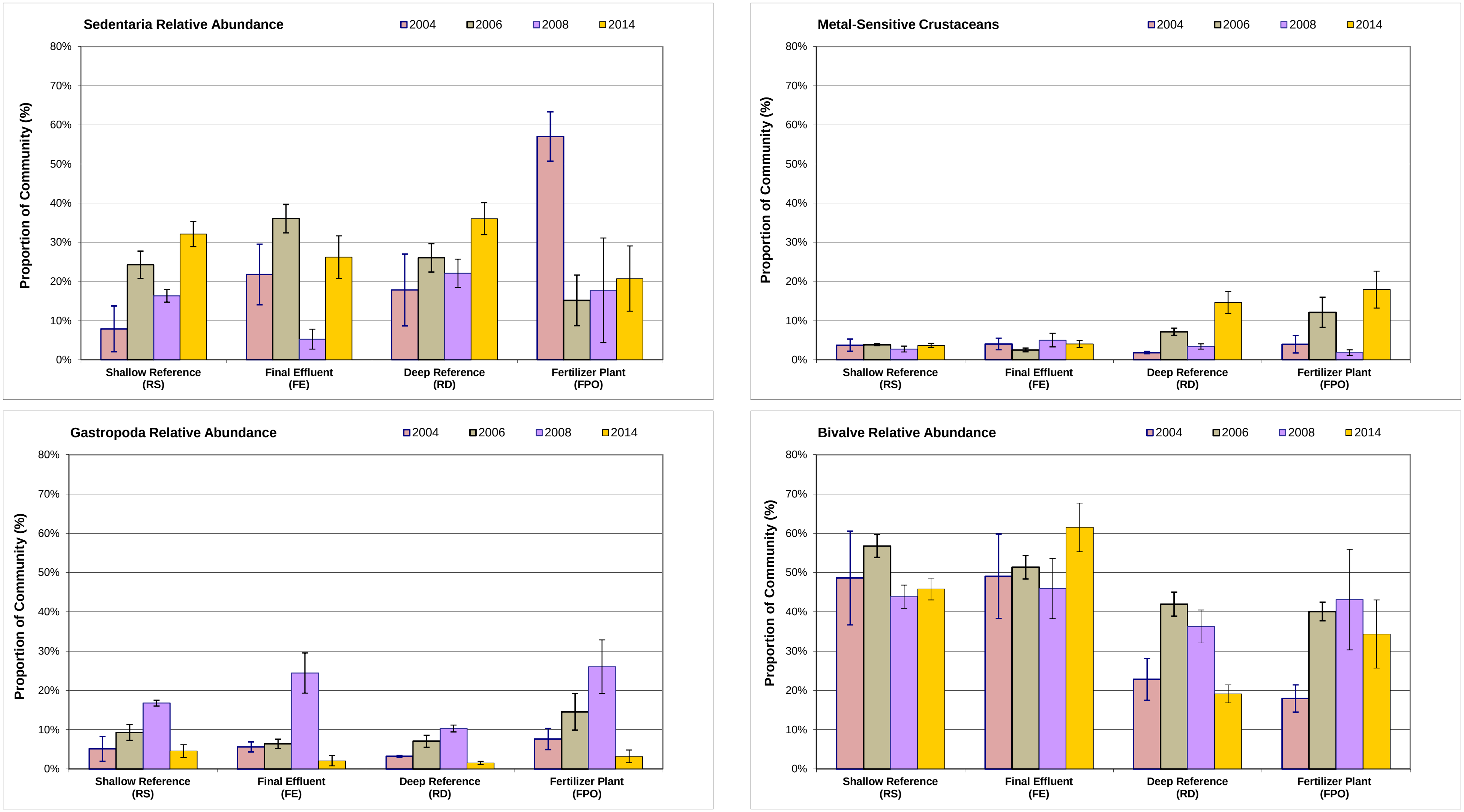


Figure 5.3: Temporal comparison of benthic invertebrate community key indices among effluent-exposed, fertilizer plant outfall, and respective reference areas (mean ± SE; n = 5) since the onset of a control-impact monitoring approach at the Brunswick Smelter, 2004 - 2014.



Sedentaria Relative Abundance

Metal-Sensitive Crustaceans

Gastropoda Relative Abundance

Bivalve Relative Abundance

Figure 5.4: Temporal comparison of benthic invertebrate community dominant groups among effluent-exposed, fertilizer plant outfall, and respective reference areas (mean ± SE; n = 5) since the onset of a control-impact monitoring approach at the Brunswick Smelter, 2004 - 2014.

Table 5.3: Benthic invertebrate community statistical comparison results between the fertilizer plant outfall (FPO) and deep reference (RD) study areas, Brunswick Smelter Benthic Monitoring Program, October 2014.

Metric	Statistical Test Results				Summary Statistics					
	Significant Difference Between Areas?	***p*-value**	**Statistical Analysis[a]**	**Magnitude of Difference [b] (No. of SD)**	**Area**	**Mean**	**Standard Deviation**	**Standard Error**	**Minimum**	**Maximum**
Density (Individuals/m^2)	YES	0.017	α	-1.9	Deep Reference	8,782	2,819	1,261	5,905	12,654
					Fertilizer Plant Outfall	3,548	2,664	1,191	489	6,003
Richness (Number of Taxa)	NO	0.303	α	-	Deep Reference	26.6	5.7	2.5	21.0	36.0
					Fertilizer Plant Outfall	22.6	5.8	2.6	14.0	28.0
Simpson's Diversity	NO	0.902	α	-	Deep Reference	0.859	0.040	0.018	0.796	0.899
					Fertilizer Plant Outfall	0.863	0.053	0.023	0.788	0.910
Simpson's Evenness (E)	NO	0.695	α	-	Deep Reference	0.894	0.040	0.018	0.827	0.925
					Fertilizer Plant Outfall	0.906	0.050	0.022	0.826	0.955
Shannon-Weiner Diversity (H')	NO	0.929	α	-	Deep Reference	3.428	0.342	0.153	2.967	3.864
					Fertilizer Plant Outfall	3.402	0.546	0.244	2.700	3.849
Shannon-Weiner Evenness (J')	NO	0.517	α	-	Deep Reference	0.728	0.061	0.027	0.624	0.787
					Fertilizer Plant Outfall	0.764	0.099	0.044	0.605	0.876
Bray-Curtis Index	YES	0.007	β	5.1	Deep Reference	0.245	0.081	0.036	0.129	0.325
					Fertilizer Plant Outfall	0.660	0.244	0.109	0.370	0.930
Errantia (%)	NO	0.333	δ	-	Deep Reference	26.1%	10.4%	4.7%	12.9%	41.2%
					Fertilizer Plant Outfall	19.9%	6.0%	2.7%	10.8%	27.4%
Sedentaria (%)	NO	0.437	δ	-	Deep Reference	36.0%	9.2%	4.1%	24.1%	48.7%
					Fertilizer Plant Outfall	20.7%	18.6%	8.3%	0.0%	41.4%
Metal-Sensitive Crustaceans (%)	NO	0.597	δ	-	Deep Reference	14.7%	6.2%	2.8%	4.6%	21.5%
					Fertilizer Plant Outfall	17.9%	10.5%	4.7%	8.4%	35.0%
Gastropoda (%)	NO	0.256	γ	-	Deep Reference	1.5%	0.9%	0.4%	0.0%	2.2%
					Fertilizer Plant Outfall	3.2%	3.6%	1.6%	0.0%	8.4%
Bivalvia (%)	NO	0.116	δ	-	Deep Reference	19.1%	5.1%	2.3%	11.2%	25.5%
					Fertilizer Plant Outfall	34.3%	19.4%	8.7%	16.2%	65.7%

[a] Data analysis included: α - data untransformed, single factor ANOVA test; β - data untransformed, single factor ANOVA test results confirmed using t-test assuming unequal variance; γ - data logit tran
single factor ANOVA test results confirmed using Mann-Whitney U-test; and, δ - data logit transformed, single-factor ANOVA test conducted.

[b] Magnitude calculated by comparing the difference between the reference area and effluent-exposed area means divided by the reference area standard deviation.

▨ Highlighted values indicates significant difference between study areas based on ANOVA p-value less than 0.10.

Reference study areas suggesting differences in community structure (Figure 5.1), no significant differences were indicated between these study areas for any dominant taxonomic groups (Figure 5.2; Table 5.3). Therefore, the significant difference in Bray-Curtis Index indicated between study areas likely reflected variability in organism density at Fertilizer Plant Outfall area stations rather than any marked differences in overall taxonomic composition (see Appendix Table C.1).

As in previous studies, benthic invertebrate community endpoints were highly variable among Fertilizer Plant Outfall area stations in 2014, suggesting a ‘patchy’ distribution of benthic invertebrates in this area. Notably, lowest density, highest Bray-Curtis Index (suggesting greatest difference from reference) and marked differences in community composition were apparent at Fertilizer Plant Outfall (FPO) stations FPO-3 and FPO-4 compared to other FPO stations and to the Deep Reference stations (Appendix Table C.1). These two Fertilizer Plant Outfall stations were associated with a compact gypsum deposit, whereas natural substrates were more prevalent at the remaining three FPO stations (Appendix Table B.1) indicating more advanced recovery to natural habitat conditions at these latter stations. This suggested that differences in benthic invertebrate community endpoints between the Fertilizer Plant Outfall area and reference were likely driven largely by altered physical habitat at the Fertilizer Plant Outfall (i.e., the compact gypsum bed). Historical reports had also attributed differences in benthic invertebrate community richness and community assemblage at the Fertilizer Plant Outfall compared to reference with altered physical habitat due to the discharge of gypsum-based slurry at the Fertilizer Plant Outfall in the past (e.g., Minnow 2005, 2007, 2009).

5.2.2 Temporal Comparisons

Temporal comparisons indicated only minor change in the number of indices that differed significantly between the Fertilizer Plant Outfall area and reference in 2014 versus the previous three studies, with only the Bray-Curtis Index showing any consistent differences study-to-study (Table 5.2). This was consistent with no significant changes in sediment metal concentrations at the Fertilizer Plant Outfall in 2014 compared to studies conducted from 2004 – 2008 (Section 4.2). Two-way factorial analysis of the benthic endpoints indicated that only taxonomic richness differed significantly at the Fertilizer Plant Outfall area in 2014 compared to 2008 when simultaneously considering changes at the Deep Reference area (Figures 5.3 and 5.4; Appendix Table C.5). However, this difference reflected increased richness at the Fertilizer Plant Outfall area relative to reference in 2014 compared to 2008 (Figure 5.3), suggesting closer comparability between areas in 2014 (i.e., improved conditions). This slight improvement in benthic invertebrate community condition at the Fertilizer Plant Outfall in 2014 was consistent with slow but on-going habitat recovery, including erosion, dissipation and/or burial of the gypsum bed, over time as reported by Minnow (2015).

6.0 CONCLUSIONS

The objectives of the Brunswick Smelter 2014 BMP were to evaluate any current effluent-related effects on sediment quality and benthic invertebrates in the Baie des Chaleurs, to document current sediment quality and benthic invertebrate community conditions at the area historically influenced by the gypsum-based effluent deposit at the Fertilizer Plant outfall, and to compare the 2014 results to previous studies to assess any changes in sediment quality and/or benthic invertebrate conditions over time. To meet these objectives, *in-situ* water quality, sediment quality and benthic invertebrate community assessment was conducted at the active lead smelter Final Effluent discharge area and the historical Fertilizer Plant Outfall area using two areas that have been relatively uninfluenced by current or historical smelter operations in the Baie des Chaleurs (Shallow- and Deep-Reference areas) as a basis for the evaluation of effects. The principal conclusions from the Brunswick Smelter 2014 BMP study are:

1) No smelter-related influences on *in-situ* water quality were indicated at the Final Effluent area or the Fertilizer Plant Outfall area in 2014 based on similarity in water temperature, dissolved oxygen, salinity, pH and turbidity (as reflected by Secchi depth) between surface and bottom measures, and through comparisons to Baie des Chaleurs reference areas.

2) At the Final Effluent area, sediment metal concentrations were elevated compared to reference, with lead and zinc concentrations greater than guideline Probable Effect Levels (PEL) and arsenic, cadmium and copper above guideline threshold effect levels (i.e., ISQG) in 2014. The benthic invertebrate community of the Final Effluent area in 2014 showed significantly lower density, diversity and evenness, as well as significant differences in Bray-Curtis Index, compared to reference. However, in some cases, the differences in benthic metrics between areas were not ecologically meaningful (based on comparison to accepted environmental monitoring CES), and no differences in the relative abundance of metal-sensitive groups were indicated between areas, suggesting that any effects associated with sediment metal concentrations at the Final Effluent area were minor. Nevertheless, temporal comparisons indicated higher sediment metal concentrations at the Final Effluent area in 2014 compared to the 2004 – 2008 studies, as well as significantly lower benthic invertebrate community density and differences in community structure in 2014 versus these earlier studies. Although these temporal differences in benthic invertebrate community endpoints were subtle (e.g., most benthic indices at the Final Effluent area in 2014 were within historical ranges, no differences in abundance of metal-sensitive groups were indicated), higher

sediment metal concentrations at this area over time suggested a potential causal link. Because lead smelter effluent quantity and quality have remained relatively consistent since 2006, the most likely contributors to elevated metal concentrations in sediment near the current lead smelter discharge in 2014 compared to 2008 were dredging activity at the Port of Belledune in 2010, and significant erosion of the former slag pile in December 2010 as a result of an especially large storm event. In turn, higher sediment metal concentrations at the Final Effluent area in 2014 may have contributed to temporal differences in benthic invertebrate community endpoints indicated at this area since 2008.

3) At the Fertilizer Plant Outfall, sediment was characterized by high concentrations of calcium, strontium and uranium, and minor elevation in antimony, lead and zinc concentrations compared to reference. However, no metal concentrations were above PEL, and only lead and zinc were above ISQG threshold levels. The benthic invertebrate community of the Fertilizer Plant Outfall area in 2014 showed significantly lower density and significant differences in Bray-Curtis Index, compared to reference, which appeared to be associated with altered physical habitat at the Fertilizer Plant Outfall (i.e., the compact gypsum bed). Temporal comparisons indicated no significant changes in sediment metal concentrations at the Fertilizer Plant Outfall in 2014 compared to studies conducted from 2004 – 2008. In addition, no substantial changes in benthic invertebrate community endpoints were indicated since 2008 at the Fertilizer Plant Outfall area, perhaps with the exception of a slight improvement in taxonomic richness relative to reference. In turn, this suggested slow but continuous habitat recovery with time at the area affected by gypsum deposits from the former Fertilizer Plant discharge (e.g., through erosion, dissipation and/or burial of the gypsum bed).

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APPENDIX A

WATER AND EFFLUENT QUALITY INFORMATION

Table A.1: Summary of surface and bottom field-based water quality measures, Brunswick Smelter Benthic Monitoring Program, October 2014.

Location		Date Sampled	Coordinates (latitude longitude)	Tide Corrected Depth (m)	Secchi Depth[a] (m)	Profile Depth	Temp. (°C)	Dissolved Oxygen		Salinity (ppt)	pH (units)
								(mg/L)	(% sat.)		
Shallow Reference	RS-1	7-Oct-14	47 54.962	3.42	> 5.2	surface	12.86	9.19	103.2	27.30	7.87
			65 53.160			bottom	12.85	9.18	103.0	27.31	7.88
	RS-2	8-Oct-14	47 55.156	3.48	> 5.4	surface	12.92	8.82	99.0	27.28	7.85
			65 53.574			bottom	12.90	8.77	98.4	27.29	7.85
	RS-3	8-Oct-14	47 55.113	3.45	> 5.5	surface	12.98	8.83	99.3	27.28	7.83
			65 53.540			bottom	12.89	8.76	98.4	27.29	7.82
	RS-4	8-Oct-14	47 55.096	2.89	> 5.1	surface	13.11	8.88	99.9	26.98	7.81
			65 53.524			bottom	12.86	8.74	98.0	27.21	7.80
	RS-5	8-Oct-14	47 55.122	2.74	> 5.0	surface	13.10	8.87	99.8	27.12	7.84
			65 53.577			bottom	12.84	8.69	97.4	27.20	7.83
Final Effluent Outfall	FE-1	9-Oct-14	47 54.115	3.36	4.4	surface	12.43	8.88	98.7	27.32	7.87
			65 49.541			bottom	12.41	8.85	98.4	27.33	7.87
	FE-2	10-Oct-14	47 54.087	2.93	> 3.6	surface	12.09	8.50	94.5	26.97	7.82
			65 49.528			bottom	12.10	8.57	94.4	26.94	7.81
	FE-3	6-Oct-14	47 54.067	2.82	> 4.3	surface	12.92	9.02	101.2	27.10	8.10
			65 49.548			bottom	12.64	9.00	100.4	27.15	8.10
	FE-4	6-Oct-14	47 54.012	3.64	5.0	surface	12.61	9.04	100.7	27.08	8.09
			65 49.398			bottom	12.54	8.97	99.9	27.15	8.09
	FE-5	6-Oct-14	47 54.037	3.14	4.5	surface	12.66	9.02	100.6	27.01	8.07
			65 49.452			bottom	12.49	8.95	99.5	27.11	8.07
Deep Reference	RD-1	8-Oct-14	47 55.169	7.21	4.9	surface	12.54	8.83	90.2	27.05	7.84
			65 53.026			bottom	12.50	8.67	96.4	27.11	7.83
	RD-2	8-Oct-14	47 55.136	6.80	-	surface	12.79	8.80	98.4	27.09	7.84
			65 53.051			bottom	12.54	8.70	96.8	27.12	7.84
	RD-3	9-Oct-14	47 55.181	7.25	5.2	surface	12.38	8.73	97.0	27.45	7.86
			65 53.061			bottom	12.39	8.67	96.3	27.46	7.86
	RD-4	9-Oct-14	47 55.147	6.87	5.2	surface	12.38	8.89	98.8	27.33	7.87
			65 53.086			bottom	12.37	8.82	98.0	27.26	7.87
	RD-5	9-Oct-14	47 55 181	7.23	5.1	surface	12.29	9.10	100.8	27.26	7.88
			65 53.112			bottom	12.31	9.07	100.6	27.28	7.88
Fertilizer Plant Outfall	FPO-1	9-Oct-14	47 54.721	6.51	5.9	surface	15.59	8.40	99.5	27.31	7.80
			65 51.447			bottom	12.53	8.54	95.2	27.37	7.84
	FPO-2	9-Oct-14	47 54.736	6.74	5.6	surface	14.41	8.39	97.1	27.32	7.81
			65 51.329			bottom	12.61	8.52	95.4	27.36	7.83
	FPO-3	9-Oct-14	47 54.780	6.96	5.5	surface	12.76	8.52	95.3	27.18	7.82
			65 51.194			bottom	12.34	8.57	95.0	27.17	7.83
	FPO-4	6-Oct-14	47 54.806	6.92	6.2	surface	13.20	9.10	102.8	27.13	8.11
			65 51.104			bottom	12.75	9.17	102.6	27.23	8.12
	FPO-5	6-Oct-14	47 54.803	6.24	6.4	surface	13.60	9.15	104.1	27.10	8.10
			65 50.990			bottom	12.78	9.22	103.2	27.21	8.12

[a] Secchi depth greater than water depth indicated by a ' > '; Secchi depth greater than water depth take into account tide level at time of sampling.

Table A.2: Summary of *in-situ* bottom water quality measures and station depth, Brunswick Smelter Benthic Monitoring Program, October 2014.

Parameter	Study Area	Mean	Standard Deviation	Standard Error	95% Confidence Interval		Min	Max
					Lower Bound	Upper Bound		
Station Depth (m)	Reference - Shallow (RS)	3.2	0.4	0.2	2.8	3.6	2.7	3.5
	Final Effluent Outfall (FE)	3.2	0.3	0.1	2.8	3.6	2.8	3.6
	Reference - Deep (RD)	7.1	0.2	0.1	6.8	7.3	6.8	7.3
	Fertilizer Plant Outfall (FPO)	6.7	0.3	0.1	6.3	7.0	6.2	7.0
Temperature (°C)	Reference - Shallow (RS)	12.87	0.02	0.01	12.84	12.90	12.84	12.90
	Final Effluent Outfall (FE)	12.43	0.21	0.09	12.18	12.69	12.10	12.64
	Reference - Deep (RD)	12.42	0.10	0.04	12.30	12.54	12.31	12.54
	Fertilizer Plant Outfall (FPO)	12.60	0.18	0.08	12.38	12.83	12.34	12.78
Dissolved Oxygen (mg/L)	Reference - Shallow (RS)	8.83	0.20	0.09	8.58	9.08	8.69	9.18
	Final Effluent Outfall (FE)	8.87	0.18	0.08	8.65	9.09	8.57	9.00
	Reference - Deep (RD)	8.79	0.17	0.08	8.57	9.00	8.67	9.07
	Fertilizer Plant Outfall (FPO)	8.80	0.36	0.16	8.36	9.25	8.52	9.22
Salinity (ppt)	Reference - Shallow (RS)	27.26	0.05	0.02	27.20	27.32	27.20	27.31
	Final Effluent Outfall (FE)	27.14	0.14	0.06	26.96	27.31	26.94	27.33
	Reference - Deep (RD)	27.25	0.14	0.06	27.07	27.42	27.11	27.46
	Fertilizer Plant Outfall (FPO)	27.27	0.09	0.04	27.15	27.38	27.17	27.37
pH (pH units)	Reference - Shallow (RS)	7.84	0.03	0.01	7.80	7.87	7.80	7.88
	Final Effluent Outfall (FE)	7.99	0.14	0.06	7.82	8.16	7.81	8.10
	Reference - Deep (RD)	7.86	0.02	0.01	7.83	7.88	7.83	7.88
	Fertilizer Plant Outfall (FPO)	7.95	0.16	0.07	7.75	8.14	7.83	8.12
Secchi Depth (m)	Reference - Shallow (RS)	5.2	0.2	0.1	4.9	5.5	5.0	5.5
	Final Effluent Outfall (FE)	4.4	0.5	0.2	3.7	5.0	3.6	5.0
	Reference - Deep (RD)	5.1	0.1	0.1	4.9	5.4	4.9	5.2
	Fertilizer Plant Outfall (FPO)	5.9	0.4	0.2	5.4	6.4	5.5	6.4

Table A.3: Summary of *in-situ* water quality and depth statistical comparisons among study areas, Brunswick Smelter Benthic Monitoring Program, October 2014.

Parameter	**Five-group Comparison**			**Pair-wise Comparisons**				
	Significant Difference Among Areas?	**p-value**	**Statistical Test**	**(I) Area**	**(J) Area**	**Significant Difference Between Two Areas?**	**p-value**	**Statistical Test[a]**
Station Depth (m)	YES	0.000	ANOVA	Reference - Shallow (RS)	Final Effluent Outfall (FE)	NO	1.000	Tukey's HSD
				"	Reference - Deep (RD)	YES	0.000	
				"	Fertilizer Plant Outfall (FPO)	YES	0.000	
				Final Effluent Outfall (FE)	Reference - Deep (RD)	YES	0.000	
				"	Fertilizer Plant Outfall (FPO)	YES	0.000	
				Reference - Deep (RD)	Fertilizer Plant Outfall (FPO)	NO	0.207	
Temperature (°C)	YES	0.001	ANOVA	Reference - Shallow (RS)	Final Effluent Outfall (FE)	YES	0.001	Tukey's HSD
				"	Reference - Deep (RD)	YES	0.001	
				"	Fertilizer Plant Outfall (FPO)	YES	0.049	
				Final Effluent Outfall (FE)	Reference - Deep (RD)	NO	0.999	
				"	Fertilizer Plant Outfall (FPO)	NO	0.305	
				Reference - Deep (RD)	Fertilizer Plant Outfall (FPO)	NO	0.252	
Dissolved Oxygen (mg/L)	NO	0.953	ANOVA	Reference - Shallow (RS)	Final Effluent Outfall (FE)	NO	1.000	Tamhane's
				"	Reference - Deep (RD)	NO	1.000	
				"	Fertilizer Plant Outfall (FPO)	NO	1.000	
				Final Effluent Outfall (FE)	Reference - Deep (RD)	NO	0.979	
				"	Fertilizer Plant Outfall (FPO)	NO	1.000	
				Reference - Deep (RD)	Fertilizer Plant Outfall (FPO)	NO	1.000	
Salinity (ppt)	NO	0.252	ANOVA	Reference - Shallow (RS)	Final Effluent Outfall (FE)	NO	0.335	Tukey's HSD
				"	Reference - Deep (RD)	NO	0.997	
				"	Fertilizer Plant Outfall (FPO)	NO	0.999	
				Final Effluent Outfall (FE)	Reference - Deep (RD)	NO	0.435	
				"	Fertilizer Plant Outfall (FPO)	NO	0.285	
				Reference - Deep (RD)	Fertilizer Plant Outfall (FPO)	NO	0.989	
pH (pH units)	NO	0.112	ANOVA	Reference - Shallow (RS)	Final Effluent Outfall (FE)	NO	0.341	Tamhane's
				"	Reference - Deep (RD)	NO	0.841	
				"	Fertilizer Plant Outfall (FPO)	NO	0.724	
				Final Effluent Outfall (FE)	Reference - Deep (RD)	NO	0.460	
				"	Fertilizer Plant Outfall (FPO)	NO	0.999	
				Reference - Deep (RD)	Fertilizer Plant Outfall (FPO)	NO	0.848	
Secchi Depth (m)	-	-	-	Reference - Shallow (RS)	Final Effluent Outfall (FE)	Not Applicable	-	ANOVA
				"	Reference - Deep (RD)	Not Applicable	-	
				"	Fertilizer Plant Outfall (FPO)	Not Applicable	-	
				Final Effluent Outfall (FE)	Reference - Deep (RD)	Not Applicable	-	
				"	Fertilizer Plant Outfall (FPO)	Not Applicable	-	
				Reference - Deep (RD)	Fertilizer Plant Outfall (FPO)	YES	0.020	

[a] Post-hoc analysis of 1-way ANOVA among all areas protected for multiple comparisons

Table A.4: Summary of effluent discharge (m^3) from the lead smelter Waste Water Treatment Plant (WWTP), Brunswick Smelter, 2006 - 2014.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2006	72,212	55,153	76,286	96,488	96,197	77,505	75,663	44,807	59,368	84,697	102,627	75,581	**916,584**
2007	59,976	57,963	90,335	76,337	88,710	87,575	80,684	74,258	60,635	70,079	88,375	73,130	**908,057**
2008	68,607	70,972	58,713	101,239	94,966	95,320	89,928	97,031	85,653	103,744	108,623	83,952	**1,058,748**
2009	56,345	50,601	75,182	123,112	99,326	87,634	92,429	79,466	57,662	88,982	74,837	91,695	**977,271**
2010	82,691	68,730	53,609	80,047	99,692	82,717	91,452	63,193	107,892	106,032	76,623	119,482	**1,032,160**
2011	72,082	52,591	83,234	95,219	112,799	99,620	85,373	118,828	85,790	67,386	59,260	67,125	**999,307**
2012	52,684	62,582	90,183	109,324	94,065	80,073	82,407	83,374	53,967	82,541	69,539	66,112	**926,851**
2013	70,729	46,461	90,183	59,446	84,198	93,491	88,464	98,862	94,512	63,494	48,938	52,655	**891,433**
2014	53,858	54,753	54,588	107,938	98,273	85,563	94,193	84,901	66,197	68,645	94,227	95,260	**958,396**
Average	65,465	57,756	74,701	94,350	96,470	87,722	86,733	82,747	74,631	81,733	80,339	80,555	**963,201**

Table A.5: Yearly average trace metal concentrations (mg/L) of various site-related discharges at the Brunswick Smelter, 2006 - 2014.

Location	Metal	2006	2007	2008	2009	2010	2011	2012	2013	2014
Lead Smelter Final Effluent	Arsenic	0.020	0.030	0.031	0.027	0.017	0.017	0.019	0.007	0.011
	Cadmium	0.016	0.020	0.023	0.021	0.010	0.024	0.028	0.044	0.045
	Copper	0.011	0.010	0.010	0.011	0.006	0.010	0.009	0.008	0.013
	Iron	0.070	0.100	0.096	0.054	0.023	0.100	0.083	0.100	0.015
	Lead	0.040	0.030	0.032	0.042	0.020	0.016	0.026	0.009	0.011
	Zinc	0.142	0.170	0.345	0.237	0.156	0.210	0.476	0.279	0.200
Salt Water Outlet	Arsenic	0.055	0.018	0.017	0.018	0.011	0.012	0.012	-	-
	Cadmium	0.025	0.032	0.034	0.054	0.017	0.020	0.016	-	-
	Copper	0.008	0.029	0.030	0.040	0.015	0.016	0.015	-	-
	Iron	0.073	<0.5	0.491	<0.5	<0.5	<0.5	<0.5	-	-
	Lead	0.033	0.063	0.051	0.068	0.034	0.049	0.030	-	-
	Zinc	0.113	0.095	0.089	0.091	0.099	0.103	0.109	-	-
West Diversion Ditch	Arsenic	-	-	<0.02	0.03	0.02	<0.02	<0.02	<0.02	0.023
	Cadmium	-	-	<0.01	0.01	0.02	<0.01	<0.01	<0.01	<0.01
	Copper	-	-	<0.01	0.01	0.03	<0.01	<0.01	<0.01	0.012
	Iron	-	-	0.03	0.03	0.09	0.05	0.045	0.029	0.186
	Lead	-	-	<0.02	0.03	0.11	0.06	0.072	0.035	0.093
	Zinc	-	-	0.06	0.03	0.04	0.038	0.045	0.056	0.039
East Diversion Ditch	Arsenic	-	-	<0.020	<0.020	<0.020	< 0.02	< 0.02	< 0.02	< 0.02
	Cadmium	-	-	<0.010	<0.010	<0.010	< 0.01	<0.01	<0.01	<0.01
	Copper	-	-	<0.010	<0.010	0.01	<0.01	<0.01	<0.01	<0.01
	Iron	-	-	0.054	0.038	0.065	0.183	0.103	0.064	0.075
	Lead	-	-	0.04	0.028	0.025	0.042	0.020	0.031	0.029
	Zinc	-	-	0.068	0.036	0.04	0.059	0.053	0.059	0.034

APPENDIX B

SEDIMENT QUALITY DATA

SEDIMENT DATA QUALITY REVIEW

APPENDIX B SEDIMENT DATA QUALITY REVIEW

Quality Assurance/Quality Control (QA/QC) implemented for the Brunswick Smelter 2014 Benthic Monitoring Program (BMP) included a Data Quality Review (DQR) of the sediment data to provide an evaluation of how well data quality compared to prescribed goals referred to as Data Quality Objectives (DQO), which were set *a priori*. This DQR report provides a comparison of target data quality to actual data quality, subsequently discussing the consequences of any failures to meet DQO. By completing this step, the quality of the data for the program can be effectively evaluated and demonstrated.

B.1 Quality Control Measures, Sample Types and DQO

Quality control (QC) measures used to gauge the analytical adequacy and scientific defensibility of data collected in the current study can be broadly grouped into a) **reagent blank analysis** (i.e., evaluation of the contribution of reagents and the preparative analytical steps to errors in measurement), b) **accuracy measures** (i.e., the degree of agreement between an observed value and the true value) and, c) **precision measures** (i.e., the degree of variation among individual measurements of the same variable among replicate analyses of a sample). Three types of QC samples were prepared in the laboratory or collected in the field for assessment as part of the sediment quality study component. These samples, and a description of each, include the following:

- **Laboratory (Reagent) Blanks** are randomly selected laboratory analysis vials that are filled with de-ionized water and/or appropriate laboratory reagent(s) which are analyzed as a regular sample. These samples allow an assessment of the potential contribution of any contaminants associated with the analysis vial, the laboratory reagents, and/or sample handling to the reported concentrations in water (or applicable digests). The DQO for sediment laboratory (reagent) blanks was set at two-times the laboratory method detection limit (MDL).

- **Laboratory Duplicates** are replicate sub-samples created in the laboratory from randomly selected field samples which are sub-sampled and then analyzed separately using identical methods. These samples allow an assessment of variability that may occur during laboratory analysis (i.e., analytical precision). The DQO for laboratory sediment duplicates was ± 20% relative percent difference between laboratory replicates.

- **Field Duplicates** are replicate samples collected from randomly selected field stations using identical collection and handling methods that are then analyzed separately in the laboratory. Field duplicates were collected as split-samples in this study. Field duplicate samples may reflect small-scale spatial differences in the distribution of analytes, variability associated with sampling, sample handling/contamination in the field, and/or any analytical imprecision. The DQO for field sediment duplicates was ± 40% relative percent difference between field replicates.

B.2 Sediment DQR Results

Reagent Blank Analyses

Data quality objectives for reagent blank analyses were met for the majority of sediment chemistry parameters, with only tin not meeting the DQO of two-times the MDL (Table B-DQR.1) suggesting potential influences of laboratory equipment and/or the reagent itself to the results of test sample analyses. Because reagent blank analyses for tin was four-times higher than its MDL in approximately half of the samples tested (suggesting that tin data may not be accurate representations of true environmental conditions), and because tin is not a parameter of concern at the Brunswick Smelter, data for tin were not included in further data analysis and interpretation for the sediment quality component of the 2014 BMP. However, reagent blank analyses for all other parameters in the six samples assessed returned non-detectable analyte concentrations, indicating no inadvertent contamination of samples within the laboratory during analysis.

Laboratory and Field Precision

Laboratory precision, evaluated as the relative percent difference (RPD) between laboratory duplicates, indicated that most parameters were within the relative percent difference DQO of 20% (Table B-DQR.2). However, comparisons between duplicate samples indicated that arsenic, cadmium, copper, rubidium and thallium were each slightly outside of the target RPD in one of the three samples assessed (Table B-DQR.2). Although the margin by which these metals failed to meet the DQO was small and, in part, may have reflected an artifact of RPD analysis (i.e., at low concentrations, small absolute differences in duplicate concentrations can result in relatively large RPD), the DQR suggested some potential for minor internal variation among individual lab results for these parameters. Therefore, some caution was warranted in the evaluation of these metals when reported concentrations are near MDL during interpretation of sediment quality data for the Brunswick Smelter BMP in 2014.

Field precision was evaluated through the analysis of field duplicates collected at stations FE-4 and FPO-4. Comparison of RPD in metal concentrations between field duplicates indicated that all metals were within the DQO of ±40% RPD for the Final Effluent area station (i.e., FE-4), with the majority of metals also within ±40% RPD for the Fertilizer Plant Outfall area station (i.e., FPO-4; Table B-DQR.3). Although the RPD in metal concentrations between field duplicates collected at Station FPO-4 did not meet DQO for antimony, lead, vanadium and zinc, concentrations of antimony and vanadium were near MDL, and therefore small absolute differences in duplicate concentrations corresponded to these metals not meeting DQO. High RPD in lead and zinc concentrations between field duplicate samples collected at the Fertilizer Plant Outfall area likely reflect high small-scale spatial variability in metal distribution within sediment at this area, rather than any sample handling/contamination in the field and/or analytical imprecision. The Fertilizer Plant Outfall demonstrates varying levels of habitat recovery (Minnow 2015), and therefore sediment metal concentrations at this area are not expected to be uniformly distributed within the substrate as a result of differential patterns in erosion/deposition/gypsum dissipation at this area.

B.3 Sediment DQR Conclusions

Overall, the sediment quality DQR indicated that data were of acceptable quality. Relatively few sediment quality parameters did not meet acceptable DQO, and none consistently failed to meet DQO for all QC sample types. Those that did not meet respective DQO typically showed either very low margins of error relative to respective criteria and/or were observed at low concentrations (often near MDL) which led to relatively small incremental differences in concentrations between replicates resulting in failure to meet DQO. Notable exceptions included frequent detection of tin in reagent blanks, and thus, tin data were not included in further analysis and interpretation for the sediment quality component of the 2014 BMP. Minor laboratory-based variability in reporting of arsenic, cadmium, copper, rubidium and thallium was also indicated and, as a result, some caution is warranted in the interpretation of data associated with these parameters in sediment samples in the current study. However, on the whole, laboratory performance met acceptable criteria, with the resulting data considered scientifically defensible.

Table B-DQR.1: Laboratory reagent blank data, Brunswick Smelter 2014 Benthic Monitoring Program.

Parameter	Method Detection Limit	Replicate 1	Replicate 2	Replicate 3	Replicate 4	Replicate 5	Replicate 6
Aluminum	1	< 1	< 1	< 1	1	< 1	< 1
Antimony	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Arsenic	1	< 1	< 1	< 1	< 1	< 1	< 1
Barium	1	< 1	< 1	< 1	< 1	< 1	< 1
Beryllium	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Bismuth	1	< 1	< 1	< 1	< 1	< 1	< 1
Boron	1	< 1	< 1	< 1	< 1	< 1	< 1
Cadmium	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Calcium	50	< 50	< 50	< 50	< 50	< 50	< 50
Chromium	1	< 1	< 1	< 1	< 1	< 1	< 1
Cobalt	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Copper	1	< 1	< 1	< 1	< 1	< 1	< 1
Iron	20	< 20	< 20	< 20	< 20	< 20	< 20
Lead	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Lithium	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Magnesium	10	< 10	< 10	< 10	< 10	< 10	< 10
Manganese	1	< 1	< 1	< 1	< 1	< 1	< 1
Molybdenum	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	1	< 1	< 1	< 1	< 1	< 1	< 1
Potassium	20	< 20	< 20	< 20	< 20	< 20	< 20
Rubidium	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Selenium	1	< 1	< 1	< 1	< 1	< 1	< 1
Silver	0.1	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Sodium	50	< 50	< 50	< 50	< 50	< 50	< 50
Strontium	1	< 1	< 1	< 1	< 1	< 1	< 1
Tellurium	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Thallium	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Tin	1	4	4	4	< 1	< 1	1
Uranium	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Vanadium	1	< 1	< 1	< 1	< 1	< 1	< 1
Zinc	1	< 1	< 1	< 1	< 1	< 1	< 1

▨ Indicates value did not meet Data Quality Objective of less than 2-times MDL for respective parameter.

Table B-DQR.2: Assessment of laboratory precision, Brunswick Smelter 2014 Benthic Monitoring Program.

Metal	Method Detection Limit	FPO-2 Replicate A	FPO-2 Replicate B	Relative Percent Difference	RS-2 Replicate A	RS-2 Replicate B	Relative Percent Difference	BD-2 Replicate A	BD-2 Replicate B	Relative Percent Difference
Aluminum	1	10200	10300	1%	11300	11300	0%	3100	2990	4%
Antimony	0.1	0.2	0.2	0%	< 0.1	0.1	0%	0.4	0.4	0%
Arsenic	1	5	5	0%	4	5	22%	1	< 1	0%
Barium	1	54	63	15%	118	107	10%	58	57	2%
Beryllium	0.1	0.5	0.5	0%	0.6	0.6	0%	< 0.1	< 0.1	0%
Bismuth	1	< 1	< 1	0%	< 1	< 1	0%	< 1	< 1	0%
Boron	1	12	11	9%	7	7	0%	2	2	0%
Cadmium	0.01	0.82	0.81	1%	0.32	0.34	6%	0.11	0.09	20%
Calcium	50	17300	17200	1%	24800	24400	2%	154000	154000	0%
Chromium	1	23	23	0%	26	25	4%	3	3	0%
Cobalt	0.1	6.7	6.7	0%	9.5	9.5	0%	0.5	0.5	0%
Copper	1	13	10	26%	9	9	0%	4	4	0%
Iron	20	12600	12600	0%	17600	17700	1%	660	620	6%
Lead	0.1	42.5	40.2	6%	19.7	20.2	3%	8.5	9	6%
Lithium	0.1	14.6	14.7	1%	20.4	20.1	1%	0.5	0.5	0%
Magnesium	10	6040	6110	1%	8310	8330	0%	530	510	4%
Manganese	1	203	208	2%	305	311	2%	8	8	0%
Molybdenum	0.1	0.8	0.8	0%	0.3	0.3	0%	0.3	0.3	0%
Nickel	1	21	21	0%	28	28	0%	2	2	0%
Potassium	20	1500	1530	2%	1320	1390	5%	370	340	8%
Rubidium	0.1	7.6	7.8	3%	7.6	8.2	8%	1	0.8	22%
Selenium	1	< 1	< 1	0%	< 1	< 1	0%	< 1	< 1	0%
Silver	0.1	< 0.1	< 0.1	0%	< 0.1	< 0.1	0%	< 0.1	< 0.1	0%
Sodium	50	3700	3750	1%	2330	2550	9%	4140	4280	3%
Strontium	1	64	62	3%	25	24	4%	501	497	1%
Tellurium	0.1	< 0.1	< 0.1	0%	< 0.1	< 0.1	0%	< 0.1	< 0.1	0%
Thallium	0.1	0.4	0.3	29%	0.3	0.3	0%	0.2	0.2	0%
Tin	1	< 1	< 1	0%	< 1	< 1	0%	< 1	< 1	0%
Uranium	0.1	18.5	16.7	10%	0.7	0.7	0%	23.1	20.5	12%
Vanadium	1	24	24	0%	32	33	3%	1	1	0%
Zinc	1	74	76	3%	53	55	4%	9	10	11%

▨ Indicates value did not meet Data Quality Objective of 20% RPD for respective parameter

Table B-DQR.3: Assessment of field precision, Brunswick Smelter 2014 Benthic Monitoring Program.

Metal	Method Detection Limit	FE-4 Replicate A	FE-4 Replicate B	Relative Percent Difference	FPO-4 Replicate A	FPO-4 Replicate B	Relative Percent Difference
Aluminum	1	10200	10000	2%	2950	3045	3%
Antimony	0.1	0.6	0.6	0%	0.6	0.4	40%
Arsenic	1	24	22	9%	1	1	0%
Barium	1	42	56	29%	54	57.5	6%
Beryllium	0.1	0.3	0.4	29%	0.1	0.1	0%
Bismuth	1	2	< 1	0%	< 1	< 1	0%
Boron	1	7	6	15%	2	2	0%
Cadmium	0.01	2.64	2.62	1%	0.11	0.1	10%
Calcium	50	10600	11100	5%	158000	154000	3%
Chromium	1	34	34	0%	4	3	29%
Cobalt	0.1	11.8	11.5	3%	0.5	0.5	0%
Copper	1	56	55	2%	5	4	22%
Iron	20	18100	18000	1%	710	640	10%
Lead	0.1	594	575	3%	13.8	8.75	45%
Lithium	0.1	14.2	14.3	1%	0.4	0.5	22%
Magnesium	10	8670	8620	1%	510	520	2%
Manganese	1	239	237	1%	8	8	0%
Molybdenum	0.1	0.3	0.3	0%	0.3	0.3	0%
Nickel	1	29	28	4%	2	2	0%
Potassium	20	960	950	1%	350	355	1%
Rubidium	0.1	5.2	5.1	2%	0.9	0.9	0%
Selenium	1	< 1	< 1	0%	< 1	< 1	0%
Silver	0.1	0.2	0.2	0%	< 0.1	< 0.1	0%
Sodium	50	1850	2040	10%	4040	4210	4%
Strontium	1	18	20	11%	504	499	1%
Tellurium	0.1	< 0.1	< 0.1	0%	< 0.1	< 0.1	0%
Thallium	0.1	3.1	3.1	0%	0.2	0.2	0%
Tin	1	3	3	0%	< 1	< 1	0%
Uranium	0.1	0.4	0.4	0%	21.3	21.8	2%
Vanadium	1	35	34	3%	2	1	67%
Zinc	1	1250	1240	1%	30	9.5	104%

▨ Indicates value did not meet Data Quality Objective of 40% RPD for respective parameter

TABLES AND FIGURES

Table B.1: Summary of habitat characteristics at Baie des Chaleurs sampling areas, Brunswick Smelter Benthic Monitoring Program, October 2014.

Area	Station	Station Substrate Description	General Sampling Area Description
Reference (Shallow)	RS-1	fine sand; dark to medium brown transitioning to grey at depth suggesting anoxia; slight sulphur odour	Cobble and gravel with small patches of fine sand; sampling conducted at relatively large expanse of compact sand. Water slightly blue-green, clear.
	RS-2	compact medium to coarse sand with some gravel; brown at surface transitioning to grey with depth (2-3 cm) suggesting anoxia, but no sulphur odour	
	RS-3	sand with some gravel; medium brown transitioning to dark grey with depth; no sulphur odour detected	
	RS-4	fine sand; medium brown throughout, with no anoxia suggested; no sulphur odour	
	RS-5	fine sand; medium brown transitioning to grey with depth, suggesting anoxia; no sulphur odour detected	
Final Effluent Outfall	FE-1	sand; medium brown throughout; no anoxia or unusual odours	Coarse sand beach and nearshore area transitioning to gravel-cobble offshore. Water slightly blue-green, slightly turbid only under windy conditions.
	FE-2	sand; medium brown throughout; no anoxia or unusual odours	
	FE-3	sand to silt-sand; medium brown with black/grey layer present at depth suggesting anoxia; slight sulphur odour	
	FE-4	sand; medium brown throughout; no anoxia or unusual odours	
	FE-5	sand; medium brown throughout; no anoxia or unusual odours	
Reference (Deep)	RD-1	coarse sand with some gravel; medium brown throughout; no sulphur odour	Substrate mainly gravel or gravel-cobble, with some patches of sand or sand-gravel. Water slightly blue-green, clear.
	RD-2	coarse sand and gravel; dark brown becoming dark grey with depth (0.5 cm below sediment surface); slight sulphur odour	
	RD-3	sand with gravel; medium brown throughout; no anoxia or unusual odours	
	RD-4	sand with gravel; medium brown throughout; no anoxia or unusual odours	
	RD-5	pea-sized gravel; no anoxia or unusual odours	
Fertilizer Plant Outfall	FPO-1	silt-sand with some gravel; no gypsum visible; medium to dark brown, becoming darker with depth suggesting slight anoxia; metallic odour	Substrate variable, including semi-compact to compact gypsum, silt-sand, sand, and sand-gravel mixitures that may overlie gypsum. Substrate often with metallic or sulphur odour. Water blue-green, clear.
	FPO-2	sand and gravel; light brown with no anoxia suggested; strong metallic odour	
	FPO-3	gravel with sand overlying semi-compact to compact gypsum; medium brown to grey substrate, depending on amount of gypsum present; no anoxia; strong metallic odour	
	FPO-4	fine sand over compact gypsum; grey-brown colouration; no anoxia or unusual odour	
	FPO-5	sand; no gypsum visible; medium brown with no anoxia suggested; moderate metallic/sulphur odour	

Table B.2: Physical and chemical sediment quality replicate data, Brunswick Smelter Benthic Monitoring Program, October 2014.

Parameter	Units	Method Detection Limit	CSQG^{a}		Reference (Shallow)					Final Effluent Outfall					Reference (Deep)					Fertilizer Plant Outfall				
			ISQG	PEL	RS-1 Oct. 7/14	RS-2 Oct. 8/14	RS-3 Oct. 9/14	RS-4 Oct. 9/14	RS-5 Oct. 9/14	FE-1 Oct. 9/14	FE-2 Oct. 10/14	FE-3 Oct. 6/14	FE-4 Oct. 6/14	FE-5 Oct. 6/14	RD-1 Oct. 9/14	RD-2 Oct. 9/14	RD-3 Oct. 9/14	RD-4 Oct. 9/14	RD-5 Oct. 9/14	FPO-1 Oct. 9/14	FPO-2 Oct. 9/14	FPO-3 Oct. 7/14	FPO-4 Oct. 6/14	FPO-5 Oct. 6/14
Gravel	%	0.1	-	-	1.7	2.7	2.9	< 0.1	< 0.1	16.2	5.0	1.7	< 0.1	1.3	1.7	9.3	3.7	12.2	56.5	4.4	15.8	37.2	4.7	< 0.1
Sand	%	0.1	-	-	95.9	91.9	91.8	96.6	94.7	81.8	92.7	95.1	97.7	97.4	94.6	83.9	93.4	82.6	40.3	68.1	69.7	54.5	52.1	99.4
Silt	%	0.1	-	-	1.2	3.2	2.9	1.7	2.9	0.8	1.1	1.5	1.0	0.4	1.7	3.5	1.1	2.7	1.7	23.1	12.8	8.0	42.8	< 0.1
Clay	%	0.1	-	-	1.2	2.1	2.4	1.8	2.4	1.1	1.3	1.7	1.3	1.0	2.0	3.3	1.8	2.5	1.5	4.3	1.7	0.3	0.5	1.1
Total Organic Carbon	%	0.1	-	-	0.4	0.6	0.5	0.4	0.6	0.3	0.4	0.5	0.4	0.3	0.4	0.5	0.3	0.4	0.4	1.3	0.7	0.2	< 0.1	0.1
Aluminum	mg/kg	1	-	-	11,400	11,300	11,300	11,500	11,500	10,500	9,850	10,100	10,100	10,200	9,430	10,500	9,200	10,400	9,440	13,900	10,250	5,180	3,013	1,530
Antimony	mg/kg	0.1	-	-	< 0.1	< 0.1	0.1	0.1	< 0.1	0.4	0.2	0.4	0.6	1.0	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	0.2	1.1	0.5	0.5
Arsenic	mg/kg	1	7.2	41.6	4	5	5	4	5	15	12	19	23	34	6	6	6	5	6	7	5	8	< 1	2
Barium	mg/kg	1	-	-	56	113	116	127	76	183	150	133	49	128	35	78	21	83	17	69	59	35	56	12
Beryllium	mg/kg	0.1	-	-	0.6	0.6	0.6	0.7	0.6	0.4	0.4	0.4	0.4	0.4	0.5	0.6	0.5	0.6	0.5	0.7	0.5	0.4	< 0.1	0.2
Bismuth	mg/kg	1	-	-	< 1	< 1	< 1	< 1	< 1	2	< 1	< 1	2	4	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Boron	mg/kg	1	-	-	5	7	7	6	7	6	7	8	7	7	7	8	6	7	6	17	12	5	2	3
Cadmium	mg/kg	0.1	0.7	4.2	0.37	0.33	0.35	0.38	0.35	1.94	1.47	2.02	2.63	2.63	0.16	0.29	0.18	0.29	0.13	0.83	0.82	0.70	0.10	0.43
Calcium	mg/kg	50	-	-	31,400	24,600	26,100	30,000	29,100	9,160	7,860	12,000	10,850	11,300	5,370	6,470	5,510	6,390	2,880	19,900	17,250	58,500	155,333	16,400
Chromium	mg/kg	1	52.3	161	25	26	25	26	26	35	31	34	34	34	22	24	22	24	20	31	23	19	3	7
Cobalt	mg/kg	0.1	-	-	9.4	9.5	9.4	9.8	9.5	10.4	9.4	10.9	11.7	13.4	7.7	8.5	7.6	8.6	7.5	10.4	6.7	3.5	0.5	0.9
Copper	mg/kg	1	18.7	109	8	9	9	9	9	30	20	37	56	77	7	9	8	8	8	16	12	21	4	5
Iron	mg/kg	20	-	-	16,800	17,650	17,500	18,000	17,700	17,500	16,000	17,500	18,050	20,000	14,400	15,900	13,800	15,900	16,400	20,400	12,600	5,970	663	2,060
Lead	mg/kg	0.1	30.2	113	20	20	19	19	18	336	206	374	585	860	23	27	26	24	15	83	41	192	10	66
Lithium	mg/kg	0.1	-	-	19.9	20.3	19.6	20.0	19.9	14.8	13.6	14.6	14.3	13.8	16.4	18.2	16.0	18.1	17.3	22.7	14.7	4.8	0.5	1.4
Magnesium	mg/kg	10	-	-	8,190	8,320	8,250	8,430	8,510	8,750	8,150	8,610	8,645	8,590	7,060	7,740	6,930	7,870	7,290	9,310	6,075	2,100	517	860
Manganese	mg/kg	1	-	-	345	308	318	337	328	243	220	249	238	249	216	232	211	232	370	294	206	72	8	40
Molybdenum	mg/kg	0.1	-	-	0.2	0.3	0.7	0.3	0.3	0.3	0.2	0.3	0.3	0.4	0.2	0.4	0.2	0.3	0.3	1.2	0.8	1.1	0.3	0.6
Nickel	mg/kg	1	30	50	28	28	28	29	27	29	27	29	29	29	23	26	23	26	23	33	21	8	2	2
Potassium	mg/kg	20	-	-	1,290	1,355	1,330	1,300	1,370	1,180	1,060	1,040	955	940	1,270	1,420	1,230	1,380	1,060	1,940	1,515	940	353	360
Rubidium	mg/kg	0.1	-	-	7.4	7.9	7.5	7.3	7.7	6.4	5.6	5.5	5.2	5.1	7.2	8	6.9	7.9	6.1	9.9	7.7	4.3	0.9	1.4
Selenium	mg/kg	1	-	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Silver	mg/kg	0.1	1	2.2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	0.3	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	< 0.1	0.1	< 0.1	< 0.1
Sodium	mg/kg	50	-	-	2,080	2,440	2,610	1,870	2,890	1,870	2,410	2,430	1,945	2,090	2,350	3,090	2,460	2,280	2,480	5,230	3,725	2,610	4,153	1,990
Strontium	mg/kg	1	-	-	25	25	24	25	25	21	19	24	19	20	14	17	13	17	11	34	63	219	501	65
Tellurium	mg/kg	0.1	-	-	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	-	-	0.3	0.3	0.3	0.3	0.3	1.7	1.5	1.6	3.1	2.5	0.3	0.3	0.3	0.4	0.2	0.4	0.4	0.3	0.2	< 0.1
Tin	mg/kg	1	-	-	< 1	< 1	< 1	< 1	< 1	2	< 1	3	3	7	< 1	< 1	< 1	< 1	< 1	< 1	< 1	3	< 1	< 1
Uranium	mg/kg	0.1	-	-	0.5	0.7	0.7	0.8	0.6	0.6	0.5	0.4	0.4	0.5	0.5	0.7	0.5	0.7	0.6	3.1	17.6	70.8	21.6	9.8
Vanadium	mg/kg	1	-	-	31	33	33	34	33	38	36	35	35	39	29	31	28	33	31	37	24	14	1	8
Zinc	mg/kg	1	124	272	55	54	53	56	53	593	326	844	1,245	1,840	42	54	53	51	47	124	75	556	16	108

[a] Canadian Sediment Quality Guidelines (CSQG) for the protection of marine life include Interim Sediment Quality Guidelines (ISQG) and Probable Effect Level (PEL) guidelines for arsenic, cadmium, chromium, copper, lead and zinc. Guidelines for nickel and silver available from the BC MOE (2014).

🟦	Indicates concentration is above respective ISQG
🟩	Indicates concentration is above respective CSQG PEL

Table B.3: Statistical summary of physical and chemical sediment quality, Brunswick Smelter Benthic Monitoring Program, October 2014.

Parameter	Units	Method Detection Limit	CSQG[a]		Reference (Shallow)			Final Effluent Outfall			Reference (Deep)			Fertilizer Plant Outfall		
			ISQG	PEL	Mean	Standard Deviation	Standard Error	Mean	Standard Deviation	Standard Error	Mean	Standard Deviation	Standard Error	Mean	Standard Deviation	Standard Error
Gravel	%	0.1	-	-	1.5	1.4	0.6	4.9	6.6	2.9	16.7	22.7	10.1	12.4	15.0	6.7
Sand	%	0.1	-	-	94.2	2.2	1.0	92.9	6.5	2.9	79.0	22.3	10.0	68.8	18.8	8.4
Silt	%	0.1	-	-	2.4	0.9	0.4	1.0	0.4	0.2	2.1	1.0	0.4	17.4	16.5	7.4
Clay	%	0.1	-	-	2.0	0.5	0.2	1.3	0.3	0.1	2.2	0.7	0.3	1.6	1.6	0.7
Total Organic Carbon	%	0.1	-	-	0.50	0.10	0.04	0.38	0.08	0.04	0.40	0.07	0.03	0.48	0.52	0.23
Aluminum	mg/kg	1	-	-	11,400	100	45	10,150	235	105	9,794	608	272	6,775	5,173	2,313
Antimony	mg/kg	0.1	-	-	0.1	0.0	0.0	0.5	0.3	0.1	< 0.1	0.0	0.0	0.5	0.4	0.2
Arsenic	mg/kg	1	7.2	41.6	5	1	0	21	9	4	6	0	0	5	3	1
Barium	mg/kg	1	-	-	98	30	13	129	49	22	47	32	14	46	23	10
Beryllium	mg/kg	0.1	-	-	0.6	0.0	0.0	0.4	0.0	0.0	0.5	0.1	0.0	0.4	0.2	0.1
Bismuth	mg/kg	1	-	-	< 1	0	0	2	1	1	< 1	0	0	< 1	0	0
Boron	mg/kg	1	-	-	6	1	0	7	1	0	7	1	0	8	6	3
Cadmium	mg/kg	0.1	0.7	4.2	0.36	0.02	0.01	2.14	0.50	0.22	0.21	0.08	0.03	0.58	0.31	0.14
Calcium	mg/kg	50	-	-	28,240	2,813	1,258	10,234	1,690	756	5,324	1,454	650	53,477	59,612	26,659
Chromium	mg/kg	1	52.3	161	26	1	0	34	2	1	22	2	1	17	11	5
Cobalt	mg/kg	0.1	-	-	9.5	0.2	0.1	11.2	1.5	0.7	8.0	0.5	0.2	4.4	4.2	1.9
Copper	mg/kg	1	18.7	109	9	0	0	44	23	10	8	1	0	12	7	3
Iron	mg/kg	20	-	-	17,530	447	200	17,810	1,442	645	15,280	1,117	499	8,339	8,179	3,658
Lead	mg/kg	0.1	30.2	113	19	1	0	472	256	114	23	5	2	79	69	31
Lithium	mg/kg	0.1	-	-	19.9	0.2	0.1	14.2	0.5	0.2	17.2	1.0	0.4	8.8	9.6	4.3
Magnesium	mg/kg	10	-	-	8,340	130	58	8,549	231	103	7,378	413	185	3,772	3,803	1,701
Manganese	mg/kg	1	-	-	327	15	7	240	12	5	252	67	30	124	121	54
Molybdenum	mg/kg	0.1	-	-	0.4	0.2	0.1	0.3	0.1	0.0	0.3	0.1	0.0	0.8	0.4	0.2
Nickel	mg/kg	1	30	50	28	1	0	29	1	0	24	2	1	13	14	6
Potassium	mg/kg	20	-	-	1,329	34	15	1,035	96	43	1,272	142	63	1,022	703	314
Rubidium	mg/kg	0.1	-	-	7.6	0.2	0.1	5.6	0.5	0.2	7.2	0.8	0.3	4.8	3.9	1.8
Selenium	mg/kg	1	-	-	< 1	0.0	0.0	< 1	0.0	0.0	< 1	0.0	0.0	< 1	0.0	0.0
Silver	mg/kg	0.1	1.0	2.2	< 0.1	0.0	0.0	0.2	0.1	0.0	< 0.1	0.0	0.0	0.1	0.0	0.0
Sodium	mg/kg	50	-	-	2,378	408	183	2,149	260	116	2,532	322	144	3,542	1,278	572
Strontium	mg/kg	1	-	-	25	0	0	21	2	1	14	3	1	176	195	87
Tellurium	mg/kg	0.1	-	-	< 0.1	0.0	0.0	< 0.1	0.0	0.0	< 0.1	0.0	0.0	< 0.1	0.0	0.0
Thallium	mg/kg	0.1	-	-	0.3	0.0	0.0	2.1	0.7	0.3	0.3	0.1	0.0	0.3	0.1	0.1
Uranium	mg/kg	0.1	-	-	0.7	0.1	0.1	0.5	0.1	0.0	0.6	0.1	0.0	24.6	26.8	12.0
Vanadium	mg/kg	1	-	-	33	1	0.5	37	2	1	30	2	1	17	14	6
Zinc	mg/kg	1	124	272	54	1	1	970	593	265	49	5	2	176	216	97

[a] Canadian Sediment Quality Guidelines (CSQG) for the protection of marine life include Interim Sediment Quality Guidelines (ISQG) and Probable Effect Level (PEL) guidelines for arsenic, cadmium, chromium, copper, lead and zinc. Guidelines for nickel and silver available from the BC MOE (2014).

🟦 Indicates value is above respective ISQG.

🟩 Indicates value is above respective CSQG PEL.

Table B.4: Physical sediment characteristic statistical comparisons among study areas, Brunswick Smelter Benthic Monitoring Program, October 2014. All statistical analyses conducted using logit transformed data.

Parameter	Four-group Comparison			Pair-wise *post-hoc* Comparisons				
	Significant Difference Among Areas?	**p-value**	**Statistical Test[a]**	**(I) Area**	**(J) Area**	**Significant Difference Between Two Areas?**	**p-value**	**Statistical Test[b]**
Gravel (%)	NO	0.185	ANOVA*	Reference - Shallow (RS)	Final Effluent Outfall (FE)	NO	0.844	Tukey's HSD
				"	Reference - Deep (RD)	NO	0.164	
				"	Fertilizer Plant Outfall (FPO)	NO	0.418	
				Final Effluent Outfall (FE)	Reference - Deep (RD)	NO	0.527	
				"	Fertilizer Plant Outfall (FPO)	NO	0.872	
				Reference - Deep (RD)	Fertilizer Plant Outfall (FPO)	NO	0.922	
Sand (%)	NO	0.207	ANOVA*	Reference - Shallow (RS)	Final Effluent Outfall (FE)	NO	1.000	Tukey's HSD
				"	Reference - Deep (RD)	NO	0.517	
				"	Fertilizer Plant Outfall (FPO)	NO	0.344	
				Final Effluent Outfall (FE)	Reference - Deep (RD)	NO	0.496	
				"	Fertilizer Plant Outfall (FPO)	NO	0.327	
				Reference - Deep (RD)	Fertilizer Plant Outfall (FPO)	NO	0.988	
Silt-Clay (%)	YES	0.025	ANOVA*	Reference - Shallow (RS)	Final Effluent Outfall (FE)	YES	0.084	Tamhane's
				"	Reference - Deep (RD)	NO	1.000	
				"	Fertilizer Plant Outfall (FPO)	NO	0.690	
				Final Effluent Outfall (FE)	Reference - Deep (RD)	YES	0.088	
				"	Fertilizer Plant Outfall (FPO)	NO	0.304	
				Reference - Deep (RD)	Fertilizer Plant Outfall (FPO)	NO	0.686	
TOC (%)	NO	0.570	ANOVA	Reference - Shallow (RS)	Final Effluent Outfall (FE)	NO	0.358	Tamhane's
				"	Reference - Deep (RD)	NO	0.500	
				"	Fertilizer Plant Outfall (FPO)	NO	0.927	
				Final Effluent Outfall (FE)	Reference - Deep (RD)	NO	0.999	
				"	Fertilizer Plant Outfall (FPO)	NO	0.998	
				Reference - Deep (RD)	Fertilizer Plant Outfall (FPO)	NO	0.993	

[a] The results of ANOVA tests marked by an asterisk were confirmed using the Krukal-Wallis H test (KW) to account for non-normal data at one or more study areas. KW test p-values for four-group gravel, sand and silt-clay were 0.161, 0.151 and 0.045, respectively, confirming significant differences indicated by ANOVA.

[b] Post-hoc analysis of 1-way ANOVA among all areas protected for multiple comparisons. Tukey's HSD and Tamhane's tests used for data with equal and unequal variance, respectively.

Table B.5: Summary of the magnitude of difference in sediment metal concentrations of smelter effluent-exposed (FE) and fertilizer plant outfall (FPO) stations compared to respective reference areas, Brunswick Smelter Benthic Monitoring Program, October 2014.

Metal	Final Effluent Outfall versus Reference (Shallow)	Fertilizer Plant Outfall versus Reference (Deep)
Aluminum	0.9	0.7
Antimony	5.2	4.7
Arsenic	4.6	0.8
Barium	1.3	1.0
Beryllium	0.6	0.7
Bismuth	1.9	1.0
Boron	1.1	1.1
Cadmium	6.0	2.7
Calcium	0.4	**10.0**
Chromium	1.3	0.7
Cobalt	1.2	0.6
Copper	5.0	1.4
Iron	1.0	0.5
Lead	**24.5**	3.4
Lithium	0.7	0.5
Magnesium	1.0	0.5
Manganese	0.7	0.5
Molybdenum	0.8	2.9
Nickel	1.0	0.5
Potassium	0.8	0.8
Rubidium	0.7	0.7
Selenium	1.0	1.0
Silver	1.6	1.2
Sodium	0.9	1.4
Strontium	0.8	**12.2**
Tellurium	1.0	1.0
Thallium	6.9	0.9
Uranium	0.7	**41.0**
Vanadium	1.1	0.6
Zinc	**17.9**	3.6

🟦	Denotes mean parameter concentration 2 to 5 times higher than respective mean reference value
🟧	Denotes mean parameter concentration 5 to 10 times higher than respective mean reference value
🟪	Denotes mean parameter concentration greater than 10 times higher the respective mean reference value

Table B.6: Final Effluent study area sediment quality statistical comparison results for key smelter-related metals between Brunswick Smelter Benthic Monitoring Program studies conducted in 2008 and 2014.

Metal	Statistical Test Results			Summary Statistics (mg/kg)					
	Significant Difference Between Areas?	*p* -value	Statistical Analysis[a]	Year	Mean	Standard Deviation	Standard Error	Minimum	Maximum
Antimony	NO	0.264	α	**2008**	0.33	0.15	0.07	0.20	0.55
				2014	0.52	0.30	0.14	0.20	1.00
Arsenic	YES	0.035	α	**2008**	12.0	1.9	0.8	10.0	15.0
				2014	20.6	8.6	3.8	12.0	34.0
Cadmium	YES	0.015	α	**2008**	1.35	0.30	0.13	1.01	1.72
				2014	2.14	0.50	0.22	1.47	2.63
Copper	YES	0.024	α	**2008**	19	6	3	13	28
				2014	44	23	10	20	77
Lead	YES	0.005	α	**2008**	143	48	21	85	194
				2014	472	256	114	206	860
Thallium	NO	0.959	α	**2008**	2.04	0.58	0.26	1.35	2.90
				2014	2.08	0.69	0.31	1.50	3.10
Zinc	YES	0.082	α	**2008**	241	110	49	110	358
				2014	970	593	265	326	1,840

[a] Data analysis included: α - data log transformed, single factor ANOVA test

▨ Highlighted values indicates significant difference between study areas based on ANOVA p-value less than 0.10.

Table B.7: Two-way ANOVA results for evaluation of differences between 2008 and 2014 for key sediment metal concentrations at the Final Effluent (FE) area taking Shallow Reference (RS) area data into account, Brunswick Smelter Benthic Monitoring Program, October 2014.

Metal	Source	Significant Difference Indicated?	p-value	Power
Antimony	Time	Yes	0.000	1.000
	Area	No	0.247	0.204
	Time*Area	No	0.247	0.204
Arsenic	Time	Yes	0.000	1.000
	Area	No	0.210	0.233
	Time*Area	Yes	0.003	0.903
Cadmium	Time	Yes	0.000	1.000
	Area	Yes	0.033	0.591
	Time*Area	Yes	0.003	0.914
Copper	Time	Yes	0.000	1.000
	Area	Yes	0.008	0.808
	Time*Area	Yes	0.023	0.656
Lead	Time	Yes	0.000	1.000
	Area	Yes	0.002	0.939
	Time*Area	Yes	0.001	0.955
Thallium	Time	Yes	0.000	1.000
	Area	No	0.165	0.278
	Time*Area	No	0.137	0.312
Zinc	Time	Yes	0.000	1.000
	Area	Yes	0.003	0.911
	Time*Area	Yes	0.003	0.898

Table B.8: Final effluent and reference (shallow) study area Principal Component Analysis (PCA) sediment metal weightings based on Brunswick Smelter Benthic Monitoring Program data from 2004 - 2014.

Sediment Chemistry Parameter	Sediment Metal PC Axis-1 (41.0 %)	Sediment Metal PC Axis-2 (31.8 %)	Sediment Metal PC Axis-3 (9.3 %)	Sediment Metal PC Axis-4 (5.0 %)
Lead	0.9777	0.1392	-0.0042	0.0686
Arsenic	0.9452	0.2233	-0.0203	0.0666
Zinc	0.9394	0.1547	-0.0021	0.2034
Copper	0.9040	0.0597	0.1843	0.2776
Thallium	0.8803	0.4078	-0.0334	-0.1190
Cadmium	0.8660	0.4036	-0.0682	0.0045
Lithium	-0.8423	0.3311	-0.1218	0.2468
Rubidium	-0.7906	0.4778	0.2096	-0.0728
Beryllium	-0.7805	0.4418	-0.2473	0.2024
Chromium	0.7696	0.4896	-0.1614	-0.2202
Antimony	0.7558	0.0533	0.4109	0.2635
Manganese	-0.6701	0.6151	-0.2242	0.0959
Calcium	-0.6366	0.6082	-0.2066	0.1652
Iron	-0.0497	0.9076	0.0651	-0.1408
Aluminum	-0.1937	0.8739	-0.3892	-0.1344
Magnesium	0.3019	0.8364	0.2090	-0.2525
Vanadium	0.3453	0.8104	0.0322	-0.3106
Potassium	-0.4536	0.7372	0.2699	-0.3330
Strontium	-0.1508	0.7161	0.4863	-0.0808
Nickel	0.3665	0.7091	-0.4097	0.0528
Boron	-0.0129	0.6890	0.2965	0.0436
Cobalt	0.5420	0.6212	-0.3306	0.3599
Molybdenum	-0.1296	0.5831	0.4227	0.5030
Uranium	-0.4998	0.5390	0.0559	0.3698
Sodium	-0.2035	-0.0510	0.9113	-0.0027

▨ Indicates heavy positively-weighted parameter on respective sediment chemistry PCA axis.

■ Indicates heavy negatively-weighted parameter on respective sediment chemistry PCA axis.

Table B.9: Fertilizer Plant Outfall study area statistical comparison results for key indicator metals between Brunswick Smelter Benthic Monitoring Program studies conducted in 2008 and 2014.

Metal	Statistical Test Results			Summary Statistics (mg/kg)					
	Significant Difference Between Areas?	*p* -value	Statistical Analysis[a]	Year	Mean	Standard Deviation	Standard Error	Minimum	Maximum
Antimony	NO	0.634	α	**2008**	0.61	0.40	0.18	0.10	1.15
				2014	0.47	0.39	0.17	0.10	1.10
Cadmium	NO	0.674	β	**2008**	0.6	0.7	0.3	0.2	1.8
				2014	0.6	0.3	0.1	0.1	0.8
Calcium	NO	0.953	α	**2008**	61,706	61,384	27,452	9,230	160,000
				2014	53,477	59,612	26,659	16,400	155,333
Lead	NO	0.229	α	**2008**	31	22	10	14	65
				2014	79	69	31	10	192
Molybdenum	NO	0.286	α	**2008**	0.54	0.25	0.11	0.30	0.90
				2014	0.80	0.37	0.16	0.30	1.20
Strontium	NO	0.805	α	**2008**	230	216	96	22	553
				2014	176	195	87	34	501
Uranium	NO	0.635	α	**2008**	35.06	27.50	12.30	3.00	72.30
				2014	24.59	26.80	11.99	3.10	70.80
Zinc	NO	0.276	α	**2008**	62	55	25	16	134
				2014	176	216	97	16	556

[a] Data analysis included: α - data log transformed, single factor ANOVA test; β - data log transformed, single factor ANOVA test result confirmed with Mann-Whitney U-test.

▨ Highlighted values indicates significant difference between study areas based on ANOVA p-value less than 0.10.

Table B.10: Two-way ANOVA results for evaluation of differences between 2008 and 2014 for key sediment metal concentrations at the Fertilizer Plant Outfall (FPO) area taking Deep Reference (RD) area data into account, Brunswick Smelter Benthic Monitoring Program, October 2014.

Metal	Source	Significant Difference Indicated?	p-value	Power
Antimony	Time	Yes	0.002	0.933
	Area	No	0.182	0.259
	Time*Area	No	0.671	0.069
Cadmium	Time	Yes	0.009	0.800
	Area	No	0.346	0.150
	Time*Area	No	0.888	0.052
Calcium	Time	Yes	0.000	0.996
	Area	No	0.689	0.067
	Time*Area	No	0.776	0.059
Lead	Time	No	0.111	0.355
	Area	No	0.246	0.205
	Time*Area	No	0.196	0.245
Molybdenum	Time	Yes	0.001	0.967
	Area	No	0.292	0.176
	Time*Area	No	0.497	0.100
Strontium	Time	Yes	0.000	0.999
	Area	No	0.692	0.067
	Time*Area	No	0.919	0.051
Uranium	Time	Yes	0.000	1.000
	Area	No	0.599	0.080
	Time*Area	No	0.664	0.070
Zinc	Time	No	0.312	0.166
	Area	No	0.166	0.276
	Time*Area	No	0.391	0.132

Table B.11: Fertilizer plant outfall and reference (deep) study area Principal Component Analysis (PCA) sediment metal weightings based on Brunswick Smelter Benthic Monitoring Program data from 2004 - 2014.

Sediment Chemistry Parameter	Sediment Metal PC Axis-1 (60.3 %)	Sediment Metal PC Axis-2 (16.3 %)	Sediment Metal PC Axis-3 (10.9 %)
Lithium	0.9874	-0.0232	0.0637
Cobalt	0.9871	0.0311	-0.0788
Iron	0.9866	-0.0461	0.1036
Vanadium	0.9717	-0.0035	0.1461
Nickel	0.9679	0.0596	-0.2051
Magnesium	0.9664	0.0394	-0.1846
Chromium	0.9619	0.1478	-0.0057
Rubidium	0.9528	0.1180	0.0629
Aluminum	0.9229	0.1685	-0.2444
Manganese	0.9136	-0.0781	0.3012
Arsenic	0.8966	0.1831	0.0643
Beryllium	0.8884	0.1453	-0.1704
Potassium	0.8740	0.2947	-0.2537
Uranium	-0.7677	0.5433	0.0395
Boron	0.7670	0.2401	0.0306
Antimony	-0.7178	0.5103	0.0123
Strontium	-0.7167	0.5950	-0.3065
Copper	0.6079	0.5737	0.1981
Thallium	0.5872	0.5012	-0.4593
Molybdenum	-0.2176	0.8552	0.1018
Cadmium	-0.2327	0.7785	0.2260
Calcium	-0.5988	0.6135	-0.4085
Zinc	0.2013	0.3496	0.8887
Lead	0.0539	0.4764	0.8224
Sodium	0.1571	0.4892	-0.5651

▨ Indicates heavy positively-weighted parameter on respective sediment chemistry PCA axis.

■ Indicates heavy negatively-weighted parameter on respective sediment chemistry PCA axis.

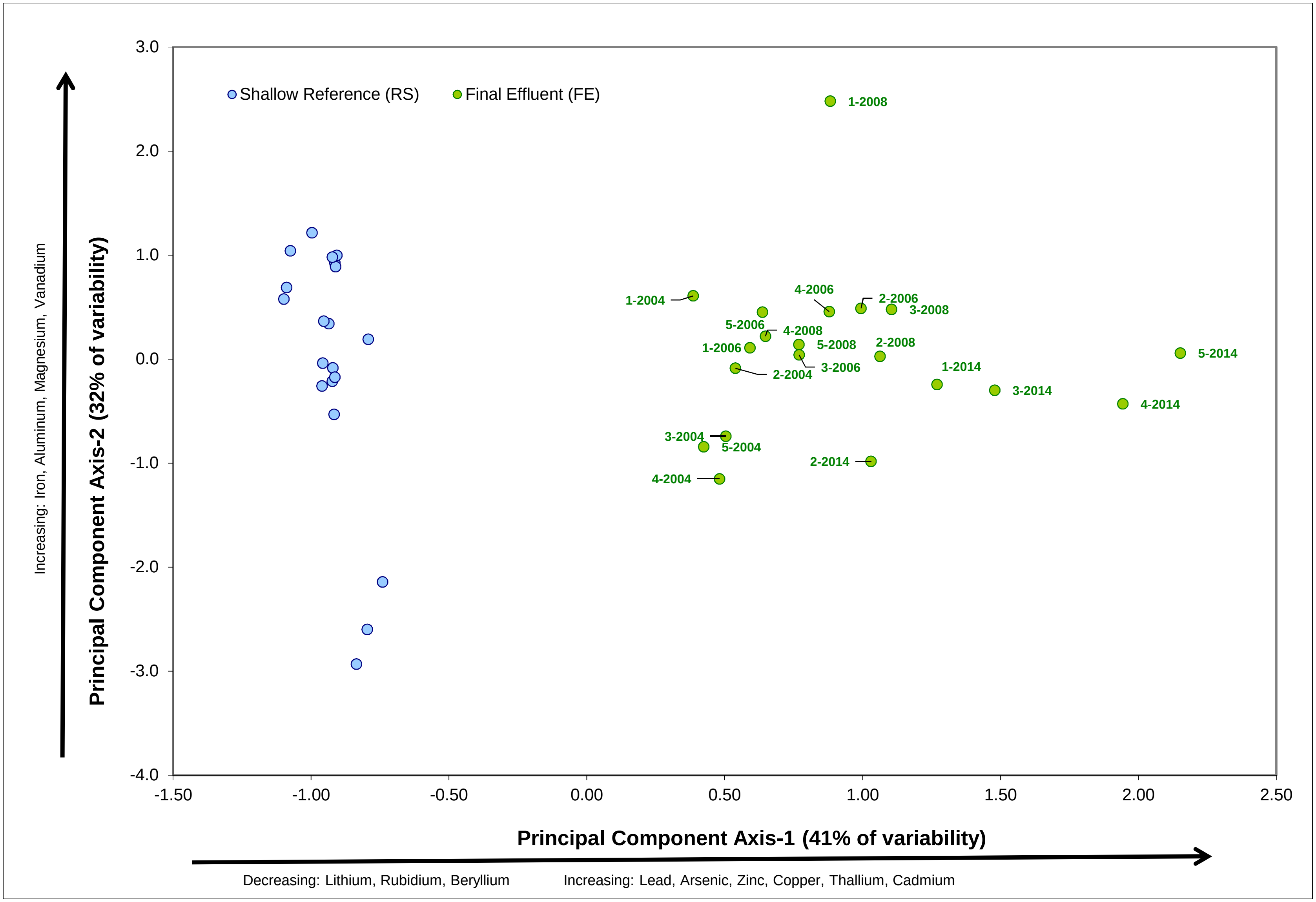

Figure B.1: **Principal components scores for the Final Effluent (FE) and Shallow Reference (RS) station sediment metal concentration data collected from Brunswick Smelter Benthic Monitoring Programs from 2004 - 2014. Final Effluent labels indicate station number and year of sampling.**

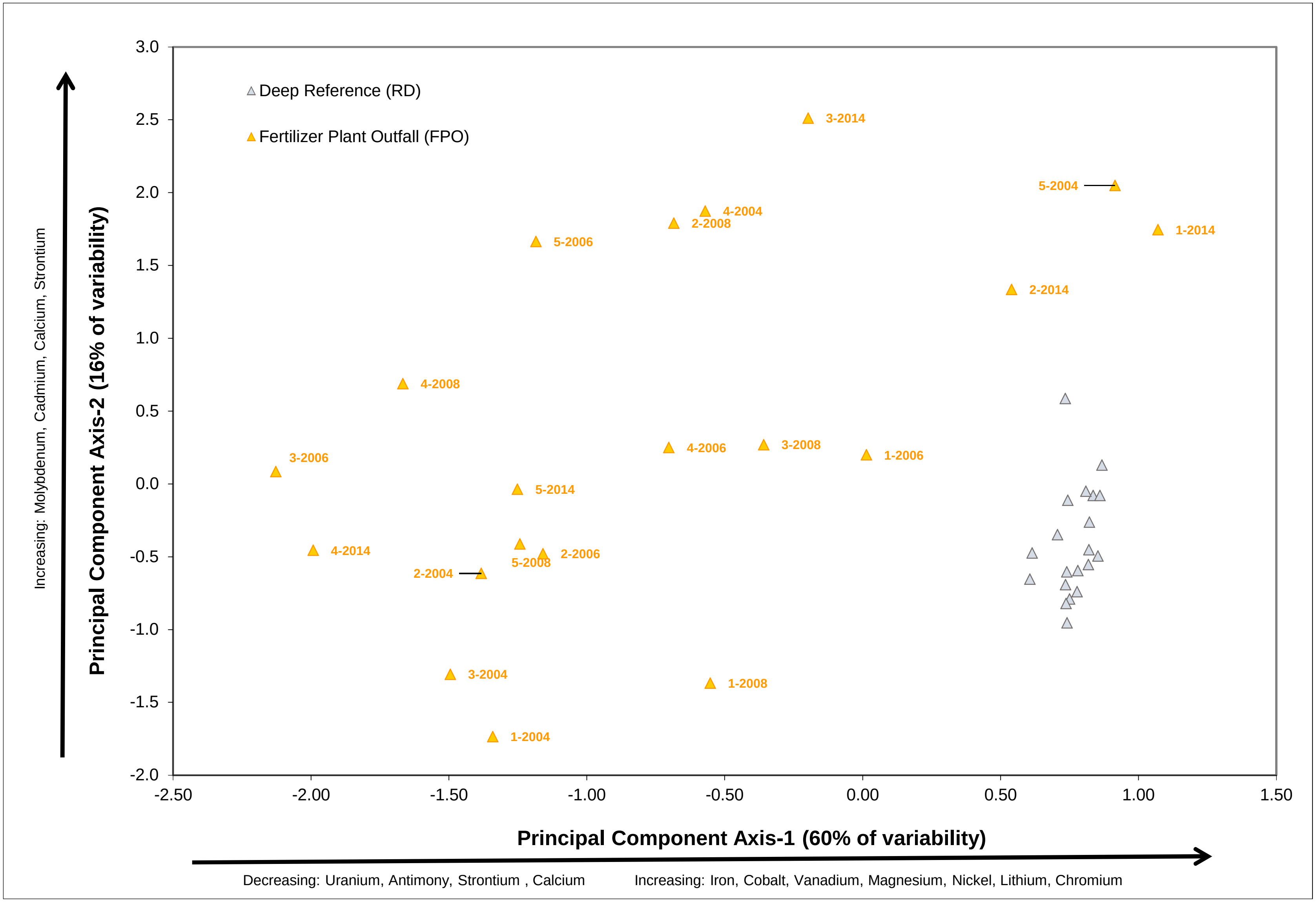

Figure B.2: Principal components scores for the Fertilzer Plant Outfall (FPO) and Deep Reference (RD) station sediment metal concentration data collected from Brunswick Smelter Benthic Monitoring Programs from 2004 - 2014. Fertilizer Plant Outfall labels indicate station number and year of sampling.

APPENDIX C

BENTHIC INVERTEBRATE COMMUNITY DATA

BENTHIC INVERTEBRATE COMMUNITY DATA QUALITY REVIEW

APPENDIX C BENTHIC DATA QUALITY ASSESSMENT

Quality Assurance/Quality Control (QA/QC) implemented for the Brunswick Smelter 2014 Benthic Monitoring Program included a Data Quality Review (DQR) of the benthic invertebrate community data to provide an evaluation of how well laboratory data quality compared to prescribed goals (i.e., Data Quality Objectives [DQO]) established *a priori*. This DQR report provides an evaluation of the benthic invertebrate community laboratory processing results, including a discussion of the consequences for any failures to achieve DQO. By completing this step, the quality of the data for the program can be effectively evaluated and demonstrated.

C.1 Quality Control Measures and DQO

Sub-sampling error and organism recovery checks were used to assess quality control for the laboratory processing of benthic invertebrate community samples. These quality control measures, and target DQO for each, are defined below.

- **Sub-Sampling Error** is assessed for studies in which benthic invertebrate community samples require sub-sampling (due to excessive sample volume and/or invertebrate density). By comparing the numbers of benthic invertebrates recovered between at least two sub-samples, this measure provides an evaluation of how effective the sub-sampling method was in evenly dividing the original sample. Therefore, sub-sampling error provides a measure of analytical precision. The processing of entire benthic invertebrate community samples in representative sample fractions also allows an evaluation of sub-sampling accuracy. The DQO for sub-sampling error precision/accuracy was ≤20%.

- **Organism Recovery Checks** for benthic invertebrate community samples involve the re-processing of previously sorted material from a randomly selected sample to determine the number of invertebrates that were not recovered during the original sample processing. The reprocessing is conducted by an analyst not involved during the original processing to reduce any bias. This check allows the determination of accuracy through assessment of recovery efficiency. The DQO for organism recovery checks was ≥90%.

C.2 Benthic Invertebrate Community Sample DQR Results

Precision and accuracy of the sub-sampled benthic invertebrate community samples met the DQO of 20% (Table C-DQR.1). The objective for percent organism recovery was also achieved for each of the two re-sorted samples, with an average percent recovery of approximately 93% (Table C-DQR-2). Therefore, the benthic invertebrate community sample data were of acceptable quality, meeting all established precision, accuracy and percent recovery QC criteria.

Table C-DQR.1: Subsampling error assessment for Brunswick Smelter Benthic Monitoring Program samples, October 2014.

Station	Whole Organisms	Number of Organisms in Fraction 1	Number of Organisms in Fraction 2	Number of Organisms in Fraction 3	Number of Organisms in Fraction 4	Actual Density*	Precision % range		Accuracy	
									min	max
FP0-5	1	223	231	238	248	940	2.9	10.1	1.3	5.5
FP0-5	1	454	486	-	-	940	6.6	-	3.4	-

* whole large organisms excluded in calculations.

min = minimum absolute % error

max = maximum absolute % error

Table C-DQR.2: Percent recovery of organisms from benthic invertebrate samples, Brunswick Smelter Benthic Monitoring Program, October 2014.

Station	Number of Organisms Recovered	Number of Organisms in Re-sort	Percent Recovery
RS-1	386	419	92.1%
RD-1	481	510	94.3%
		Average % Recovery	93.2%

Table C-DQR.3: Benthic invertebrate sample sorted fraction amounts, Brunswick Smelter Benthic Monitoring Program, October 2014.

Station	Fraction Sorted	Station	Fraction Sorted
FE-1	Whole	RS-1	Whole
FE-2	1/2	RS-2	1/2
FE-3	Whole[b]	RS-3	1/4
FE-4	1/4	RS-4	1/4
FE-5	1/4	RS-5	1/4
FPO-1	1/4	RD-1	1/4
FPO-2	1/4	RD-2	1/4
FPO-3	Whole	RD-3	1/4
FPO-4	Whole	RD-4	1/4
FPO-5	Whole[a]	RD-5	1/4

[a] four quarters and two halves sorted for subsampling error calculations.

[b] bivalves sub-sampled for 1/4 of sample.

QA/QC Notes

Immatures were not counted toward total number of taxa unless they were the sole representative of their taxa group.

TABLES AND FIGURES

Table C.1: Benthic invertebrate community data for the Brunswick Smelter Benthic Monitoring Program, October 2014. Densities expressed in number of organisms per square meter.

Study Area	Shallow Reference (RS)					Final Effluent Area (FE)				
Replicate	1	2	3	4	5	1	2	3	4	5
P. Sarcodina										
O. Foraminiferida	0	26	0	0	26	6	13	0	0	0
HYDROIDS/ANEMONES										
P. Cnidaria										
Cl. Anthozoa	0	0	0	0	0	0	0	0	0	0
ROUNDWORMS										
P. Nematoda	0	51	102	153	281	0	0	0	0	0
UNSEGMENTED WORMS										
P. Nemertea	0	0	0	0	0	0	13	13	0	0
P. Annelida										
BRISTLE WORMS										
Cl. Polychaeta (Errantia)										
F. Glyceridae										
Glycera dibranchiata	0	0	0	0	0	0	0	6	0	0
Glycera	0	0	0	0	0	6	13	**13**	26	26
F. Goniadidae										
Goniada maculata	0	0	0	0	0	0	0	0	0	0
F. Lumbrineridae										
Lumbrineris	0	0	0	0	0	0	0	0	0	0
Ninoe nigripes	0	0	0	0	0	0	0	0	0	0
F. Nephtyidae										
Aglaophamus circinata	0	0	0	0	0	0	0	0	0	0
Nephtys caeca	102	542	408	1,403	510	102	77	13	230	128
Nephtys incisa	0	0	0	0	0	0	0	0	0	0
Nephtys neotena	6	13	0	26	0	0	0	0	0	0
F. Nereidae										
Neanthes virens	0	0	0	0	0	0	0	0	0	0
F. Pholoidae										
Pholoe longa	0	13	0	26	0	0	0	0	0	0
Pholoe tecta	0	179	26	26	102	0	0	0	0	0
F. Phyllodocidae										
Eteone longa/flava	0	0	0	0	0	38	26	26	26	0
Phyllodoce mucosa	0	13	77	77	102	26	51	57	51	0
F. Polynoidae										
Harmothoe extenuata	0	0	0	0	0	0	0	0	0	0
indeterminate	0	0	0	0	0	0	0	0	0	0
F. Protodrilidae										
Protodriloides symbioticus	89	293	306	230	102	0	0	0	0	0
F. Syllidae										
Exogone hebes	0	26	0	0	0	0	0	0	0	0
indeterminate	0	0	0	0	0	0	0	0	0	0
Cl. Polychaeta (Sedentaria)										
F. Capitellidae										
Mediomastus ambiseta	0	0	0	0	0	0	0	0	0	0
F. Cirratulidae										
Tharyx acutus	0	0	0	0	0	0	0	0	0	0
F. Flabelligeridae										

Table C.1: Benthic invertebrate community data for the Brunswick Smelter Benthic Monitoring Program, October 2014. Densities expressed in number of organisms per square meter.

Study Area	Shallow Reference (RS)					Final Effluent Area (FE)				
Replicate	1	2	3	4	5	1	2	3	4	5
Pherusa affinis	0	0	0	0	0	0	0	0	0	0
Pherusa (immature)	0	0	0	0	0	0	0	0	0	0
F. Maldanidae										
Clymenella torquata	0	13	51	0	0	0	0	13	0	0
F. Orbiniidae										
Leitoscoloplos	0	0	0	0	0	6	0	0	0	26
Scoloplos armiger	0	0	0	26	26	0	0	0	0	0
F. Paraonidae										
Aricidea	6	0	0	0	0	0	0	0	0	0
F. Pectinariidae										
Pectinaria gouldi	0	64	26	0	0	13	0	64	0	0
F. Sabellidae										
Euchone elegans	0	0	0	0	0	0	0	0	0	0
F. Sphaerodoridae										
Sphaerodoropsis minuta	0	0	0	0	0	6	0	0	0	0
F. Spionidae										
Polydora cornuta	0	0	0	0	0	0	0	0	0	0
Polydora quadrilobata	0	0	0	0	0	0	0	0	26	0
Prionospio steenstrupi	13	38	0	0	0	6	0	0	0	0
Pygospio elegans	0	293	51	77	230	0	13	19	128	0
Spiophanes bombyx	695	4,235	2,500	1,837	2,781	383	1,467	485	791	1,352
Spio	0	0	0	0	0	0	0	0	0	0
ARTHROPODS										
P. Arthropoda										
SP. Crustacea										
SEED SHRIMPS										
Cl. Ostracoda	0	0	0	0	0	0	0	0	0	0
BARNACLES										
Cl. Cirripedia										
F. Balanidae										
Balanus	0	0	0	0	0	0	0	0	0	0
Cl. Malacostraca										
WATER SCUDS										
O. Amphipoda										
indeterminate	0	0	0	0	0	0	0	0	0	0
F. Ampeliscidae										
Ampelisca	0	0	0	0	0	0	0	0	0	0
F. Aoridae										
Unciola irrorata	0	0	51	26	26	0	13	0	0	26
F. Corophiidae										
Corophium crassicorne	6	0	0	0	0	0	0	0	0	0
Corophium	0	0	0	0	0	0	0	0	0	0
F. Lysianassidae										
Orchomenella minuta	0	0	0	0	0	6	0	0	0	0
F. Oedicerotidae										
Monoculodes	0	0	0	0	0	0	0	0	0	0
F. Photidae										
Photis reinhardi	32	89	102	153	51	6	51	0	0	0
F. Phoxocephalidae										
Phoxocephalus holbolli	0	0	0	0	0	0	13	0	0	0

Table C.1: Benthic invertebrate community data for the Brunswick Smelter Benthic Monitoring Program, October 2014. Densities expressed in number of organisms per square meter.

Study Area	Shallow Reference (RS)					Final Effluent Area (FE)				
Replicate	1	2	3	4	5	1	2	3	4	5
CUMACEANS										
O. Cumacea										
F. Bodotriidae										
Pseudoleptocuma minor	6	0	0	0	0	0	0	0	0	0
F. Diastylidae										
Diastyis	13	255	230	153	77	32	77	19	51	26
Oxyurostylis smithi	0	64	77	0	77	6	89	45	153	77
F. Lampropidae										
Lamprops quadriplicata	0	0	0	0	0	0	13	51	0	0
F. Leuconidae										
Eudorella	0	0	0	0	0	0	0	0	0	0
AQUATIC SOW BUGS										
O. Isopoda										
F. Idoteidae										
Edotea triloba	0	13	0	0	51	0	0	6	51	0
CRABS and SHRIMP										
O. Decapoda										
Infraorder Anomura										
TRUE CRABS										
Infraorder Brachyura										
F. Cancridae										
Cancer irroratus	0	0	0	0	0	0	0	0	0	0
SHRIMPS										
Infraorder Caridea										
F. Crangonidae										
Crangon septemspinosa	13	26	0	0	0	13	0	0	0	0
MOLLUSCS										
P. Mollusca										
SNAILS										
Cl. Gastropoda										
indeterminate	0	**13**	0	0	**26**	0	0	0	0	0
F. Calyptraeidae										
Crepidula fornicata	0	0	0	0	0	0	0	0	0	0
F. Nassariidae										
Nassarius trivittatus	274	166	383	255	204	6	13	96	255	26
F. Naticidae										
Lunatia heros	13	0	0	0	0	0	0	0	51	0
F.Turridae										
indeterminate	0	0	0	0	0	0	0	0	0	0
CLAMS										
Cl. Bivalvia										
indeterminate	0	**51**	**26**	0	0	0	0	0	0	0
F. Anomiidae										
Anomia simplex	0	0	0	0	0	0	0	0	0	0
F. Arcticidae										
Arctica islandica	0	0	0	0	0	0	0	0	0	0
F. Cardiidae										
Cerastoderma pinnulatum	0	0	0	0	0	0	0	0	0	0
F. Hiatellidae										
Hiatella arctica	0	0	0	0	0	0	0	0	0	0

Table C.1: Benthic invertebrate community data for the Brunswick Smelter Benthic Monitoring Program, October 2014. Densities expressed in number of organisms per square meter.

Study Area	Shallow Reference (RS)					Final Effluent Area (FE)				
Replicate	1	2	3	4	5	1	2	3	4	5
F. Mactridae										
Spisula solidissima	108	561	332	689	714	293	268	638	230	51
F. Myidae										
Mya arenaria	19	957	970	281	510	102	102	128	153	26
F. Mytilidae										
Mytilus edulis	421	395	842	230	306	185	77	38	51	51
F. Solenidae										
Ensis directus	0	0	51	0	0	0	0	0	0	0
F. Tellinidae										
Macoma balthica	19	0	0	0	26	0	0	0	0	0
Tellina agilis	836	2,462	2,551	1,709	2,143	829	1,148	3,266	1,939	2,092
F. Veneridae										
Pitar morrhuanus	0	0	0	0	0	0	0	0	0	0
P. Echinodermata										
SAND DOLLARS										
Cl. Echinoidea										
F. Echinarachniidae										
Echinarachnius parma	0	0	0	0	26	0	0	0	26	0
Total Abundance of Organisms	2,671	10,851	9,162	7,377	8,397	2,070	3,537	4,996	4,238	3,907
Total Number of Taxa *	18	24	19	18	21	20	19	18	17	12
Simpson's Diversity (1-D)	0.794	0.778	0.820	0.833	0.806	0.772	0.713	0.545	0.742	0.591
Simpson's Evenness (E)	0.841	0.812	0.866	0.882	0.846	0.812	0.753	0.577	0.788	0.645
Shannon-Weiner Diversity (H')	2.724	2.876	3.025	3.051	3.021	2.708	2.444	1.898	2.731	1.738
Shannon-Weiner Evenness (J')	0.653	0.627	0.712	0.732	0.688	0.627	0.575	0.455	0.668	0.485
Bray-Curtis Index	0.509	0.191	0.128	0.183	0.086	0.598	0.393	0.433	0.350	0.340
Percent Composition										
Errantia	7.4%	9.9%	8.9%	24.2%	9.7%	8.3%	4.7%	2.3%	7.9%	3.9%
Nephtys sp. (%)	4.0%	5.1%	4.5%	19.4%	6.1%	4.9%	2.2%	0.3%	5.4%	3.3%
Protodriloides symbioticus	3.3%	2.7%	3.3%	3.1%	1.2%	0.0%	0.0%	0.0%	0.0%	0.0%
Sedentaria	26.7%	42.8%	28.7%	26.3%	36.2%	20.0%	41.8%	11.6%	22.3%	35.3%
Spionidae (%)	26.5%	42.1%	27.8%	25.9%	35.9%	18.8%	41.8%	10.1%	22.3%	34.6%
Prionospio steenstrupi	0.5%	0.4%	0.0%	0.0%	0.0%	0.3%	0.0%	0.0%	0.0%	0.0%
Spiophanes bombyx	26.0%	39.0%	27.3%	24.9%	33.1%	18.5%	41.5%	9.7%	18.7%	34.6%
Metal-Sensitive Crustaceans (%)	2.1%	3.8%	5.0%	4.5%	2.8%	2.4%	7.2%	2.3%	4.8%	3.3%
Gastropoda (Nassarius)	10.7%	1.6%	4.2%	3.5%	2.7%	0.3%	0.4%	1.9%	7.2%	0.7%
Bivalves (%)	52.5%	40.8%	52.1%	39.4%	44.1%	68.1%	45.1%	81.5%	56.0%	56.8%
Tellina agilis	31.3%	22.7%	27.8%	23.2%	25.5%	40.0%	32.5%	65.4%	45.8%	53.5%

* Bold entries excluded from taxa count.

Table C.1: Benthic invertebrate community data for the Brunswick Smelter Benthic Monitoring Program, October 2014. Densities expressed in number of organisms per square meter.

Study Area	Deep Reference (RD)					Fertilizer Plant Outfall Area (FPO)				
Replicate	1	2	3	4	5	1	2	3	4	5
P. Sarcodina										
O. Foraminiferida	26	26	26	0	0	26	26	0	0	0
HYDROIDS/ANEMONES										
P. Cnidaria										
Cl. Anthozoa	0	0	0	0	0	26	0	0	0	0
ROUNDWORMS										
P. Nematoda	153	0	204	77	77	0	51	0	0	0
UNSEGMENTED WORMS										
P. Nemertea	26	0	0	0	32	83	128	13	0	0
P. Annelida										
BRISTLE WORMS										
Cl. Polychaeta (Errantia)										
F. Glyceridae										
Glycera dibranchiata	0	0	0	0	0	0	0	0	0	0
Glycera	0	0	0	0	0	0	51	0	0	6
F. Goniadidae										
Goniada maculata	0	0	0	0	0	6	0	0	0	0
F. Lumbrineridae										
Lumbrineris	0	0	0	0	6	0	0	0	0	0
Ninoe nigripes	0	0	0	26	0	351	325	13	0	6
F. Nephtyidae										
Aglaophamus circinata	26	0	0	0	0	0	0	0	0	0
Nephtys caeca	421	223	210	344	83	51	0	0	0	45
Nephtys incisa	0	0	0	0	0	45	6	0	0	0
Nephtys neotena	26	204	26	459	281	0	51	0	0	0
F. Nereidae										
Neanthes virens	0	0	0	0	0	0	26	89	64	0
F. Pholoidae										
Pholoe longa	153	51	102	0	0	83	0	0	0	0
Pholoe tecta	281	77	26	51	77	0	0	0	0	0
F. Phyllodocidae										
Eteone longa/flava	77	26	230	51	134	255	332	6	13	26
Phyllodoce mucosa	561	77	153	179	51	204	268	26	13	96
F. Polynoidae										
Harmothoe extenuata	0	0	0	0	0	0	0	0	0	6
indeterminate	0	0	0	0	0	51	51	0	0	0
F. Protodrilidae										
Protodriloides symbioticus	1,741	102	1,709	179	3,164	0	0	0	0	1,021
F. Syllidae										
Exogone hebes	179	0	102	0	0	0	0	0	0	0
indeterminate	0	0	0	0	332	0	0	0	0	0
Cl. Polychaeta (Sedentaria)										
F. Capitellidae										
Mediomastus ambiseta	0	0	0	0	0	51	204	0	0	0
F. Cirratulidae										
Tharyx acutus	0	0	0	26	0	26	0	0	0	0
F. Flabelligeridae										

Table C.1: Benthic invertebrate community data for the Brunswick Smelter Benthic Monitoring Program, October 2014. Densities expressed in number of organisms per square meter.

Study Area	Deep Reference (RD)					Fertilizer Plant Outfall Area (FPO)				
Replicate	1	2	3	4	5	1	2	3	4	5
Pherusa affinis	0	0	0	0	6	0	32	0	0	0
Pherusa (immature)	0	0	0	0	0	26	0	0	0	0
F. Maldanidae										
Clymenella torquata	230	0	6	26	0	0	0	0	0	0
F. Orbiniidae										
Leitoscoloplos	0	0	26	0	26	89	83	0	0	0
Scoloplos armiger	0	0	0	0	0	0	0	0	0	45
F. Paraonidae										
Aricidea	0	26	0	0	51	0	0	0	0	0
F. Pectinariidae										
Pectinaria gouldi	51	26	0	64	32	0	6	0	0	0
F. Sabellidae										
Euchone elegans	51	0	0	0	0	0	0	0	0	0
F. Sphaerodoridae										
Sphaerodoropsis minuta	26	0	0	0	0	51	26	0	0	0
F. Spionidae										
Polydora cornuta	0	0	0	0	0	0	26	6	0	0
Polydora quadrilobata	0	0	0	0	0	0	0	0	0	0
Prionospio steenstrupi	485	1,199	1,072	466	2,858	816	1,027	0	0	0
Pygospio elegans	0	0	0	0	0	0	0	0	0	0
Spiophanes bombyx	2,207	1,627	1,888	1,537	1,072	568	867	6	0	1,531
Spio	0	0	0	0	0	26	0	0	0	0
ARTHROPODS										
P. Arthropoda										
SP. Crustacea										
SEED SHRIMPS										
Cl. Ostracoda	51	0	51	0	0	0	0	0	0	0
BARNACLES										
Cl. Cirripedia										
F. Balanidae										
Balanus	0	0	0	0	0	0	255	0	0	0
Cl. Malacostraca										
WATER SCUDS										
O. Amphipoda										
indeterminate	**51**	0	0	0	0	0	0	0	0	0
F. Ampeliscidae										
Ampelisca	0	0	0	0	26	0	0	0	0	0
F. Aoridae										
Unciola irrorata	51	0	77	0	0	0	0	0	0	0
F. Corophiidae										
Corophium crassicorne	0	0	0	0	0	0	0	0	0	0
Corophium	26	0	0	0	0	0	0	0	0	0
F. Lysianassidae										
Orchomenella minuta	26	0	26	26	26	102	0	6	13	26
F. Oedicerotidae										
Monoculodes	0	0	26	26	0	0	0	19	6	0
F. Photidae										
Photis reinhardi	587	204	332	434	51	77	0	19	0	19
F. Phoxocephalidae										
Phoxocephalus holbolli	26	26	0	0	51	0	26	0	0	0

Table C.1: Benthic invertebrate community data for the Brunswick Smelter Benthic Monitoring Program, October 2014. Densities expressed in number of organisms per square meter.

Study Area	Deep Reference (RD)					Fertilizer Plant Outfall Area (FPO)				
Replicate	1	2	3	4	5	1	2	3	4	5
CUMACEANS										
O. Cumacea										
F. Bodotriidae										
Pseudoleptocuma minor	0	0	0	0	0	0	0	0	0	13
F. Diastylidae										
Diastyis	970	791	944	765	306	408	434	57	83	1,933
Oxyurostylis smithi	0	0	0	77	0	0	0	0	13	108
F. Lampropidae										
Lamprops quadriplicata	0	0	0	0	0	0	0	0	0	0
F. Leuconidae										
Eudorella	102	0	0	0	0	0	0	0	0	0
AQUATIC SOW BUGS										
O. Isopoda										
F. Idoteidae										
Edotea triloba	26	0	0	0	0	0	0	6	0	0
CRABS and SHRIMP										
O. Decapoda										
Infraorder Anomura										
TRUE CRABS										
Infraorder Brachyura										
F. Cancridae										
Cancer irroratus	0	0	0	0	0	0	6	6	6	0
SHRIMPS										
Infraorder Caridea										
F. Crangonidae										
Crangon septemspinosa	0	0	0	0	0	0	0	6	6	6
MOLLUSCS										
P. Mollusca										
SNAILS										
Cl. Gastropoda										
indeterminate	0	0	0	0	0	0	0	0	0	0
F. Calyptraeidae										
Crepidula fornicata	0	0	0	26	0	0	0	0	0	0
F. Nassariidae										
Nassarius trivittatus	255	77	0	96	153	0	0	26	70	140
F. Naticidae										
Lunatia heros	0	0	0	0	0	0	0	0	0	0
F.Turridae										
indeterminate	6	51	0	0	0	0	0	0	0	0
CLAMS										
Cl. Bivalvia										
indeterminate	0	**179**	**306**	**281**	**357**	0	0	0	0	0
F. Anomiidae										
Anomia simplex	0	0	0	0	0	0	26	6	0	0
F. Arcticidae										
Arctica islandica	0	26	0	0	0	0	0	0	0	0
F. Cardiidae										
Cerastoderma pinnulatum	51	0	0	0	26	51	0	32	13	0
F. Hiatellidae										
Hiatella arctica	0	0	0	0	0	0	51	0	0	13

Table C.1: Benthic invertebrate community data for the Brunswick Smelter Benthic Monitoring Program, October 2014. Densities expressed in number of organisms per square meter.

Study Area	Deep Reference (RD)					Fertilizer Plant Outfall Area (FPO)				
Replicate	1	2	3	4	5	1	2	3	4	5
F. Mactridae										
Spisula solidissima	816	0	306	26	0	77	77	32	153	281
F. Myidae										
Mya arenaria	0	128	26	179	51	26	0	38	249	19
F. Mytilidae										
Mytilus edulis	77	255	179	128	77	919	919	64	134	45
F. Solenidae										
Ensis directus	51	0	0	0	26	0	0	0	0	0
F. Tellinidae										
Macoma balthica	0	0	0	0	0	51	0	0	0	0
Tellina agilis	2,220	504	1,046	619	587	383	102	13	0	612
F. Veneridae										
Pitar morrhuanus	6	0	0	0	0	0	0	0	0	0
P. Echinodermata										
SAND DOLLARS										
Cl. Echinoidea										
F. Echinarachniidae										
Echinarachnius parma	536	0	64	0	0	0	0	0	0	6
Total Abundance of Organisms	12,654	5,905	9,163	6,168	10,019	4,928	5,482	489	836	6,003
Total Number of Taxa *	36	21	25	24	27	28	28	21	14	22
Simpson's Diversity (1-D)	0.899	0.846	0.874	0.882	0.796	0.899	0.890	0.910	0.828	0.788
Simpson's Evenness (E)	0.925	0.889	0.910	0.920	0.827	0.933	0.923	0.955	0.892	0.826
Shannon-Weiner Diversity (H')	3.864	3.252	3.451	3.607	2.967	3.836	3.698	3.849	2.927	2.700
Shannon-Weiner Evenness (J')	0.747	0.740	0.743	0.787	0.624	0.798	0.769	0.876	0.769	0.605
Bray-Curtis Index	0.325	0.207	0.129	0.247	0.316	0.552	0.547	0.930	0.900	0.370
Percent Composition										
Errantia	27.4%	12.9%	27.9%	20.9%	41.2%	21.2%	20.2%	27.4%	10.8%	20.1%
Nephtys sp. (%)	3.5%	7.2%	2.6%	13.0%	3.6%	1.9%	1.0%	0.0%	0.0%	0.7%
Protodriloides symbioticus	13.8%	1.7%	18.7%	2.9%	31.6%	0.0%	0.0%	0.0%	0.0%	17.0%
Sedentaria	24.1%	48.7%	32.7%	34.4%	40.4%	33.5%	41.4%	2.5%	0.0%	26.3%
Spionidae (%)	21.3%	47.9%	32.3%	32.5%	39.2%	28.6%	35.0%	2.5%	0.0%	25.5%
Prionospio steenstrupi	3.8%	20.3%	11.7%	7.6%	28.5%	16.6%	18.7%	0.0%	0.0%	0.0%
Spiophanes bombyx	17.4%	27.6%	20.6%	24.9%	10.7%	11.5%	15.8%	1.2%	0.0%	25.5%
Metal-Sensitive Crustaceans (%)	14.5%	17.3%	15.3%	21.5%	4.6%	11.9%	8.4%	20.7%	13.8%	35.0%
Gastropoda (Nassarius)	2.1%	2.2%	0.0%	2.0%	1.5%	0.0%	0.0%	5.3%	8.4%	2.3%
Bivalves (%)	25.5%	18.5%	20.3%	20.0%	11.2%	30.6%	21.4%	37.8%	65.7%	16.2%
Tellina agilis	17.5%	8.5%	11.4%	10.0%	5.9%	7.8%	1.9%	2.7%	0.0%	10.2%

* Bold entries excluded from taxa count.

Table C.2: Benthic invertebrate community statistical comparison results between final effluent-exposed (FE) and shallow reference (RS study areas for miscellaneous taxa, Brunswick Smelter Benthic Monitoring Program, October 2014.

Metric	Statistical Test Results				Summary Statistics					
	Significant Difference Between Areas?	*p* -value	Statistical Analysis[a]	Magnitude of Difference [b] (No. of SD)	Area	Mean	Standard Deviation	Standard Error	Minimum	Maximum
Nephtys (%) Errantia	NO	0.120	γ	-	Shallow Reference	7.8%	6.5%	2.9%	4.0%	19.4%
					Final Effluent Area	3.2%	2.1%	0.9%	0.3%	5.4%
Protodrilodes (%) Errantia	YES	0.000	γ	-3.1	Shallow Reference	2.7%	0.9%	0.4%	1.2%	3.3%
					Final Effluent Area	0.0%	0.0%	0.0%	0.0%	0.0%
Spionidae (%) (Sedentaria)	NO	0.306	δ	-	Shallow Reference	31.6%	7.1%	3.2%	25.9%	42.1%
					Final Effluent Area	25.5%	12.7%	5.7%	10.1%	41.8%
Prionospio (%) Sedentaria	NO	0.580	γ	-	Shallow Reference	0.2%	0.2%	0.1%	0.0%	0.5%
					Final Effluent Area	0.1%	0.1%	0.1%	0.0%	0.3%
Spiophanes (%) Sedentaria	NO	0.322	δ	-	Shallow Reference	30.1%	5.9%	2.6%	24.9%	39.0%
					Final Effluent Area	24.6%	13.0%	5.8%	9.7%	41.5%
Tellina agilis (%) Bivalvia	YES	0.005	δ	6.0	Shallow Reference	26.1%	3.6%	1.6%	22.7%	31.3%
					Final Effluent Area	47.4%	12.7%	5.7%	32.5%	65.4%

[a] Data analysis included: γ - data logit transformed, single factor ANOVA test results confirmed using Mann-Whitney U-test; and, δ - data logit transformed, single-factor ANOVA test conducted.

[b] Magnitude calculated by comparing the difference between the reference area and effluent-exposed area means divided by the reference area standard deviation.

▨ Highlighted values indicates significant difference between study areas based on ANOVA p-value less than 0.10.

Table C.3: Two-way ANOVA results for evaluation of differences between 2008 and 2014 for benthic invertebrate community survey endpoints at the Final Effluent (FE) area taking Shallow Reference (RS) area data into account, Brunswick Smelter Benthic Monitoring Program, October 2014.

Metric	Source	Significant Difference Indicated?	p-value	Power
Density	Time	Yes	0.010	0.778
	Area	Yes	0.000	0.998
	Time*Area	Yes	0.030	0.610
Richness	Time	No	0.478	0.105
	Area	No	0.886	0.052
	Time*Area	No	0.538	0.091
Simpson's Diversity	Time	Yes	0.083	0.412
	Area	No	0.980	0.050
	Time*Area	No	0.128	0.326
Simpson's Evenness	Time	Yes	0.074	0.435
	Area	No	0.961	0.050
	Time*Area	No	0.136	0.314
Shannon-Weiner Diversity	Time	No	0.111	0.355
	Area	No	0.900	0.052
	Time*Area	Yes	0.067	0.455
Shannon-Weiner Evenness	Time	Yes	0.070	0.446
	Area	No	0.878	0.052
	Time*Area	Yes	0.057	0.486
Bray-Curtis Index	Time	Yes	0.002	0.940
	Area	No	0.481	0.104
	Time*Area	No	0.572	0.084
Errantia (% of community)	Time	Yes	0.005	0.860
	Area	Yes	0.015	0.730
	Time*Area	No	0.719	0.064
Sedentaria (% of community)	Time	No	0.195	0.246
	Area	Yes	0.014	0.734
	Time*Area	No	0.687	0.067
Metal-Sensitive Crustaceans (% of community)	Time	No	0.589	0.081
	Area	No	0.392	0.131
	Time*Area	No	0.505	0.098
Gastropoda (% of community)	Time	No	0.221	0.223
	Area	Yes	0.000	1.000
	Time*Area	Yes	0.040	0.558
Bivalvia (% of community)	Time	No	0.125	0.332
	Area	No	0.119	0.341
	Time*Area	No	0.211	0.232

Table C.4: Benthic invertebrate community statistical comparison results between the fertilizer plant outfall (FPO) and deep reference (RD) study areas for miscellaneous taxa, Brunswick Smelter Benthic Monitoring Program, October 2014.

Metric	Statistical Test Results				Summary Statistics					
	Significant Difference Between Areas?	*p* -value	Statistical Analysis[a]	Magnitude of Difference [b] (No. of SD)	Area	Mean	Standard Deviation	Standard Error	Minimum	Maximum
Nephtys (%) Errantia	NO	0.825	ε	-	Deep Reference	6.0%	4.3%	1.9%	2.6%	13.0%
					Fertilizer Plant Outfall	0.7%	0.8%	0.4%	0.0%	1.9%
Protodrilodes (%) Errantia	YES	0.020	γ	-0.8	Deep Reference	13.7%	12.3%	5.5%	1.7%	31.6%
					Fertilizer Plant Outfall	3.4%	7.6%	3.4%	0.0%	17.0%
Spionidae (%) (Sedentaria)	NO	0.396	δ	-	Deep Reference	34.6%	9.8%	4.4%	21.3%	47.9%
					Fertilizer Plant Outfall	18.3%	16.0%	7.2%	0.0%	35.0%
Prionospio (%) Sedentaria	YES	0.037	γ	-0.7	Deep Reference	14.4%	10.0%	4.5%	3.8%	28.5%
					Fertilizer Plant Outfall	7.1%	9.7%	4.3%	0.0%	18.7%
Spiophanes (%) Sedentaria	NO	0.597	δ	-	Deep Reference	20.2%	6.6%	3.0%	10.7%	27.6%
					Fertilizer Plant Outfall	10.8%	10.6%	4.7%	0.0%	25.5%
Tellina agilis (%) Bivalvia	NO	0.734	δ	-	Deep Reference	10.7%	4.4%	1.9%	5.9%	17.5%
					Fertilizer Plant Outfall	4.5%	4.3%	1.9%	0.0%	10.2%

[a] Data analysis included: γ - data logit transformed, single factor ANOVA test results confirmed using Mann-Whitney U-test; δ - data logit transformed, single-factor ANOVA test conducted; and, ε - data logit transformed, single factor ANOVA test results confirmed using t-test assuming unequal variance.

[b] Magnitude calculated by comparing the difference between the reference area and effluent-exposed area means divided by the reference area standard deviation.

▨ Highlighted values indicates significant difference between study areas based on ANOVA p-value less than 0.10.

Table C.5: Two-way ANOVA results for evaluation of differences between 2008 and 2014 for benthic invertebrate community survey endpoints at the Fertilizer Plant Outfall (FPO) area taking Deep Reference (RD) area data into account, Brunswick Smelter Benthic Monitoring Program, October 2014.

Metric	Source	Significant Difference Indicated?	p-value	Power
Density	Time	No	0.472	0.107
	Area	No	0.453	0.112
	Time*Area	No	0.122	0.336
Richness	Time	Yes	0.001	0.975
	Area	No	0.751	0.061
	Time*Area	Yes	0.020	0.678
Simpson's Diversity	Time	No	0.268	0.190
	Area	Yes	0.066	0.457
	Time*Area	No	0.241	0.209
Simpson's Evenness	Time	No	0.437	0.117
	Area	Yes	0.079	0.423
	Time*Area	No	0.331	0.157
Shannon-Weiner Diversity	Time	No	0.131	0.322
	Area	No	0.136	0.315
	Time*Area	No	0.155	0.290
Shannon-Weiner Evenness	Time	No	0.924	0.051
	Area	No	0.150	0.295
	Time*Area	No	0.605	0.079
Bray-Curtis Index	Time	Yes	0.000	1.000
	Area	No	0.403	0.128
	Time*Area	No	0.115	0.348
Errantia (% of community)	Time	Yes	0.080	0.419
	Area	Yes	0.001	0.960
	Time*Area	No	0.551	0.088
Sedentaria (% of community)	Time	No	0.379	0.136
	Area	No	0.260	0.195
	Time*Area	No	0.897	0.052
Metal-Sensitive Crustaceans (% of community)	Time	No	0.560	0.087
	Area	Yes	0.006	0.851
	Time*Area	No	0.925	0.051
Gastropoda (% of community)	Time	Yes	0.066	0.458
	Area	No	0.201	0.241
	Time*Area	No	0.756	0.060
Bivalvia (% of community)	Time	No	0.235	0.213
	Area	No	0.137	0.313
	Time*Area	No	0.546	0.089

APPENDIX F

MINNOW (2015B) MUSSEL REPRODUCTION AND GROWTH STUDY AND FISH HEALTH STUDY

Brunswick Smelter 2014 Caged Bivalve and Fish Population Survey

Report Prepared For:
Glencore Canada Corp., Brunswick Smelter
Belledune, NB

Prepared By:
Minnow Environmental Inc.
Georgetown, ON.

March 2015

Brunswick Smelter 2014
Caged Bivalve and Fish Population Survey

Prepared for:

Glencore Canada Corp., Brunswick Smelter

Prepared by:

Minnow Environmental Inc.

Paul LePage, M.Sc.
Project Manager

Cynthia Russel, B.Sc.
Project Principal

March 2015

EXECUTIVE SUMMARY

Glencore Canada Corporation (Glencore) operates the Brunswick Smelter complex on the south shore of the Baie des Chaleurs near the Village of Belledune, New Brunswick. In addition to a lead smelter and bulk handling facility that have been in operation since 1966, the complex also historically included a zinc smelting facility and a fertilizer plant, which were closed in 1972 and 1996, respectively. Among other metals, the lead smelter has been a source of arsenic, cadmium, lead, thallium and zinc to the Baie des Chaleurs marine environment as a direct result of the discharge of treated process wastewater (effluent). The Brunswick Smelter complex may also contribute metals to the Baie des Chaleurs via atmospheric stack emissions (that can also include sulphur dioxide and nitrogen oxides), fugitive dust and surface water runoff from the site. Until closure of the fertilizer plant, a gypsum-based slurry, produced as an effluent waste product from the plant, was also discharged into the Baie des Chaleurs just north of a breakwater that currently bounds the Port of Belledune.

Glencore recently completed detailed risk assessment studies to examine possible influences of Brunswick Smelter emissions on human health in residential areas, as well as on ecological receptors in nearby terrestrial and freshwater environments. To further characterize ecological risks associated with the Brunswick Smelter complex, Intrinsik Environmental Sciences Inc. (Intrinsik) was commissioned by Glencore to examine ecological risks in the Baie des Chaleurs marine environment adjacent to the complex. This Caged Bivalve and Fish Population Survey was conducted at the Brunswick Smelter in 2014 to build upon available effects assessment information and, in turn, support development of the Risk Characterization component of the Brunswick Smelter marine ecological risk assessment (Marine ERA), which will be developed by Intrinsik.

The objectives of the Brunswick Smelter 2014 Caged Bivalve and Fish Population Survey were to evaluate any differences in shellfish and fin-fish health endpoints of survival, growth, reproduction and/or energy usage at the smelter-exposed area of the Baie des Chaleurs compared to reference conditions. The survey employed multiple control-impact and control-impact approaches to evaluate potential smelter-related influences on the health of blue mussels (*Mytilus edulis*) and Atlantic tomcod (*Microgadus tomcod*), respectively, in the Baie des Chaleurs adjacent to the Brunswick Smelter complex. The principal conclusions from the survey were:

- Blue mussels caged at the smelter-exposed areas contained higher soft tissue cadmium and lead concentrations compared to the reference area, with soft tissue concentrations of other metals similar between study areas. No smelter-related influences on survival of caged blue mussel were indicated in the Baie des Chaleurs. In addition, the growth of caged blue mussels was more rapid at the smelter-exposed area compared to reference, suggesting no adverse influences of smelter operations on blue mussel growth endpoints. Greater growth rates near the smelter were hypothesized to reflect a nutrient source from the smelter complex (e.g., metal micro-nutrients) and/or possible slight differences in natural habitat variables (e.g., water temperature) compared to the reference area. Although caged blue mussel condition (weight-at-length relationship) at some smelter-exposed cages differed significantly from reference, the size of the indicated differences was small (i.e., approximately 2 – 3%). Coupled with the growth analysis results that indicated slightly faster growth at the smelter-exposed areas, the survey suggested higher allocation of energy use to growth (e.g., shell size increase) at the smelter-exposed area compared to reference. Overall, despite higher soft tissue metal concentrations, no marked adverse smelter-related influences on blue mussel survival and growth were indicated in the Baie des Chaleurs adjacent to the Brunswick Smelter complex.

- Female tomcod collected at the Baie des Chaleurs smelter-exposed area showed significantly slower growth in length, as well as significantly smaller relative gonad size and egg size, compared to reference. However, the differences in female total length and relative gonad size between these study areas were within ecological CES, suggesting that these differences were within the range of variability found normally between populations. In addition, no significant differences in female tomcod population age structure, fecundity and indicators of energy storage/use (i.e., condition and relative liver size) were indicated between the smelter-exposed and reference areas. Thus, despite an ecologically relevant, significantly smaller egg size in female tomcod of the smelter-exposed area compared to reference, the difference in this reproductive endpoint likely reflected natural differences in gonad development due to differing female tomcod population spawning timing between these areas.
- Male tomcod collected at the Baie des Chaleurs smelter-exposed area showed no significant difference in survival (i.e., age structure), growth, reproduction, or energy use compared to representative reference conditions, suggesting no adverse effects from the Brunswick Smelter operations to male tomcod. However, very small sample sizes were obtained for male tomcod at both study areas, possibly reflecting pre-spawning migration away from the study areas, and therefore the results of the male tomcod population survey should be viewed with caution.

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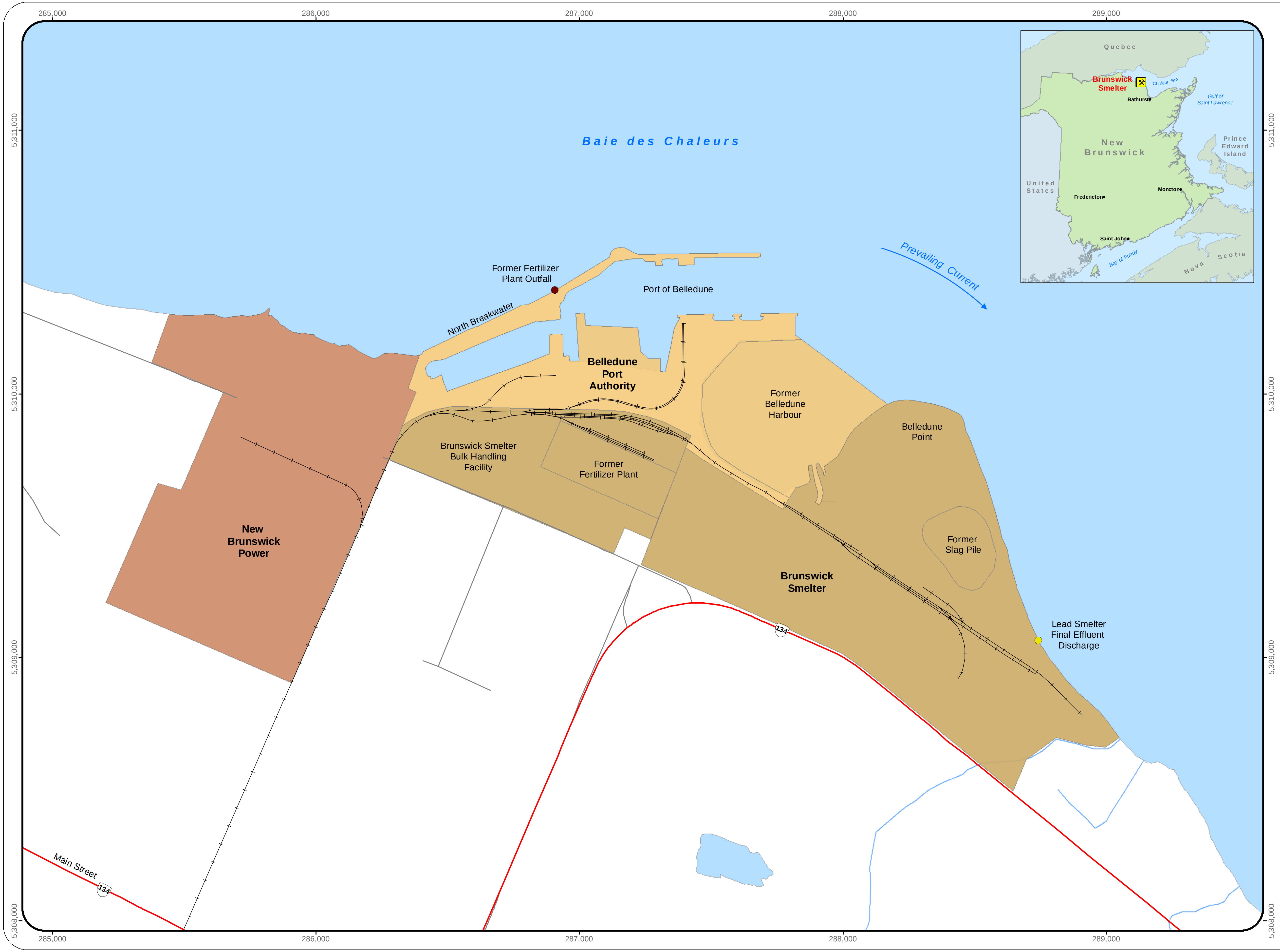
1.0 INTRODUCTION

1.1 Site Description and Study Background

Glencore Canada Corporation (Glencore) operates the Brunswick Smelter complex on the south shore of the Baie des Chaleurs near the Village of Belledune, New Brunswick (Figure 1.1). In addition to a lead smelter and bulk handling facility that have been in operation since 1966, the complex also historically included a zinc smelting facility and a fertilizer plant, which were closed in 1972 and 1996, respectively. Among other metals, the lead smelter has been a source of arsenic, cadmium, lead, thallium and zinc to the Baie des Chaleurs marine environment as a direct result of the discharge of treated process wastewater (effluent). The Brunswick Smelter complex may also contribute metals to the Baie des Chaleurs via atmospheric stack emissions (that can also include sulphur dioxide and nitrogen oxides), fugitive dust and surface water runoff from the site. Until closure of the fertilizer plant, a gypsum-based slurry, produced as an effluent waste product from the plant, was also discharged into the Baie des Chaleurs just north of a breakwater that currently bounds the Port of Belledune (Figure 1.1). Although gypsum (i.e., calcium sulphate) generally exhibits high solubility in seawater, dispersion of the slurry at the outfall location was insufficient to achieve complete gypsum dissolution resulting in the historical development of a relatively insoluble gypsum bed north of the Port of Belledune breakwater, in the vicinity of the (former) discharge.

Environmental monitoring and specialized investigations have been implemented routinely in the Baie des Chaleurs (including the former Belledune Harbour) by the Brunswick Smelter since the mid-1960s to evaluate influences of the Brunswick Smelter complex operations on shellfish tissue metal concentrations and benthic invertebrate communities. The shellfish tissue monitoring has included native blue mussel (*Mytilus edulis*) sampling and culture studies, as well as native lobster (*Homarus americanus*) sampling. Briefly, these studies indicated that cadmium, lead, and zinc concentrations can be elevated in native blue mussel soft tissues to as far as approximately 6 km east of the smelter, but that any elevation in lead and/or cadmium concentrations in lobster muscle and hepatopancreas (i.e., digestive gland) tissues were mainly confined to areas within the inner portion of the former Belledune Harbour. A total of 28 benthic invertebrate community (benthic) surveys have been implemented in the Baie des Chaleurs adjacent to the smelter complex, with the most recent results indicating significantly lower density and differences in community structure at the area receiving lead smelter effluent compared to reference (Minnow 2015). However, the magnitude of these differences was below ecologically significant levels and, coupled with significantly comparable relative abundance of metal-sensitive groups at the smelter effluent-exposed and reference



Features

- ● Former Fertilizer Plant Outfall
- ● Lead Smelter Final Effluent Discharge
- ▨ Brunswick Smelter
- ▨ New Brunswick Power
- ▨ Belledune Port Authority
- ▨ Waterbody
- — Watercourse
- — Highway
- — Road
- ┼ Railway

N
W E
S

350 175 0 350
Meters

MAP INFORMATION
Datum: NAD 83 Map Projection: UTM Zone 20N
Data Source:Province of New Brunswick, Service New Brunswick - GoeNB. All rights reserved.
Created By: M.LaPalme
Creation Date: February 2015
Project No.: 2539

Figure 1.1: Location of the Brunswick Smelter

Created by:

minnow environmental inc.

areas, the ecological differences between areas were determined to be minor. Subtle benthic invertebrate community differences were also indicated between the former fertilizer plant discharge-affected area and reference, likely reflecting altered habitat conditions as a result of a compact gypsum bed at this location (Minnow 2015).

Glencore has recently completed detailed risk assessment studies to examine possible influences of Brunswick Smelter emissions on human health in residential areas, as well as on ecological receptors in nearby terrestrial and freshwater environments (Intrinsik et al. 2008, Intrinsik 2013). To further characterize ecological risks associated with the Brunswick Smelter operation, Intrinsik Environmental Sciences Inc. (Intrinsik) was commissioned by Glencore to examine the potential for ecological risks in the Baie des Chaleurs marine environment adjacent to the complex. In the Problem Formulation component of the Brunswick Smelter Marine Ecological Risk Assessment (Marine ERA), Intrinsik (2014) identified specific knowledge gaps for completion of the Marine ERA. Among others, a more detailed examination of the influence of smelter releases on marine bivalves and (fin-) fish ecological endpoints of growth, reproduction and/or condition was identified as a key data gap that required addressing as part of the Marine ERA. This Marine ERA Caged Bivalve and Fish Population Survey was conducted in 2014 to build upon available Effects Assessment information and, in turn, support development of the Risk Characterization component of the Brunswick Smelter Marine ERA (see Intrinsik 2014).

1.2 Caged Bivalve and Fish Population Survey Objective

The objective of the Brunswick Smelter 2014 Caged Bivalve and Fish Population Survey was to evaluate any differences in shellfish and fin-fish health endpoints of survival, growth, reproduction and/or energy usage at smelter-exposed areas of the Baie des Chaleurs compared to suitable reference areas. The results of this survey will be used by Intrinsik to provide an overall assessment of potential risks of historical and/or current metal/metalloid releases from the Brunswick Smelter operation to various ecological receptors in the marine environment. Intrinsik will provide the Brunswick Smelter Marine ERA under a separate cover.

1.3 Report Organization

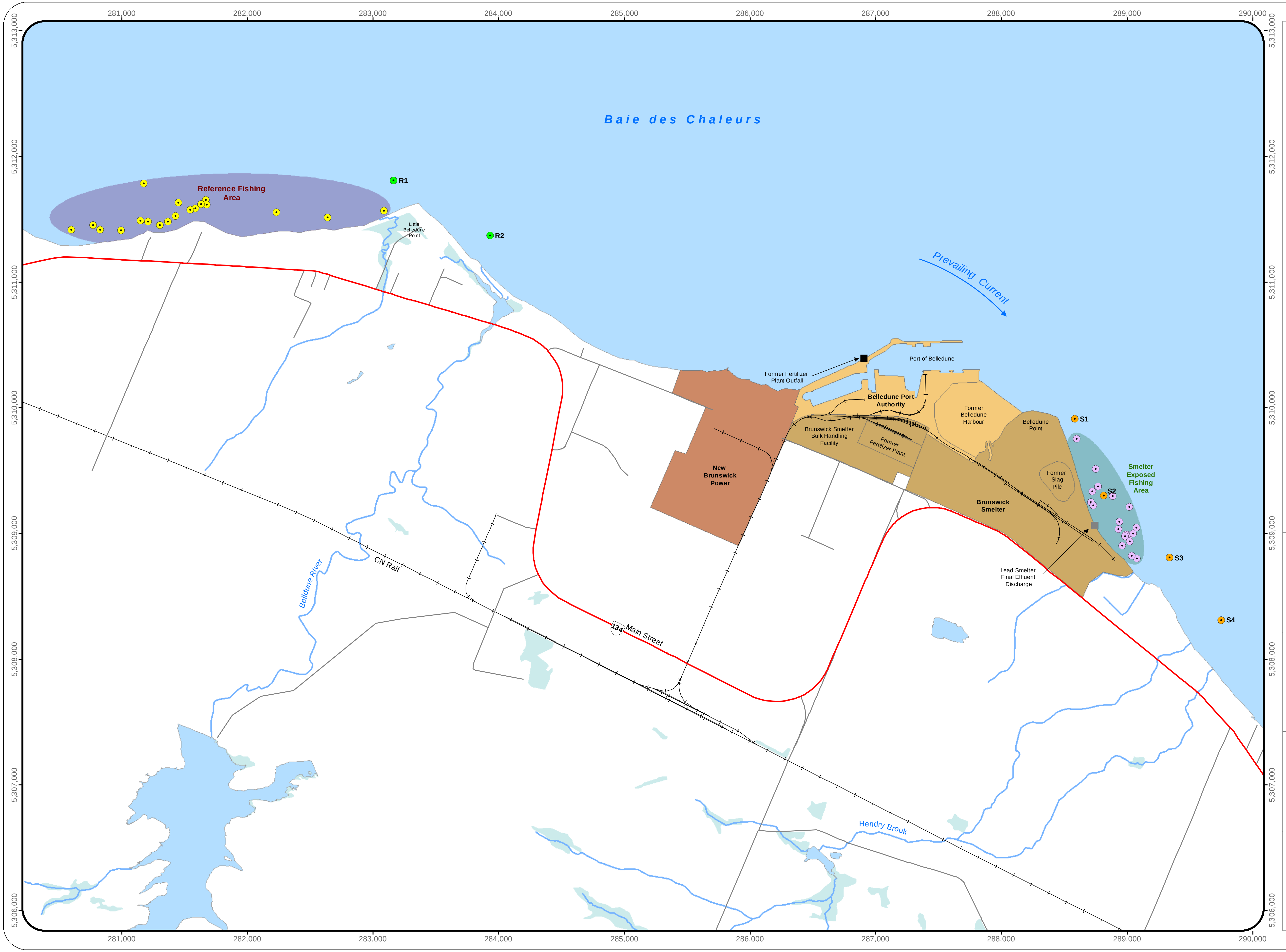
This Brunswick Smelter 2014 Caged Mussel and Fish Population Survey report is organized into five sections, excluding this introductory section. The approach, area/station locations, and methods used for sample collection, sample processing and data analyses are presented in Section 2.0. The results of the caged mussel survey are presented in Section 3.0, and those of the fish population survey are provided in Section 4.0. The conclusions of the Brunswick

Smelter Marine ERA Caged Bivalve and Fish Population Survey are provided in Section 5.0. Finally, all references cited in this report are listed in Section 6.0.

2.0 METHODS

The Brunswick Smelter Caged Bivalve and Fish Population Survey used a multiple control-impact and control-impact approach, respectively, to evaluate potential smelter-related influences on the health of blue mussels (*Mytilus edulis*) and Atlantic tomcod (*Microgadus tomcod*) in the Baie des Chaleurs adjacent to the Brunswick Smelter complex. Caged bivalve studies provide high discriminating power for testing the effects of industrial discharges on marine biota, partly because of the ability to provide strict environmental control (e.g., known exposure period, selection of individuals of similar size and environmental history; Salazar and Salazar 1995, Crane et al. 2007, Environment Canada 2012). Blue mussels are commonly used in caged mussel studies to assess the effects of industrial operations on the health of marine ecosystems (e.g., Andrew and Parker 1999, St-Jean et al. 2003, 2005, Crane et al. 2007). In part, this reflects the wide distribution of blue mussels and the relative ease to acquire, handle and measure them, as well as the fact that blue mussels readily bioconcentrate/accumulate metals and other chemicals from a variety of pathways, thereby providing a measure of contaminant bioavailability near the entry level of the food chain (Farrington et al. 1987, Murray et al. 1991, Metcalfe-Smith et al. 1996, Salazar and Salazar 2000, Environment Canada 2012). Fish population surveys are often an integral component of environmental monitoring studies, providing an objective, discrete measure of the biotic conditions at areas potentially influenced by industrial emissions/inputs (Barbour et al. 1999, Environment Canada 2012). Therefore, the inclusion of both caged bivalve and fish population surveys, together with benthic invertebrate community assessment information issued separately (Minnow 2015), will provide multiple lines of evidence on which to evaluate marine biological conditions in the Baie des Chaleurs as part of the Brunswick Smelter Marine ERA.

Areas of the Baie des Chaleurs used for the Brunswick Smelter 2014 Caged Bivalve and Fish Population Survey included a smelter-exposed area within 2 km east of Belledune Point, and a reference area located near Little Belledune Point extending approximately 4.5 – 7.0 km west of the Brunswick Smelter complex (Figure 2.1). Notably, the reference area is relatively uninfluenced by current or historical smelter complex-related emissions/discharges as a result of prevailing westerly winds and westerly ocean currents (Gan et al. 1997, 2004). The study areas used for the 2014 Caged Bivalve and Fish Population Survey were the same as those used for previous and routine environmental monitoring at the Brunswick Smelter (e.g., native mussel sampling and cultures, benthic invertebrate community studies).



MAP INFORMATION
Datum: NAD 83 Map Projection: UTM Zone 20N
Data Source:Province of New Brunswick, Service New Brunswick - GoeNB. All rights reserved.
Created By: M.LaPalme
Creation Date: March 2015
Project No.: 2539

Figure 2.1: Study Areas and Sampling Locations for the Brunswick Smelter Caged Bivalve and Fish Population Survey, August-October, 2014.

Created by:
minnow environmental inc.

2.1 Caged Bivalve Survey

The Brunswick Smelter 2014 Caged Bivalve survey employed a multiple control-impact experimental design to examine potential influences of seawater quality in the Baie des Chaleurs near the smelter on soft tissue metal concentrations and the survival, growth and condition of blue mussels. Four caged bivalve smelter-exposed stations were established in the Baie des Chaleurs, positioned roughly in a gradient extending from Belledune Point near the mouth of the Port of Belledune to approximately 1.3 km east of the Brunswick Smelter current lead smelter treated effluent discharge (Figure 2.1; Table 2.1). Two caged bivalve reference stations were established at Little Belledune Point, approximately 4.7 and 5.6 km west of the Brunswick Smelter operation (Figure 2.1; Table 2.1). The cages were deployed on August 5th and 6th and retreived on October 11th, 2014, resulting in a total test duration of approximately 66 days (9.4 weeks). This length of time was within the 60 – 90 day duration recommended for caged bivalve studies, providing sufficient time for measurable differences in growth and contaminant uptake (Andrews and Parker 1999, Salazar and Salazar 2000). Information regarding blue mussel source, cage design, sample measurements, laboratory analysis and data analysis are provided in respective sub-sections below.

2.1.1 Blue Mussel Source

At the outset of the caged bivalve survey, a licence to collect and transfer blue mussels to the Brunswick Smelter study area (Licence No. MCFR(scientific)-ENB-14-502) was acquired from the Department of Fisheries and Oceans (DFO) pursuant with the Canada *Fisheries Act* regulations (Part VII, Section 52) and *Management of Contaminated Fishery Regulations* (Section 4.1) The blue mussels were acquired from the Ferme Maricole du Grand Large (mussel farm) located on the Baie des Chaleurs near the town of Carleton, QC. Juvenile mussels used for the study, with target shell lengths ranging from 25 – 35 mm, were hand selected from the sorted mussel harvest 2 – 3 hours following retrieval from the farm pens. The use of juvenile blue mussels of this size range is ideal for assessing endpoints of growth and tissue metal accumulation in caged mussel surveys because greater allocation of energy is to growth (and hence, highest growth rates) and metal absorption efficiences are high for blue mussels within this size range compared to larger, older mussels (Mallet et al. 1988, Andrews and Parker 1999, Environment Canada 2012). In addition, blue mussels within this size range provide adequate tissue sample volumes to allow contaminant analysis with reasonable method detection limits.

Table 2.1: Brunswick Smelter caged bivalve station coordinates, chart datum (depth) and substrate information.

Area ID	Station ID	Coordinates (latitude longitude)	Tide Corrected Depth (m)	Substrate
Reference	R1	47 55.374 65 54.158	3.3	gravel, sand and cobble
	R2	47 55.154 65 55.531	3.4	gravel, sand and cobble
Smelter-Exposed	S1	47 54.460 65 49.756	3.1	gravel, sand and cobble
	S2	47 54.136 65 49.552	3.4	gravel, sand and cobble
	S3	47 53.880 65 49.117	3.4	gravel, cobble and sand
	S4	47 53.620 65 48.774	3.2	bedrock, with gravel-sand patches

2.1.2 Cage Design

The bivalve cage design used for the Brunswick Smelter 2014 Caged Bivalve survey was similar to those recommended for caged bivalve studies to examine effects on mussel survival and growth (Salazar and Salazar 2000, Environment Canada 2012). Briefy, an approximately 1 meter square flat cage frame was constructed of 1¼ inch diameter rigid polyvinyl chloride (PVC) pipe. As recommended by Environment Canada (2012), the PVC bivalve cage frame was soaked in seawater for a duration of approximately 24 hours prior to stocking with blue mussels to remove any water soluble and/or volatile chemicals in the PVC that may have affected the study results. Mesh ‘socks’, measuring 5 cm in diameter and 3 mm stretched mesh size, were stocked with separately compartmentalized mussels and then strung between the upper and lower frame pipes at regular intervals across the width of the bivalve cage. In total, seven sets of mesh socks were placed in each bivalve cage. The frame was attached to a mooring line and a marker buoy line. The mooring system included three 20.5 kg standard concrete blocks (i.e., 61.5 kg total mass), attached to the frame with an appropriate length of 2.5 cm diameter polypropylene rope. The cage was designed to be positively bouyant, with the frame maintained in an fully upright position near the water surface under low tide conditions for the duration of the test period. Schematics and photographs of bivalve cages similar to those used in the Brunswick Smelter 2014 Caged Bivalve study are provided by Salazar and Salazar (2000) and Environment Canada (2012). In accordance with licence conditions, marker buoys for each bivalve cage were labeled with the DFO licence information, and a DFO-supplied tag with the same information was also affixed to the cage frame.

2.1.3 Test Initiation, Cage Deployment and Retrieval, and Test Termination

Approximately 750 blue mussels were collected at the mussel farm. These mussels were placed into mesh bags and put on ice in coolers for transport to Bathurst, NB for mussel processing, organization and stocking in the mussel socks. The initial processing of the mussels included individual measurement of shell length, width and height (to the nearest 0.01 cm) using digital calipers, and whole animal wet weight (WAWW; to the nearest 0.001 g) using an Ohaus Model 123 Scout-Pro balance (Ohaus Corp., Pine Brook, NJ). Following these measurements, individual mussels were stocked into mussel socks labelled with the cage identification and sock number. Ten mussels were placed into six socks, and five mussels into one sock, for each bivalve cage (i.e., total of 65 mussels per cage). Individual compartments for each mussel in the sock tubing were created by constricting the tubing between mussels with a plastic cable tie. Once a mussel sock was fully stocked with mussels, it was placed back on ice in a cooler to await attachment to the cage just prior to deployment. A subset of ten individual mussels were dissected, with the soft tissues removed and submitted to the

Research and Productivity Council (RPC; Fredericton, NB) for analysis of tissue percent moisture and total metal concentrations on a wet weight basis using standard analytical methods.

Once all of the mussel socks were stocked, the mussels were transported to the study area for deployment by boat crew. Prior to cage deployment, the mussel socks were attached to the bivalve cages in the order dictated by station/sock identification. The bivalve cages were then deployed at each predetermined location based, in part, on water depth, substrate and bathymetric features of each area. The selected chart datum depth at which caged bivalve stations were established ranged from approximately 3.1 – 3.4 m, with placement depth of the cage frame adjusted so as to remain upright near the water surface under lowest tide conditions. Supporting measures and observations taken at each bivalve cage during deployment included tide-corrected water depth, Global Positioning System (GPS) coordinates, substrate features, *in-situ* water quality measurements and collection of seawater for chemical analysis (Note: *in-situ* measurement and seawater chemistry results for the study are presented by Intrinsik [2015]).

The cages were then left unattended for approximately 9.4 weeks, following which each bivalve cage was located and retrieved. No indication of any anthropogenic tampering or damage (e.g., inadvertent boating damage) was evident, and no relocation of the cages had occurred due to natural forces. Supporting *in-situ* water quality measurements and collection of seawater for chemical analysis was also conducted at the time of bivalve cage retrieval. Upon retrieval, the mussel socks were removed from the cages, put on ice, and transported to a laboratory at Minnow Environmental Inc. (Minnow; Georgetown, ON) where the mussels were removed from the socking and subject to the same shell dimension and weight measurements indicated above. Additionally, the mussels were dissected, with the soft tissues removed and measurements of wet weight and dry weight then assessed. Dry weight was determined following approximately three days of drying at a temperature of 60°C. For all shell dimension, WAWW and additional measurements, it was imperative that the order and orientation of each mussel sock was maintained during all of the end-of-test mussel measurements to allow the assessment of mussel growth and condition on an individual mussel basis. In some cases, considerable bio-fouling by algae, various invertebrates and/or juvenile blue mussels resulted in some blue mussels becoming inadvertently dislodged from the mussel socking during cage retrieval. These mussels were placed in labelled bags and treated in the same fashion as for the remaining intact blue mussel samples, but were not included in the final data set used to interpret effects because they often could not be ascribed to individual compartments of the mussel socks. Blue mussel mortalities were identified as any mussels in which soft tissues were absent or that possessed odour and tissue consistency suggestive of mortality. A subset of soft tissue from five blue mussel samples was also taken from each bivalve cage and submitted to RPC for analysis of total metals based on dry weight using standard analytical methods.

2.1.4 Data Analysis

Endpoints for analysis of the Brunswick Smelter 2014 Caged Bivalve survey data included survival (mortality), growth (i.e., difference in shell dimensions or weight between time of cage deployment and retrieval) and condition (length-at-soft tissue weight relationships; Table 2.2). In addition, blue mussel tissue metal concentrations were compared among the smelter-exposed and reference area samples, with relationships between growth endpoints and tissue metal concentrations explored to assess any potential causal links.

Mortalities were assessed as the percent of individual blue mussels that were confirmed dead at the end of the cage deployment period relative to the total number of mussels present at the time of cage retrieval. Notably, missing individuals were not included with mortalities because mortality (or survival) of these individuals could not be confirmed. Growth was assessed based on comparison of absolute change in individual blue mussel measurements between test initiation and test termination among the smelter-exposed and reference areas. Growth endpoints of shell length, width and height, as well as WAWW and soma weight, were compared among areas using Analysis-of-Variance (ANOVA) and *post-hoc* tests. Prior to ANOVA, all data were transformed as required to meet test assumptions of normality and homogeneity of variance. Tukey's Honestly Significant Difference (HSD) and Tamhane's *post-hoc* tests were applied in cases in which normal data with equal and unequal variance, respectively, were encountered. In instances where normality could not be achieved through data transformation, non-parametric Kruskal-Wallis (multiple group comparisons) and/or Mann-Whitney U-test (study area pair-wise comparisons) statistics were used to confirm the statistical results from the ANOVA and *post-hoc* tests using log-transformed data. Similarly, in instances in which variances of normal data could not be homogenized by log transformation, pair-wise comparisons were conducted using Student's t-tests assuming unequal variance to confirm the statistical findings of the ANOVA tests. All statistical comparisons were conducted using SPSS Version 12.0 software (SPSS Inc., Chicago, IL)

Blue mussel condition, representing the relationship of soft tissue mass to shell length and/or soma dry weight to shell length, was compared between smelter-exposed and reference area station pairs using Analysis-of-Covariance (ANCOVA; Table 2.2). Prior to conducting the ANCOVA tests, scatter plots of all variable and covariate combinations were examined to identify outliers, leverage values or other unusual data. The scatter plots were also examined

Table 2.2: Brunswick Smelter Caged Bivalve Survey effect indicators, endpoints and related statisical tests.

Effect Indicator	Effect and Supporting Endpoints	Statistical Procedure[a,b]
Survival	Percentage of individuals alive per cage at test termination	none
Growth	Change in shell length (end measurements compared to starting measurements)	ANOVA
	Change in shell width (end measurements compared to starting measurements)	ANOVA
	Change in shell height (end measurements compared to starting measurements)	ANOVA
	Change in Whole-Animal-Wet-Weight (end measurements compared to starting measurements)	ANOVA
	Soma Dry Weight	ANOVA
Energy Storage	Condition (Whole-Animal-Wet-Weight against shell length)	ANCOVA
	Condition (soma dry weight against shell length)	ANCOVA

[a] ANOVA (Analysis of Variance) used except for non-parametric data, where Mann Whitney U-test may have been used.

[b] ANCOVA (Analysis of Covariance). For the ANCOVA analyses, the first term in parentheses is the endpoint (dependent variable Y) that is analyzed for a smelter-related effect. The second term in parentheses is the covariate, X (age, weight, or length).

to ensure there was adequate overlap between reference and exposure groups, and that there was a linear relationship between the variable and the covariate. In order to verify the existence of a linear relationship, each relationship was tested using linear regression analysis by area and evaluated at an alpha level of 0.05. If it was determined that there was no significant linear regression relationship between the variable and covariate for the reference and/or exposure areas, then ANCOVA was not performed.

Once it was determined that ANCOVA could be used for statistical analysis of the data, the first step in the ANCOVA analysis was to test whether the slopes of the regression lines for the reference and exposure areas were equal. This was accomplished by including an interaction term (dependant × covariate) in the ANCOVA model and evaluating if the interaction term was significantly different, in which case the regression slopes would not be equal between areas and the resulting ANCOVA would provide spurious results. In such cases, two methodologies were employed to assess whether a full ANCOVA could proceed. In order of preference these were 1) removal of influential points using Cook's distance and re-assessment of equality of slopes, and 2) Coefficients of Determination that considered slopes equal regardless of an interaction effect (Environment Canada 2012). For the Coefficients of Determination, the full ANCOVA was completed to test for main effects, and if the r^2 value of both the parallel regression model (interaction term) and full regression model were greater than 0.8 and within 0.02 units in value, the full ANCOVA model was considered valid (Environment Canada 2012). If both methods proved unacceptable, the magnitude of effect calculation was estimated at both the minimum and maximum overlap of covariate variables between areas (Environment Canada 2012). In such cases, the statistically significant interaction effect (slopes are not equal) was not assigned a statistical difference like that provided by a full ANCOVA model. If the interaction term was not significant (i.e., homogeneous slopes between the two populations), then the full ANCOVA model was run without the interaction term to test for differences in adjusted means between the two populations. The adjusted mean was then used as an estimate of the population mean based on the value of the covariate in the ANCOVA model.

2.2 Fish Population Survey

The Brunswick Smelter 2014 Fish Population survey employed a traditional control-impact design to evaluate fish health endpoints between the smelter-exposed area and a reference area located in the Baie des Chaleurs (Figure 2.1). Field sampling for the fish population survey was conducted from October 2nd – 9th, 2014. Sampling for the fish population survey occurred within approximately 300 m of shore immediately adjacent to the Brunswick Smelter complex at the smelter-exposed area. The fish population survey reference area extended approximately 4.6 – 7.0 km west of the smelter complex, with sampling conducted within approximately 400 m of the shoreline (Figure 2.1). The fish population survey targeted Atlantic tomcod (Photo 2.1) as this species was the only relatively abundant large-bodied benthic fish species common to both study areas. Because Atlantic tomcod reside close to the substrate and often feed on invertebrates that are associated with the substrate (Scott and Scott 1988), this species represents an ideal receptor for the assessment of effects associated with exposure to environmental contaminants. Twenty sexually mature male and female Atlantic tomcod were targeted from each study area for the fish population survey. However, due to an extremely low ratio of males to females (i.e., approximately 1:20) that would have resulted in an unacceptably high number of females being sacrificed in the survey (and considerable mortality of non-target species as well), target numbers of male Atlantic tomcod were not achieved.

2.2.1 Sample Collection, Field and Laboratory Processing

Fish sampling for the Brunswick Smelter 2014 Fish Population survey was conducted under licence to collect fish for scientific purposes (Licence No. SG-RHQ-14-142) issued by the DFO pursuant with Canadian *Fisheries Act* regulations (Part VII, Section 52). Atlantic tomcod were collected using gill nets (1.5” to 2.0” [3.8 cm to 5.1 cm] mesh) set on the bottom for overnight durations. Upon retrieval of each net, all captured fish were identified and enumerated. All non-target fish and any immature Atlantic tomcod were released alive at the capture location when possible. Sexually mature Atlantic tomcod were retained separately by study area in coolers packed with ice to ensure that tissues did not deteriorate before processing (described below). For each gill net set, information including mesh size, duration of sampling, sampling depth, GPS latitude-longitude coordinates and habitat descriptions were recorded.

All retained Atlantic tomcod were transported to a dedicated field laboratory for measurements, general observations, and collection of fish tissue samples recommended for Environmental Effects Monitoring (EEM) under the federal *Fisheries Act* (Environment Canada 2012). Atlantic tomcod used for the population survey were sacrificed using a decisive blow to the head prior to processing. The external condition of each fish was then evaluated, with any abnormalities recorded on laboratory bench sheets. Atlantic tomcod total length was measured to the nearest millimetre using a standard measuring board, and weight was measured using an appropriately sized balance or spring scale. Ageing structures (otoliths, with pectoral spines used for backup) were then removed from each fish. Individual Atlantic tomcod were then opened and the sex and/or sexual maturity was determined. Whole gonads and livers were

Photo 2.1: Example of a female Atlantic tomcod (*Microgadus tomcod*) captured at the smelter-exposed area during the Brunswick Smelter 2014 Fish Population Survey.

removed from all sexually-mature fish, with each organ weighed to the nearest milligram (0.001 g) using an Ohaus Model 123 Scout-Pro balance with a surrounding draft shield. Whole ovaries from each sexually-mature female were placed in individually labelled sampling jars and preserved with a 10% buffered formalin solution for fecundity and egg size determination. During processing, fish were inspected for any internal abnormalities (e.g., parasites, lesions, tumours etc.) with appropriate descriptions recorded.

Upon completion of the field program, Atlantic tomcod ovary samples were shipped to Zeas Inc. (Nobleton, ON) for determination of fecundity and egg weight. At the laboratory, each ovary sample was drained into a 180-μm sieve and rinsed with clean water to remove the preservative. The sample was then transferred to a plastic weigh-boat and weighed to the nearest 0.001 g to determine the total weight of the preserved gonad sample. The number of eggs from three ovarian sub-samples (separated from the original sample and weighed) was enumerated with the aid of a stereo-microscope. The remainder of each sample was re-preserved in a 10% formalin solution and archived. In ten percent of previously processed ovarian samples, egg sub-samples were recounted to verify the precision of fecundity estimates. The total number of eggs in each ovarian sub-sample was calculated as follows:

$$preserved\,gonad\,sample fecundity = \frac{total\ weight\ of\ preserved\,gonad\,sample}{weight\,of\ subsample}\ x\ number\ of\ eggs\,in\,subsample$$

The fecundity estimates for each sub-sample sample were then averaged.

The whole gonad fecundity was then estimated as follows:

$$total\,fecundity = \frac{total\ weight\ of\ whole\,fresh\,gonad}{total\ weight\ of\ fresh\,gonad\ sample}\ x\ average\ preserved\ sample\,fecundity$$

Individual egg weights for each female were calculated as follows:

$$individual\ egg\ weight = \frac{weight\ of\ unpreserved\ gonad}{total\ fecundity}$$

Ageing samples were shipped to North Shore Environmental Services (NSES; Thunder Bay, ON) for otolith processing at the completion of the field program. Atlantic tomcod pectoral fin rays were used as backup ageing structures for age determinations. Otoliths were prepared for ageing using a “crack and burn” method. If fin rays were used, each was cleaned, embedded in epoxy resin and, after the epoxy hardened, sectioned using a low-speed isomet diamond saw. Each otolith or fin ray sample was then mounted on a glass slide using a mounting medium and examined under a compound microscope using transmitted light to determine fish age. For each structure, the age and edge condition was recorded along with a confidence rating for the age determination.

2.2.2 Data Analyses

Fish community data from respective smelter-exposed and reference study areas were compared based on total fish species richness, total catch, and total catch-per-unit-effort (CPUE) for each sampling method. Gill netting CPUE was calculated as the number of fish captured per 100 metre·hours^{-1}.

Fish population endpoints representing four response categories (survival, growth, reproduction and energy storage; Table 2.3) were evaluated separately for female and male Atlantic tomcod. Summary statistics including mean, median, minimum, maximum, standard deviation, standard error and sample size were calculated by study area and fish sex for all age, growth, reproduction and energy storage health endpoints. The statistical analyses of fish population survey endpoints were consistent with the procedures outlined in technical

Table 2.3: Endpoints examined for the Brunswick Smelter Fish Population Survey, October 2014.

Response			Endpoint	Statistical Procedure[a,b,c]	Critical Effect Size
Atlantic Tomcod	Juveniles and Adults	Survival	Age	ANOVA	25%
			Age-frequency distribution	K-S Test	not applicable
		Growth	Size-at-age (body weight against age)	ANCOVA	25%
			Size-at-age (length against age)	ANCOVA	25%
		Energy Storage	Condition (body weight against length)	ANCOVA	10%
			Relative liver size (liver weight against body weight)	ANCOVA	25%
	Adults Only	Reproduction	Relative gonad size (gonad weight against body weight)	ANCOVA	25%
			Relative fecundity (# of eggs/female against body weight)	ANCOVA	25%
			Relative egg size (mean egg weight against body weight)	ANCOVA	25%

[a] ANOVA (Analysis of Variance) used except for non-parametric data, where Mann Whitney U-test may have been used.

[b] ANCOVA (Analysis of Covariance). For the ANCOVA analyses, the first term in parentheses is the endpoint (dependent variable Y) that is analyzed for a smelter-related effect. The second term in parentheses is the covariate, X (age, weight, or length).

[c] K-S Test (Kolmogorov-Smirnov test).

guidance for EEM studies (Environment Canada 2012), including the use of "adjusted" body weights in the statistical analyses (whole body weight less the gonad, liver and stomach content weights). Briefly, study area differences in mean age, body weight and fork length were compared separately by sex using ANOVA, with test results that significantly violated the assumptions of normality confirmed using non-parametric Mann-Whitney U-tests. Age frequency distributions were compared using a non-parametric two-sample Kolmogorov-Smirnov (K-S) test. All other response variables were preferably compared using Analysis-of-Covariance (ANCOVA; Table 2.3) using methods identical to those described above for the blue mussel condition analysis.

For fish population survey endpoints showing significant differences, the magnitude of difference between the smelter-exposed and reference areas was calculated as described by Environment Canada (2012) using mean (ANOVA), adjusted mean (ANCOVA with no significant interaction) or predicted values (ANCOVA with significant interaction). The anti-log of the mean, adjusted mean, or predicted value was used in the equations for endpoints that were $\log_{10}$-transformed. In addition, the magnitude of difference for ANCOVA with a significant interaction was calculated for each of the minimum and maximum values of the covariate. If outliers or leverage values were observed in a data set(s) upon examination of scatter plots and residuals, then the values were removed and ANOVA or ANCOVA tests were repeated for the reduced data, with both sets of results then provided.

The magnitude of difference for any significantly differing endpoints between the smelter-exposed and reference areas were evaluated relative to Critical Effect Size (CES) commonly used in environmental monitoring programs to define any ecologically meaningful 'effects' (Environment Canada 2012). The CES is analogous to the magnitude of difference in population endpoints that could be expected to occur naturally among areas that have not been influenced by any anthropogenic inputs (e.g., between reference areas; see Munkittrick et al. 2009). For the fish population survey, the CES for endpoints of growth, reproduction and relative liver size was ±25%, and the CES for condition (i.e., weight-at-length) was 10%, consistent with those recommended for EEM (Table 2.3; Environment Canada 2012).

3.0 CAGED BIVALVE SURVEY

3.1 General Observations

Considerable bio-fouling was observed on all bivalve cages at the time of retrieval in October (Photos 3.1 – 3.4). Juvenile blue mussels with shell lengths less than 1 cm long were the most abundant fouling agent, and often provided suitable substrate for colonization by various other invertebrates (e.g., *Caprella* amphipods, echinoderms, polychaetes, colonial organisms). Juvenile blue mussels were very abundant on smelter-exposed cages S1, S2 and S3, as well as on both reference cages (R1 and R2; Photos 3.1 – 3.3). Algae were a moderate contributor to bio-fouling on most cages, with various red algae (Rhodophyta) the most abundant source of algal fouling, and individual strands of rockweed (*Fucus* sp.) occasionally present as well. Algae were the most common bio-fouling agent at smelter-exposed cage S4 (Photo 3.4). Overall, similar levels of bio-fouling were encountered among all bivalve cages, suggesting that any confounding influences associated with bio-fouling on caged blue mussel test individuals were equivocal between study areas and among bivalve cages.

3.2 Blue Mussel Soft Tissue Metal Concentrations

Blue mussels caged at the smelter-exposed areas showed similar to slightly higher soft tissue metal concentrations compared to those of the reference area cages with the exception of cadmium and lead concentrations which, on average, were approximately 3-fold and greater than 30-fold higher, respectively, in mussel soft tissues at the smelter-exposed area (Table 3.1). No substantial spatial changes in blue mussel soft tissue metal concentrations were shown between the smelter-exposed cage placed near Belledune Point (Cage S1) and the furthest cage to the east (Cage S4), suggesting similar exposure to smelter-related metals among the four bivalve cages. Notably, soft tissue metal concentrations of blue mussels placed at the Little Belledune Point reference area were comparable to concentrations reported for background waters in southern New Brunswick/Nova Scotia (e.g., median cadmium, chromium and lead concentrations near 1.5, 1.1 and 1.3 mg/kg, respectively; Chase et al. 2001), validating no substantial smelter-related influences at the reference area.

3.3 Blue Mussel Survival

Survival rates for caged blue mussels over the August-October (9.4 week) test period were high among the smelter-exposed stations, ranging from 94% to 100% (Table 3.2). The survival rate at the smelter-exposed stations was comparable to reference, which averaged 96%

Photo 3.1: Smelter-Exposed Cage S1 at time of retrieval.

Photo 3.2: Smelter-Exposed Cage S2 at time of retrieval.

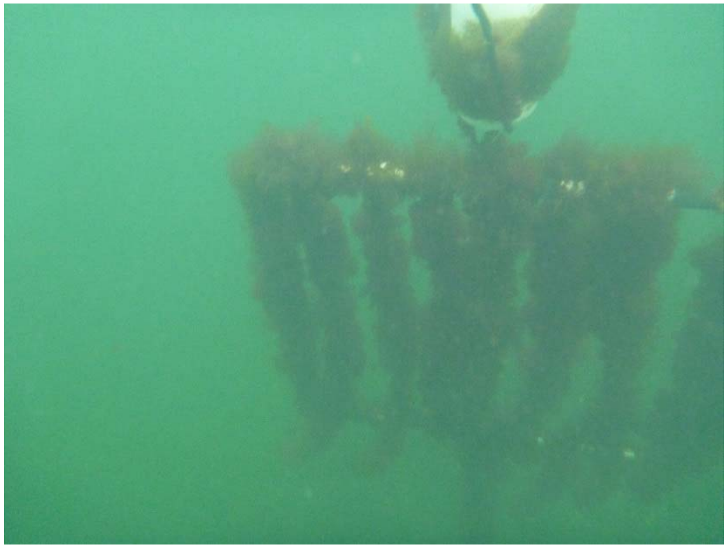


Photo 3.3: Smelter-Exposed Cage S4 at time of retrieval.

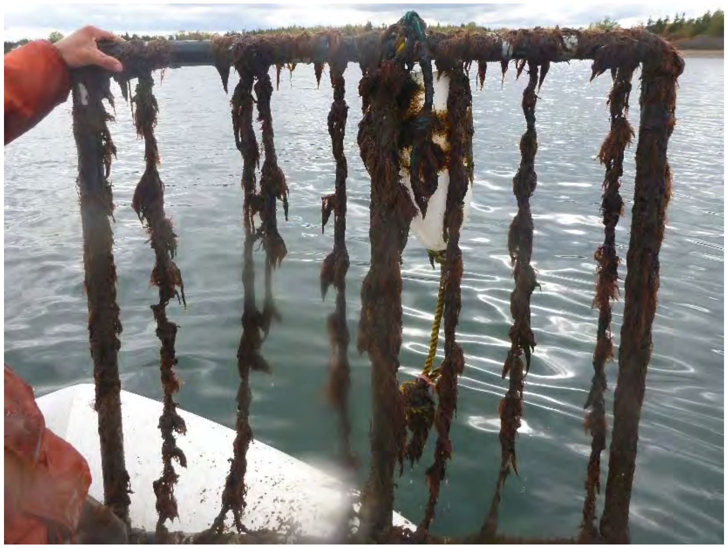


Photo 3.4: Reference Cage R2 at time of retrieval.

Table 3.1: Comparison of average caged blue mussel tissue metal concentrations (dw) between the time of cage deployment (August) and the time of cage retrieval (October), Brunswick Smelter Caged Bivalve Survey, 2014.

Analytes	Units	August Deployment	October Retrieval					
			Reference Cages		Smelter-Exposed Cages			
			R1	R2	S1	S2	S3	S4
Aluminum	mg/kg	299.7	343.5	249.2	248.4	344.8	328.6	213.6
Antimony	mg/kg	0.033	< 0.100	< 0.100	< 0.100	0.180	0.140	0.140
Arsenic	mg/kg	8.08	8.80	7.90	10.20	10.00	11.80	10.00
Barium	mg/kg	2.00	9.30	6.60	8.60	6.90	7.00	7.00
Beryllium	mg/kg	< 0.005	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
Bismuth	mg/kg	0.29	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
Boron	mg/kg	27.01	20.80	20.30	20.60	22.90	23.00	24.20
Cadmium	mg/kg	1.564	1.278	1.313	3.722	3.885	3.486	4.580
Calcium	mg/kg	5,050	2,967	2,001	2,638	5,083	4,858	3,118
Chromium	mg/kg	1.04	1.20	< 1.00	< 1.00	1.20	1.40	< 1.00
Cobalt	mg/kg	0.570	0.400	0.320	0.380	0.500	0.540	0.580
Copper	mg/kg	8.32	6.20	5.80	7.00	8.40	8.40	8.80
Iron	mg/kg	314	333	252	266	424	404	294
Lead	mg/kg	1.73	2.09	1.91	63.36	60.95	52.48	82.22
Lithium	mg/kg	0.53	0.65	0.54	0.54	0.73	0.74	0.64
Magnesium	mg/kg	3,036	3,068	2,925	2,978	3,396	3,650	3,754
Manganese	mg/kg	17.13	13.10	9.00	10.40	16.90	17.40	12.80
Molybdenum	mg/kg	0.694	0.420	0.360	0.480	0.490	0.520	0.540
Nickel	mg/kg	2.03	1.60	1.20	1.40	2.00	2.40	2.40
Potassium	mg/kg	11,045	10,751	10,466	11,540	11,724	12,520	12,660
Rubidium	mg/kg	5.569	4.960	4.650	5.060	5.230	5.600	5.480
Selenium	mg/kg	3.85	3.00	3.00	4.00	4.40	5.00	4.60
Silver	mg/kg	0.133	< 0.100	< 0.100	0.120	0.150	0.140	0.180
Sodium	mg/kg	15,260	19,820	19,050	18,700	22,110	24,640	25,540
Strontium	mg/kg	30.97	27.30	21.60	23.00	34.20	38.20	32.20
Tellurium	mg/kg	< 0.005	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
Thallium	mg/kg	< 0.005	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	0.220
Tin	mg/kg	0.094	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100
Uranium	mg/kg	0.247	0.140	< 0.100	< 0.100	< 0.100	0.120	< 0.100
Vanadium	mg/kg	1.52	2.20	1.40	1.40	2.30	2.40	2.00
Zinc	mg/kg	96.4	82.9	74.6	148.8	124.9	140.6	181.0

▨ Shading indicates average blue mussel soft tissue metal concentration greater than 2-fold higher than average reference cage concentration.

Table 3.2: Summary of blue mussel survival among caged bivalve stations between the time of cage deployment (August) and retrieval (October), Brunswick Smelter 2014 Caged Bivalve study.

Study Area	**Bivalve Cage ID**	**August Deployment**	**October Retrieval**				
		Initial Sample Size	Number Remaining Intact	Number Missing	Number Dislodged from Socking	Number of Confirmed Mortalities	Percent Survival[a]
Reference	R1	65	49	10	4	2	96.2%
	R2	65	56	0	6	3	95.2%
Smelter-Exposed	S1	64	39	17	7	1	97.8%
	S2	65	33	21	11	0	100.0%
	S3	65	43	11	8	3	94.1%
	S4	65	28	32	4	1	96.9%

[a] Survival determined as 1 - (number of mortalities / [sum of number remaining intact and number dislodged from socking]).

between the two cages (Table 3.2). Overall, no smelter-related influences on blue mussel survival were indicated in the Baie des Chaleurs adjacent to the Brunswick Smelter complex.

3.4 Blue Mussel Growth and Condition

No significant differences in blue mussel shell dimensions (i.e., length, width and height) and whole animal wet weight (WAWW) were indicated among the smelter-exposed and reference cage samples at the time of bivalve cage deployment (August; Appendix Figure A.1; Appendix Table A.13). Blue mussel condition (i.e., WAWW versus shell length) was not significantly different between the smelter-exposed and pooled reference cage mussels at the time of test initiation in August with the exception of at the smelter-exposed cage placed at Belledune Point (Cage S1; Appendix Table A.16, Appendix Figure A.2). The difference in blue mussel condition between smelter-exposed Cage S1 and the pooled reference cages represents an artifact of the sampling design and thus, must be considered during the interpretation of the condition data at test termination. Overall, with the exception of blue mussel condition data for smelter-exposed cage S1, no inadvertent bias in the assessment of blue mussel growth or condition was introduced into the caged bivalve study at test initiation.

The absolute change in blue mussel shell dimensions (i.e., length, width and height) and WAWW between test initiation and termination was, on average, greater at the smelter-exposed areas compared to reference (Figure 3.1; Appendix Tables A.6 – A.11). Statistical comparisons indicated that only the absolute change in shell height and WAWW differed significantly among study areas, with significantly greater growth in blue mussel shell height indicated at smelter-exposed cages S1, S3 and S4, and significantly greater increase in WAWW indicated at smelter-exposed cage S4, compared to shell height and WAWW changes at reference cage R1 (Figure 3.1). Collectively, the caged bivalve growth data indicated that blue mussels grew slightly more quickly at the smelter-exposed area compared to reference, suggesting no adverse influences of smelter operations on blue mussel growth endpoints. The higher growth rates at the smelter-exposed area may reflect nutrient input from the smelter (e.g., nitrogen, iron, manganese; see Millero 2006), or natural differences in environmental variables (e.g., water temperature) compared to the reference area.

The evaluation of blue mussel body condition, including assessment of WAWW- and soma dry weight-at-shell length (condition$_{waww}$ and condition$_{sdw}$, respectively), indicated some significant differences between the smelter-exposed and reference stations (Table 3.3; Figure 3.2). Although a significant difference in condition$_{waww}$ was indicated between smelter-exposed cage S1 and the pooled reference at test termination, because condition$_{waww}$ differed at the time of test initiation (as discussed above) this difference likely reflected an artifact of the study. No

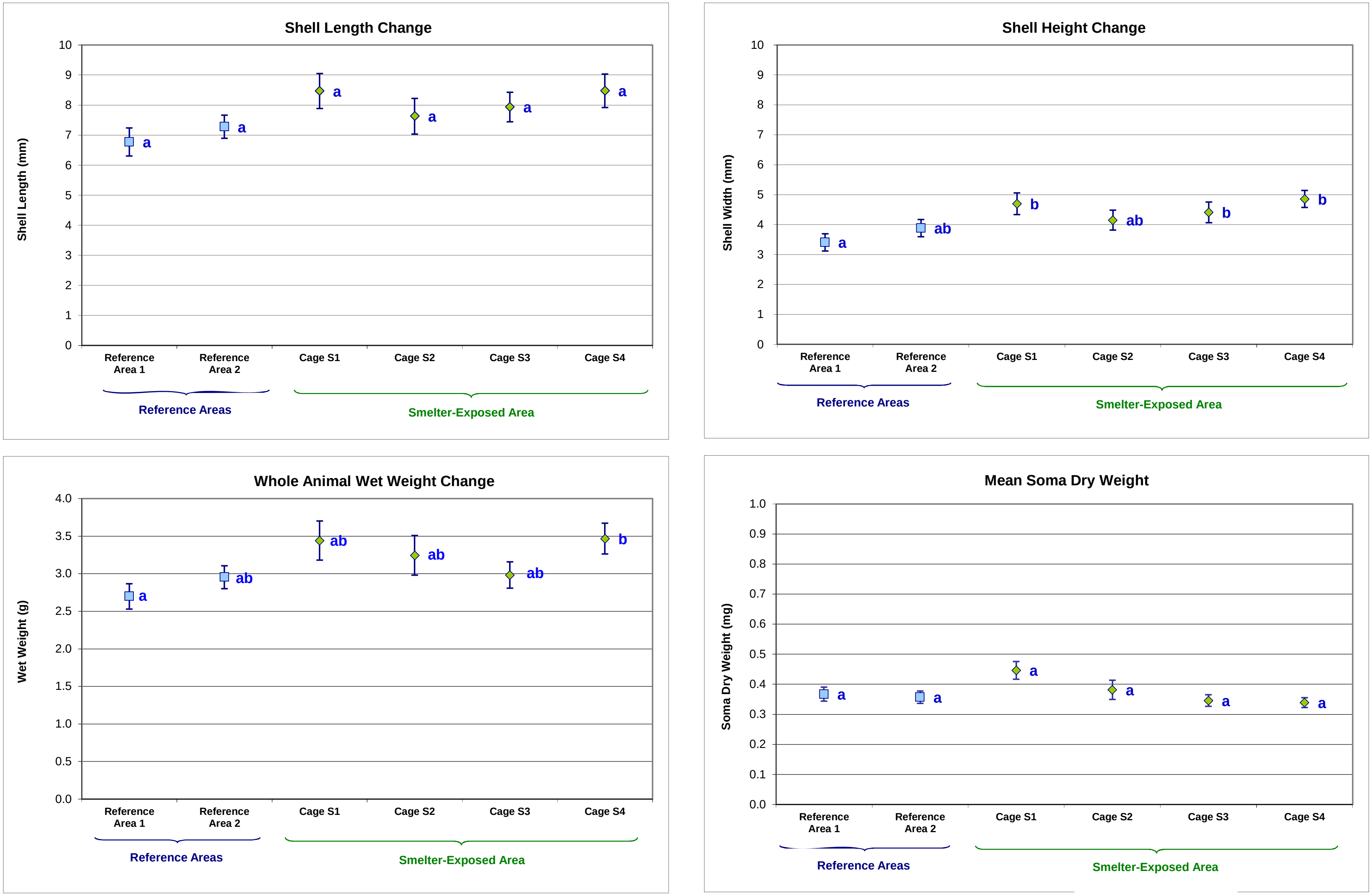


Figure 3.1: Comparison of the change in mussel shell measurements (length and width) and whole animal wet-weight from August to October, and soma dry weight in October, among study areas, Brunswick Smelter 2014 Caged Mussel Survey. Data points with the same letter do not differ signficantly.

Table 3.3: Caged blue mussel condition (WAWW- and soma dry weight-at-shell length) comparison among smelter-exposed and the pooled reference stations at time of test termination (October), Brunswick Smelter Caged Bivalve Survey, 2014.

Condition Type	Smelter-Exposed Cage	Model[1]	Statistical Difference Between Areas (*p*-value)		Mean, Adjusted Mean or Predicted Value[2]		Sample Size		Mean Square Error	MoD (%)[3,4,5]	Power
					Reference	Exposed	Ref	Exp			
WAWW	Cage S1	ANOVA[6]	Yes	0.091	0.749 (NR)	0.721	104	39	0.002045	-3.7	0.519
	Cage S2	ANCOVA[6]	No	0.603	0.734	0.740	104	33	0.002416	-	0.145
	Cage S3	ANCOVA[6]	Yes	0.034	0.737	0.719	104	43	0.002161	-2.5	0.685
	Cage S4	ANCOVA[6,7]	No	0.731	0.739	0.742	104	27	0.002073	-	0.120
Soma Dry Weight	Cage S1	ANCOVA[6]	No	0.417	2.551	2.528	104	39	0.013965	-	0.209
	Cage S2	ANCOVA[6]	No	0.548	2.528	2.508	104	33	0.016741	-	0.160
	Cage S3	ANCOVA[6]	Yes	0.049	2.532	2.484	104	43	0.014724	-1.9	0.629
	Cage S4	ANCOVA[6,7]	Yes	0.050	2.531	2.476	104	27	0.014421	-2.2	0.627

[1] Statistical tests include Analysis of Variance (ANOVA), Analysis of Covariance (ANCOVA), Mann-Whitney U-Test (MW U-test) and Kolmogorov-Smirnov test (K-S Test).

[2] The mean is reported for ANOVA, adjusted mean is reported for ANCOVA, and predicted values of the regression line equations are reported for covariate min and max values in ANCOVA where slopes were unequal.

[3] Magnitude of difference between means for reference and exposure areas calculated as: [(exposed mean -reference mean) /reference mean] x 100.

[4] Magnitude of difference between adjusted means for reference and exposed areas calculated as: [(exposed adjusted mean - reference adjusted mean) /reference adjusted mean] x 100.

[5] Magnitude of difference between predicted minimum and maximum values for reference and exposed areas calculated as: [(exposed predicted value - reference predicted value) / reference predicted value] x 100.

[6] Studentized outlier removed (samples R2-M5-05)

[7] Studentized outlier removed (samples S4-M5-03)

[8] NRR indicates no regression relationship for both the reference and smelter exposed areas at p=0.05; NR indicates no regression relationship at p=0.05. No ANCOVA appropriate as a result of NRR/NR.

[9] Statistical comparisons for all endpoints were conducted using log-transformed data with the exception of age distribution.

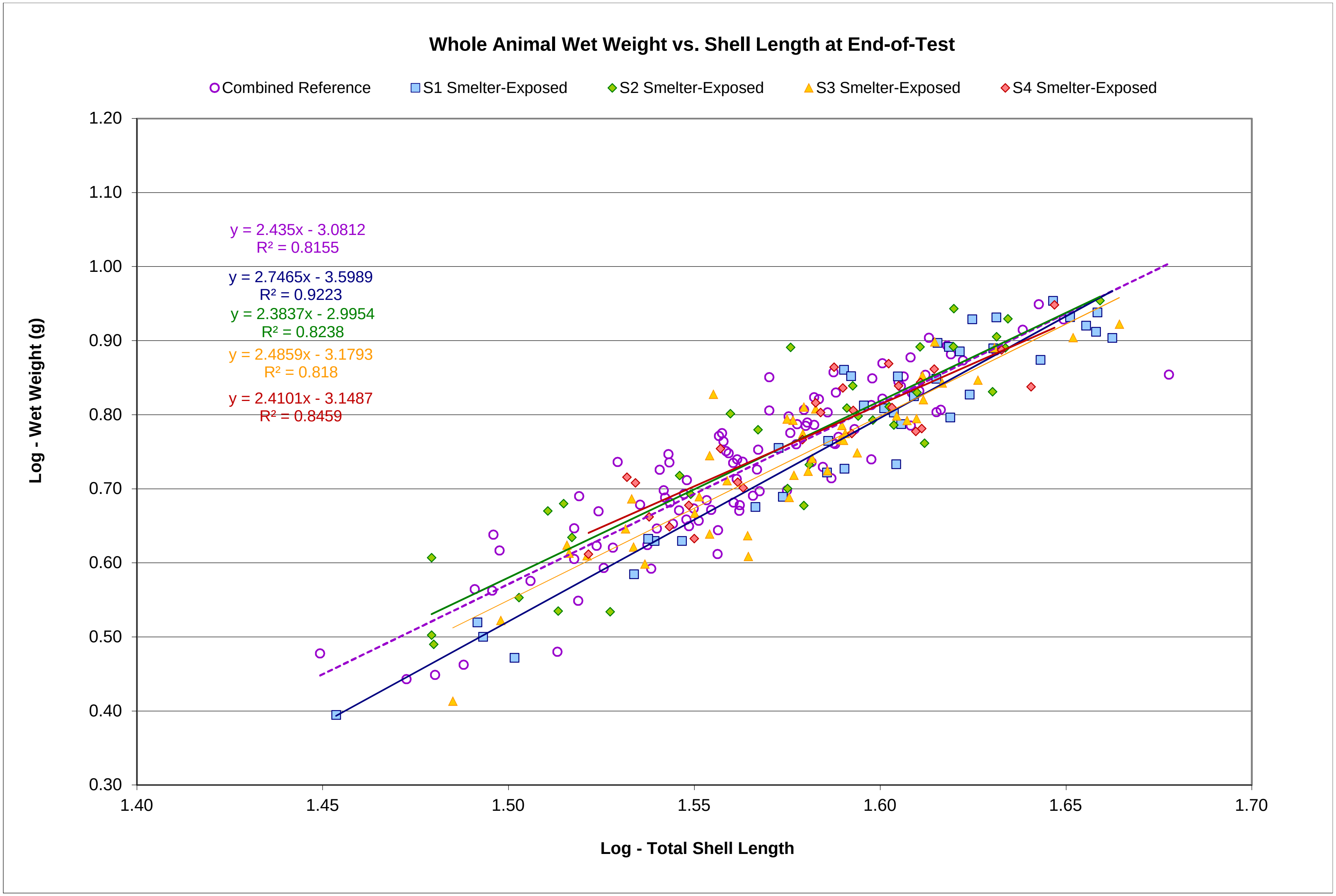


Figure 3.2: Relationships between Whole Animal Wet Weight (WAWW) and shell length in blue mussels placed in cages at smelter-exposed and reference areas after a duration of approximately 9.4 weeks (August 5th to October 11th), Brunswick Smelter 2014 Caged Bivalve Survey.

difference in condition$_{sdw}$ was shown between smelter-exposed cage S1 and the pooled reference at test termination (Table 3.3; Appendix Figure A.3). No significant difference in condition was indicated at smelter-exposed cage S2 compared to reference. Farther east from the smelter, caged blue mussel condition$_{waww}$ and condition$_{sdw}$ was significantly lower at smelter-exposed cage S3 than for the pooled reference at test termination (Table 3.3; Figure 3.2). Although the magnitude of difference was small (i.e., approximately 2%), the data suggested a potential difference in blue mussel energy usage between the cage S3 mussels and the reference mussels. Blue mussel condition$_{sdw}$ also differed significantly at smelter-exposed cage S4 compared to the pooled reference sample, which appeared to be attributable to larger sized individuals at cage S4 having lower condition than blue mussels of similar shell length at the reference area (Table 3.3; Figure 3.2). Interestingly, average soft tissue metal concentrations in caged blue mussel were similar among all of the smelter-exposed bivalve cages, and therefore the differences in energy use (i.e., condition) suggested for mussels at cages S3 and S4 compared to reference may have been related to factors other than metal exposure. Because the caged bivalve growth data indicated that blue mussels grew slightly more quickly at some smelter-exposed area cages compared to reference, the occurrence of lower condition in some blue mussels at the smelter-exposed cages compared to reference may have reflected greater allocation of energy use to growth (e.g., shell size increase) at the smelter-exposed area.

4.0 FISH POPULATION SURVEY

4.1 Fish Community

Gill netting at the smelter-exposed area of the Baie des Chaleurs indicated the presence of a total of nine fish species (Table 4.1). Although the number of fish species present at the smelter-exposed area was comparable to the reference area, a slight difference in species composition was indicated between areas, with salmonids including Atlantic salmon (*Salmo salar*) and brook trout (*Salvelinus fontinalis*) notably absent at the smelter-exposed area (Table 4.1). Atlantic tomcod and Atlantic mackerel (*Scomber scombrus*) were the most abundant fish captured at the smelter-exposed area, with these species also relatively abundant at the reference area in addition to Atlantic herring (*Clupea harengus*) and striped bass (*Morone saxitilis*). Slightly lower fish density was suggested by lower catch-per-unit-effort (CPUE) at the smelter-exposed area compared to reference (Table 4.1). Slight differences in fish community assemblage between the smelter-exposed and reference areas potentially reflected a rockier shoreline and greater sheltering provided by Belledune Point at the smelter-exposed area compared to the reference area, where sand-gravel shoreline features and exposure to wind/wave action was likely greater. This was supported by higher relative abundance of species associated with pelagic habits being captured at the reference area, including Atlantic herring and alewife (*Alosa pseudoharengus*), as well as striped bass, which are known to selectively prey on such species (Scott and Scott 1988). Overall, minor differences in fish species diversity and density indicated between the smelter-exposed and reference areas suggested by the gill netting catch data were likely related to slight differences in habitat features between these two areas.

4.2 Atlantic Tomcod Population Evaluation

4.2.1 Females

A total of 26 and 18 female Atlantic tomcod (tomcod) were collected at the smelter-exposed and reference areas of the Baie des Chaleurs, respectively, for the assessment of fish health endpoints (Appendix Tables B.3 and B.4). Female tomcod showed no difference in mean age or age distribution between the smelter exposed and reference areas (Table 4.2; Figure 4.1), suggesting similar survival between areas. Most of the mature females that were captured at both study areas were two years of age (Figure 4.1), and therefore this age category served as the focus for assessment of differences in growth between areas. No difference in mean weight of age-2 female tomcod was indicated between the smelter-exposed and reference area (Table 4.2). Although the total length of age-2 females was significantly shorter at the

Table 4.1: Summary of fish catches at smelter-exposed and reference study areas, Brunswick Smelter Fish Population Survey, October 2014.

Study Area	**Reference Area**		**Smelter-Exposed Area**	
Endpoint	Total No. Caught	CPUE[a]	Total No. Caught	CPUE[a]
Atlantic Tomcod	41	9.1	118	23.7
Atlantic Cod	1	0.2	2	0.4
Alewife	24	5.8	13	3.1
Atlantic Herring	66	14.9	4	0.7
Atlantic Mackerel	69	15.7	55	10.0
Atlantic Salmon	1	0.2	-	-
Brook Trout	7	1.4	-	-
Rainbow Smelt	4	0.9	-	-
Longhorn Sculpin	-	-	1	0.2
Shorthorn Sculpin	-	-	2	0.4
Striped Bass	43	8.9	8	1.8
Wrymouth	2	0.4	-	-
Winter Flounder	1	0.2	4	0.8
Totals	**259**	**57.6**	**207**	**41.0**
Total No. Species	**11**		**9**	

[a] Catch-per-unit-effort (CPUE) represents number of fish captured per gill netting metre-hour. Fishing effort at the smelter-exposed and reference areas totalled 142 and 98.2 m·hour^{-1} / 100 m net, respectively.

Table 4.2: Female Atlantic tomcod population comparisons between smelter-exposed and reference areas, Brunswick Smelter Fish Population Survey, October 2014.

Response	Endpoint[10]		Model[1]	Statistical Difference Between Areas (*p* -value)		Mean, Adjusted Mean or Predicted Value[2]		Sample Size		MoD (%)[3,4,5]	Power
	Parameter	Covariate				Reference	Exposed	Ref	Exp		
Survival	Age	none	ANOVA[8]	No	0.153	0.050	0.012	18	26	-	0.417
	Age Distribution	none	K-S	No	0.995	-	-	18	26	-	-
Energy Use: Growth	Adj. Body Weight	Age	ANCOVA[6]	-	-	-	-	18	26	-	-
	Adj. Body Weight at Age 2	none	ANOVA[7]	No	0.288	2.177	2.157	15	25	-	0.282
	Total Length	Age	ANCOVA[6]	-	-	-	-	18	26	-	-
	Total Length at Age 2	none	ANOVA[7]	Yes	0.057	2.177	2.157	15	25	-4.6	0.282
Energy Use: Reproduction	Gonad Weight	Adj. Body Weight	ANCOVA	Yes	0.095	0.681	0.589	18	27	-19.1	0.514
	Egg Weight	Adj. Body Weight	ANCOVA	NRR[9]	-	NR[9]	NR[9]	11	8	-	-
	Egg Weight at Age 2	none	ANOVA[7]	Yes	0.046	2.235	2.070	15	25	-31.7	0.648
	Fecundity	Adj. Body Weight	ANCOVA	No	0.498	4	5	18	26	-	0.176
Energy Storage	Adj. Body Weight	Total Length	ANCOVA	No	0.527	2.173	2.180	18	27	-	0.166
	Liver Weight	Adj. Body Weight	ANCOVA	No	0.852	0.890	0.886	18	27	-	0.106

[1] Statistical tests include Analysis of Variance (ANOVA), Analysis of Covariance (ANCOVA), Mann-Whitney U-Test (MW U-test) and Kolmogorov-Smirnov test (K-S Test).

[2] The mean is reported for ANOVA, adjusted mean is reported for ANCOVA, and predicted values of the regression line equations are reported for covariate min and max values in ANCOVA where slopes were unequal.

[3] Magnitude of difference between means for reference and smelter-exposed areas calculated as: [(exposed mean -reference mean) /reference mean] x 100.

[4] Magnitude of difference between adjusted means for reference and smelter-exposed areas calculated as: [(exposed adjusted mean - reference adjusted mean) /reference adjusted mean] x 100.

[5] Magnitude of difference between predicted minimum and maximum values for reference and exposed areas calculated as: [(exposed predicted value - reference predicted value) / reference predicted value] x 100.

[6] Insufficient age classes represented, therefore ANCOVA was not appropriate.

[7] Age-2 fish was the only age class with sufficient sample size on which to conduct statistical analysis, and therefore this age group served to assess differences in growth and egg weight.

[8] Log-transformed data were non-normal; a Mann-Whitney U-test was performed which confirmed differences indicated by ANOVA (i.e., MW U-test p = 0.157).

[9] NRR indicates no regression relationship for both the reference and smelter exposed areas at p=0.05; NR indicates no regression relationship at p=0.05. No ANCOVA appropriate as a result of NRR/NR.

[10] Statistical comparisons for all endpoints were conducted using log-transformed data with the exception of age distribution.

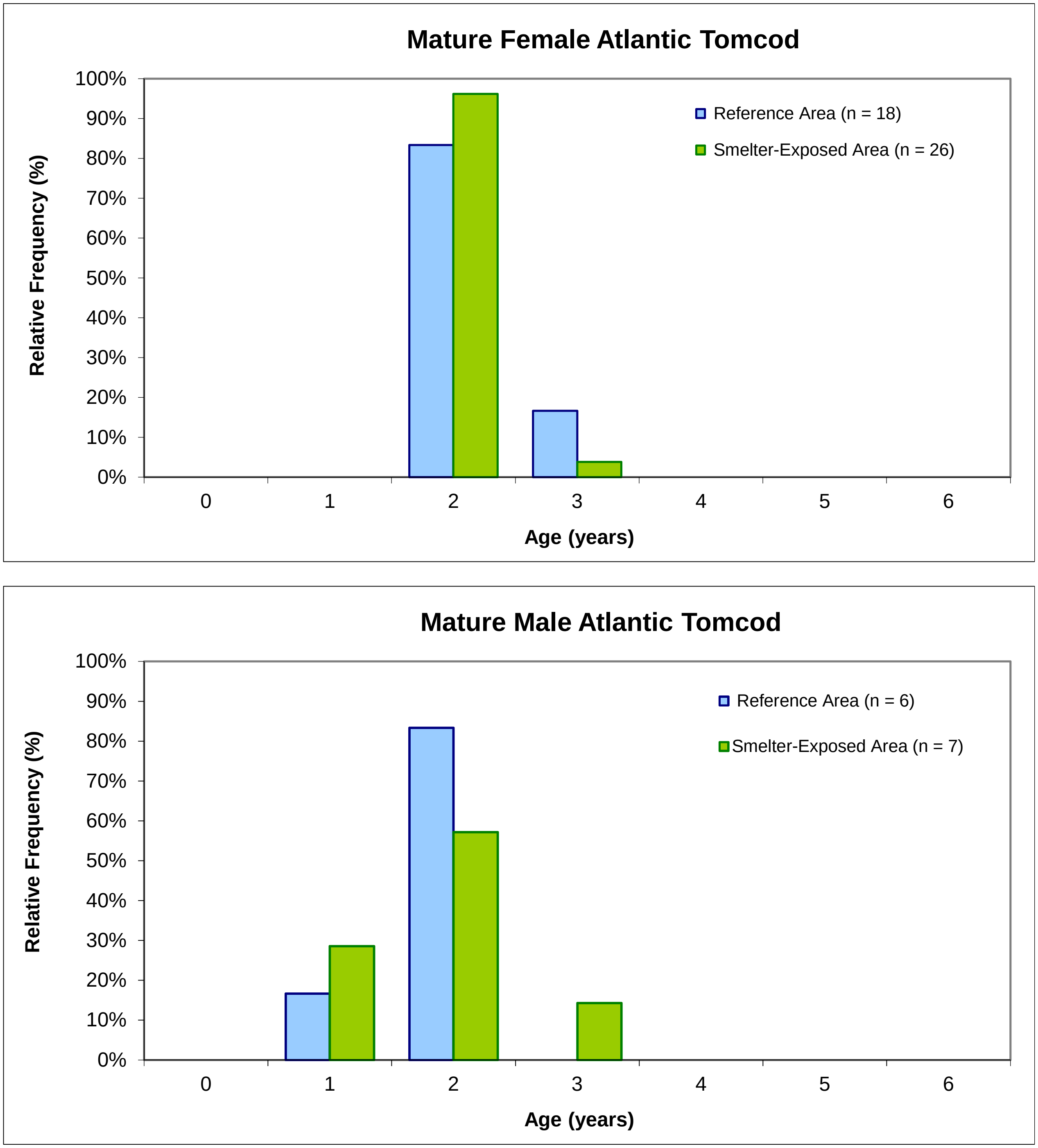


Figure 4.1: Relative age distributions of female and male Atlantic tomcod captured at smelter-exposed and reference areas, Brunswick Smelter Fish Population Survey, October 2014.

smelter-exposed area compared to reference, a small magnitude of difference was indicated between areas (i.e., -4.6%) that was well within the CES of ±25% (Table 4.2). Thus, the difference in female tomcod length indicated between the smelter-exposed and reference areas was below thresholds considered ecologically.

Relative gonad size (i.e., gonad weight-at-adjusted body weight) was significantly smaller in female tomcod collected at the smelter-exposed area compared to reference, with the smelter-exposed age-2 female tomcod also showing significantly smaller egg size than at the reference area (Table 4.2). The magnitude of difference for these differences between populations was slightly below, and slightly above, the ecologically relevant CES of ±25, respectively (Table 4.2). However, no significant difference in fecundity was indicated between the effluent-exposed and reference areas (Table 4.2), with total fecundity at both study areas (i.e., approximately 32,000 and 36,000 eggs, respectively) above averages of 20,000 – 25,000 eggs reported in various published literature (e.g., Stewart and Auster 1987, Scott and Scott 1988). It is noteworthy that tomcod normally spawn from November to February (Stewart and Auster 1987). Because the fish population survey was conducted in October, near the time of spawning, the occurrence of significantly smaller relative gonad size and smaller egg size but similar fecundity between the smelter-exposed and reference areas could reflect natural variability in spawning timing between populations, with the reference area population showing slightly more advanced gonad development.

Condition (i.e., adjusted body weight-at-length) and relative liver weight (i.e., liver weight-at-adjusted body weight) showed no significant difference between female tomcod populations at the smelter-exposed and reference areas of the Baie des Chaleurs (Table 4.2). These endpoints are generally reflective of energy storage/use in fish, with similarity in condition and relative liver weight between areas suggesting similar quantity and quality of food resources available for female tomcod at the smelter-exposed and reference areas. Examination of the stomach contents of tomcod indicated similar diet and relative mass of food items consumed between areas, with shrimp (*Crangon* sp.), other unidentified invertebrates and small fish the most important diet items at both the smelter-exposed and reference area (Appendix Tables B.7 and B.8). An assessment of the external condition of tomcod samples was not possible as a result of frequent damage from rock crab (*Cancer irroratus*) while fish were in the gill nets. No internal deformities, tumours, parasites or other abnormalities were observed in female tomcod captured at the smelter-exposed or reference study areas of the Baie des Chaleurs (Appendix Tables B.3 and B.4).

Overall, female tomcod collected at the Baie des Chaleurs smelter-exposed area showed significantly slower growth in length, as well as significantly smaller relative gonad size and egg size, compared to reference. However, the difference in total length of age-2 females between study areas was within the ecologically relevant CES, suggesting that the incremental difference in length was within the range of variability that would be expected naturally between populations unaffected by industrial operations. Moreover, a lack of any differences in population age structure, fecundity and indicators of energy storage/use (i.e., condition and relative liver size) between the smelter-exposed and reference areas suggested that the differences in reproductive endpoints could, in part, reflect natural differences in spawning timing between areas.

4.2.2 Males

A total of only 8 and 6 male tomcod were collected at the smelter-exposed and reference areas of the Baie des Chaleurs, respectively, for the assessment of fish health endpoints (Appendix Tables B.5 and B.6). Although considerable fishing effort was applied to capture tomcod at each study area, low densities of males were encountered at both the smelter-exposed and reference areas of the Baie des Chaleurs. To limit the mortality of female tomcod and other non-target fish species, fish sampling efforts were discontinued at each area once sufficient numbers of females had been captured. Because tomcod are early to mid-winter anadromous or euryhaline spawners (Stewart and Auster 1987, Everly and Boreman 1999), low densities of males at the Baie des Chaleurs areas assessed for the Fish Population Survey could potentially reflect earlier migration from these areas to river mouths for staging and/or spawning. Data available for male tomcod from this study must therefore be interpreted with great caution due to small sample sizes.

Male tomcod showed no difference in mean age or age distribution between the smelter exposed and reference areas (Table 4.3; Figure 4.1), suggesting similar survival between areas. Mature males were primarily represented by age-2 individuals (Figure 4.1), and therefore this age category served as the focus for assessment of differences in growth between areas. No difference in mean weight or total length of age-2 male tomcod was indicated between the smelter-exposed and reference area (Table 4.3). In addition, no significant difference in relative gonad size, condition, or relative liver size of male tomcod was indicated between the smelter-exposed and reference areas of the Baie des Chaleurs (Table 4.3). Finally, no internal deformities, tumours, parasites or other abnormalities were observed in male tomcod captured at the smelter-exposed and reference study areas of the Baie des Chaleurs (Appendix Tables B.5 and B.6).

Overall, the male tomcod data suggested no smelter-related influences on male tomcod survival (i.e., age structure), growth, reproduction, or energy use (i.e., condition and relative liver size) at the Baie des Chaleurs smelter-exposed area based on comparison to a

Table 4.3: Male Atlantic tomcod population comparisons between smelter-exposed and reference areas, Brunswick Smelter Fish Population Survey, October 2014.

Response	Endpoint[10]		Model[1]	Statistical Difference Between Areas (*p* -value)		Mean, Adjusted Mean or Predicted Value[2]		Sample Size		Magnitude of Difference (%)[3,4,5]	Power
	Parameter	Covariate				Reference	Smelter-Exposed	Ref	Exp		
Survival	Age	none	ANOVA	No	0.8312	0.251	0.270	6	8	-	0.107
	Age Distribution	none	K-S Test	No	1.0000	-	-	6	8	-	-
Energy Use: Growth	Adj. Body Weight	Age	ANCOVA[6]	-	-	-	-	-	-	-	-
	Adj. Body Weight at Age 2	none	ANOVA[7]	No	0.851	2.013	2.005	5	4	-	0.105
	Total Length	Age	ANCOVA[6]	-	-	-	-	-	-	-	-
	Total Length at Age 2	none	ANCOVA[7]	No	0.495	1.353	1.362	5	4	-	0.171
Energy Use: Reproduction	Gonad Weight	Adj. Body Weight	ANCOVA	No	0.955	1.040 (NR[9])	1.049	6	8	-	0.101
Energy Storage	Adj. Body Weight	Total Length	ANCOVA[8]	No	0.359	1.935	1.922	5	8	-	0.233
	Liver Weight	Adj. Body Weight	ANCOVA	No	0.886	0.468	0.457	6	8	-	0.103

[1] Statistical tests include Analysis of Variance (ANOVA), Analysis of Covariance (ANCOVA), Mann-Whitney U-Test (MW U-test) and Kolmogorov-Smirnov test (K-S Test).

[2] The mean is reported for ANOVA, adjusted mean for ANCOVA, and predicted values of the regression line equations are reported for covariate min and max values in ANCOVA where slopes were unequal

[3] Magnitude of difference between means for reference and smelter-exposed areas calculated as: [(exposed mean -reference mean) /reference mean] x 100.

[4] Magnitude of difference between adjusted means for reference and exposed areas calculated as: [(exposed adjusted mean - reference adjusted mean) /reference adjusted mean] x 100.

[5] Magnitude of difference between predicted min and max values for reference and exposed areas calculated as: [(exposed predicted value - reference predicted value) / reference predicted value] x 100.

[6] Insufficient age classes represented, therefore ANCOVA was not appropriate.

[7] Age-2 was the only age class with sufficient sample size on which to conduct statistical analysis, and therefore this age group served to assess differences in growth.

[8] Cook's outlier (RAT-23) was removed from the reference data set prior to analysis.

[9] NRR indicates no regression relationship for both the reference and smelter exposed areas at p=0.05; NR indicates no regression relationship at p=0.05.

[10] Statistical comparisons for all endpoints were conducted using log-transformed data with the exception of age distribution.

representative reference population. However, given small sample sizes, the results of the male tomcod population assessment must be viewed cautiously.

5.0 CONCLUSIONS

The objectives of the Brunswick Smelter 2014 Caged Bivalve and Fish Population Survey were to evaluate any differences in shellfish and fin-fish health endpoints of survival, growth, reproduction and/or energy usage at the smelter-exposed area of the Baie des Chaleurs compared to reference conditions. The principal conclusions from this survey are:

1) Blue mussels caged at the smelter-exposed areas contained higher soft tissue cadmium and lead concentrations compared to the reference area, with the soft tissue concentrations of other metals similar between areas. No smelter-related influences on blue mussel survival were indicated in the Baie des Chaleurs area adjacent to the Brunswick Smelter complex. In addition, the growth of blue mussels was more rapid at the smelter-exposed area compared to reference, suggesting no adverse influences of smelter operations on blue mussel growth endpoints. Greater growth rates near the smelter are hypothesized to reflect a nutrient source from the smelter complex (e.g., nitrogen or metal micro-nutrients) and/or possibly slight differences in natural habitat variables (e.g., water temperature) compared to the reference area. Caged blue mussel condition was shown to differ significantly at some smelter-exposed cages compared to reference. However, the differences were small (i.e., approximately 2 – 3%) and, coupled with results of growth analysis that indicated slightly faster growth at the smelter-exposed areas, suggested higher allocation of energy use to growth (e.g., shell size increase) at the smelter-exposed area compared to reference. Overall, despite higher soft tissue metal concentrations, no adverse smelter-related influences on blue mussel survival and growth were indicated in the Baie des Chaleurs area adjacent to the Brunswick Smelter complex.

2) Female tomcod collected at the Baie des Chaleurs smelter-exposed area showed significantly slower growth in length, as well as significantly smaller relative gonad size and egg size, compared to reference. However, the differences in female total length and relative gonad size between these study areas were within ecological CES, suggesting that these differences were within the range of variability found normally between populations. In addition, no significant differences in female tomcod population age structure, fecundity and indicators of energy storage/use (i.e., condition and relative liver size) were indicated between the smelter-exposed and reference areas. Thus, despite an ecologically relevant, significantly smaller egg size in female tomcod of the smelter-exposed area compared to reference, the difference in this reproductive endpoint likely reflected natural differences in gonad development due to differing female tomcod population spawning timing between these areas.

3) Male tomcod collected at the Baie des Chaleurs smelter-exposed area showed no significant difference in survival (i.e., age structure), growth, reproduction, or energy use compared to representative reference conditions, suggesting no adverse effects on male tomcod as a result of the Brunswick Smelter operations. Very small sample sizes were obtained for male tomcod at both study areas, possibly reflecting pre-spawning migration away from the study areas, and thus, the results of the male tomcod population survey should be viewed cautiously.

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APPENDIX A

CAGED BIVALVE SURVEY DATA

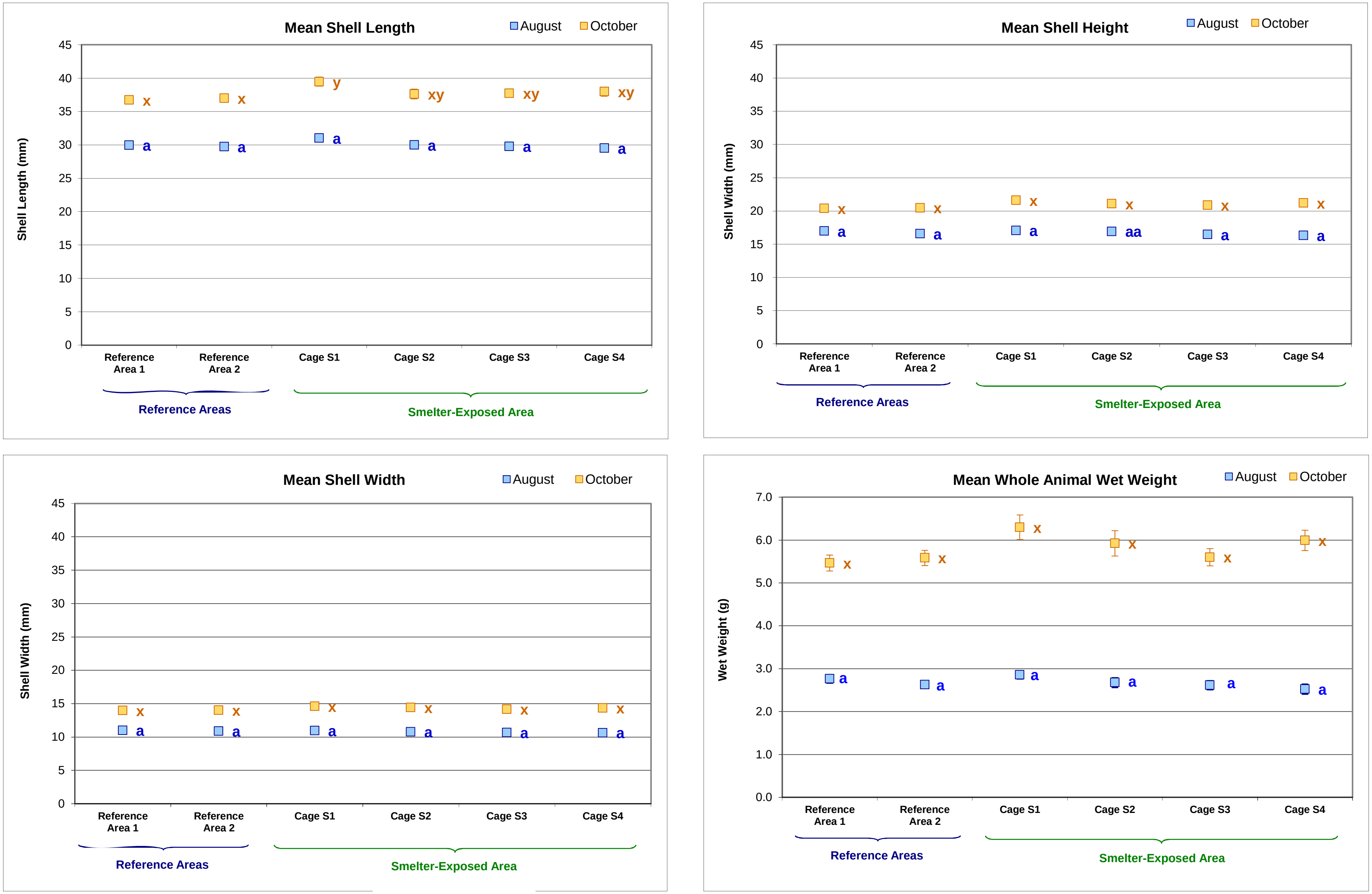


Figure A.1: Comparison of mussel mean shell measurements and mean whole animal wet-weight between deployment (August) and retrieval (October), Brunswick Smelter 2014 Caged Mussel Survey. Data points with the same letter in August or October data sets do not differ significantly.

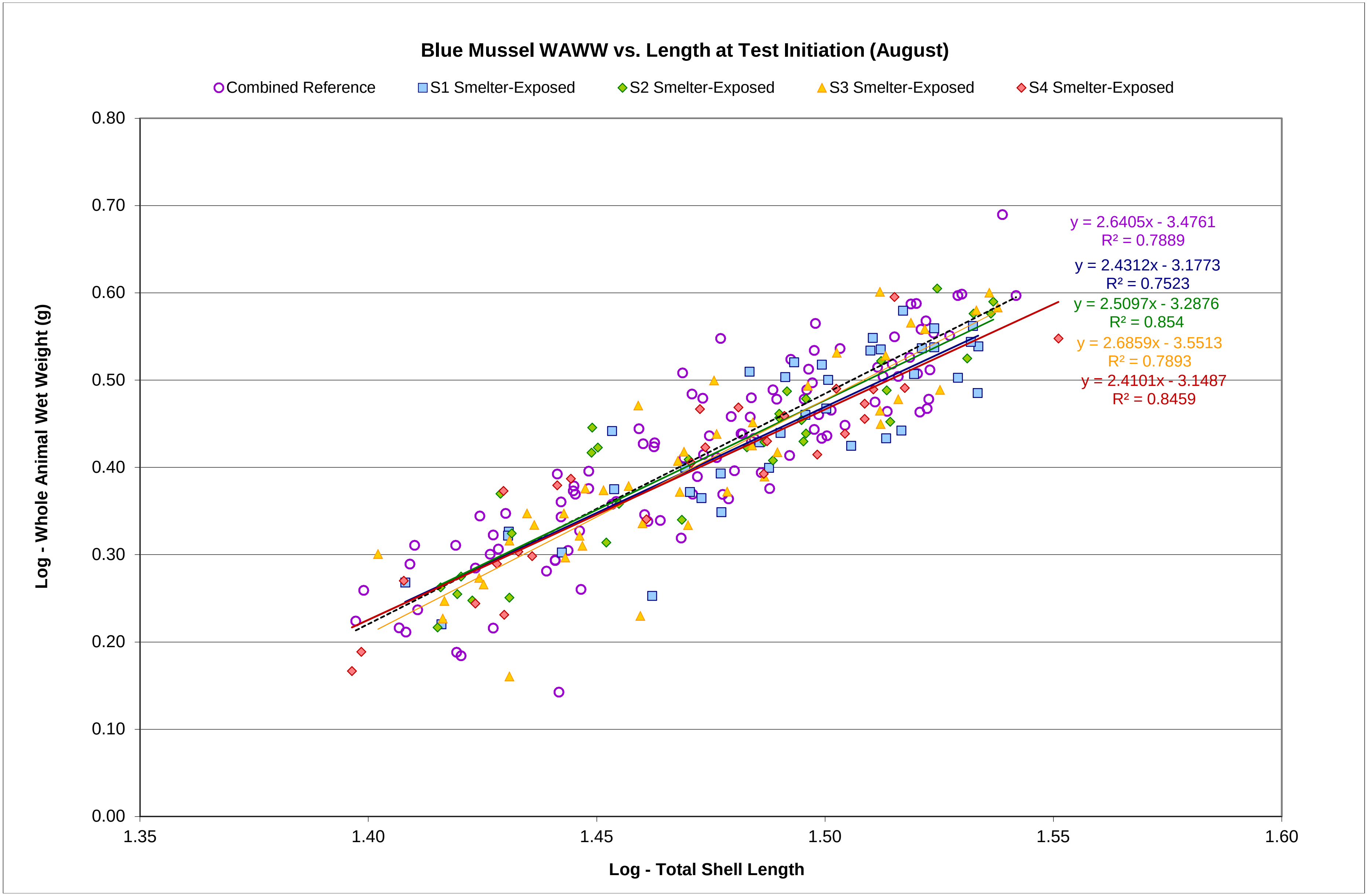


Figure A.2: Relationships between Whole Animal Wet Weight (WAWW) and shell length in blue mussels placed in cages at smelter-exposed and reference areas at test initiation (August 5th and 6th), Brunswick Smelter Caged Bivalve Survey.

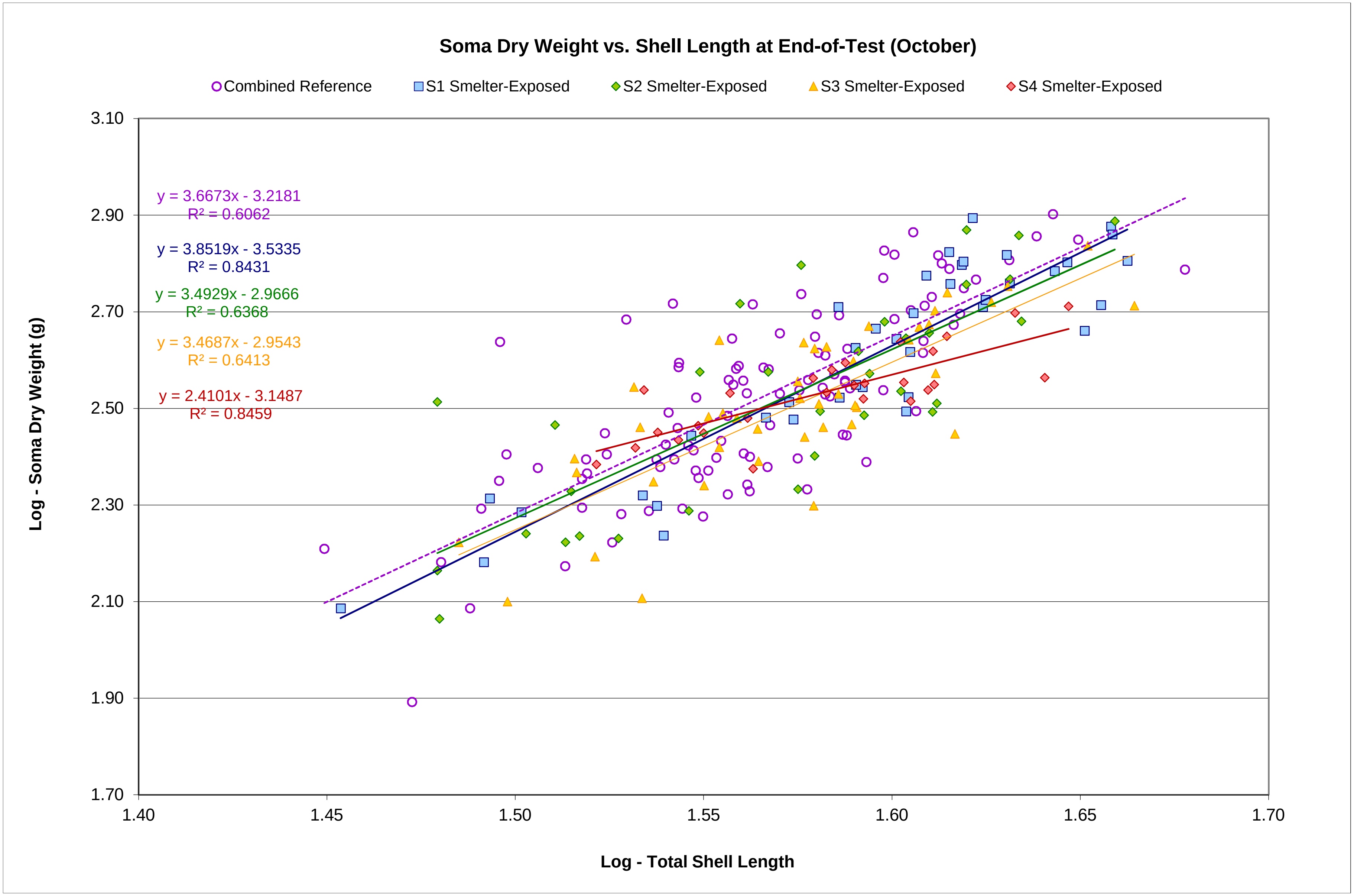


Figure A.3: **Relationships between soma dry weight and shell length in blue mussels placed in cages at smelter-exposed and reference areas after a duration of approximately 9.4 weeks (August 5th to October 11th), Brunswick Smelter Caged Bivalve Survey.**

Table A.1: Blue mussel (*Mytilus edulis*) measurement data for samples submitted for soft (soma) tissue metals analysis at initiation of the caged mussel study, August 2014.

Sample ID	Composite Sample Info.	Mussel Measures at Deployment (T_0; August)				
		Length (mm)	Width (mm)	Height (mm)	Whole Wet Weight (g)	Soma Wet Weight (g)
BM-T0-01	1	34.02	12.11	20.06	3.889	1.474
	2	29.13	10.51	15.85	2.237	0.779
	3	33.59	12.26	18.66	3.566	1.217
	4	31.24	11.36	17.42	2.697	1.081
	5	32.06	13.47	18.92	4.017	1.352
	Average	32.01	11.94	18.18	3.281	1.181
	SD	1.96	1.10	1.61	0.778	0.268
BM-T0-02	1	37.50	12.95	19.37	3.991	1.619
	2	33.74	12.77	19.02	4.035	1.555
	3	32.83	11.91	18.28	3.180	1.078
	4	33.24	11.32	17.75	3.442	1.175
	Average	34.33	12.24	18.61	3.662	1.357
	SD	2.15	0.76	0.73	0.420	0.270
BM-T0-03	1	35.07	12.27	19.24	3.673	1.352
	2	35.83	12.87	19.97	4.186	1.854
	3	31.44	12.11	17.79	2.739	1.131
	4	31.42	12.90	19.25	3.726	1.559
	Average	33.44	12.54	19.06	3.581	1.474
	SD	2.34	0.41	0.91	0.607	0.308
BM-T0-04	1	33.49	10.81	19.97	3.172	1.175
	2	34.24	12.32	18.31	3.287	1.363
	3	35.23	12.21	18.95	3.877	1.522
	4	30.60	12.24	17.75	2.994	1.256
	Average	33.39	11.90	18.75	3.333	1.329
	SD	1.99	0.72	0.95	0.382	0.150
BM-T0-05	1	30.65	12.20	17.38	2.853	1.107
	2	31.58	11.13	17.89	2.654	0.997
	3	32.80	12.32	17.36	3.154	1.168
	4	33.17	11.74	18.31	2.766	1.138
	Average	32.05	11.85	17.74	2.857	1.103
	SD	1.15	0.54	0.46	0.214	0.075
BM-T0-06	1	32.94	12.02	19.01	3.172	1.138
	2	32.68	12.09	17.66	3.172	1.273
	3	30.31	12.52	17.44	3.616	1.343
	4	33.76	12.62	19.07	3.835	1.571
	Average	32.42	12.31	18.30	3.449	1.331
	SD	1.48	0.30	0.87	0.332	0.181
BM-T0-07	1	35.54	13.28	18.24	4.221	1.975
	2	32.90	10.61	19.34	3.099	1.348
	3	30.89	10.93	16.59	2.383	0.926
	4	34.79	12.31	17.36	3.690	1.604
	Average	33.53	11.78	17.88	3.348	1.463
	SD	2.08	1.24	1.18	0.790	0.441
BM-T0-08	1	32.61	11.19	17.88	2.635	1.036
	2	31.97	11.77	19.92	3.654	1.375
	3	34.10	12.00	19.33	3.142	1.458
	4	34.78	11.80	20.43	3.799	1.537
	Average	33.37	11.69	19.39	3.308	1.352
	SD	1.30	0.35	1.10	0.530	0.220
BM-T0-09	1	35.30	12.66	18.36	3.575	1.435
	2	33.51	12.06	20.01	3.563	1.459
	3	35.44	12.27	19.21	3.969	1.672
	4	33.25	12.16	18.36	3.123	1.212
	Average	34.38	12.29	18.99	3.558	1.445
	SD	1.16	0.26	0.79	0.346	0.188
BM-T0-10	1	35.17	11.94	19.93	3.914	1.610
	2	33.35	12.34	18.35	3.695	1.418
	3	34.06	12.47	18.09	3.978	1.510
	4	33.60	12.50	18.13	4.094	1.784
	Average	34.05	12.31	18.63	3.920	1.581
	SD	0.81	0.26	0.88	0.168	0.157

Table A.2: Blue mussel soft tissue metal concentrations at time of deployment (August), Brunswick Smelter Caged Bivalve Survey, 2014.

Analytes	Units	MDL	Sample ID										Summary Statistics				
			BM-TO-01	BM-TO-02	BM-TO-03	BM-TO-04	BM-TO-05	BM-TO-06	BM-TO-07	BM-TO-08	BM-TO-09	BM-TO-10	Mean	Standard Diviation	Standard Error	Minimum	Maximum
Aluminum	mg/kg	0.5	76.6	35.7	41.6	25.2	25.7	77.9	49.9	99.0	59.5	45.3	53.6	24.4	7.7	25.2	99.0
Antimony	mg/kg	0.005	0.010	0.006	0.005	< 0.005	< 0.005	0.008	< 0.005	< 0.005	0.005	< 0.005	0.006	0.002	0.001	0.005	0.010
Arsenic	mg/kg	0.05	1.58	1.35	1.61	1.37	1.31	1.40	1.50	1.40	1.33	1.62	1.45	0.12	0.04	1.31	1.62
Barium	mg/kg	0.05	0.61	0.26	0.28	0.24	0.22	0.46	0.32	0.57	0.34	0.28	0.36	0.14	0.04	0.22	0.61
Beryllium	mg/kg	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.000	0.000	< 0.005	< 0.005
Bismuth	mg/kg	0.05	0.07	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.05	0.01	0.00	0.05	0.07
Boron	mg/kg	0.05	5.18	4.37	5.28	5.03	4.66	5.35	4.24	4.33	4.87	5.04	4.83	0.41	0.13	4.24	5.35
Cadmium	mg/kg	0.0005	0.280	0.317	0.267	0.268	0.260	0.279	0.252	0.305	0.284	0.287	0.280	0.020	0.006	0.252	0.317
Calcium	mg/kg	5	739	619	670	606	2,460	690	784	925	824	722	904	555	176	606	2,460
Chromium	mg/kg	0.05	0.28	0.16	0.17	0.13	0.14	0.24	0.16	0.24	0.19	0.16	0.19	0.05	0.02	0.13	0.28
Cobalt	mg/kg	0.005	0.107	0.095	0.109	0.084	0.086	0.121	0.087	0.126	0.095	0.110	0.102	0.015	0.005	0.084	0.126
Copper	mg/kg	0.05	1.64	1.52	1.60	1.47	1.26	1.46	1.50	1.49	1.43	1.53	1.49	0.10	0.03	1.26	1.64
Iron	mg/kg	1	76	45	47	34	35	73	52	91	59	50	56	19	6	34	91
Lead	mg/kg	0.005	0.350	0.238	0.363	0.211	0.305	0.307	0.251	0.364	0.418	0.284	0.309	0.065	0.021	0.211	0.418
Lithium	mg/kg	0.005	0.115	0.078	0.084	0.076	0.073	0.114	0.088	0.120	0.103	0.090	0.094	0.017	0.006	0.073	0.120
Magnesium	mg/kg	1	602	555	547	545	504	537	537	491	551	565	543	31	10	491	602
Manganese	mg/kg	0.05	3.52	2.96	3.31	2.92	2.41	3.45	2.83	3.75	2.77	2.75	3.07	0.42	0.13	2.41	3.75
Molybdenum	mg/kg	0.005	0.139	0.111	0.188	0.116	0.104	0.116	0.100	0.146	0.088	0.134	0.124	0.029	0.009	0.088	0.188
Nickel	mg/kg	0.05	0.39	0.34	0.42	0.29	0.31	0.41	0.30	0.45	0.34	0.38	0.36	0.05	0.02	0.29	0.45
Potassium	mg/kg	1	1,980	1,810	2,010	2,010	1,820	2,020	2,040	1,860	2,100	2,120	1,977	110	35	1,810	2,120
Rubidium	mg/kg	0.005	1.080	0.920	0.972	0.968	0.927	1.020	0.992	1.000	1.020	1.070	0.997	0.053	0.017	0.920	1.080
Selenium	mg/kg	0.05	0.80	0.71	0.73	0.60	0.59	0.65	0.72	0.66	0.72	0.72	0.69	0.06	0.02	0.59	0.80
Silver	mg/kg	0.005	0.024	0.024	0.021	0.023	0.023	0.029	0.018	0.024	0.026	0.027	0.024	0.003	0.001	0.018	0.029
Sodium	mg/kg	5	2,700	2,530	2,910	3,010	2,640	2,765	2,490	2,200	2,970	3,100	2,732	278	88	2,200	3,100
Strontium	mg/kg	0.05	5.28	4.56	4.61	4.58	8.90	4.69	5.21	6.94	5.15	5.52	5.54	1.38	0.44	4.56	8.90
Tellurium	mg/kg	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.000	0.000	< 0.005	< 0.005
Thallium	mg/kg	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.000	0.000	< 0.005	< 0.005
Tin	mg/kg	0.005	0.074	0.008	0.017	0.006	0.010	0.022	0.009	0.009	0.006	0.008	0.017	0.021	0.007	0.006	0.074
Uranium	mg/kg	0.005	0.050	0.040	0.071	0.043	0.043	0.047	0.033	0.056	0.021	0.038	0.044	0.013	0.004	0.021	0.071
Vanadium	mg/kg	0.05	0.32	0.20	0.39	0.20	0.20	0.32	0.23	0.40	0.20	0.27	0.27	0.08	0.03	0.20	0.40
Zinc	mg/kg	0.5	20.4	14.5	17.8	13.9	19.0	15.5	18.3	19.9	14.6	18.6	17.3	2.4	0.8	13.9	20.4

Table A.3: Caged blue mussel (*Mytilus edulis*) measurement data for mussels subject to soft tissue metal analysis at test termination, Brunswick Smelter Caged Bivalve Survey, 2014.

Caged Bivalve Station	**Mussel ID**	**Mussel Measures at Retrieval (T_2; October)**					
		Length (mm)	**Width (mm)**	**Height (mm)**	**Whole Wet Weight (g)**	**Soma Wet Weight (g)**	**Soma Dry Weight (g)**
R1	R1-M5-4	31.33	14.43	19.36	4.341	2.613	0.434
	R1-M6-7	38.43	13.33	20.30	5.362	2.748	0.372
	R1-M7-1	43.93	15.90	25.04	8.888	4.633	0.798
	R1-M4-7	30.76	10.64	17.46	2.897	1.643	0.122
	R1-M3-5	39.87	17.48	22.91	7.399	3.958	0.658
	Mean	36.86	14.36	21.01	5.78	3.12	0.477
	SD	5.69	2.60	2.99	2.39	1.18	0.262
	SE	2.54	1.16	1.34	1.07	0.53	0.117
R2	R2-M1-8	41.04	16.31	24.90	8.012	3.754	0.631
	R2-M2-6	41.91	16.24	24.99	7.465	3.814	0.584
	R2-M3-7	36.56	14.89	20.71	5.450	3.222	0.519
	R2-M4-5	38.63	13.82	20.31	5.174	2.524	0.279
	R2-M6-4	34.95	12.85	19.45	4.800	2.797	0.393
	Mean	38.62	14.82	22.07	6.18	3.22	0.481
	SD	2.93	1.51	2.66	1.45	0.57	0.144
	SE	1.31	0.68	1.19	0.65	0.26	0.064
S1	S1-M1-11	38.07	13.58	22.16	5.339	3.104	0.461
	S1-M3-2	41.82	16.36	23.72	7.680	4.566	0.784
	S1-M5-8	41.22	15.32	24.35	7.050	4.120	0.667
	S1-M6-5	39.91	14.68	22.23	6.436	3.085	0.441
	S1-M6-6	42.08	14.15	22.91	6.714	3.425	0.513
	Mean	40.62	14.82	23.07	6.64	3.66	0.573
	SD	1.65	1.08	0.95	0.86	0.66	0.147
	SE	0.74	0.48	0.43	0.39	0.29	0.066
S2	S2-M1-4	36.28	14.29	21.62	6.330	3.232	0.521
	S2-M2-4	**35.40**	**13.43**	**20.26**	**4.928**	**2.716**	**0.376**
	S2-M5-11	46.81	17.68	26.40	8.629	4.213	0.647
	S2-M6-12	41.26	16.23	22.87	7.712	3.313	0.430
	S2-M7-1	38.10	15.14	20.09	5.403	2.677	0.312
	Mean	39.57	15.35	22.25	6.60	3.23	0.457
	SD	4.63	1.66	2.58	1.55	0.62	0.131
	SE	2.07	0.74	1.15	0.69	0.28	0.059
S3	S3-M2-11	**39.77**	**13.44**	**22.32**	**5.950**	**2.944**	**0.378**
	S3-M2-9	33.20	12.42	18.43	4.069	1.900	0.156
	S3-M4-4	37.63	14.45	19.92	4.879	2.660	0.332
	S3-M5-8	42.30	15.36	23.84	7.026	3.559	0.525
	S3-M7-2	30.55	11.18	13.61	2.590	1.827	0.167
	Mean	36.69	13.37	19.62	4.90	2.58	0.312
	SD	4.79	1.65	3.96	1.71	0.73	0.155
	SE	2.14	0.74	1.77	0.76	0.33	0.069
S4	S4-M1-1	37.94	15.10	20.63	5.839	2.904	0.365
	S4-M2-4	33.23	13.46	19.36	4.090	2.225	0.242
	S4-M4-10	36.45	13.32	20.93	5.115	2.535	0.302
	S4-M5-1	34.03	14.62	18.46	5.196	2.414	0.262
	S4-M6-11	36.33	13.47	20.25	5.162	2.135	0.222
	Mean	35.60	13.99	19.93	5.08	2.44	0.279
	SD	1.92	0.81	1.01	0.63	0.30	0.057
	SE	0.86	0.36	0.45	0.28	0.13	0.025

Table A.4: Reference area caged blue mussel soft tissue metal concentrations at time of cage retrieval (October), Brunswick Smelter Caged Bivalve Survey, 2014.

Analytes	Units	MDL	Sample ID									
			Reference Cage R1					Reference Cage R2				
			R1-M5-4	R1-M6-7	R1-M7-1	R1-M4-7	R1-M3-5	R2-M3-7	R2-M2-6	R2-M6-4	R2-M4-5	R2-M1-8
Aluminum	mg/kg	1	338	433	122	693	132	175	516	130	179	246
Antimony	mg/kg	0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Arsenic	mg/kg	1	12	7	6	8	11	7	11	5	8	9
Barium	mg/kg	1	18	6	3	6	14	6	17	2	4	4
Beryllium	mg/kg	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Bismuth	mg/kg	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	<1
Boron	mg/kg	1	17	21	18	30	18	20	19	20	23	20
Cadmium	mg/kg	0.01	1.26	1.38	0.56	2.15	1.04	1.00	1.66	0.88	1.83	1.20
Calcium	mg/kg	50	3,545	3,310	1,280	5,150	1,550	2,080	1,660	1,560	2,380	2,325
Chromium	mg/kg	1	< 1	1	< 1	2	< 1	< 1	1	< 1	< 1	< 1
Cobalt	mg/kg	0.1	0.4	0.4	0.2	0.6	0.4	0.2	0.5	0.2	0.4	0.3
Copper	mg/kg	1	5	7	4	9	6	5	6	7	6	5
Iron	mg/kg	20	315	410	130	650	160	180	480	150	200	250
Lead	mg/kg	0.1	3.3	1.7	1.1	2.7	1.7	1.5	2.8	1.3	1.7	2.3
Lithium	mg/kg	0.1	0.6	0.7	0.4	1.2	0.4	0.5	0.7	0.4	0.6	0.5
Magnesium	mg/kg	10	2,180	3,110	2,760	4,830	2,460	2,740	2,640	2,770	3,760	2,715
Manganese	mg/kg	1	13	16	5	23	9	8	14	7	8	8
Molybdenum	mg/kg	0.1	0.5	0.3	0.2	0.6	0.5	0.3	0.5	0.3	0.3	0.4
Nickel	mg/kg	1	2	2	< 1	2	1	< 1	2	< 1	1	1
Potassium	mg/kg	20	9,985	10,400	10,600	13,300	9,470	9,490	10,700	9,640	12,000	10,500
Rubidium	mg/kg	0.1	5.2	4.8	4.3	6.1	4.4	4.3	5.4	3.9	5.2	4.5
Selenium	mg/kg	1	3	3	2	4	3	2	3	3	4	3
Silver	mg/kg	0.1	0.1	< 0.1	< 0.1	0.1	< 0.1	< 0.1	< 0.1	0.1	0.1	< 0.1
Sodium	mg/kg	50	12,500	19,400	19,700	32,400	15,100	17,700	15,800	16,900	27,400	17,450
Strontium	mg/kg	1	24	31	16	47	19	22	19	18	28	21
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Tin	mg/kg	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Uranium	mg/kg	0.1	< 0.1	< 0.1	< 0.1	0.3	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Vanadium	mg/kg	1	3	2	< 1	3	2	1	3	< 1	1	1
Zinc	mg/kg	1	81	75	32	146	81	54	104	48	125	42

Table A.5: Smelter-exposed area caged blue mussel soft tissue metal concentrations at time of cage retrieval (October), Brunswick Smelter Caged Bivalve Survey, 2014

Analytes	Units	MDL	Sample ID																			
			Smelter-Exposed Cage S1					Smelter-Exposed Cage S2					Smelter-Exposed Cage S3					Smelter-Exposed Cage S4				
			S1-M6-5	S1-M3-2	S1-M1-11	S1-M6-6	S1-M5-8	S2-M7-1	S2-M6-12	S2-M1-4	S2-M2-4	S2-M5-11	S3-M4-4	S3-M7-2	S3-M2-9	S3-M5-8	S3-M2-11	S4-M5-1	S4-M4-10	S4-M2-4	S4-M6-11	S4-M1-1
Aluminum	mg/kg	1	193	109	278	348	314	356	287	175	176	730	798	102	470	174	99	178	237	311	68	274
Antimony	mg/kg	0.1	< 0.1	< 0.1	0.1	< 0.1	0.1	0.2	0.3	0.1	0.1	0.2	0.2	< 0.1	0.2	0.1	0.1	0.1	0.1	0.2	0.1	0.2
Arsenic	mg/kg	1	15	9	8	9	10	10	11	8	12	9	14	14	11	10	10	10	9	11	10	10
Barium	mg/kg	1	10	5	7	8	13	6	9	3	9	8	14	2	6	7	6	4	8	9	6	8
Beryllium	mg/kg	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Bismuth	mg/kg	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Boron	mg/kg	1	21	20	20	21	21	25	22	20	23	25	21	22	26	22	24	28	22	25	25	21
Cadmium	mg/kg	0.01	3.43	2.25	2.93	5.42	4.58	5.59	3.63	4.59	3.65	1.97	3.28	3.52	5.06	3.03	2.54	5.21	4.29	4.21	5.81	3.38
Calcium	mg/kg	50	2,670	2,070	4,220	2,060	2,170	5,800	2,450	2,235	12,300	2,630	12,000	4,220	3,020	2,500	2,550	2,410	2,630	4,330	2,810	3,410
Chromium	mg/kg	1	< 1	< 1	< 1	1	1	1	1	1	< 1	2	2	< 1	2	< 1	< 1	1	1	1	< 1	1
Cobalt	mg/kg	0.1	0.4	0.2	0.3	0.5	0.5	0.7	0.6	0.3	0.4	0.5	0.8	0.3	0.7	0.4	0.5	0.5	0.5	0.5	0.9	0.5
Copper	mg/kg	1	7	5	6	8	9	10	9	7	8	8	9	8	9	9	7	10	8	10	7	9
Iron	mg/kg	20	210	140	280	350	350	480	380	240	260	760	870	170	580	240	160	270	320	390	140	350
Lead	mg/kg	0.1	62.0	32.6	54.4	105.0	62.8	69.0	54.4	103.5	45.6	32.3	64.1	45.2	66.8	50.7	35.6	75.3	71.5	83.1	100.0	81.2
Lithium	mg/kg	0.1	0.5	0.4	0.6	0.6	0.6	0.8	0.7	0.5	0.6	1.1	1.1	0.6	0.9	0.6	0.5	0.7	0.7	0.7	0.5	0.6
Magnesium	mg/kg	10	3,160	2,830	3,120	2,940	2,840	3,980	3,410	2,690	3,260	3,640	2,870	3,860	4,360	3,430	3,730	4,200	3,750	3,850	3,750	3,220
Manganese	mg/kg	1	10	7	10	12	13	17	14	14	13	27	29	13	21	12	12	17	12	12	8	15
Molybdenum	mg/kg	0.1	0.5	0.4	0.4	0.5	0.6	0.6	0.5	0.4	0.5	0.5	0.7	0.4	0.6	0.5	0.4	0.4	0.6	0.6	0.6	0.5
Nickel	mg/kg	1	1	< 1	1	2	2	3	2	< 1	2	2	3	< 1	4	2	2	2	2	2	4	2
Potassium	mg/kg	20	11,500	11,400	12,600	11,400	10,800	12,800	11,200	10,220	12,600	11,800	11,900	13,000	12,900	12,400	12,400	15,300	11,300	12,700	13,200	10,800
Rubidium	mg/kg	0.1	5.4	4.5	5.2	5.3	4.9	5.7	5.0	4.3	5.4	5.8	6.4	5.3	5.8	5.4	5.1	5.8	5.0	5.8	5.9	4.9
Selenium	mg/kg	1	5	3	3	5	4	5	5	4	4	4	5	6	5	4	5	5	4	5	5	4
Silver	mg/kg	0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.3	0.1	0.1	< 0.1	< 0.1	0.3	0.1	0.2	0.2
Sodium	mg/kg	50	21,600	17,200	18,600	17,600	18,500	26,400	23,800	16,750	21,300	22,300	17,200	26,600	30,500	23,800	25,100	29,200	25,600	26,200	25,700	21,000
Strontium	mg/kg	1	25	19	27	21	23	38	25	21	61	26	55	41	38	27	30	32	27	37	35	30
Tellurium	mg/kg	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Thallium	mg/kg	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	0.2	0.2	0.3	0.2
Tin	mg/kg	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Uranium	mg/kg	0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	0.1	< 0.1	< 0.1	< 0.1	0.1	0.1	< 0.1	0.2	< 0.1	< 0.1	< 0.1	0.1	< 0.1	0.1	< 0.1
Vanadium	mg/kg	1	1	< 1	1	2	2	2	3	2	2	3	4	< 1	3	2	2	2	2	2	2	2
Zinc	mg/kg	1	152	99	100	210	183	124	115	215	109	62	132	210	161	108	92	198	170	176	232	129

Table A.6: Caged blue mussel (*Mytilus edulis*) measurement data for reference station R1 at deployment (August) and retrieval (October) sampling events, Brunswick Smelter Caged Bivalve Survey, 2014.

Mussel Station Code	Mussel ID	Mussel Measures at Deployment (T_1; August)				Mussel Measures at Retrieval (T_2; October)						Δ Measures (T_2 - T_1)			
		Length (mm)	Width (mm)	Height (mm)	Whole Wet Weight (g)	Length (mm)	Width (mm)	Height (mm)	Whole Wet Weight (g)	Soma Wet Weight (g)	Soma Dry Weight (g)	Length (mm)	Width (mm)	Height (mm)	Whole Wet Weight (g)
R1-M1	R1-M1-01	31.45	11.44	17.06	2.776	35.76	12.98	18.89	4.835	2.420	0.250	4.31	1.54	1.83	2.059
	R1-M1-02	30.23	10.05	15.68	2.076	missing*									
	R1-M1-03	30.03	10.37	15.71	2.339	47.62	15.92	24.23	7.145	3.963	0.613	17.59	5.55	8.52	4.806
	R1-M1-04	27.94	9.75	15.77	2.125	35.32	13.57	19.54	5.146	2.669	0.333	7.38	3.82	3.77	3.021
	R1-M1-05	26.47	10.24	14.95	2.136	missing*									
	R1-M1-06	31.29	11.97	16.79	3.055	missing*									
	R1-M1-07	26.82	9.70	15.49	2.025	34.47	12.35	17.94	4.205	2.100	0.248	7.65	2.65	2.45	2.180
	R1-M1-08	29.01	11.56	16.49	2.652	33.40	13.80	18.57	4.196	2.304	0.281	4.39	2.24	2.08	1.544
	R1-M1-09	33.34	12.15	17.78	3.249	40.33	15.01	21.04	6.889	3.899	0.732	6.99	2.86	3.26	3.640
	R1-M1-10	26.92	10.24	16.25	2.224	31.45	12.99	17.86	4.133	2.142	0.254	4.53	2.75	1.61	1.909
R1-M2	R1-M2-01	27.96	10.22	14.65	1.821	41.23	15.65	21.00	6.357	3.650	0.615	13.27	5.43	6.35	4.536
	R1-M2-02	33.02	12.13	18.23	3.866	38.16	14.01	20.56	5.440	2.726	0.349	5.14	1.88	2.33	1.574
	R1-M2-03	30.16	11.13	17.38	2.872	38.54	15.02	22.58	6.352	3.292	0.493	8.38	3.89	5.20	3.480
	R1-M2-04	30.21	11.17	16.23	2.489	34.55	12.74	18.92	3.908	2.231	0.239	4.34	1.57	2.69	1.419
	R1-M2-05	30.00	12.48	18.79	3.529	38.68	16.23	22.74	7.194	2.903	0.361	8.68	3.75	3.95	3.665
	R1-M2-06	28.07	9.85	17.16	2.375	31.31	11.37	18.10	3.650	2.112	0.224	3.24	1.52	0.94	1.275
	R1-M2-07	27.63	10.45	16.07	2.468	37.17	15.42	22.22	6.389	3.274	0.452	9.54	4.97	6.15	3.921
	R1-M2-08	26.75	9.65	15.52	1.644	34.67	13.98	20.87	4.427	2.360	0.266	7.92	4.33	5.35	2.783
	R1-M2-09	31.86	12.43	17.62	3.436	35.26	13.57	18.96	4.928	2.477	0.259	3.40	1.14	1.34	1.492
	R1-M2-10	33.67	12.17	18.31	3.555	36.43	14.14	20.14	5.163	2.847	0.340	2.76	1.97	1.83	1.608
R1-M3	R1-M3-01	28.07	10.66	17.20	2.612	missing*									
	R1-M3-02	30.86	11.10	16.91	3.007	42.77	15.70	23.56	7.699	3.914	0.641	11.91	4.60	6.65	4.692
	R1-M3-03	33.32	11.18	18.17	3.006	39.60	12.97	20.99	5.489	2.713	0.345	6.28	1.79	2.82	2.483
	R1-M3-04	34.58	12.17	19.70	4.892	38.74	14.62	21.14	6.757	3.144	0.420	4.16	2.45	1.44	1.865
	R1-M3-05	26.25	10.34	14.36	2.045	39.87	17.48	22.91	7.399	3.958	0.658	13.62	7.14	8.55	5.354
	R1-M3-06	31.06	11.44	16.56	2.592	36.36	13.16	18.23	4.797	2.452	0.255	5.30	1.72	1.67	2.205
	R1-M3-07	33.27	12.09	18.85	3.698	36.44	13.90	20.37	5.487	2.282	0.220	3.17	1.81	1.52	1.789
	R1-M3-08	31.47	10.30	19.46	3.673	37.17	14.38	23.40	7.088	2.832	0.339	5.70	4.08	3.94	3.415
	R1-M3-09	33.13	12.24	18.51	3.216	38.68	14.60	20.63	5.773	2.768	0.358	5.55	2.36	2.12	2.557
	R1-M3-10	33.88	12.05	18.90	3.968	38.72	14.03	20.34	5.755	2.564	0.278	4.84	1.98	1.44	1.787
R1-M4	R1-M4-01	33.19	11.87	17.79	3.615	36.89	13.36	19.74	5.316	2.360	0.239	3.70	1.49	1.95	1.701
	R1-M4-02	29.34	9.92	15.79	2.191	missing*									
	R1-M4-03	24.96	9.29	15.13	1.675	29.69	11.00	17.01	2.772	1.630	0.078	4.73	1.71	1.88	1.097
	R1-M4-04	27.85	10.28	15.36	2.360	32.94	12.43	17.80	4.428	2.098	0.226	5.09	2.15	2.44	2.068
	R1-M4-05	24.79	11.51	17.01	3.095	34.31	12.83	18.84	4.768	2.045	0.194	9.52	1.32	1.83	1.673
	R1-M4-06	27.62	9.78	16.37	2.167	missing*									
	R1-M4-07	28.87	9.80	17.01	2.218	30.76	10.64	17.46	2.897	1.643	0.122	1.89	0.84	0.45	0.679
	R1-M4-08	27.68	10.46	16.06	2.293	36.92	13.96	21.27	5.656	2.989	0.381	9.24	3.50	5.21	3.363
	R1-M4-09	27.27	9.19	15.47	1.795	missing*									
	R1-M4-10	26.57	10.52	16.22	2.210	30.97	12.07	17.68	3.665	1.908	0.196	4.40	1.55	1.46	1.455
R1-M5	R1-M5-01	35.11	11.34	18.67	3.605	missing*									
	R1-M5-02	32.72	12.25	16.58	3.108	missing*									
	R1-M5-03	28.85	10.59	17.29	2.673	32.94	12.70	17.96	4.026	2.015	0.197	4.09	2.11	0.67	1.353
	R1-M5-04	30.75	11.36	17.31	2.375	31.33	14.43	19.36	4.341	2.613	0.434	0.58	3.07	2.05	1.966
	R1-M5-05	29.58	10.98	17.24	2.340	37.66	15.88	19.69	5.960	3.473	0.545	8.08	4.90	2.45	3.620
	R1-M5-06	32.71	12.10	17.59	3.300	36.35	13.90	19.94	5.429	2.717	0.361	3.64	1.80	2.35	2.129
	R1-M5-07	27.93	9.65	15.88	2.239	missing*									
	R1-M5-08	29.84	12.38	17.12	2.907	missing*									
	R1-M5-09	28.46	9.87	16.30	2.296	33.84	13.58	20.40	5.445	2.968	0.483	5.38	3.71	4.10	3.149
	R1-M5-10	32.43	11.83	17.81	2.984	41.34	15.30	22.35	6.401	3.195	0.471	8.91	3.47	4.54	3.417
R1-M6	R1-M6-01	33.12	11.77	17.21	3.328	dead									
	R1-M6-02	28.02	10.64	17.36	2.775	missing*									
	R1-M6-03	29.94	10.38	16.41	2.577	37.98	14.17	22.56	6.403	3.031	0.445	8.04	3.79	6.15	3.826
	R1-M6-04	27.68	10.28	16.23	2.204	35.31	12.83	19.98	4.552	2.329	0.235	7.63	2.55	3.75	2.348
	R1-M6-05	30.12	10.45	16.72	2.312	36.49	11.54	19.12	4.676	2.262	0.213	6.37	1.09	2.40	2.364
	R1-M6-06	27.35	9.30	14.90	1.792	missing*									
	R1-M6-07	31.57	10.63	17.42	2.711	38.43	13.33	20.30	5.362	2.748	0.372	6.86	2.70	2.88	2.651
	R1-M6-08	30.11	10.92	18.15	2.869	missing*									
	R1-M6-09	28.07	10.96	17.13	2.486	36.19	14.79	22.14	5.632	2.882	0.382	8.12	3.83	5.01	3.146
	R1-M6-10	31.36	12.31	17.45	3.254	39.87	15.63	20.58	6.627	3.356	0.484	8.51	3.32	3.13	3.373
R1-M7	R1-M7-01	31.29	10.70	18.26	3.006	43.93	15.90	25.04	8.888	4.633	0.798	12.64	5.20	6.78	5.882
	R1-M7-02	31.52	10.63	17.64	2.887	39.62	14.85	22.12	7.058	4.087	0.671	8.10	4.22	4.48	4.171
	R1-M7-03	27.60	9.64	14.28	1.965	36.00	13.59	20.25	4.090	2.419	0.305	8.40	3.95	5.97	2.125
	R1-M7-04	30.47	11.90	17.15	3.018	38.33	15.12	22.40	6.616	2.755	0.335	7.86	3.22	5.25	3.598
	R1-M7-05	30.99	10.90	17.48	2.873	dead									
Summary Statistics	n	65	65	65	65	49	49	49	49	49	49	49	49	49	49
	Average	29.91	10.91	16.90	2.722	36.751	13.95	20.40	5.461	2.779	0.367	6.77	2.96	3.41	2.698
	SD	2.47	0.94	1.22	0.638	3.560	1.44	1.92	1.299	0.669	0.162	3.27	1.40	2.03	1.183
	SE	0.31	0.12	0.15	0.079	0.509	0.21	0.27	0.186	0.096	0.023	0.47	0.20	0.29	0.169
	Median	30.03	10.70	17.06	2.652	36.490	13.96	20.34	5.440	2.717	0.340	6.37	2.70	2.69	2.364
	Minimum	24.79	9.19	14.28	1.644	29.690	10.64	17.01	2.772	1.630	0.078	0.58	0.84	0.45	0.679
	Maximum	35.11	12.48	19.70	4.892	47.620	17.48	25.04	8.888	4.633	0.798	17.59	7.14	8.55	5.882

* Includes four blue mussels dislodged from the socking material (see Appendix Table A.7)

Table A.7: Caged blue mussel (*Mytilus edulis*) measurement data for reference station R2 at deployment (August) and retrieval (October) sampling events, Brunswick Smelter Caged Bivalve Survey, 2014.

Mussel Station Code	Mussel ID	Mussel Measures at Deployment (T_1; August)				Mussel Measures at Retrieval (T_2; October)						Δ Measures (T_2 - T_1)			
		Length (mm)	Width (mm)	Height (mm)	Whole Wet Weight (g)	Length (mm)	Width (mm)	Height (mm)	Whole Wet Weight (g)	Soma Wet Weight (g)	Soma Dry Weight (g)	Length (mm)	Width (mm)	Height (mm)	Whole Wet Weight (g)
R2-M1	R2-M1-01	25.60	8.90	14.62	1.627	36.80	12.88	20.32	4.900	2.685	0.384	11.20	3.98	5.70	3.273
	R2-M1-02	30.45	11.31	17.69	2.868	37.82	14.84	21.63	6.121	2.808	0.362	7.37	3.53	3.94	3.253
	R2-M1-03	31.65	10.66	17.68	2.730	39.19	13.57	21.07	6.027	2.595	0.245	7.54	2.91	3.39	3.297
	R2-M1-04	28.40	9.85	16.12	2.279	40.95	15.58	26.18	7.139	3.849	0.656	12.55	5.73	10.06	4.860
	R2-M1-05	25.51	9.05	14.95	1.645	35.58	12.87	19.43	4.536	2.333	0.235	10.07	3.82	4.48	2.891
	R2-M1-06	33.81	11.88	19.67	3.952	37.80	13.15	22.14	5.753	2.235	0.215	3.99	1.27	2.47	1.801
	R2-M1-07	26.26	8.83	15.01	1.542	34.82	13.47	19.78	4.984	3.257	0.521	8.56	4.64	4.77	3.442
	R2-M1-08	31.33	11.39	17.80	3.082	41.04	16.31	24.90	8.012	3.754	0.631	9.71	4.92	7.10	4.930
	R2-M1-09	25.65	10.26	14.73	1.946	33.02	13.01	19.38	3.537	2.191	0.248	7.37	2.75	4.65	1.591
	R2-M1-10	31.72	11.00	18.05	2.920	41.60	15.96	22.57	7.609	3.677	0.561	9.88	4.96	4.52	4.689
R2-M2	R2-M2-01	29.57	11.26	17.06	3.049	38.22	14.69	20.86	6.659	3.031	0.407	8.65	3.43	3.80	3.610
	R2-M2-02	28.79	12.38	15.99	2.781	34.73	14.85	18.93	5.313	2.528	0.310	5.94	2.47	2.94	2.532
	R2-M2-03	30.47	10.15	17.37	2.690	43.49	16.14	25.41	8.211	4.359	0.718	13.02	5.99	8.04	5.521
	R2-M2-04	33.29	11.95	17.61	2.934	38.80	14.11	20.02	5.886	2.815	0.348	5.51	2.16	2.41	2.952
	R2-M2-05	25.75	9.51	13.45	1.725	35.86	13.86	19.59	4.689	2.370	0.271	10.11	4.35	6.14	2.964
	R2-M2-06	27.60	10.49	14.61	1.967	41.91	16.24	24.99	7.465	3.814	0.584	14.31	5.75	10.38	5.498
	R2-M2-07	29.10	10.69	16.37	2.184	37.58	13.64	19.19	4.984	2.335	0.249	8.48	2.95	2.82	2.800
	R2-M2-08	31.45	12.28	17.10	3.420	40.57	16.02	22.57	7.539	2.970	0.412	9.12	3.74	5.47	4.119
	R2-M2-09	29.45	10.74	15.49	2.576	35.15	12.78	18.39	4.683	2.452	0.265	5.70	2.04	2.90	2.107
	R2-M2-10	25.48	9.25	14.47	1.510	missing*									
R2-M3	R2-M3-01	26.51	9.81	15.60	1.926	28.14	11.10	17.20	3.002	1.815	0.162	1.63	1.29	1.60	1.076
	R2-M3-02	28.92	10.46	15.58	2.178	39.60	14.87	22.47	6.498	3.646	0.589	10.68	4.41	6.89	4.320
	R2-M3-03	29.65	10.55	17.02	2.452	35.47	13.08	18.32	4.711	2.040	0.189	5.82	2.53	1.30	2.259
	R2-M3-04	25.06	9.14	15.91	1.816	30.22	10.45	17.87	2.807	1.780	0.152	5.16	1.31	1.96	0.991
	R2-M3-05	25.21	8.87	13.81	1.483	dead									
	R2-M3-06	26.75	10.33	15.08	2.101	32.06	13.22	18.01	3.761	2.225	0.238	5.31	2.89	2.93	1.660
	R2-M3-07	26.71	10.11	14.49	1.997	36.56	14.89	20.71	5.450	3.222	0.519	9.85	4.78	6.22	3.453
	R2-M3-08	31.08	12.92	17.43	3.341	36.03	15.42	19.36	5.904	2.898	0.362	4.95	2.50	1.93	2.563
	R2-M3-09	27.88	10.12	16.71	2.341	36.25	13.79	20.21	5.596	2.694	0.387	8.37	3.67	3.50	3.255
	R2-M3-10	33.00	11.73	18.74	3.356	41.50	15.44	21.29	7.816	3.500	0.496	8.50	3.71	2.55	4.460
R2-M4	R2-M4-01	28.19	10.51	16.69	2.263	missing*									
	R2-M4-02	27.86	10.00	15.72	2.392	34.85	12.99	19.45	4.874	2.273	0.248	6.99	2.99	3.73	2.482
	R2-M4-03	27.65	10.64	12.89	1.388	32.60	12.65	15.03	3.018	1.829	0.149	4.95	2.01	2.14	1.630
	R2-M4-04	25.71	9.65	15.15	2.045	36.10	14.27	20.76	5.955	3.015	0.441	10.39	4.62	5.61	3.910
	R2-M4-05	31.42	12.23	17.19	3.140	38.63	13.82	20.31	5.174	2.524	0.279	7.21	1.59	3.12	2.034
	R2-M4-06	32.63	11.23	17.46	2.911	35.37	12.73	19.56	4.459	2.346	0.227	2.74	1.50	2.10	1.548
	R2-M4-07	32.56	11.22	18.55	3.195	40.79	14.87	22.80	6.789	3.546	0.538	8.23	3.65	4.25	3.594
	R2-M4-08	26.32	8.97	12.80	1.528	35.02	13.45	18.94	4.492	2.126	0.196	8.70	4.48	6.14	2.964
	R2-M4-09	31.94	12.14	17.54	2.808	40.27	15.35	21.97	6.987	3.471	0.505	8.33	3.21	4.43	4.179
	R2-M4-10	31.79	10.91	16.27	3.242	missing*									
R2-M5	R2-M5-01	30.51	11.38	15.80	2.712	40.58	15.73	21.42	6.094	3.208	0.436	10.07	4.35	5.62	3.382
	R2-M5-02	29.73	11.67	17.26	3.015	34.92	14.43	19.68	5.577	2.408	0.288	5.19	2.76	2.42	2.562
	R2-M5-03	32.81	10.96	18.79	3.192	36.95	12.66	20.78	4.971	2.544	0.292	4.14	1.70	1.99	1.779
	R2-M5-04	27.05	9.88	15.17.	2.108	missing*									
	R2-M5-05	30.62	10.77	15.98	2.478	36.07	12.94	18.51	4.756	1.654	0.098	5.45	2.17	2.53	2.278
	R2-M5-06	29.43	11.53	17.03	3.223	34.94	14.14	20.03	5.436	2.778	0.385	5.51	2.61	3.00	2.213
	R2-M5-07	28.08	10.41	15.18	2.230	missing*									
	R2-M5-08	32.47	11.43	18.72	3.270	37.62	13.63	21.16	6.274	2.814	0.345	5.15	2.20	2.44	3.004
	R2-M5-09	29.83	11.57	16.70	2.731	33.74	12.77	18.19	4.171	2.007	0.191	3.91	1.20	1.49	1.440
	R2-M5-10	33.17	11.70	15.77	2.906	36.01	12.86	17.57	4.405	2.188	0.210	2.84	1.16	1.80	1.499
R2-M6	R2-M6-01	27.72	10.13	16.35	1.995	dead									
	R2-M6-02	34.82	11.58	19.07	3.953	44.61	15.59	24.47	8.481	4.370	0.707	9.79	4.01	5.40	4.528
	R2-M6-03	27.78	9.92	16.05	2.018	38.02	14.28	21.87	6.093	3.227	0.495	10.24	4.36	5.82	4.075
	R2-M6-04	29.41	9.99	16.58	2.085	34.95	12.85	19.45	4.800	2.797	0.393	5.54	2.86	2.87	2.715
	R2-M6-05	30.33	10.81	17.67	2.744	38.06	14.43	21.54	6.154	3.082	0.412	7.73	3.62	3.87	3.410
	R2-M6-06	30.31	10.89	17.03	2.746	36.50	13.40	18.73	4.760	2.352	0.251	6.19	2.51	1.70	2.014
	R2-M6-07	33.40	12.01	19.17	3.581	38.22	14.24	21.05	6.111	2.962	0.338	4.82	2.23	1.88	2.530
	R2-M6-08	28.51	9.50	15.23	1.109	dead									
	R2-M6-09	27.48	9.23	15.20	1.910	33.55	11.85	18.32	3.916	2.056	0.167	6.07	2.62	3.12	2.006
	R2-M6-10	29.74	11.03	15.68	2.598	40.61	15.54	22.56	6.748	3.407	0.516	10.87	4.51	6.88	4.150
R2-M7	R2-M7-01	30.80	11.64	17.91	3.083	36.13	13.80	20.04	5.804	2.332	0.354	5.33	2.16	2.13	2.721
	R2-M7-02	27.61	9.62	15.76	2.121	missing*									
	R2-M7-03	33.11	12.36	19.52	3.871	40.40	15.06	22.50	7.103	3.071	0.312	7.29	2.70	2.98	3.232
	R2-M7-04	32.75	11.69	17.78	3.545	33.44	12.71	17.76	4.671	2.353	0.254	0.69	1.02	-0.02	1.126
	R2-M7-05	29.02	12.24	16.26	2.680	33.04	13.99	19.43	4.896	2.168	0.232	4.02	1.75	3.17	2.216
Summary Statistics	n	65	65	64	65	56	56	56	56	56	56	56	56	56	56
	Average	29.46	10.73	16.45	2.542	37.013	13.99	20.48	5.581	2.764	0.357	7.28	3.13	3.88	2.953
	SD	2.56	1.03	1.56	0.674	3.249	1.30	2.19	1.334	0.644	0.152	2.86	1.28	2.13	1.131
	SE	0.32	0.13	0.20	0.084	0.434	0.17	0.29	0.178	0.086	0.020	0.38	0.17	0.28	0.151
	Median	29.45	10.74	16.36	2.598	36.530	13.84	20.13	5.514	2.690	0.342	7.33	2.90	3.15	2.922
	Minimum	25.06	8.83	12.80	1.109	28.140	10.45	15.03	2.807	1.654	0.098	0.69	1.02	-0.02	0.991
	Maximum	34.82	12.92	19.67	3.953	44.610	16.31	26.18	8.481	4.370	0.718	14.31	5.99	10.38	5.521

* Includes six blue mussels dislodged from the socking material (see Appendix Table A.7)

Table A.8: Caged blue mussel (*Mytilus edulis*) measurement data for smelter-exposed station S1 at deployment (August) and retrieval (October) sampling events, Brunswick Smelter Caged Bivalve Survey, 2014.

Mussel Station Code	Mussel ID	Mussel Measures at Deployment (T_1; August)				Mussel Measures at Retrieval (T_2; October)						Δ Measures (T_2 - T_1)			
		Length (mm)	Width (mm)	Height (mm)	Whole Wet Weight (g)	Length (mm)	Width (mm)	Height (mm)	Whole Wet Weight (g)	Soma Wet Weight (g)	Soma Dry Weight (g)	Length (mm)	Width (mm)	Height (mm)	Whole Wet Weight (g)
S1-M1	S1-M1-01	27.85	9.02	16.48	1.950	missing*									
	S1-M1-02	30.90	10.67	16.57	2.503	missing*									
	S1-M1-03	29.52	11.28	16.63	2.446	missing*									
	S1-M1-04	32.57	12.19	19.71	3.790	missing*									
	S1-M1-05	30.00	10.82	16.40	2.472	38.52	15.84	20.23	5.270	3.414	0.513	8.52	5.02	3.83	2.798
	S1-M1-06	25.67	9.38	14.87	1.588	missing*									
	S1-M1-07	28.00	10.18	14.62	2.271	missing*									
	S1-M1-08	32.24	11.08	18.11	3.160	missing*									
	S1-M1-09	26.95	10.08	15.92	2.024	missing*									
	S1-M1-10	24.97	9.06	14.01	1.504	missing*									
S1-M2	S1-M2-01	34.16	11.43	18.66	3.457	41.54	16.02	23.21	7.788	3.907	0.627	7.38	4.59	4.55	4.331
	S1-M2-02	31.67	9.77	17.43	3.163	39.41	15.30	20.93	6.490	3.343	0.463	7.74	5.53	3.50	3.327
	S1-M2-03	32.39	12.67	17.61	3.534	38.93	14.81	23.83	7.253	3.565	0.422	6.54	2.14	6.22	3.719
	S1-M2-04	34.19	13.18	21.44	4.094	missing*									
	S1-M2-05	32.35	11.56	18.33	3.418	37.38	14.44	19.27	5.686	2.928	0.326	5.03	2.88	0.94	2.268
	S1-M2-06	31.57	11.59	16.37	3.294	39.10	15.44	22.60	7.111	3.139	0.350	7.53	3.85	6.23	3.817
	S1-M2-07	32.02	11.70	18.25	3.316	missing*									
	S1-M2-08	32.80	10.78	18.68	2.421	missing*									
	S1-M2-09	27.69	10.28	14.63	1.883	missing*									
	S1-M2-10	28.33	10.33	16.02	2.385	missing*									
S1-M3	S1-M3-01	28.43	10.68	15.66	2.371	38.55	14.45	20.36	5.813	2.888	0.333	10.12	3.77	4.70	3.442
	S1-M3-02	31.13	11.73	17.56	3.314	41.82	16.36	23.72	7.680	4.566	0.784	10.69	4.63	6.16	4.366
	S1-M3-03	34.07	12.22	18.35	3.648	40.15	14.09	21.94	6.349	2.861	0.312	6.08	1.87	3.59	2.701
	S1-M3-04	32.04	10.63	15.63	2.659	37.48	12.92	18.71	4.887	2.820	0.300	5.44	2.29	3.08	2.228
	S1-M3-05	25.59	9.18	14.49	1.853	28.42	9.88	15.28	2.479	1.653	0.122	2.83	0.70	0.79	0.626
	S1-M3-06	33.07	11.16	18.74	3.213	42.78	17.53	23.98	8.533	4.259	0.574	9.71	6.37	5.24	5.320
	S1-M3-07	30.99	12.66	18.28	3.187	41.25	15.57	22.84	7.882	4.444	0.573	10.26	2.91	4.56	4.695
	S1-M3-08	32.61	10.08	17.69	2.711	45.97	15.55	25.22	8.009	4.367	0.639	13.36	5.47	7.53	5.298
	S1-M3-09	28.63	10.83	15.63	2.265	missing*									
	S1-M3-10	30.44	10.99	18.17	3.233	44.31	16.45	24.92	8.986	4.256	0.635	13.87	5.46	6.75	5.753
S1-M4	S1-M4-01	25.36	8.24	14.39	1.392	missing*									
	S1-M4-02	29.33	10.28	17.29	2.152	missing*									
	S1-M4-03	26.96	10.33		2.120	31.13	12.21	16.39	3.162	1.951	0.206	4.17	1.88		1.042
	S1-M4-04	30.74	10.04	16.47	2.508	40.33	13.33	21.46	6.126	3.250	0.498	9.59	3.29	4.99	3.618
	S1-M4-05	31.64	10.47	16.61	2.934	45.23	15.53	23.93	8.318	3.782	0.518	13.59	5.06	7.32	5.384
	S1-M4-06	29.42	10.57	17.44	2.576	missing*									
	S1-M4-07	28.40	10.38	17.59	2.764	42.70	16.89	24.87	7.750	4.340	0.658	14.30	6.51	7.28	4.986
	S1-M4-08	26.42	9.77	14.02	1.847	missing*									
	S1-M4-09	28.58	8.36	15.63	1.778	killed during deployment									
	S1-M4-10	29.08	9.84	16.52	2.192	missing*									
S1-M5	S1-M5-01	30.92	11.42	17.16	2.750	40.65	15.70	22.37	6.681	3.674	0.596	9.73	4.28	5.21	3.931
	S1-M5-02	26.95	9.64	16.20	2.097	35.21	12.90	20.28	4.258	2.447	0.278	8.26	3.26	4.08	2.161
	S1-M5-03	30.01	10.58	16.73	2.232	34.62	11.89	18.73	4.259	2.115	0.173	4.61	1.31	2.00	2.027
	S1-M5-04	34.15	10.91	18.00	3.056	45.51	15.54	22.90	8.160	4.465	0.753	11.36	4.63	4.90	5.104
	S1-M5-05	29.71	10.82	16.17	2.316	40.25	15.35	20.43	7.103	3.318	0.414	10.54	4.53	4.26	4.787
	S1-M5-06	32.52	11.53	17.70	3.428	41.58	15.63	22.38	6.251	3.890	0.637	9.06	4.10	4.68	2.823
	S1-M5-07	33.41	11.58	18.82	3.572	missing*									
	S1-M5-08	30.59	10.71	16.99	2.683	41.22	15.32	24.35	7.050	4.120	0.667	10.63	4.61	7.36	4.367
	S1-M5-09	29.47	10.86	17.21	2.510	45.55	17.03	25.68	8.670	4.284	0.725	16.08	6.17	8.47	6.160
	S1-M5-10	26.06	9.93	14.78	1.660	31.74	12.04	17.45	2.962	1.977	0.193	5.68	2.11	2.67	1.302
S1-M6	S1-M6-01	32.98	11.38	17.61	2.412	dead									
	S1-M6-02	33.32	11.73	18.97	3.715	missing*									
	S1-M6-03	34.03	11.67	16.84	3.496	38.94	13.23	20.38	5.333	2.698	0.354	4.91	1.56	3.54	1.837
	S1-M6-04	31.31	10.62	17.08	2.885	34.18	12.61	18.44	3.841	2.030	0.209	2.87	1.99	1.36	0.956
	S1-M6-05	28.98	9.41	13.30	1.789	39.91	14.68	22.23	6.436	3.085	0.441	10.93	5.27	8.93	4.647
	S1-M6-06	32.86	10.72	18.34	2.767	42.08	14.15	22.91	6.714	3.425	0.513	9.22	3.43	4.57	3.947
	S1-M6-07	29.54	9.92	14.45	2.353	42.15	16.04	24.06	8.482	4.255	0.531	12.61	6.12	9.61	6.129
	S1-M6-08	33.41	12.54	19.67	3.625	40.21	13.82	22.75	5.405	2.665	0.334	6.80	1.28	3.08	1.780
	S1-M6-09	28.87	10.21	16.30	2.341	missing*									
	S1-M6-10	33.20	11.61	18.35	3.438	43.97	15.75	22.87	7.476	4.218	0.609	10.77	4.14	4.52	4.038
S1-M7	S1-M7-01	33.81	11.07	17.21	3.182	34.48	12.96	18.86	4.288	2.123	0.199	0.67	1.89	1.65	1.106
	S1-M7-02	33.41	12.01	18.40	3.448	44.78	15.84	24.76	8.544	3.456	0.458	11.37	3.83	6.36	5.096
	S1-M7-03	32.89	12.18	18.11	3.796	36.85	13.90	20.08	4.733	2.540	0.303	3.96	1.72	1.97	0.937
	S1-M7-04	27.69	10.41	15.41	2.006	31.02	12.15	17.43	3.307	1.803	0.152	3.33	1.74	2.02	1.301
	S1-M7-05	33.29	11.00	17.14	2.667	missing*									
Summary Statistics	n	65	65	64	65	39	39	39	39	39	39	39	39	38	39
	Average	30.49	10.77	16.94	2.702	39.48	14.59	21.62	6.296	3.290	0.446	8.47	3.65	4.70	3.440
	SD	2.59	1.02	1.58	0.665	4.34	1.69	2.62	1.793	0.870	0.184	3.63	1.64	2.24	1.630
	SE	0.32	0.13	0.20	0.083	0.69	0.27	0.42	0.287	0.139	0.029	0.58	0.26	0.36	0.261
	Median	30.90	10.72	17.11	2.659	40.21	15.30	22.37	6.490	3.343	0.458	9.06	3.83	4.57	3.719
	Minimum	24.97	8.24	13.30	1.392	28.42	9.88	15.28	2.479	1.653	0.122	0.67	0.70	0.79	0.626
	Maximum	34.19	13.18	21.44	4.094	45.97	17.53	25.68	8.986	4.566	0.784	16.08	6.51	9.61	6.160

* Includes seven blue mussels dislodged from the socking material (see Appendix Table A.7)

Table A.9: Caged blue mussel (*Mytilus edulis*) measurement data for smelter-exposed station S2 at deployment (August) and retrieval (October) sampling events, Brunswick Smelter Caged Bivalve Survey, 2014.

Mussel Station Code	Mussel ID	Mussel Measures at Deployment (T_1; August)				Mussel Measures at Retrieval (T_2; October)						∆ Measures (T_2 - T_1)			
		Length (mm)	Width (mm)	Height (mm)	Whole Wet Weight (g)	Length (mm)	Width (mm)	Height (mm)	Whole Wet Weight (g)	Soma Wet Weight (g)	Soma Dry Weight (g)	Length (mm)	Width (mm)	Height (mm)	Whole Wet Weight (g)
S2-M1	S2-M1-01	26.01	9.54	14.44	1.647	32.61	12.42	16.03	3.428	1.868	0.167	6.60	2.88	1.59	1.781
	S2-M1-02	31.25	10.80	17.93	2.845	40.15	14.87	23.19	6.110	3.362	0.442	8.90	4.07	5.26	3.265
	S2-M1-03	29.42	10.01	16.95	2.188	30.15	12.66	19.38	4.046	2.448	0.326	0.73	2.65	2.43	1.858
	S2-M1-04	28.20	10.82	17.91	2.647	36.28	14.29	21.62	6.330	3.232	0.521	8.08	3.47	3.71	3.683
	S2-M1-05	31.40	12.33	18.11	3.466	missing*									
	S2-M1-06	31.32	10.54	17.03	2.747	45.62	16.21	23.49	8.998	4.556	0.772	14.30	5.67	6.46	6.251
	S2-M1-07	32.62	11.97	17.96	3.079	39.00	15.04	21.88	6.444	3.317	0.415	6.38	3.07	3.92	3.365
	S2-M1-08	26.32	9.51	14.27	1.883	32.89	12.84	19.52	4.308	1.947	0.172	6.57	3.33	5.25	2.425
	S2-M1-09	25.84	9.98	14.57	1.959	missing*									
	S2-M1-10	31.28	11.03	16.01	2.690	42.68	16.08	21.44	6.778	4.160	0.631	11.40	5.05	5.43	4.088
S2-M2	S2-M2-01	31.08	11.81	16.90	2.960	missing*									
	S2-M2-02	27.41	9.89	14.29	1.849	missing*									
	S2-M2-03	29.52	9.93	17.59	2.565	40.92	13.71	21.78	5.775	2.795	0.324	11.40	3.78	4.19	3.210
	S2-M2-04	28.32	9.72	15.30	2.060	35.40	13.43	20.26	4.928	2.716	0.376	7.08	3.71	4.96	2.868
	S2-M2-05	33.27	12.45	18.82	3.857	missing*									
	S2-M2-06	30.27	10.29	17.16	2.618	missing*									
	S2-M2-07	32.44	10.69	15.68	2.677	missing*									
	S2-M2-08	26.97	9.77	16.06	1.782	37.66	17.81	23.89	7.783	3.876	0.626	10.69	8.04	7.83	6.001
	S2-M2-09	32.53	12.12	17.59	3.412	missing*									
	S2-M2-10	29.29	11.92	17.68	3.124	missing*									
S2-M3	S2-M3-01	27.20	10.01	15.31	1.753	missing*									
	S2-M3-02	26.85	10.17	16.48	2.343	36.91	15.49	23.61	6.023	2.911	0.376	10.06	5.32	7.13	3.680
	S2-M3-03	28.36	9.31	15.92	1.921	missing*									
	S2-M3-04	30.90	10.47	17.86	2.863	39.27	14.04	22.63	6.286	3.254	0.373	8.37	3.57	4.77	3.423
	S2-M3-05	32.22	10.71	18.14	2.782	missing*									
	S2-M3-06	31.12	11.47	16.68	2.997	missing*									
	S2-M3-07	30.97	12.26	18.10	3.425	missing*									
	S2-M3-08	26.78	10.03	14.42	1.889	missing*									
	S2-M3-09	30.67	11.15	18.19	2.687	43.02	17.43	23.56	7.767	4.353	0.721	12.35	6.28	5.37	5.080
	S2-M3-10	31.32	11.03	18.18	3.010	42.79	15.77	25.20	8.045	3.948	0.585	11.47	4.74	7.02	5.035
S2-M4	S2-M4-01	30.40	10.55	17.43	2.648	40.73	14.79	24.42	6.762	3.330	0.453	10.33	4.24	6.99	4.114
	S2-M4-02	27.69	9.18	16.30	2.232	missing*									
	S2-M4-03	26.47	8.18	14.98	1.768	41.66	16.45	22.10	7.80	4.004	0.571	15.19	8.27	7.12	6.032
	S2-M4-04	30.78	11.51	15.27	2.470	missing*									
	S2-M4-05	29.16	10.31	17.33	2.277	missing*									
	S2-M4-06	28.14	9.75	15.66	2.228	missing*									
	S2-M4-07	32.32	12.51	18.08	3.687	missing*									
	S2-M4-08	30.41	11.01	16.08	2.551	missing*									
	S2-M4-09	25.86	10.06	15.23	1.918	missing*									
	S2-M4-10	27.77	10.07	16.17	2.140	missing*									
S2-M5	S2-M5-01	26.27	10.31	14.76	1.798	31.83	12.50	17.49	3.574	1.838	0.174	5.56	2.19	2.73	1.776
	S2-M5-02	28.12	11.46	17.88	2.790	32.72	13.64	20.82	4.787	2.141	0.213	4.60	2.18	2.94	1.997
	S2-M5-03	34.42	13.02	17.97	3.889	39.14	15.47	19.93	6.905	2.835	0.306	4.72	2.45	1.96	3.016
	S2-M5-04	28.58	11.49	15.89	2.191	missing*									
	S2-M5-05	34.08	10.75	18.65	3.768	37.97	12.31	20.08	4.759	2.460	0.252	3.89	1.56	1.43	0.991
	S2-M5-06	27.00	9.21	14.98	2.111	30.19	10.69	16.57	3.090	1.629	0.116	3.19	1.48	1.59	0.979
	S2-M5-07	33.97	11.71	18.77	3.348	40.03	14.05	21.65	6.473	2.905	0.343	6.06	2.34	2.88	3.125
	S2-M5-08	28.04	10.66	15.80	1.998	missing*									
	S2-M5-09	26.05	9.63	14.81	1.831	30.15	11.88	17.36	3.181	1.698	0.146	4.10	2.25	2.55	1.350
	S2-M5-10	25.10	10.26	14.86	1.559	missing*									
S2-M6	S2-M6-01	31.02	12.11	17.61	3.070	41.67	17.51	23.82	8.778	4.625	0.740	10.65	5.40	6.21	5.708
	S2-M6-02	30.71	11.49	16.98	2.902	missing*									
	S2-M6-03	28.50	11.11	13.85	2.282	32.40	14.05	17.87	4.677	2.458	0.292	3.90	2.94	4.02	2.395
	S2-M6-04	30.90	10.59	17.52	2.893	33.68	12.39	18.51	3.420	1.950	0.170	2.78	1.80	0.99	0.527
	S2-M6-05	31.58	12.18	17.90	3.085	missing*									
	S2-M6-06	25.93	8.99	13.50	1.491	missing*									
	S2-M6-07	25.83	8.92	14.78	1.599	missing*									
	S2-M6-08	32.53	10.73	18.63	3.325	39.63	14.39	22.39	6.205	3.430	0.478	7.10	3.66	3.76	2.880
	S2-M6-09	28.11	10.81	16.11	2.612	35.16	13.09	18.90	5.222	2.301	0.194	7.05	2.28	2.79	2.610
	S2-M6-10	34.38	12.28	19.57	3.768	43.09	15.64	23.59	8.502	3.576	0.479	8.71	3.36	4.02	4.734
S2-M7	S2-M7-01	32.68	12.65	17.61	2.833	38.10	15.14	20.09	5.403	2.677	0.312	5.42	2.49	2.48	2.570
	S2-M7-02	31.13	11.96	17.80	3.086	missing*									
	S2-M7-03	30.34	10.90	17.33	2.639	missing*									
	S2-M7-04	33.46	12.41	18.30	4.027	40.81	15.33	23.18	7.794	2.777	0.311	7.35	2.92	4.88	3.767
	S2-M7-05	30.80	10.66	17.27	2.558	37.59	13.82	19.57	5.018	2.304	0.215	6.79	3.16	2.30	2.460
Summary Statistics	n	65	65	65	65	33	33	33	33	33	33	33	33	33	33
	Average	29.69	10.79	16.66	2.601	37.63	14.40	21.09	5.921	2.960	0.382	7.63	3.65	4.15	3.244
	SD	2.53	1.07	1.47	0.649	4.29	1.72	2.44	1.700	0.851	0.184	3.39	1.67	1.93	1.517
	SE	0.31	0.13	0.18	0.081	0.75	0.30	0.42	0.296	0.148	0.032	0.59	0.29	0.34	0.264
	Median	30.34	10.71	16.98	2.639	38.10	14.29	21.62	6.110	2.835	0.343	7.08	3.33	4.02	3.125
	Minimum	25.10	8.18	13.50	1.491	30.15	10.69	16.03	3.090	1.629	0.116	0.73	1.48	0.99	0.527
	Maximum	34.42	13.02	19.57	4.027	45.62	17.81	25.20	8.998	4.625	0.772	15.19	8.27	7.83	6.251

Table A.10: Caged blue mussel (*Mytilus edulis*) measurement data for smelter-exposed station S3 at deployment (August) and retrieval (October) sampling events, Brunswick Smelter Caged Bivalve Survey, 2014.

Mussel Station Code	Mussel ID	Mussel Measures at Deployment (T_1; August)				Mussel Measures at Retrieval (T_2; October)						Δ Measures (T_2 - T_1)			
		Length (mm)	Width (mm)	Height (mm)	Whole Wet Weight (g)	Length (mm)	Width (mm)	Height (mm)	Whole Wet Weight (g)	Soma Wet Weight (g)	Soma Dry Weight (g)	Length (mm)	Width (mm)	Height (mm)	Whole Wet Weight (g)
S3-M1	S3-M1-01	27.31	10.13	16.19	2.158	34.00	13.56	19.01	4.423	2.825	0.350	6.69	3.43	2.82	2.265
	S3-M1-02	32.60	10.73	17.43	3.374	35.59	12.65	18.53	4.889	2.524	0.304	2.99	1.92	1.10	1.515
	S3-M1-03	27.12	11.03	15.57	2.497	dead									
	S3-M1-04	28.64	9.69	16.44	2.392	38.88	14.86	23.35	6.102	3.006	0.396	10.24	5.17	6.91	3.710
	S3-M1-05	27.89	10.21	14.46	2.306	missing*									
	S3-M1-06	31.51	11.98	17.78	3.047	missing*									
	S3-M1-07	30.34	10.79	15.93	2.282	missing*									
	S3-M1-08	29.90	10.98	16.12	3.159	34.13	12.96	17.64	4.858	2.435	0.289	4.23	1.98	1.52	1.699
	S3-M1-09	29.94	10.67	16.53	2.744	32.79	12.95	17.71	4.207	2.280	0.249	2.85	2.28	1.18	1.463
	S3-M1-10	33.51	11.28	17.75	3.083	38.84	13.77	20.44	5.839	2.643	0.293	5.33	2.49	2.69	2.756
S3-M2	S3-M2-01	28.78	12.03	16.06	2.957	37.72	16.15	23.13	6.200	2.932	0.433	8.94	4.12	7.07	3.243
	S3-M2-02	27.94	9.90	15.96	2.097	37.58	13.97	21.45	6.226	3.158	0.360	9.64	4.07	5.49	4.129
	S3-M2-03	28.28	10.41	15.85	2.365	38.96	14.77	20.22	5.951	2.738	0.318	10.68	4.36	4.37	3.586
	S3-M2-04	32.81	10.95	16.89	3.006	38.25	13.82	21.64	6.425	3.116	0.424	5.44	2.87	4.75	3.419
	S3-M2-05	32.51	11.28	18.05	2.917	46.17	15.77	25.32	8.360	3.821	0.516	13.66	4.49	7.27	5.443
	S3-M2-06	30.10	10.21	17.62	2.356	38.07	13.58	21.52	5.294	2.778	0.323	7.97	3.37	3.90	2.938
	S3-M2-07	26.56	9.10	15.84	1.876	37.74	13.12	23.15	5.226	2.480	0.276	11.18	4.02	7.31	3.350
	S3-M2-08	32.51	12.37	18.40	3.993	35.90	14.86	22.24	6.722	3.048	0.309	3.39	2.49	3.84	2.729
	S3-M2-09	31.35	10.60	17.77	3.115	33.20	12.42	18.43	4.069	1.900	0.156	1.85	1.82	0.66	0.954
	S3-M2-10	33.25	12.15	17.91	3.619	41.37	14.82	20.67	6.963	2.605	0.280	8.12	2.67	2.76	3.344
S3-M3	S3-M3-01	33.02	12.19	17.46	3.678	44.87	17.38	24.76	8.018	4.160	0.687	11.85	5.19	7.30	4.340
	S3-M3-02	28.02	10.27	16.63	2.376	32.83	12.89	18.48	4.103	2.155	0.233	4.81	2.62	1.85	1.727
	S3-M3-03	33.74	12.18	18.13	3.258	missing*									
	S3-M3-04	30.84	10.43	15.59	2.481	missing*									
	S3-M3-05	28.47	10.38	15.74	2.347	missing*									
	S3-M3-06	29.99	10.97	15.92	2.699	missing*									
	S3-M3-07	26.20	8.19	14.95	1.708	missing*									
	S3-M3-08	26.08	10.70	14.13	1.686	31.47	12.86	17.16	3.329	1.769	0.126	5.39	2.16	3.03	1.643
	S3-M3-09	29.36	10.53	16.04	2.556	34.17	11.70	18.39	4.182	1.832	0.128	4.81	1.17	2.35	1.626
	S3-M3-10	27.98	9.97	15.09	2.043	38.53	14.51	20.43	5.299	2.900	0.339	10.55	4.54	5.34	3.256
S3-M4	S3-M4-01	30.99	12.06	16.87	3.508	missing*									
	S3-M4-02	32.36	11.81	19.39	3.474	missing*									
	S3-M4-03	27.21	10.18	15.55	2.224	40.72	15.49	22.74	6.233	3.152	0.472	13.51	5.31	7.19	4.009
	S3-M4-04	30.49	11.09	16.16	2.828	37.63	14.45	19.92	4.879	2.660	0.332	7.14	3.36	3.76	2.051
	S3-M4-05	28.17	10.25	15.72	2.224	missing*									
	S3-M4-06	31.26	10.84	16.79	2.793	dead									
	S3-M4-07	26.31	9.68	14.91	1.866	missing*									
	S3-M4-08	27.72	10.64	15.82	2.224	39.25	15.30	23.03	5.605	3.077	0.468	11.53	4.66	7.21	3.381
	S3-M4-09	32.52	10.64	17.68	2.816	36.69	12.42	20.11	4.061	2.295	0.246	4.17	1.78	2.43	1.245
	S3-M4-10	34.13	11.89	19.20	3.801	40.48	14.08	21.12	6.196	3.449	0.466	6.35	2.19	1.92	2.395
S3-M5	S3-M5-01	28.84	10.11	16.36	2.167	35.49	12.61	19.32	4.645	2.173	0.219	6.65	2.50	2.96	2.478
	S3-M5-02	30.28	10.42	18.82	2.911	dead									
	S3-M5-03	25.91	9.07	14.78	1.716	missing*									
	S3-M5-04	28.96	9.74	16.64	2.447	missing*									
	S3-M5-05	31.52	10.66	16.82	2.603	missing*									
	S3-M5-06	26.97	9.65	13.83	1.447	35.82	13.97	17.50	4.353	2.260	0.263	8.85	4.32	3.67	2.906
	S3-M5-07	26.10	9.05	14.92	1.766	37.97	14.88	22.20	6.462	3.278	0.421	11.87	5.83	7.28	4.696
	S3-M5-08	29.51	10.09	16.93	2.157	42.30	15.36	23.84	7.026	3.559	0.525	12.79	5.27	6.91	4.869
	S3-M5-09	30.87	10.95	15.48	2.614	42.73	15.68	23.68	7.772	3.899	0.566	11.86	4.73	8.20	5.158
	S3-M5-10	25.24	10.97	14.63	1.999	35.82	17.06	20.22	5.554	3.037	0.438	10.58	6.09	5.59	3.555
S3-M6	S3-M6-01	27.74	9.50	16.08	1.980	34.41	12.31	18.94	3.967	2.070	0.223	6.67	2.81	2.86	1.987
	S3-M6-02	30.48	10.47	17.08	2.661	40.22	14.09	22.52	6.282	3.171	0.439	9.74	3.62	5.44	3.621
	S3-M6-03	29.39	10.56	16.61	2.355	38.17	13.81	20.44	5.508	2.817	0.289	8.78	3.25	3.83	3.153
	S3-M6-04	25.38	8.17	13.99	1.327	missing*									
	S3-M6-05	30.67	10.05	16.32	2.451	36.67	12.07	19.84	4.332	2.482	0.287	6.00	2.02	3.52	1.881
	S3-M6-06	27.69	9.43	15.26	1.863	missing*									
	S3-M6-07	31.05	11.00	17.51	2.729	missing*									
	S3-M6-08	29.45	11.19	16.71	2.618	38.92	14.89	20.33	5.827	2.847	0.321	9.47	3.70	3.62	3.209
	S3-M6-09	26.62	8.84	15.18	1.844	36.21	14.00	20.81	5.140	2.891	0.302	9.59	5.16	5.63	3.296
	S3-M6-10	26.97	9.68	15.17	2.070	37.95	14.84	22.51	5.949	2.871	0.199	10.98	5.16	7.34	3.879
S3-M7	S3-M7-01	34.24	11.89	18.83	3.760	missing*									
	S3-M7-02	28.81	10.29	13.61	1.698	30.55	11.18	13.61	2.590	1.827	0.167	1.74	0.89	0.00	0.892
	S3-M7-03	34.35	12.20	18.83	3.983	40.89	14.92	22.36	6.612	3.096	0.374	6.54	2.72	3.53	2.629
	S3-M7-04	34.50	12.06	18.13	3.830	40.87	15.56	22.65	7.123	3.561	0.504	6.37	3.50	4.52	3.293
	S3-M7-05	31.81	11.07	17.57	3.398	41.18	15.59	26.23	7.912	3.760	0.549	9.37	4.52	8.66	4.514
Summary Statistics	n	65	65	65	65	43	43	43	43	43	43	43	43	43	43
	Average	29.71	10.59	16.44	2.590	37.72	14.14	20.87	5.598	2.822	0.346	7.93	3.50	4.41	2.982
	SD	2.51	0.97	1.36	0.656	3.38	1.40	2.47	1.304	0.579	0.126	3.23	1.33	2.28	1.140
	SE	0.31	0.12	0.17	0.081	0.52	0.21	0.38	0.199	0.088	0.019	0.49	0.20	0.35	0.174
	Median	29.51	10.60	16.32	2.481	37.95	14.08	20.67	5.605	2.847	0.321	8.12	3.43	3.84	3.209
	Minimum	25.24	8.17	13.61	1.327	30.55	11.18	13.61	2.590	1.769	0.126	1.74	0.89	0.00	0.892
	Maximum	34.50	12.37	19.39	3.993	46.17	17.38	26.23	8.360	4.160	0.687	13.66	6.09	8.66	5.443

* Includes eight blue mussels dislodged from the socking material (see Appendix Table A.7)

Table A.11: Caged blue mussel (*Mytilus edulis*) measurement data for smelter-exposed station S4 at deployment (August) and retrieval (October) sampling events, Brunswick Smelter Caged Mussel Survey, 2014.

Mussel Station Code	Mussel ID	Mussel Measures at Deployment (T_1; August)				Mussel Measures at Retrieval (T_2; October)						Δ Measures (T_2 - T_1)			
		Length (mm)	Width (mm)	Height (mm)	Whole Wet Weight (g)	Length (mm)	Width (mm)	Height (mm)	Whole Wet Weight (g)	Soma Wet Weight (g)	Soma Dry Weight (g)	Length (mm)	Width (mm)	Height (mm)	Whole Wet Weight (g)
S4-M1	S4-M1-01	29.56	11.00	17.25	2.542	37.94	15.10	20.63	5.839	2.904	0.365	8.38	4.10	3.38	3.297
	S4-M1-02	30.27	11.44	16.55	2.942	36.57	12.83	19.50	5.027	1.412	0.237	6.30	1.39	2.95	2.085
	S4-M1-03	30.61	10.40	16.70	2.566	missing*									
	S4-M1-04	32.92	11.63	17.45	3.097	40.82	15.15	22.34	6.979	3.135	0.415	7.90	3.52	4.89	3.882
	S4-M1-05	29.68	9.58	16.13	2.402	missing*									
	S4-M1-06	29.71	10.94	16.31	2.752	missing*									
	S4-M1-07	32.26	10.98	18.66	2.971	44.35	16.29	23.13	8.877	3.613	0.514	12.09	5.31	4.47	5.906
	S4-M1-08	34.10	11.86	18.39	3.524	missing*									
	S4-M1-09	28.71	10.32	17.04	2.473	missing*									
	S4-M1-10	25.87	9.71	14.27	1.643	missing*									
S4-M2	S4-M2-01	32.26	11.23	17.87	2.854	39.15	14.71	23.12	6.398	2.969	0.356	6.89	3.48	5.25	3.544
	S4-M2-02	30.10	10.06	16.10	2.119	missing*									
	S4-M2-03	29.67	11.61	15.98	3.123	missing*									
	S4-M2-04	27.28	9.99	15.33	1.988	33.23	13.46	19.36	4.090	2.225	0.242	5.95	3.47	4.03	2.102
	S4-M2-05	29.69	12.38	17.46	2.930	38.69	15.36	23.20	7.314	2.900	0.393	9.00	2.98	5.74	4.384
	S4-M2-06	25.55	9.76	14.11	1.621	missing*									
	S4-M2-07	31.19	10.25	17.58	2.700	missing*									
	S4-M2-08	24.91	8.51	12.75	1.468	34.94	13.22	18.93	4.455	2.317	0.272	10.03	4.71	6.18	2.987
	S4-M2-09	30.66	10.94	17.04	2.470	40.27	14.48	23.23	6.903	3.247	0.327	9.61	3.54	6.19	4.433
	S4-M2-10	28.90	10.11	15.53	2.190	40.10	14.24	20.71	6.452	2.887	0.358	11.20	4.13	5.18	4.262
S4-M3	S4-M3-01	26.78	9.88	14.83	1.830	missing*									
	S4-M3-02	29.93	10.82	17.20	2.792	missing*									
	S4-M3-03	26.90	8.92	14.78	1.703	38.90	14.52	21.79	6.859	2.790	0.353	12.00	5.60	7.01	5.156
	S4-M3-04	28.83	9.78	15.69	2.027	missing*									
	S4-M3-05	30.71	11.21	16.69	2.691	40.85	14.56	22.50	6.046	2.710	0.354	10.14	3.35	5.81	3.355
	S4-M3-06	32.75	11.67	17.86	3.937	41.17	15.22	22.09	7.274	3.249	0.446	8.42	3.55	4.23	3.337
	S4-M3-07	25.70	9.60	14.29	1.661	missing*									
	S4-M3-08	29.41	10.24	16.03	2.445	missing*									
	S4-M3-09	28.73	11.31	17.40	2.514	missing*									
	S4-M3-10	32.44	12.32	18.82	3.379	missing*									
S4-M4	S4-M4-01	31.80	11.02	16.00	3.091	39.12	13.89	20.83	5.952	2.702	0.331	7.32	2.87	4.83	2.861
	S4-M4-02	26.89	10.03	16.07	2.360	38.37	14.90	22.17	6.356	2.866	0.380	11.48	4.87	6.10	3.996
	S4-M4-03	28.41	11.56	15.33	2.390	missing*									
	S4-M4-04	33.22	11.51	18.29	3.362	missing*									
	S4-M4-05	27.09	9.67	14.95	2.011	36.06	14.12	21.15	5.677	2.858	0.340	8.97	4.45	6.20	3.666
	S4-M4-06	29.86	10.64	16.63	2.534	missing*									
	S4-M4-07	31.73	11.16	18.83	3.227	missing*									
	S4-M4-08	30.48	11.49	17.00	3.171	missing*									
	S4-M4-09	31.94	9.93	18.38	2.745	40.02	14.25	24.37	7.395	3.155	0.434	8.08	4.32	5.99	4.650
	S4-M4-10	26.51	9.27	14.83	1.754	36.45	13.32	20.93	5.115	2.535	0.302	9.94	4.05	6.10	3.361
S4-M5	S4-M5-01	27.82	11.13	16.42	2.438	34.03	14.62	18.46	5.196	2.414	0.262	6.21	3.49	2.04	2.758
	S4-M5-02	30.98	11.40	15.90	2.877	42.92	17.32	22.89	7.718	3.543	0.498	11.94	5.92	6.99	4.841
	S4-M5-03	25.57	9.41	13.81	1.863	27.45	12.10	17.55	3.643	1.528	0.070	1.88	2.69	3.74	1.780
	S4-M5-04	27.62	11.45	16.38	2.547	missing*									
	S4-M5-05	33.02	11.47	18.83	2.976	missing*									
	S4-M5-06	26.80	10.17	14.29	1.947	35.48	13.03	20.55	4.292	2.423	0.281	8.68	2.86	6.26	2.345
	S4-M5-07	25.03	9.30	14.37	1.544	40.70	13.87	20.54	5.992	2.739	0.345	15.67	4.57	6.17	4.448
	S4-M5-08	33.79	11.48	17.61	3.332	missing*									
	S4-M5-09	26.25	9.18	14.27	1.590	missing*									
	S4-M5-10	29.59	11.17	16.93	2.449	missing*									
S4-M6	S4-M6-01	29.77	10.42	17.30	2.649	35.36	14.22	19.90	4.763	2.440	0.291	5.59	3.80	2.60	2.114
	S4-M6-02	27.38	10.32	15.01	2.044	missing*									
	S4-M6-03	26.01	9.47	14.57	1.712	missing*									
	S4-M6-04	28.11	10.18	15.88	2.193	missing*									
	S4-M6-05	27.63	10.87	16.99	2.396	34.21	12.98	18.47	5.104	1.934	0.345	6.58	2.11	1.48	2.708
	S4-M6-06	29.00	10.52	15.55	2.277	missing*									
	S4-M6-07	32.40	12.24	17.51	3.087	34.50	12.57	20.68	4.593	2.346	0.282	2.10	0.33	3.17	1.506
	S4-M6-08	31.50	10.42	17.51	2.599	38.25	15.06	22.36	6.546	2.593	0.341	6.75	4.64	4.85	3.947
	S4-M6-09	31.96	10.86	17.55	3.275	missing*									
	S4-M6-10	28.38	10.12	16.47	2.248	missing*									
S4-M7	S4-M7-01	35.57	12.18	17.93	3.529	43.71	15.90	22.04	6.885	2.974	0.366	8.14	3.72	4.11	3.356
	S4-M7-02	31.76	11.05	18.09	3.217	missing*									
	S4-M7-03	27.87	9.88	14.95	1.991	missing*									
	S4-M7-04	30.96	11.98	18.43	3.325	missing*									
	S4-M7-05	31.44	10.88	15.71	2.736	dead									
Summary Statistics	n	65	65	65	65	28	28	28	28	28	28	28	28	28	28
	Average	29.54	10.65	16.41	2.536	37.99	14.33	21.19	5.991	2.693	0.339	8.47	3.71	4.86	3.467
	SD	2.50	0.90	1.44	0.582	3.63	1.17	1.71	1.246	0.518	0.087	2.95	1.20	1.50	1.080
	SE	0.31	0.11	0.18	0.072	0.69	0.22	0.32	0.236	0.098	0.016	0.56	0.23	0.28	0.204
	Median	29.68	10.82	16.47	2.534	38.53	14.37	21.04	6.019	2.765	0.345	8.40	3.64	5.04	3.359
	Minimum	24.91	8.51	12.75	1.468	27.45	12.10	17.55	3.643	1.412	0.070	1.88	0.33	1.48	1.506
	Maximum	35.57	12.38	18.83	3.937	44.35	17.32	24.37	8.877	3.613	0.514	15.67	5.92	7.01	5.906

* Includes four blue mussels dislodged from the socking material (see Appendix Table A.7)

Table A.12: Caged blue mussel (*Mytilus edulis*) measurement data for dislodged samples from reference and smelter-exposed bivalve cages retrieved in October, Brunswick Smelter Caged Bivalve Survey, 2014.

Mussel Station Code	Mussel Measures at Retrieval (T_2; October)						Total No. Dislodged
	Length (mm)	Width (mm)	Height (mm)	Whole Wet Weight (g)	Soma Wet Weight (g)	Soma Dry Weight (g)	
R1	32.57	12.10	18.71	3.679	2.072	0.213	4
	38.34	14.71	20.67	5.665	3.550	0.642	
	42.84	16.02	24.25	8.224	4.187	0.671	
	44.29	15.37	24.57	8.687	4.066	0.654	
R2	37.96	14.75	20.17	5.297	3.066	0.363	6
	37.92	15.50	21.83	5.914	2.935	0.402	
	40.20	15.70	22.50	6.625	3.800	0.629	
	39.92	16.14	22.06	7.380	3.852	0.625	
	41.59	15.55	21.06	6.646	3.326	0.498	
	30.41	12.66	15.94	2.511	2.061	0.241	
S1	36.38	13.89	19.19	5.888	3.513	0.565	7
	39.22	15.32	22.36	6.695	3.630	0.490	
	38.07	13.58	22.16	5.339	3.104	0.461	
	31.65	13.41	19.22	4.050	2.374	0.321	
	36.32	14.97	21.38	5.462	3.273	0.456	
	41.47	15.58	23.83	7.537	4.001	0.648	
	39.79	13.89	19.34	4.040	1.400	0.235	
S2	38.96	17.01	22.03	7.160	3.989	0.705	11
	40.59	15.42	23.15	6.986	3.480	0.468	
	39.12	17.17	24.00	7.037	3.345	0.443	
	37.49	14.24	20.54	5.011	2.699	0.344	
	36.02	14.94	19.35	5.350	3.152	0.517	
	37.92	14.09	22.00	5.664	2.766	0.327	
	35.48	13.87	19.78	5.022	2.503	0.287	
	46.81	17.68	26.40	8.629	4.213	0.647	
	38.89	14.85	22.45	6.194	3.020	0.424	
	41.26	16.23	22.87	7.712	3.313	0.430	
	36.54	14.93	22.10	6.086	3.090	0.402	
S3	38.11	15.10	21.33	6.763	3.152	0.493	8
	39.77	13.44	22.32	5.950	2.944	0.378	
	36.28	13.90	18.97	4.769	2.629	0.264	
	35.85	12.88	20.38	4.684	2.302	0.243	
	42.39	17.18	22.56	6.250	3.252	0.437	
	39.50	14.96	20.81	6.385	3.578	0.548	
	38.71	15.93	21.22	6.847	3.192	0.438	
	42.07	15.96	24.62	7.497	3.496	0.496	
S4	33.92	12.88	18.09	4.313	2.202	0.243	4
	36.46	12.87	21.39	5.425	2.558	0.342	
	38.07	14.51	21.53	4.994	2.879	0.372	
	36.33	13.47	20.25	5.162	2.135	0.222	

Table A.13: Blue mussel measurement comparisons among stations at time of cage deployment (August), Brunswick Smelter Caged Bivalve Survey, 2014. Statistical analyses completed using log-transformed data.

Metric	Six-group Comparison			Pair-wise Comparisons				
	Significant Difference Among Areas?	p-value	Statistical Test	(I) Area	(J) Area	Significant Difference Between Two Areas?	p-value	Statistical Test[a]
Length (mm)	NO	0.226	ANOVA	Reference Cage R1	Reference Cage R2	NO	0.898	Tukey's HSD
				" " "	Cage S1	NO	0.804	
				" " "	Cage S2	NO	0.995	
				" " "	Cage S3	NO	0.997	
				" " "	Cage S4	NO	0.958	
				Reference Cage R2	Cage S1	NO	0.188	
				" " "	Cage S2	NO	0.995	
				" " "	Cage S3	NO	0.992	
				" " "	Cage S4	NO	1.000	
				Cage S1	Cage S2	NO	0.474	
				" "	Cage S3	NO	0.509	
				" "	Cage S4	NO	0.282	
				Cage S2	Cage S3	NO	1.000	
				" "	Cage S4	NO	1.000	
				Cage S3	Cage S4	NO	0.999	
Width (mm)	NO	0.547	ANOVA	Reference Cage R1	Reference Cage R2	NO	0.887	Tukey's HSD
				" " "	Cage S1	NO	0.959	
				" " "	Cage S2	NO	0.973	
				" " "	Cage S3	NO	0.439	
				" " "	Cage S4	NO	0.687	
				Reference Cage R2	Cage S1	NO	1.000	
				" " "	Cage S2	NO	1.000	
				" " "	Cage S3	NO	0.974	
				" " "	Cage S4	NO	0.999	
				Cage S1	Cage S2	NO	1.000	
				" "	Cage S3	NO	0.919	
				" "	Cage S4	NO	0.990	
				Cage S2	Cage S3	NO	0.890	
				" "	Cage S4	NO	0.982	
				Cage S3	Cage S4	NO	0.999	
Height (mm)	NO	0.122	ANOVA	Reference Cage R1	Reference Cage R2	NO	0.435	Tukey's HSD
				" " "	Cage S1	NO	1.000	
				" " "	Cage S2	NO	0.922	
				" " "	Cage S3	NO	0.439	
				" " "	Cage S4	NO	0.354	
				Reference Cage R2	Cage S1	NO	0.422	
				" " "	Cage S2	NO	0.954	
				" " "	Cage S3	NO	1.000	
				" " "	Cage S4	NO	1.000	
				Cage S1	Cage S2	NO	0.914	
				" "	Cage S3	NO	0.426	
				" "	Cage S4	NO	0.342	
				Cage S2	Cage S3	NO	0.956	
				" "	Cage S4	NO	0.919	
				Cage S3	Cage S4	NO	1.000	
Whole Wet Weight (g)	NO	0.399	ANOVA	Reference Cage R1	Reference Cage R2	NO	0.477	Tukey's HSD
				" " "	Cage S1	NO	1.000	
				" " "	Cage S2	NO	0.868	
				" " "	Cage S3	NO	0.813	
				" " "	Cage S4	NO	0.589	
				Reference Cage R2	Cage S1	NO	0.667	
				" " "	Cage S2	NO	0.987	
				" " "	Cage S3	NO	0.995	
				" " "	Cage S4	NO	1.000	
				Cage S1	Cage S2	NO	0.959	
				" "	Cage S3	NO	0.931	
				" "	Cage S4	NO	0.771	
				Cage S2	Cage S3	NO	1.000	
				" "	Cage S4	NO	0.997	
				Cage S3	Cage S4	NO	0.999	

[a] Post-hoc analysis of 1-way ANOVA among all areas protected for multiple comparisons

Table A.14: Blue mussel measurement comparisons among stations at time of cage retrieval (October), Brunswick Smelter Caged Bivalve Survey, 2014. Statistical analyses completed using log-transformed data.

Parameter	Six-group Comparison			Pair-wise Comparisons				
	Significant Difference Among Areas?	p-value	Statistical Test	(I) Area	(J) Area	Significant Difference Between Two Areas?	p-value	Statistical Test[a]
Length (mm)	YES	0.029	ANOVA	Reference Cage R1	Reference Cage R2	NO	0.999	Tukey's HSD
				" " "	Cage S1	YES	0.016	
				" " "	Cage S2	NO	0.929	
				" " "	Cage S3	NO	0.800	
				" " "	Cage S4	NO	0.735	
				Reference Cage R2	Cage S1	YES	0.038	
				" " "	Cage S2	NO	0.988	
				" " "	Cage S3	NO	0.939	
				" " "	Cage S4	NO	0.888	
				Cage S1	Cage S2	NO	0.327	
				" "	Cage S3	NO	0.373	
				" "	Cage S4	NO	0.670	
				Cage S2	Cage S3	NO	1.000	
				" "	Cage S4	NO	0.998	
				Cage S3	Cage S4	NO	1.000	
Width (mm)	NO	0.343	ANOVA	Reference Cage R1	Reference Cage R2	NO	1.000	Tukey's HSD
				" " "	Cage S1	NO	0.378	
				" " "	Cage S2	NO	0.791	
				" " "	Cage S3	NO	0.987	
				" " "	Cage S4	NO	0.844	
				Reference Cage R2	Cage S1	NO	0.451	
				" " "	Cage S2	NO	0.857	
				" " "	Cage S3	NO	0.997	
				" " "	Cage S4	NO	0.899	
				Cage S1	Cage S2	NO	0.995	
				" "	Cage S3	NO	0.797	
				" "	Cage S4	NO	0.994	
				Cage S2	Cage S3	NO	0.985	
				" "	Cage S4	NO	1.000	
				Cage S3	Cage S4	NO	0.991	
Height (mm)	NO	0.159	ANOVA	Reference Cage R1	Reference Cage R2	NO	1.000	Tukey's HSD
				" " "	Cage S1	NO	0.194	
				" " "	Cage S2	NO	0.821	
				" " "	Cage S3	NO	0.954	
				" " "	Cage S4	NO	0.663	
				Reference Cage R2	Cage S1	NO	0.209	
				" " "	Cage S2	NO	0.853	
				" " "	Cage S3	NO	0.969	
				" " "	Cage S4	NO	0.699	
				Cage S1	Cage S2	NO	0.940	
				" "	Cage S3	NO	0.715	
				" "	Cage S4	NO	0.993	
				Cage S2	Cage S3	NO	0.998	
				" "	Cage S4	NO	1.000	
				Cage S3	Cage S4	NO	0.980	
Whole Wet Weight (g)	NO	0.248	ANOVA	Reference Cage R1	Reference Cage R2	NO	0.999	Tukey's HSD
				" " "	Cage S1	NO	0.270	
				" " "	Cage S2	NO	0.882	
				" " "	Cage S3	NO	0.998	
				" " "	Cage S4	NO	0.619	
				Reference Cage R2	Cage S1	NO	0.451	
				" " "	Cage S2	NO	0.973	
				" " "	Cage S3	NO	1.000	
				" " "	Cage S4	NO	0.802	
				Cage S1	Cage S2	NO	0.947	
				" "	Cage S3	NO	0.566	
				" "	Cage S4	NO	0.999	
				Cage S2	Cage S3	NO	0.986	
				" "	Cage S4	NO	0.997	
				Cage S3	Cage S4	NO	0.863	

[a] Post-hoc analysis of 1-way ANOVA among all areas protected for multiple comparisons

Table A.15: Blue mussel change in measurements among smelter-exposed and reference stations between the time of cage deployment (August) and retrieval (October), Brunswick Smelter Caged Bivalve Survey, 2014. Statistical analyses completed using log-transformed data.

Parameter	Six-group Comparison			Pair-wise Comparisons				
	Significant Difference Among Areas?	p-value	Statistical Test	(I) Area	(J) Area	Significant Difference Between Two Areas?	p-value	Statistical Test[a]
Length Difference (mm)	NO	0.274	ANOVA	Reference Cage R1	Reference Cage R2	NO	0.936	Tukey's HSD
				" " "	Cage S1	NO	0.404	
				" " "	Cage S2	NO	0.921	
				" " "	Cage S3	NO	0.600	
				" " "	Cage S4	NO	0.280	
				Reference Cage R2	Cage S1	NO	0.891	
				" " "	Cage S2	NO	1.000	
				" " "	Cage S3	NO	0.976	
				" " "	Cage S4	NO	0.741	
				Cage S1	Cage S2	NO	0.970	
				" "	Cage S3	NO	0.999	
				" "	Cage S4	NO	0.999	
				Cage S2	Cage S3	NO	0.997	
				" "	Cage S4	NO	0.886	
				Cage S3	Cage S4	NO	0.983	
Width Difference (mm)	NO	0.120	ANOVA	Reference Cage R1	Reference Cage R2	NO	0.971	Tukey's HSD
				" " "	Cage S1	NO	0.403	
				" " "	Cage S2	NO	0.275	
				" " "	Cage S3	NO	0.372	
				" " "	Cage S4	NO	0.272	
				Reference Cage R2	Cage S1	NO	0.822	
				" " "	Cage S2	NO	0.668	
				" " "	Cage S3	NO	0.804	
				" " "	Cage S4	NO	0.645	
				Cage S1	Cage S2	NO	1.000	
				" "	Cage S3	NO	1.000	
				" "	Cage S4	NO	0.999	
				Cage S2	Cage S3	NO	1.000	
				" "	Cage S4	NO	1.000	
				Cage S3	Cage S4	NO	0.999	
Height Difference (mm)	YES	0.006	ANOVA	Reference Cage R1	Reference Cage R2	NO	0.398	Tukey's HSD
				" " "	Cage S1	YES	0.036	
				" " "	Cage S2	NO	0.309	
				" " "	Cage S3	YES	0.077	
				" " "	Cage S4	YES	0.005	
				Reference Cage R2	Cage S1	NO	0.791	
				" " "	Cage S2	NO	0.999	
				" " "	Cage S3	NO	0.933	
				" " "	Cage S4	NO	0.303	
				Cage S1	Cage S2	NO	0.973	
				" "	Cage S3	NO	0.999	
				" "	Cage S4	NO	0.959	
				Cage S2	Cage S3	NO	0.998	
				" "	Cage S4	NO	0.647	
				Cage S3	Cage S4	NO	0.847	
Whole Wet Weight Difference (g)	NO	0.170	ANOVA	Reference Cage R1	Reference Cage R2	NO	0.970	Tamhane's
				" " "	Cage S1	NO	0.838	
				" " "	Cage S2	NO	0.969	
				" " "	Cage S3	NO	0.981	
				" " "	Cage S4	YES	0.026	
				Reference Cage R2	Cage S1	NO	1.000	
				" " "	Cage S2	NO	1.000	
				" " "	Cage S3	NO	1.000	
				" " "	Cage S4	NO	0.363	
				Cage S1	Cage S2	NO	1.000	
				" "	Cage S3	NO	1.000	
				" "	Cage S4	NO	0.999	
				Cage S2	Cage S3	NO	1.000	
				" "	Cage S4	NO	0.975	
				Cage S3	Cage S4	NO	0.545	
Some Dry Weight at Retrieval (g)	NO	0.207	ANOVA	Reference Cage R1	Reference Cage R2	NO	1.000	Tamhane's
				" " "	Cage S1	NO	0.634	
				" " "	Cage S2	NO	1.000	
				" " "	Cage S3	NO	1.000	
				" " "	Cage S4	NO	1.000	
				Reference Cage R2	Cage S1	NO	0.379	
				" " "	Cage S2	NO	1.000	
				" " "	Cage S3	NO	1.000	
				" " "	Cage S4	NO	1.000	
				Cage S1	Cage S2	NO	0.902	
				" "	Cage S3	NO	0.323	
				" "	Cage S4	NO	0.438	
				Cage S2	Cage S3	NO	1.000	
				" "	Cage S4	NO	1.000	
				Cage S3	Cage S4	NO	1.000	

[a] Post-hoc analysis of 1-way ANOVA among all areas protected for multiple comparisons

Table A.16: Caged blue mussel condition (soma dry weight at shell length) comparison among smelter-exposed and reference stations at time of test termination (October), Brunswick Smelter Caged Bivalve Survey, 2014.

Reference Cage	Smelter-Exposed Cage	Model[1,8]	Statistical Difference Between Areas (*p* -value)		Mean, Adjusted Mean or Predicted Value[2]		Sample Size		Mean Square Error	MoD (%)[3,4,5]	Power
					Reference	Exposed	Ref	Exp			
Combined Cage R1 and Cage R2	Cage S1	ANCOVA[6]	No	0.417	2.551	2.528	104	39	0.013965	-	0.209
	Cage S2	ANCOVA[6]	No	0.548	2.528	2.508	104	33	0.016741	-	0.160
	Cage S3	ANCOVA[6]	Yes	0.049	2.532	2.484	104	43	0.014724	-1.9	0.629
	Cage S4	ANCOVA[6,7]	Yes	0.050	2.531	2.476	104	27	0.014421	-2.2	0.627

[1] Statistical tests include Analysis of Variance (ANOVA), Analysis of Covariance (ANCOVA), Mann-Whitney U-Test (MW U-test) and Kolmogorov-Smirnov test (K-S Test).

[2] The mean is reported for ANOVA, adjusted mean is reported for ANCOVA, and predicted values of the regression line equations are reported for covariate min and max values in ANCOVA where slopes were unequal.

[3] Magnitude of difference between means for reference and exposure areas calculated as: [(exposed mean -reference mean) /reference mean] x 100.

[4] Magnitude of difference between adjusted means for reference and exposed areas calculated as: [(exposed adjusted mean - reference adjusted mean) /reference adjusted mean] x 100.

[5] Magnitude of difference between predicted minimum and maximum values for reference and exposed areas calculated as: [(exposed predicted value - reference predicted value) / reference predicted value] x 100.

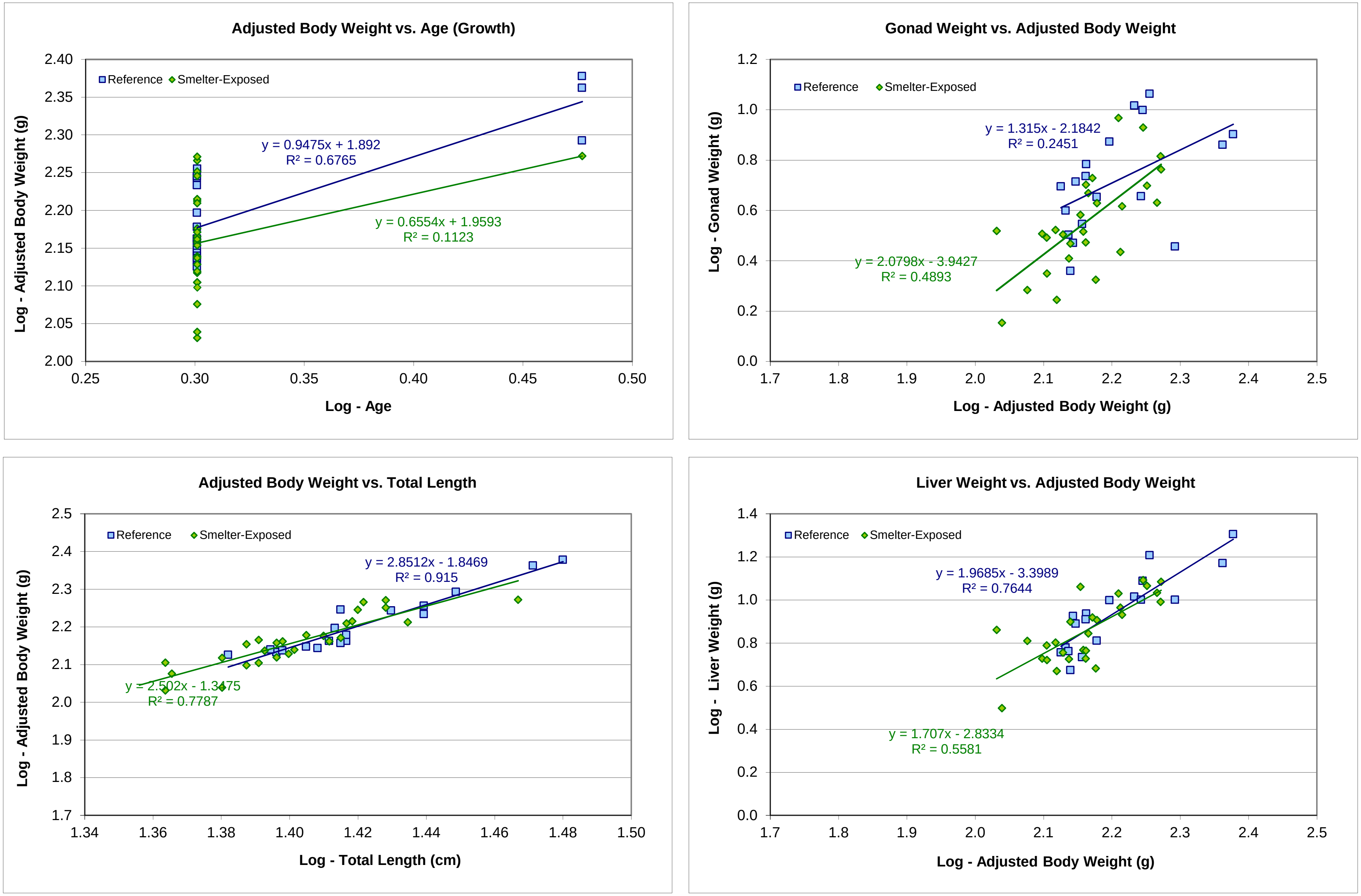
[6] Studentized outlier removed (samples R2-M5-05)

[7] Studentized outlier removed (samples S4-M5-03)

[8] Statistical comparisons for all endpoints were conducted using log-transformed data with the exception of age distribution.

APPENDIX B

FISH POPULATION SURVEY DATA



Adjusted Body Weight vs. Age (Growth)

Gonad Weight vs. Adjusted Body Weight

Adjusted Body Weight vs. Total Length

Liver Weight vs. Adjusted Body Weight

Figure B.1: Relationships between various female Atlantic tomcod meristics from fish collected at smelter-exposed (SE) and reference (REF) study areas, Brunswick Smelter Fish Population Survey, October 2014.

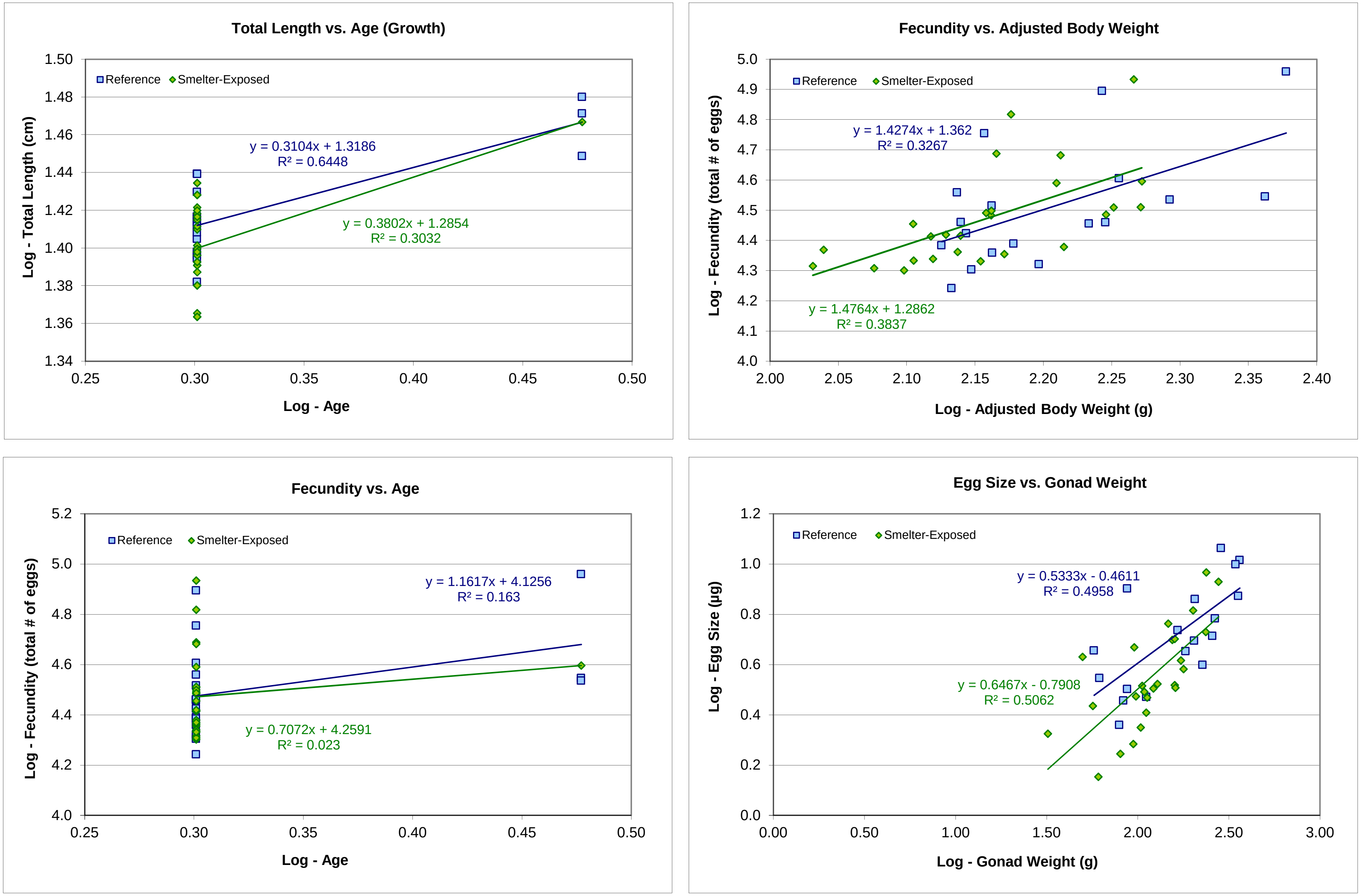


Figure B.1: Relationships between various female Atlantic tomcod meristics from fish collected at smelter-exposed (SE) and reference (REF) study areas, Brunswick Smelter Fish Population Survey, October 2014.

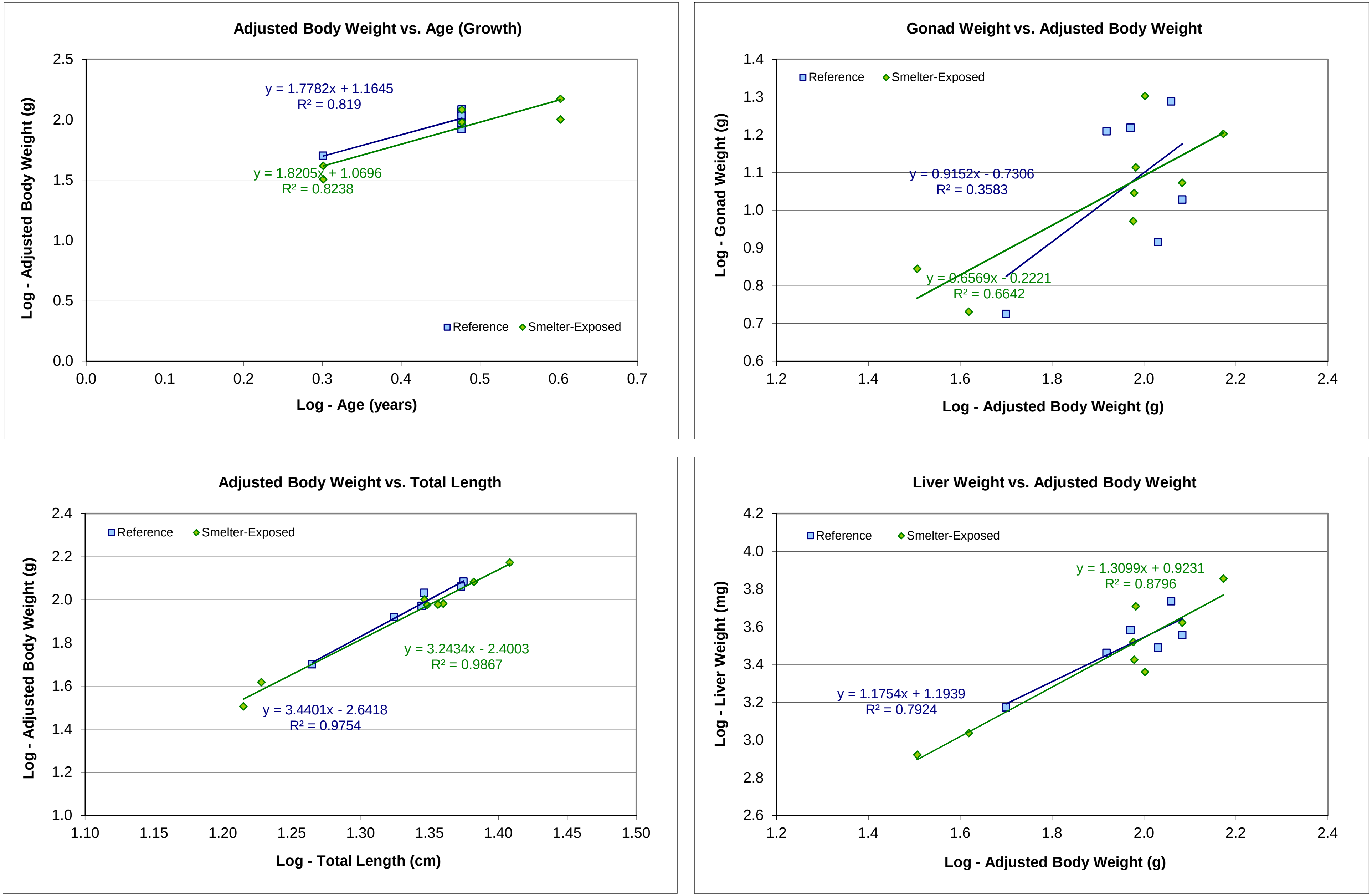


Figure B.2: Comparison of male Atlantic tomcod meristic relationships between smelter-exposed (SE) and reference (REF) area populations, Brunswick Smelter Fish Population Survey, October 2014.

Table B.1: Gill net catch records for fish collected in the reference (REF) study area of the Baie des Chaleurs, Brunswick Smelter Fish Population Survey, October 2014.

Gill Netting Station	Location (NAD83)		Net Length (m)	Set Date	Lift Date	Set Time	Lift Time	Total Time (hrs)	Mesh (in)	Effort (m*hr/ 100 m of gill net)	Alewife		Atlantic Cod		Atlantic Herring		Atlantic Mackerel		Atlantic Salmon		Atlantic Tomcod		Brook Trout		Rainbow Smelt		Striped Bass		Winter Flounder		Wrymouth	
	Easting	Northing									No. Caught	CPUE	No. Caught	CPUE	No. Caught	CPUE	No. Caught	CPUE	No. Caught	CPUE	No. Caught	CPUE	No. Caught	CPUE	No. Caught	CPUE	No. Caught	CPUE	No. Caught	CPUE	No. Caught	CPUE
RGN-1	283084	5311569	30.48	3-Oct-14	4-Oct-14	15:45	9:00	17.25	3	5.26	0	0.00	0	0.00	0	0.00	1	0.19	0	0.00	0	0.00	0	0.00	0	0.00	7	1.33	0	0.00	0	0.00
RGN-2	282637	5311518	22.86	3-Oct-14	4-Oct-14	15:50	9:30	17.67	2.5	4.04	2	0.50	0	0.00	0	0.00	12	2.97	0	0.00	0	0.00	0	0.00	0	0.00	2	0.50	0	0.00	0	0.00
RGN-3	282228	5311559	22.86	3-Oct-14	4-Oct-14	16:00	9:50	17.83	2	4.08	1	0.25	0	0.00	0	0.00	6	1.47	0	0.00	0	0.00	1	0.25	0	0.00	0	0.00	0	0.00	0	0.00
RGN-4	281668	5311657	30.48	3-Oct-14	4-Oct-14	16:15	10:10	17.92	3	5.46	0	0.00	0	0.00	0	0.00	2	0.37	1	0.18	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
RGN-5	281585	5311589	22.86	3-Oct-14	4-Oct-14	16:20	10:40	18.33	2	4.19	1	0.24	0	0.00	33	7.87	5	1.19	0	0.00	1	0.24	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
RGN-6	281449	5311632	22.86	3-Oct-14	4-Oct-14	16:25	10:30	18.08	2.5	4.13	0	0.00	0	0.00	3	0.73	21	5.08	0	0.00	1	0.24	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
RGN-7	281148	5311489	22.86	4-Oct-14	5-Oct-14	11:30	8:45	21.25	2	4.86	0	0.00	0	0.00	3	0.62	1	0.21	0	0.00	0	0.00	3	0.62	0	0.00	3	0.62	0	0.00	0	0.00
RGN-8	281208	5311482	22.86	4-Oct-14	5-Oct-14	11:30	10:30	23.00	2.5	5.26	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	3	0.57	0	0.00	8	1.52	0	0.00	0	0.00
RGN-9	281676	5311619	22.86	4-Oct-14	5-Oct-14	11:45	9:55	22.17	2	5.07	2	0.39	0	0.00	2	0.39	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	4	0.79	0	0.00	0	0.00
RGN-10	281629	5311621	22.86	4-Oct-14	5-Oct-14	11:55	9:45	21.83	2.5	4.99	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	4	0.80	0	0.00	1	0.20
RGN-11	280771	5311457	22.86	4-Oct-14	5-Oct-14	17:45	8:50	15.08	2	3.45	6	1.74	0	0.00	0	0.00	0	0.00	0	0.00	3	0.87	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
			22.86	5-Oct-14	6-Oct-14	8:50	10:30	25.67		5.87	2	0.34	0	0.00	5	0.85	12	2.05	0	0.00	3	0.51	0	0.00	0	0.00	1	0.17	0	0.00	0	0.00
RGN-12	281545	5311575	22.86	4-Oct-14	5-Oct-14	18:10	9:20	15.17	1.5	3.47	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.29	0	0.00	0	0.00	1	0.29	0	0.00	0	0.00
RGN-13	281425	5311528	22.86	4-Oct-14	5-Oct-14	18:15	9:20	15.08	2	3.45	3	0.87	0	0.00	3	0.87	0	0.00	0	0.00	9	2.61	0	0.00	0	0.00	4	1.16	0	0.00	0	0.00
			22.86	5-Oct-14	6-Oct-14	9:20	10:00	24.67		5.64	0	0.00	0	0.00	7	1.24	1	0.18	0	0.00	8	1.42	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
RGN-14	281173	5311786	22.86	4-Oct-14	5-Oct-14	18:25	9:35	15.17	2	3.47	1	0.29	0	0.00	4	1.15	5	1.44	0	0.00	0	0.00	0	0.00	1	0.29	0	0.00	0	0.00	0	0.00
RGN-15	281365	5311483	22.86	5-Oct-14	6-Oct-14	11:00	9:50	22.83	2	5.22	0	0.00	1	0.19	0	0.00	0	0.00	0	0.00	3	0.57	0	0.00	0	0.00	2	0.38	0	0.00	0	0.00
RGN-16	281303	5311455	22.86	5-Oct-14	6-Oct-14	11:15	9:45	22.50	2	5.14	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	5	0.97	0	0.00	0	0.00	2	0.39	1	0.19	0	0.00
RGN-17	280829	5311417	22.86	5-Oct-14	6-Oct-14	11:20	10:45	23.42	2.5	5.35	2	0.37	0	0.00	4	0.75	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	4	0.75	0	0.00	1	0.19
RGN-18	280599	5311427	22.86	5-Oct-14	6-Oct-14	11:30	10:15	22.75	2	5.20	4	0.77	0	0.00	2	0.38	3	0.58	0	0.00	6	1.15	0	0.00	3	0.58	1	0.19	0	0.00	0	0.00
RGN-19	280993	5311413	22.86	5-Oct-14	6-Oct-14	14:45	10:55	20.17	1.5	4.61	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.22	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
									Total	**98.20**	**24**	**5.76**	**1**	**0.19**	**66**	**14.86**	**69**	**15.72**	**1**	**0.18**	**41**	**9.10**	**7**	**1.43**	**4**	**0.87**	**43**	**8.89**	**1**	**0.19**	**2**	**0.39**

Total CPUE = total # of fish / 100 m of gill net / hour

Table B.2: Gill net catch records for fish collected in the smelter-exposed (SE) study area of the Baie des Chaleurs, Brunswick Smelter Fish Population Survey, October 2014.

Gill Netting Station	Location (NAD83)		Net Length (m)	Set Date	Lift Date	Set Time	Lift Time	Total Time (hrs)	Mesh (in)	Effort (m*hr/ 100 m of gill net)	Alewife		Atlantic Cod		Atlantic Herring		Atlantic Mackerel		Atlantic Salmon		Atlantic Tomcod		Brook Trout		Longhorn Sculpin		Shorthorn Sculpin		Striped Bass		Winter Flounder	
	Easting	Northing									No. Caught	CPUE	No. Caught	CPUE	No. Caught	CPUE	No. Caught	CPUE	No. Caught	CPUE	No. Caught	CPUE	No. Caught	CPUE	No. Caught	CPUE	No. Caught	CPUE	No. Caught	CPUE	No. Caught	CPUE
SGN-1	289074	5309047	30.48	2-Oct-14	3-Oct-14	14:30	9:40	19.17	4	5.84	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.17
SGN-2	288937	5309094	30.48	2-Oct-14	3-Oct-14	14:40	9:10	18.50	4	5.64	0	0.00	0	0.00	0	0.00	8	1.42	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
SGN-3	289015	5309212	30.48	2-Oct-14	3-Oct-14	14:50	10:00	19.17	5	5.84	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.17	0	0.00	0	0.00
SGN-4	288886	5309299	30.48	2-Oct-14	3-Oct-14	15:00	10:15	19.25	5	5.87	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
SGN-5	288769	5309376	30.48	2-Oct-14	3-Oct-14	15:15	13:40	22.42	4	6.83	0	0.00	0	0.00	0	0.00	3	0.44	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
SGN-6	289014	5308980	22.86	2-Oct-14	3-Oct-14	15:55	9:25	17.50	2	4.00	1	0.25	0	0.00	0	0.00	4	1.00	0	0.00	11	2.75	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
SGN-7	288750	5309516	30.48	2-Oct-14	3-Oct-14	16:10	10:40	18.50	3	5.64	0	0.00	0	0.00	0	0.00	5	0.89	0	0.00	0	0.00	0	0.00	1	0.18	0	0.00	0	0.00	0	0.00
SGN-8	288598	5309755	30.48	2-Oct-14	3-Oct-14	16:28	11:30	19.03	3	5.80	0	0.00	0	0.00	0	0.00	4	0.69	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
SGN-9	288710	5309249	22.86	2-Oct-14	3-Oct-14	16:20	10:20	18.00	2	4.11	11	2.67	0	0.00	0	0.00	0	0.00	0	0.00	5	1.22	0	0.00	0	0.00	0	0.00	4	0.97	0	0.00
SGN-10	289075	5308802	22.86	6-Oct-14	7-Oct-14	12:00	8:50	20.83	2	4.76	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	9	1.89	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
			22.86	7-Oct-14	8-Oct-14	8:50	11:15	26.42		6.04	0	0.00	0	0.00	0	0.00	2	0.33	0	0.00	4	0.66	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
			22.86	8-Oct-14	9-Oct-14	11:15	8:00	20.75		4.74	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	18	3.79	0	0.00	0	0.00	0	0.00	3	0.63	0	0.00
SGN-11	289000	5308991	22.86	6-Oct-14	7-Oct-14	12:10	8:30	20.33	2	4.65	0	0.00	0	0.00	0	0.00	5	1.08	0	0.00	7	1.51	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
			22.86	7-Oct-14	8-Oct-14	8:30	10:30	26.00		5.94	0	0.00	0	0.00	4	0.67	18	3.03	0	0.00	13	2.19	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
			22.86	8-Oct-14	9-Oct-14	10:30	8:45	22.25		5.09	0	0.00	0	0.00	0	0.00	1	0.20	0	0.00	10	1.97	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
SGN-12	288985	5308990	22.86	6-Oct-14	7-Oct-14	12:15	8:20	20.08	1.5	4.59	0	0.00	1	0.22	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
SGN-13	288930	5309035	22.86	6-Oct-14	7-Oct-14	12:20	8:15	19.92	2	4.55	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
SGN-14	288721	5309336	22.86	6-Oct-14	7-Oct-14	12:30	9:20	20.83	2	4.76	0	0.00	0	0.00	0	0.00	1	0.21	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.21
SGN-15	288729	5309225	22.86	6-Oct-14	7-Oct-14	12:35	9:10	20.58	2	4.71	0	0.00	0	0.00	0	0.00	1	0.21	0	0.00	0	0.00	0	0.00	0	0.00	1	0.21	0	0.00	1	0.21
SGN-16	289022	5308936	22.86	7-Oct-14	8-Oct-14	9:00	11:30	26.50	2	6.06	0	0.00	0	0.00	0	0.00	1	0.17	0	0.00	2	0.33	0	0.00	0	0.00	0	0.00	1	0.17	0	0.00
SGN-17	289047	5309003	22.86	7-Oct-14	8-Oct-14	9:30	10:55	25.42	2	5.81	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	10	1.72	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
			22.86	8-Oct-14	9-Oct-14	10:55	8:30	21.58		4.93	1	0.20	0	0.00	0	0.00	0	0.00	0	0.00	10	2.03	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
SGN-18	289035	5308825	22.86	7-Oct-14	8-Oct-14	9:45	11:15	25.50	1.5	5.83	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	5	0.86	0	0.00	0	0.00	0	0.00	0	0.00	1	0.17
			22.86	8-Oct-14	9-Oct-14	11:15	8:15	21.00		4.80	0	0.00	1	0.21	0	0.00	0	0.00	0	0.00	2	0.42	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
SGN-19	288958	5308905	22.86	7-Oct-14	8-Oct-14	9:50	11:00	25.17	2	5.75	0	0.00	0	0.00	0	0.00	1	0.17	0	0.00	4	0.70	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
			22.86	8-Oct-14	9-Oct-14	11:00	8:30	21.50		4.91	0	0.00	0	0.00	0	0.00	1	0.20	0	0.00	5	1.02	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
SGN-20	288984	5308979	22.86	8-Oct-14	9-Oct-14	11:40	8:55	21.25	2	4.86	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	3	0.62	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
									Total	**142.37**	**13**	**3.13**	**2**	**0.43**	**4**	**0.67**	**55**	**10.03**	**0**	**0.00**	**118**	**23.65**	**0**	**0.00**	**1**	**0.18**	**2**	**0.38**	**8**	**1.77**	**4**	**0.77**

Total CPUE = total # of fish / 100 m of gill net / hour

Table B.3: Female Atlantic tomcod measurement data collected from the reference area, Brunswick Smelter Fish Population Survey, October 2014.

Specimen ID	Age (yrs)	Total Length (cm)	Body Weight (g)	Gonad Weight (g)	Liver Weight (g)	Adjusted Body Weight (g)[a]	Fulton's Condition Factor (K)	Total Fecundity	Egg Weight (µg)	Abnormalities
RAT-01	2	27.5	192	10.369	10.336	171.072	0.923	28,577	363	-
RAT-02	3	30.2	270	7.973	20.156	238.536	0.980	90,975	88	frayed tail
RAT-03	2	25.4	157	5.166	7.742	140.356	0.958	20,122	257	-
RAT-04	2	26.1	164	6.069	8.616	145.377	0.922	22,859	265	-
RAT-05	2	26.1	163	4.491	6.461	150.668	0.917	24,532	183	-
RAT-06	2	27.5	209	11.550	16.107	180.028	1.005	40,336	286	part of caudal peduncle missing
RAT-07	2	25.9	179	7.459	9.945	157.260	1.030	20,945	356	frayed tail
RAT-08	3	29.6	255	7.248	14.796	230.222	0.983	35,128	206	-
RAT-09	2	26.9	190	4.521	9.991	174.926	0.976	78,485	58	-
RAT-10	2	24.9	148	3.967	5.993	135.732	0.959	17,448	227	-
RAT-12	2	26.0	160	3.510	5.417	143.444	0.910	56,832	62	-
RAT-14	2	24.1	150	4.945	5.691	133.485	1.072	24,191	204	frayed tail
RAT-15	2	26.0	203	9.949	12.231	175.912	1.155	28,852	345	-
RAT-17	2	25.8	168	5.444	8.117	145.241	0.978	32,791	166	-
RAT-18	3	28.1	210	2.859	10.006	196.068	0.946	34,276	83	lower jaw malformed
RAT-19	2	25.6	151	2.955	8.403	139.149	0.900	26,517	111	-
RAT-21	2	24.8	152	2.287	4.711	137.903	0.997	28,890	79	-
RAT-22	2	25.0	153	3.178	5.774	137.044	0.979	36,233	88	frayed tail
total sample size	18	18	18	18	18	18	18	18	18	6
average	2.2	26.4	182	5.774	9.472	162.912	0.977	35,999	190	na
median	2.0	26.0	166	5.056	8.510	148.023	0.977	28,871	194	na
standard deviation	0.4	1.6	36	2.765	4.135	31.785	0.062	20,011	105	na
standard error	0.1	0.4	8	0.652	0.975	7.492	0.015	4,717	25	na
minimum	2	24.1	148	2.287	4.711	133.485	0.900	17,448	58	na
maximum	3	30.2	270	11.550	20.156	238.536	1.155	90,975	363	na

[a] Adjusted body weight represents whole body weight less the liver, gonad and stomach content weight. Adjusted body weight used for statistical analyses

Table B.4: Female Atlantic tomcod measurement data collected from the smelter-exposed area, Brunswick Smelter Fish Populatior Survey, October 2014.

Specimen ID	Age (yrs)	Total Length (cm)	Body Weight (g)	Gonad Weight (g)	Liver Weight (g)	Adjusted Body Weight (g)[a]	Fulton's Condition Factor (K)	Total Fecundity	Egg Weight (ug)	Abnormalities
SAT-01	2	26.4	201	4.272	10.808	184.498	1.092	85,915	50	-
SAT-02	2	23.1	119	3.300	7.259	107.461	0.965	20,691	159	-
SAT-03	2	25.7	159	2.113	4.811	150.017	0.937	65,784	32	-
SAT-04	2	24.6	139	3.103	6.156	127.235	0.934	28,542	109	-
SAT-05	2	24.9	153	3.277	5.857	143.866	0.991	31,020	106	-
SAT-07	3	29.3	205	5.796	12.140	187.064	0.815	39,489	147	-
SAT-09	2	24.6	159	4.664	6.998	146.400	1.068	48,774	96	-
SAT-10	2	25.2	150	2.940	7.926	137.803	0.937	26,099	113	-
SAT-11	2	27.2	175	2.725	9.207	163.068	0.870	48,107	57	-
SAT-12	2	24.0	141	3.330	6.348	131.081	1.020	25,948	128	-
SAT-14	2	26.0	163	5.361	8.297	148.346	0.927	22,685	236	-
SAT-15	2	26.2	178	4.135	8.541	164.029	0.990	23,956	173	-
SAT-16	2	24.4	134	3.219	5.341	125.306	0.922	20,039	161	-
SAT-17	2	23.2	128	1.924	6.461	119.123	1.025	20,366	94	caudal fin and peduncle damaged
SAT-19	2	26.8	195	4.995	11.631	178.374	1.013	32,330	155	-
SAT-20	3	23.1	135	2.238	5.265	127.311	1.095	21,565	104	caudal fin damaged
SAT-21	2	26.8	203	6.535	9.788	186.667	1.055	32,434	201	-
SAT-22	2	24.7	145	2.564	5.320	137.116	0.962	23,038	111	-
SAT-23	2	26.1	182	9.269	10.728	162.003	1.024	38,962	238	-
SAT-24	2	24.0	114	1.424	3.147	109.429	0.825	23,420	61	caudal fin damaged
SAT-25	2	25.1	149	3.197	5.693	134.429	0.942	26,270	122	caudal fin damaged
SAT-26	2	25.8	155	2.975	5.340	145.095	0.903	30,465	98	-
SAT-27	2	24.9	139	1.756	4.673	131.576	0.900	21,862	80	-
SAT-28	2	25.0	156	5.032	5.817	145.151	0.998	31,525	160	caudal fin damaged
SAT-29	2	24.4	158	3.821	11.521	142.542	1.088	21,461	178	caudal fin damaged
SAT-30		25.4	163	4.253	8.072	150.665	0.995	-	-	caudal fin damaged
SAT-31	2	26.3	197	8.506	12.358	176.064	1.083	30,647	278	-
SAT-33		19.2	59	1.153	2.289	55.391	0.832	-	-	-
SAT-34		24.7	154	-	-	-	1.022	-	-	-
SAT-35		27.6	205	-	-	-	0.975	-	-	caudal fin damaged
SAT-36		27.0	192	-	-	-	0.975	-	-	caudal fin damaged
SAT-37		26.6	170	-	-	-	0.903	-	-	-
SAT-38		25.6	140	-	-	-	0.834	-	-	caudal fin damaged
SAT-39		23.7	114	-	-	-	0.856	-	-	-
SAT-40		25.7	165	-	-	-	0.972	-	-	-
SAT-41		25.4	145	-	-	-	0.885	-	-	-
SAT-42		24.6	132	-	-	-	0.887	-	-	-
SAT-43		26.1	195	-	-	-	1.097	-	-	caudal fin damaged
SAT-44		24.6	150	-	-	-	1.008	-	-	caudal fin damaged
SAT-45		24.4	137	-	-	-	0.943	-	-	-
SAT-46		24.0	160	-	-	-	1.157	-	-	-
SAT-47		26.1	178	-	-	-	1.001	-	-	caudal fin damaged
SAT-48		25.5	147	-	-	-	0.887	-	-	-
SAT-49		25.6	152	-	-	-	0.906	-	-	caudal fin damaged
SAT-50		26.9	193	-	-	-	0.992	-	-	-
SAT-51		25.2	146	-	-	-	0.912	-	-	-
SAT-52		25.2	146	-	-	-	0.912	-	-	-
SAT-53		24.9	135	-	-	-	0.874	-	-	-
SAT-54		22.7	120	-	-	-	1.026	-	-	-
SAT-55		28.6	231	-	-	-	0.987	-	-	-
SAT-56		26.7	181	-	-	-	0.951	-	-	caudal fin damaged
SAT-57		24.5	139	-	-	-	0.945	-	-	-
SAT-58		25.2	164	-	-	-	1.025	-	-	caudal fin damaged
SAT-59		24.5	137	-	-	-	0.932	-	-	caudal fin damaged
SAT-60		22.9	117	-	-	-	0.974	-	-	-
SAT-62		24.0	127	-	-	-	0.919	-	-	-
total sample size	26	56	56	28	28	28	56	26	26	18
average	2.1	25.2	156	3.853	7.421	143.468	0.964	32,361	132	na
median	2.0	25.2	153	3.289	6.730	144.481	0.964	27,406	117	na
standard deviation	0.3	1.6	30	1.942	2.746	27.971	0.077	15,293	61	na
standard error	0.1	0.2	4	0.367	0.519	5.286	0.010	2,999	12	na
minimum	2	19.2	59	1.153	2.289	55.391	0.815	20,039	32	na
maximum	3	29.3	231	9.269	12.358	187.064	1.157	85,915	278	na

[a] Adjusted body weight represents whole body weight less the liver, gonad and stomach content weight. Adjusted body weight used for statistical analyses

Table B.5: Male Atlantic tomcod measurement data collected from the reference area, Brunswick Smelter Fish Population Survey, October 2014.

Specimen ID	Age (yrs)	Total Length (cm)	Body Weight (g)	Gonad Weight (g)	Liver Weight (g)	Adjusted Body Weight (g)[a]	Fulton's Condition Factor (K)	Abnormalities
RAT-11	1	18.4	59	5.307	1.485	50.095	0.939	-
RAT-13	2	23.7	139	10.665	3.595	121.229	1.044	-
RAT-16	2	21.1	103	16.163	2.886	82.990	1.096	-
RAT-20	2	23.6	140	19.401	5.416	114.706	1.065	-
RAT-23	2	22.2	121	8.229	3.076	107.448	1.106	caudal fin damaged
RAT-24	2	22.1	118	16.532	3.823	93.589	1.093	caudal fin damaged
total sample size	6	6	6	6	6	6	6	2
average	1.8	21.9	113	12.716	3.380	95.010	1.057	na
median	2.0	22.2	120	13.414	3.336	100.519	1.079	na
standard deviation	0.4	2.0	30	5.484	1.290	26.054	0.062	na
standard error	0.2	0.8	12	2.239	0.526	10.636	0.025	na
minimum	1	18.4	59	5.307	1.485	50.095	0.939	na
maximum	2	23.7	140	19.401	5.416	121.229	1.106	na

[a] Adjusted body weight represents whole body weight less the liver, gonad and stomach content weight. Adjusted body weight used for statistical analyses

Table B.6: Male Atlantic tomcod measurement data collected from the smelter-exposed area, Brunswick Smelter Fish Population Survey, October 2014.

Specimen ID	Age (yrs)	Total Length (cm)	Body Weight (g)	Gonad Weight (g)	Liver Weight (g)	Adjusted Body Weight (g)[a]	Fulton's Condition Factor (K)	Abnormalities
SAT-06	3	25.6	172	15.951	7.160	148.889	1.025	-
SAT-08	2	22.3	111	9.364	3.307	94.701	1.001	-
SAT-13	3	22.2	124	20.095	2.298	100.491	1.133	-
SAT-18	2	22.9	115	12.998	5.116	95.954	0.958	-
SAT-32	1	16.4	40	7.001	0.835	32.064	0.905	-
SAT-61	2	24.1	137	11.838	4.194	120.968	0.979	caudal fin damaged
SAT-63	2	22.7	109	11.113	2.664	95.223	0.932	-
SAT-64	1	16.9	48	5.384	1.088	41.528	0.994	-
total sample size	8	8	8	8	8	8	8	1
average	2.0	21.6	107	11.718	3.333	91.227	0.991	na
median	2.0	22.5	113	11.476	2.986	95.589	0.987	na
standard deviation	0.8	3.3	44	4.751	2.117	38.389	0.069	na
standard error	0.3	1.2	16	1.680	0.748	13.572	0.025	na
minimum	1	16.4	40	5.384	0.835	32.064	0.905	na
maximum	3	25.6	172	20.095	7.160	148.889	1.133	na

[a] Adjusted body weight represents whole body weight less the liver, gonad and stomach content weight. Adjusted body weight used for statistical analyses

Table B.7: Atlantic tomcod stomach content information for fish collected from the reference area, Brunswick Smelter Fish Population Survey, October 2014.

Specimen ID	Sex	Age (yrs)	Adjusted Body Weight (g)[a]	Gut Content Weight (g)	Gut Contents
RAT-01	F	2	171.072	0.223	shrimp
RAT-02	F	3	238.536	3.335	shrimp
RAT-03	F	2	140.356	3.736	shrimp
RAT-04	F	2	145.377	3.938	shrimp
RAT-05	F	2	150.668	1.380	shrimp
RAT-06	F	2	180.028	1.315	shrimp
RAT-07	F	2	157.260	4.336	shrimp, winter flounder
RAT-08	F	3	230.222	2.734	shrimp
RAT-09	F	2	174.926	0.562	shrimp
RAT-10	F	2	135.732	2.308	shrimp
RAT-11	M	1	50.095	1.613	shrimp
RAT-12	F	2	143.444	7.629	shrimp, gravel
RAT-13	M	2	121.229	3.511	shrimp, gravel, winter flounder
RAT-14	F	2	133.485	5.879	shrimp
RAT-15	F	2	175.912	4.908	shrimp
RAT-16	M	2	82.990	0.961	shrimp
RAT-17	F	2	145.241	9.198	shrimp, sand lance
RAT-18	F	3	196.068	1.067	shrimp, sand lance
RAT-19	F	2	139.149	0.493	shrimp
RAT-20	M	2	114.706	0.477	shrimp
RAT-21	F	2	137.903	7.099	shrimp
RAT-22	F	2	137.044	7.004	shrimp, sand lance
RAT-23	M	2	107.448	2.247	shrimp
RAT-24	M	2	93.589	4.056	shrimp
Average (all fish)		2.1	145.9	3.334	shrimp predominant

[a] Adjusted body weight calculated as total body weight less the mass of gonad, liver and stomach contents.

Table B.8: Atlantic tomcod stomach content information for fish collected from the smelter-exposed area, Brunswick Smelter Fish Population Survey, October 2014.

Specimen ID	Sex	Age (yrs)	Adjusted Body Weight (g)[a]	Gut Content Weight (g)[b]	Gut Content
SAT-01	F	2	184.498	1.422	shrimp
SAT-02	F	2	107.461	0.980	shrimp, unidentied fish
SAT-03	F	2	150.017	2.059	polychaete
SAT-04	F	2	127.235	2.506	shrimp
SAT-05	F	2	143.866	nm	empty
SAT-06	M	3	148.889	nm	empty
SAT-07	F	3	187.064	nm	unidentified invertebrate
SAT-08	M	2	94.701	3.628	shrimp, sand lance
SAT-09	F	2	146.400	0.938	shrimp
SAT-10	F	2	137.803	1.331	shrimp
SAT-11	F	2	163.068	nm	unidentified invertebrate
SAT-12	F	2	131.081	0.241	shrimp
SAT-13	M	3	100.491	1.116	shrimp
SAT-14	F	2	148.346	0.996	winter flounder
SAT-15	F	2	164.029	1.295	shrimp
SAT-16	F	2	125.306	0.134	shrimp
SAT-17	F	2	119.123	0.492	unidentified invertebrate
SAT-18	M	2	95.954	0.932	shrimp
SAT-19	F	2	178.374	nm	empty
SAT-20	F	2	127.311	0.186	unidentified invertebrate
SAT-21	F	2	186.667	0.010	unidentified invertebrate
SAT-22	F	2	137.116	nm	empty
SAT-23	F	2	162.003	nm	empty
SAT-24	F	2	109.429	nm	empty
SAT-25	F	2	134.429	5.681	shrimp, rock crab
SAT-26	F	2	145.095	1.590	winter flounder
SAT-27	F	2	131.576	0.995	unidentified fish
SAT-28	F	2	145.151	nm	empty
SAT-29	F	2	142.542	0.116	unidentified invertebrate
SAT-30	F		150.665	0.010	unidentified invertebrate
SAT-31	F	2	176.064	0.072	unidentified invertebrate
SAT-32	M	1	32.064	nm	empty
SAT-33	F		55.391	0.067	unidentified invertebrate
SAT-61	M	2	120.968	nm	empty
SAT-63	M	2	95.223	nm	empty
SAT-64	M	1	41.528	nm	empty
Average (all fish)		2.0	131.859	1.165	shrimp predominant

[a] Adjusted body weight represents whole body weight less the liver, gonad and gut content weight.

[b] nm (not measurable) refers to fish where the gut content was empty

APPENDIX G

STATISTICAL COMPARISONS BETWEEN STUDY AREA AND REFERENCE AREA CONCENTRATIONS FOR MARINE WATER AND SEDIMENTS AND MARINE BIVALVES

G-1.0 STATISTICAL COMPARISON BETWEEN STUDY AREA AND REFERENCE AREA CONCENTRATIONS FOR MARINE SURFACE WATER AND SEDIMENTS

Maximum marine surface water (summer and fall samples) and sediment concentrations from the study area were compared to relevant marine water and sediment guidelines, respectively, and to the 95th percentile reference area concentrations (See Section 4.0 in the Main Report). Chemicals having maximum study area concentrations greater than the applicable guideline and the 95th percentile of reference concentration were carried forward for additional assessment. For chemicals that lacked a relevant guideline, but had a maximum study area concentration greater than the 95th percentile of reference concentration underwent additional statistical analyses to determine whether there was a significant difference in study area versus reference area concentrations. Statistical analysis of marine surface waters and sediments are provided in Sections G-1.1 and G-1.2, respectively.

For each of the chemicals undergoing statistical analysis, boxplots were generated to provide a visual comparison between the reference site and each of the study areas (Table G-1 for surface water and Table G-4 for sediments). Statistical analysis was not possible to be conducted when three were no detectable concentrations of chemicals in the reference and / or study area samples. Therefore, comparisons between sites for these chemicals are discussed on a case-by-case basis. For the remaining chemicals, Dunnett's multiple comparison tests were performed to compare study area and reference area marine water and sediment concentrations (Table G-2 for water and H-5 for sediments). Data were log transformed prior to analysis to improve data normality.

G-1.1 Statistical Evaluation of Marine Surface Water Data

Statistical analysis was conducted on the following chemicals for which marine water quality guidelines were not available, and for which the study area concentration (in either the summer or fall samples) exceeded the 95th percentile reference area concentration:

- aluminum,
- barium,
- boron,
- iron,
- lithium,
- manganese,
- silicon,
- thallium,
- uranium,
- calcium
- magnesium,
- sodium, and
- nitrogen.

For each of these chemicals, boxplots were generated to provide a visual comparison between the reference site and each of the study areas for the summer (Table G-1) and fall (Table G-2).

For samples collected during the summer, statistical analysis was not possible for aluminum, iron, manganese and thallium since reference area concentrations were either all not detected or the majority of samples were not detected. In these cases, data from the study area were reviewed in conjunction with the reference data set to determine whether the chemical should be carried forward for further assessment (See Table G-1). Based on this review aluminum, iron, manganese and thallium were all considered to have elevated concentrations over the reference area since either all or the majority of samples in the study area were detected for these chemicals. As such, there chemicals were carried forward for further discussion. For the remaining chemicals, two sample t-tests were performed to compare the water concentrations from the reference area to those from the study area (Table G-1). Data were log transformed prior to analysis to improve data normality.

Table G-1 Results of Two Sample T-Tests Comparing Reference Site Analyte Concentrations to Study Area Sumer Water Concentrations

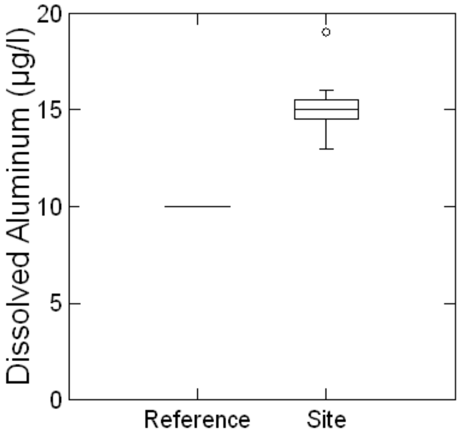
Analyte	**Boxplot**[a]	**T-Test**[b] **Result (p-value)**
Dissolved Aluminum		NA

Table G-1 Results of Two Sample T-Tests Comparing Reference Site Analyte Concentrations to Study Area Sumer Water Concentrations

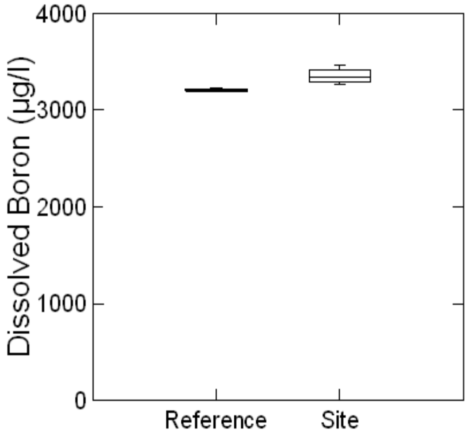
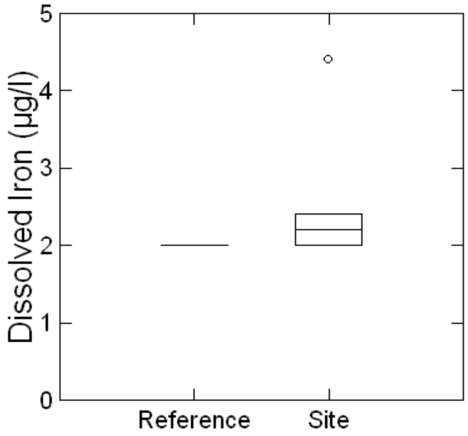
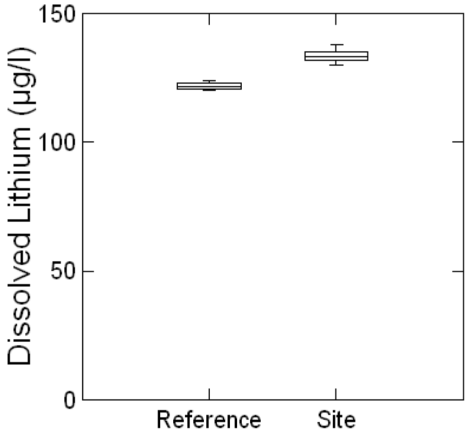
Analyte	**Boxplot[a]**	**T-Test[b] Result (p-value)**
Dissolved Boron		0.004
Dissolved Iron		NA
Dissolved Lithium		<0.001

Table G-1 Results of Two Sample T-Tests Comparing Reference Site Analyte Concentrations to Study Area Sumer Water Concentrations

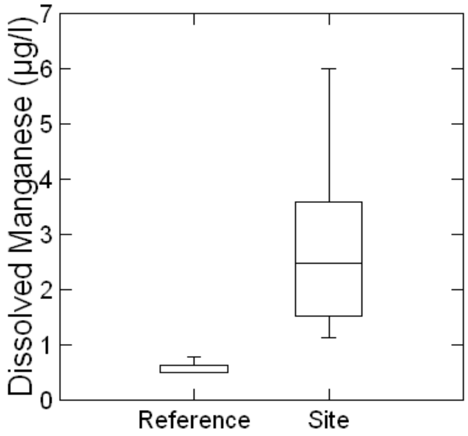
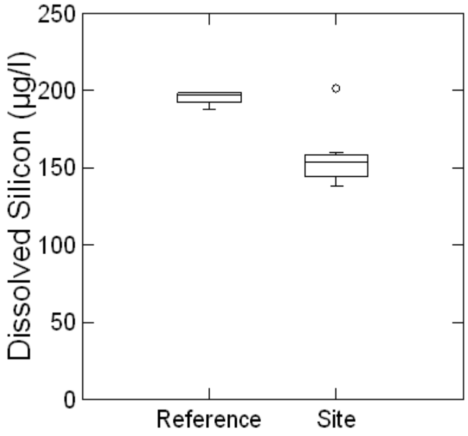
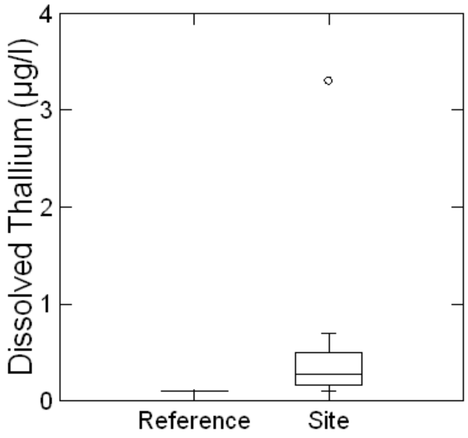
Analyte	**Boxplot**[a]	**T-Test**[b] **Result (p-value)**
Dissolved Manganese		NA
Dissolved Silicon		0.003
Dissolved Thallium		NA

Table G-1 Results of Two Sample T-Tests Comparing Reference Site Analyte Concentrations to Study Area Sumer Water Concentrations

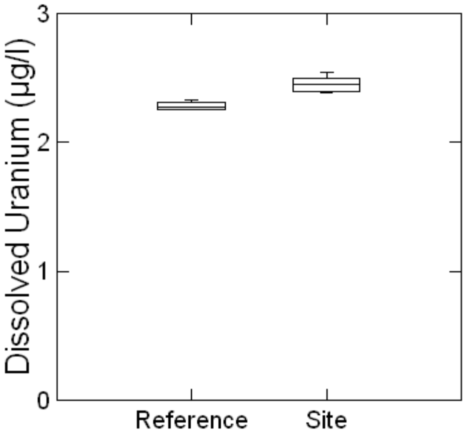
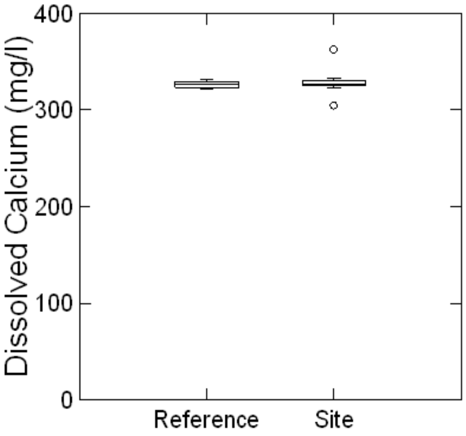
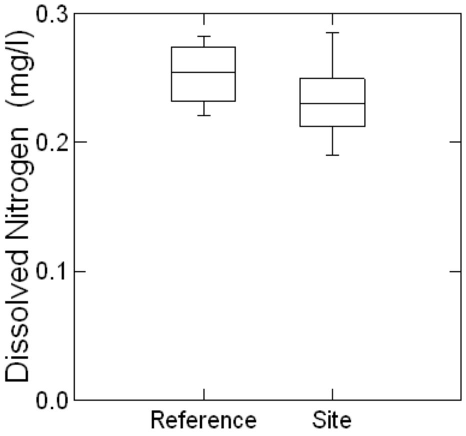
Analyte	**Boxplot[a]**	**T-Test[b] Result (p-value)**
Dissolved Uranium		<0.001
Dissolved Calcium		0.805

Table G-1 Results of Two Sample T-Tests Comparing Reference Site Analyte Concentrations to Study Area Sumer Water Concentrations

Analyte	Boxplot[a]	T-Test[b] Result (p-value)
Dissolved Nitrogen		0.267

Notes:
NP = Not performed. Statistical analysis not performed due to lack of detected data from the reference site. See discussion of results in text.

[a] The top and bottom of each box indicate the 75th and 25th percentiles of the data, respectively. The middle line in each box indicates the median (50th percentile). The whiskers indicate the lowest datum that is within 1.5 times the interquartile range (IQR, which equals the 75th percentile minus the 25th percentile) from the bottom of the box and the highest datum that is within 1.5 IQR from the top of the box. Values that are greater than 1.5 IQR but less than or equal to 3 IQR from the box are indicated with asterisks. Values that are more than 3 IQR from the box are indicated by empty circles.

[b] Data were log-transformed prior to analysis to improve data normality

For samples collected during the fall, statistical analysis was not possible for silicon since there were no detected concentrations of this chemical in the reference site samples. Therefore, the comparison between reference site and study area for this analyte was made qualitatively based on the observed data, see details below. For the remaining chemicals, two sample t-tests were performed to compare the water concentrations from the reference area to those from the study area (Table G-2). Data were log transformed prior to analysis to improve data normality.

For silicon, reported concentrations in water were below detection limit for all samples from the reference site (n=4), but were greater than the detection limit for the majority of samples from the study area (i.e., 5 out of 9 samples). Therefore, silicon was considered to be elevated above the reference area in the study area and was carried forward for further discussion in marine waters. For all remaining chemicals, they were only carried forward for further discussion in marine waters if the statistical analysis shown in Table G-1 indicated that concentrations differed significantly from that of the reference area.

Table G-2 Results of Two Sample T-Tests Comparing Reference Site Analyte Concentrations to Study Area Fall Water Concentrations

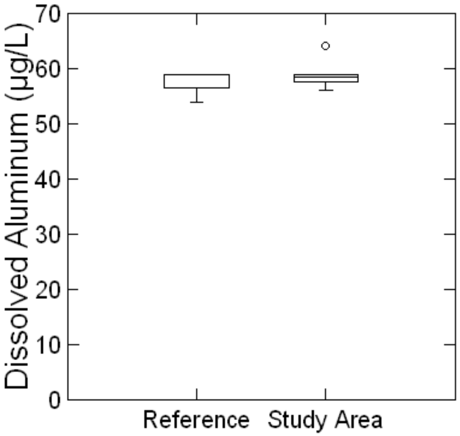
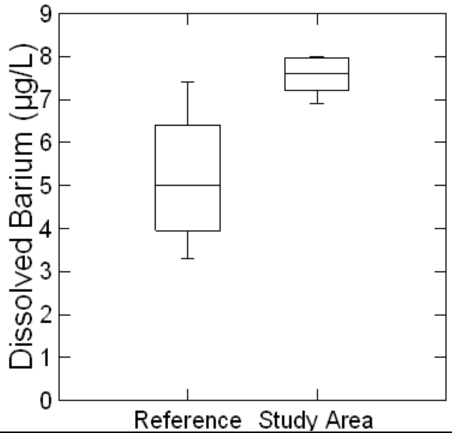
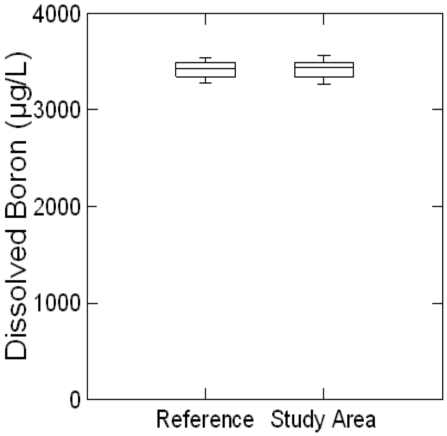
Analyte	Boxplot[a]	T-Test[b] Result (p-value)
Dissolved Aluminum		0.509
Dissolved Barium		0.005
Dissolved Boron		0.957

Table G-2 Results of Two Sample T-Tests Comparing Reference Site Analyte Concentrations to Study Area Fall Water Concentrations

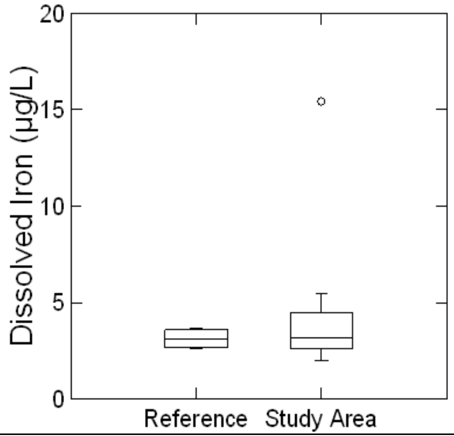
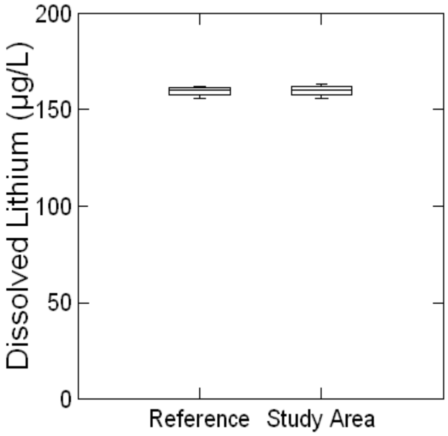
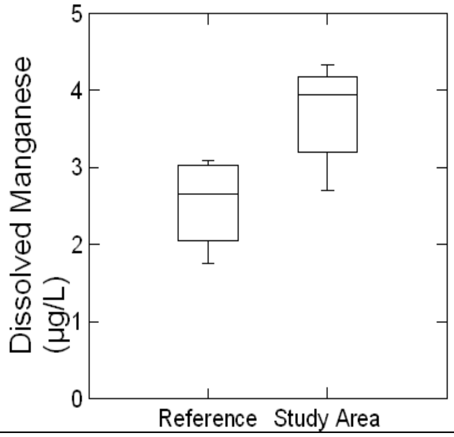
Analyte	Boxplot[a]	T-Test[b] Result (p-value)
Dissolved Iron		0.569
Dissolved Lithium		0.880
Dissolved Manganese		0.010

Table G-2 Results of Two Sample T-Tests Comparing Reference Site Analyte Concentrations to Study Area Fall Water Concentrations

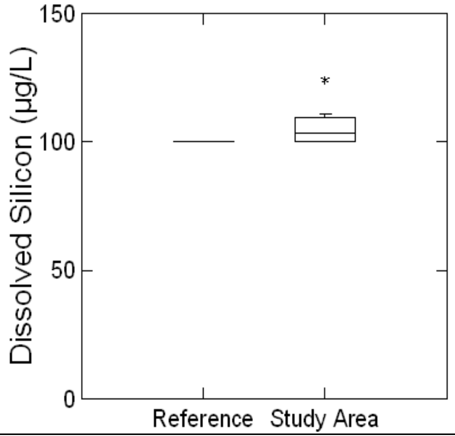
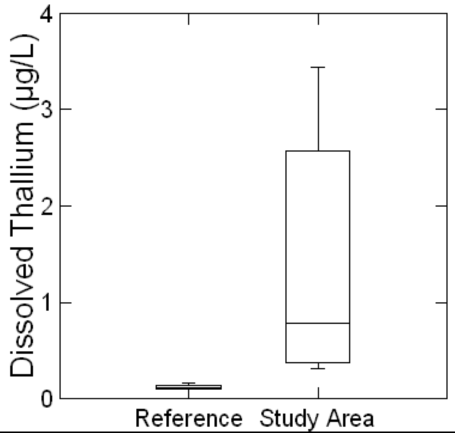
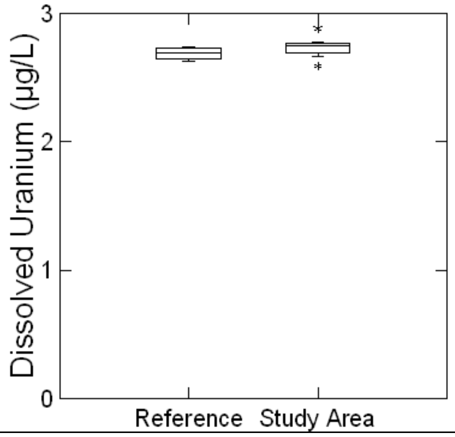
Analyte	Boxplot[a]	T-Test[b] Result (p-value)
Dissolved Silicon		NP
Dissolved Thallium		0.003
Dissolved Uranium		0.338

Table G-2 Results of Two Sample T-Tests Comparing Reference Site Analyte Concentrations to Study Area Fall Water Concentrations

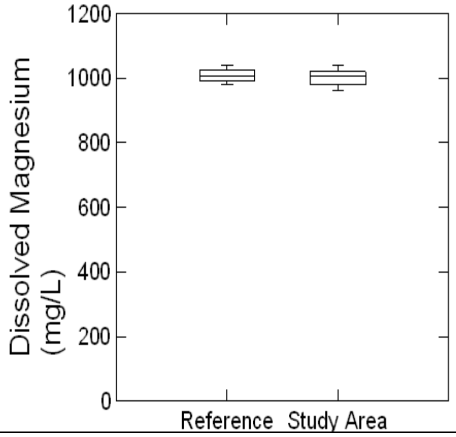
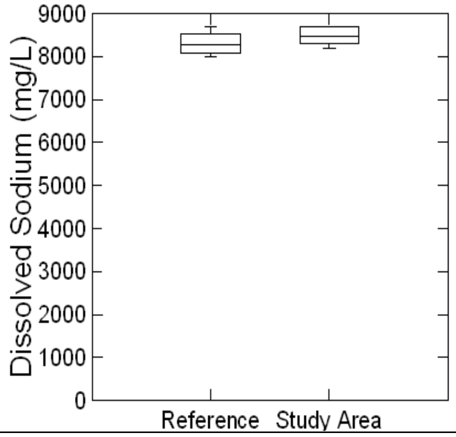
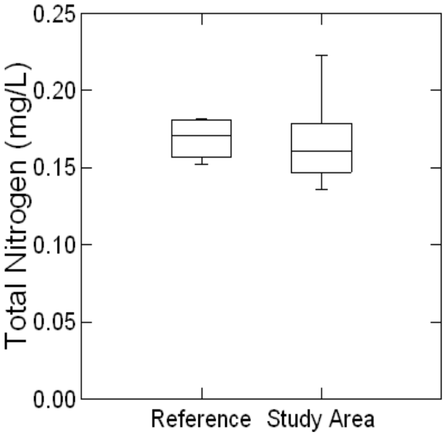
Analyte	Boxplot[a]	T-Test[b] Result (p-value)
Dissolved Magnesium		0.740
Dissolved Sodium		0.290
Total Nitrogen		0.796

Table G-2 Results of Two Sample T-Tests Comparing Reference Site Analyte Concentrations to Study Area Fall Water Concentrations

Analyte	Boxplot[a]	T-Test[b] Result (p-value)

Notes:
NP = Not performed. Statistical analysis not performed due to lack of detected data from the reference site. See discussion of results in text.

[a] The top and bottom of each box indicate the 75th and 25th percentiles of the data, respectively. The middle line in each box indicates the median (50th percentile). The whiskers indicate the lowest datum that is within 1.5 times the interquartile range (IQR, which equals the 75th percentile minus the 25th percentile) from the bottom of the box and the highest datum that is within 1.5 IQR from the top of the box. Values that are greater than 1.5 IQR but less than or equal to 3 IQR from the box are indicated with asterisks. Values that are more than 3 IQR from the box are indicated by empty circles.

[b] Data were log-transformed prior to analysis to improve data normality

A list of chemicals in marine surface waters carried forward for further discussion based on either the summer or fall sampling are provided in Table G-3.

Table G-3 Summary of Statistical Comparison Reference Site Analyte Concentrations to Study Area Concentration (Summer and Fall, 2014)

Analyte	Significantly Different from Reference Site (Summer) ($p<0.05$)?	Notes (Summer)	Significantly Different from Reference Site (Fall) ($p<0.05$)?	Notes (Fall)
Dissolved Aluminum	NP	All samples were non-detect in reference area, therefore no statistical comparison carried out. Aluminum carried forward for further assessment since all study area samples (i.e., 8 out of 8 samples) had detectable concentrations	N	
Dissolved Barium	NA		Y	
Dissolved Boron	Y		N	
Dissolved Iron	NP	All samples were non-detect in reference area, therefore no statistical comparison carried out. Iron carried forward for further assessment since concentrations were greater than the detection limit (<2 µg/L) for 4 out of the 8 study area samples (detected at 2.4 µg/L in 3 samples and 4.4 µg/Lin one sample)	N	
Dissolved Lithium	Y		N	
Dissolved Manganese	NP	The majority of samples (3/4) were non-detect in reference area, therefore no statistical	Y	

Table G-3 Summary of Statistical Comparison Reference Site Analyte Concentrations to Study Area Concentration (Summer and Fall, 2014)

Analyte	Significantly Different from Reference Site (Summer) ($p<0.05$)?	Notes (Summer)	Significantly Different from Reference Site (Fall) ($p<0.05$)?	Notes (Fall)
		comparison carried out. Manganese carried forward as a COPC since concentrations were greater than the detection limit for all samples from the study area (i.e., 8 out of 8 samples)		
Dissolved Silicon	Y		NP	All samples were non-detect in reference area, therefore no statistical comparison carried out. Silicon carried forward for further assessment since concentrations were greater than the detection limit for the majority of samples from the study area (i.e., 5 out of 9 samples)
Dissolved Thallium	NP	All samples were non-detect in reference area, therefore no statistical comparison carried out. Thallium carried forward for further assessment since concentrations were greater than the detection limit in 7 if 8 study area samples	Y	
Dissolved Uranium	Y		N	
Dissolved Calcium	N		NA	
Dissolved Magnesium	NA		N	
Dissolved Sodium	NA		N	
Total Nitrogen	N		N	

Notes:

N = No statistical difference, analyte not carried forward; Y = Yes a statistical difference, analyte carried forward; NP = not performed due to non-detectable concentrations in reference; NA = not applicable – chemical not carried forward for this sampling period since the maximum concentration was less than the 95th percentile of reference.

Analytes with study area concentrations significantly higher than those in the reference area and as such were carried forward for further evaluation in addition to analytes carried forward for additional evaluation based on qualitative considerations are shaded.

G-1.2 Statistical Evaluation of Marine Sediment Data

Study area sediments were grouped into 3 separate areas [fertilizer plant outfall (FPO), final effluent location (FE) and smelter sediment transect location (SST2)] and compared to relevant guidelines and the 95th percentile reference area concentration. Statistical analysis was conducted on chemicals for which marine water quality guidelines were not available, and for which the study area concentration exceeded the 95th percentile reference area concentration. Table G-3 provides a list of which chemicals were carried forward for statistical analysis in which of the sediment areas (FPO, FE and / or SST2).

For each analyte carried forward for statistical analysis, a Dunnett's multiple comparison test was performed to compare the concentrations at each site to the concentrations reported for that analyte in sediment from the reference site (Table G-4). The full results from these analyses are reported in Table G-5 and Table G-6 provides a summary that indicates the sites at which each analyte differed significantly from the reference site.

Table G-4 Chemicals for Which No Guidelines were Available and Study Area Sediment Concentrations in Either FPO, FE or SST2 Exceeded the 95th Percentile Reference Area Concentrations

Analyte	FPO	FE	SST2
Aluminum	√		
Antimony	√	√	√
Barium		√	√
Bismuth		√	
Boron	√		√
Calcium	√		
Cobalt	√	√	
Iron	√	√	
Lithium	√	√	
Magnesium	√	√	
Molybdenum	√		
Potassium	√		
Rubidium	√		
Sodium	√		
Strontium	√		
Thallium		√	√
Tin	√	√	
Uranium	√		
Vanadium	√	√	√

Notes:
FPO = fertilizer plant outfall; FE = final effluent; SST = smelter sediment transect
√ = chemical had no marine sediment quality guideline available and the maximum concentrations was greater than the 95th percentile reference area concentration; these chemicals were carried forward for statistical analysis

Table G -5 Results of Dunnett's Tests Comparing Reference Site Analyte Concentrations to Analyte Concentrations at Sites FPO, FE, and SST2

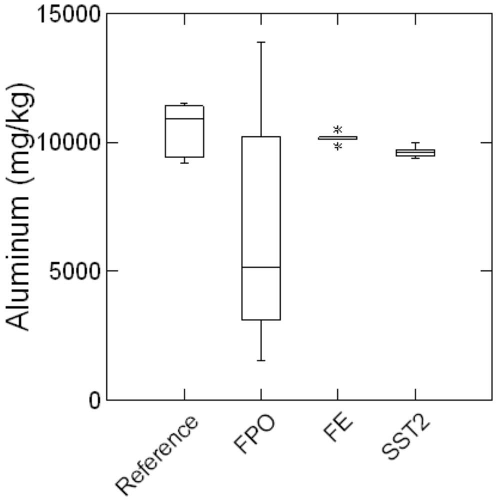
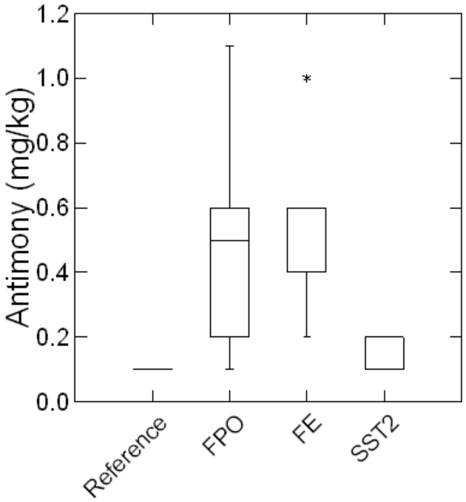
Analyte	Boxplot[a]	Dunnett's Test[b] Results (p-value)		
		FPO	FE	SST2
Aluminum		0.008	NA	NA
Antimony		NP	NP	NP

Table G -5 Results of Dunnett's Tests Comparing Reference Site Analyte Concentrations to Analyte Concentrations at Sites FPO, FE, and SST2

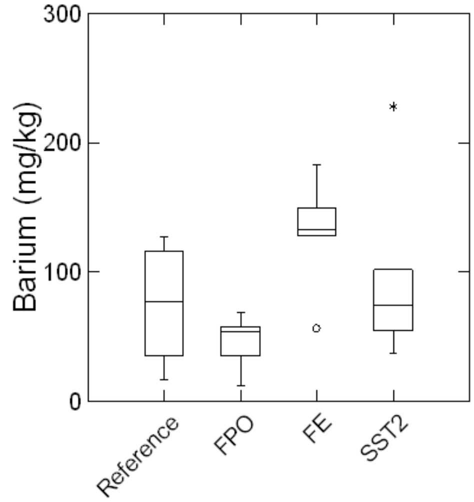
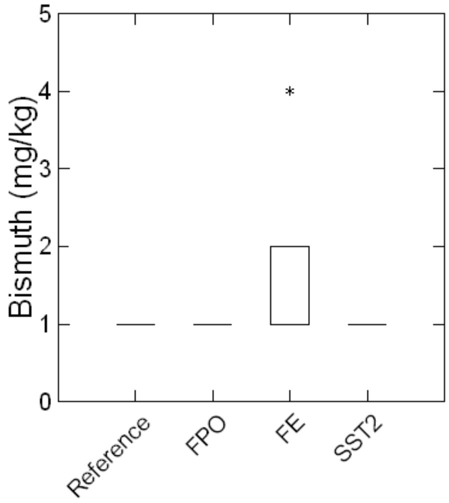
Analyte	Boxplot[a]	Dunnett's Test[b] Results (p-value)		
		FPO	FE	SST2
Barium		NA	0.175	0.775
Bismuth		NA	NP	NA

Table G -5 Results of Dunnett's Tests Comparing Reference Site Analyte Concentrations to Analyte Concentrations at Sites FPO, FE, and SST2

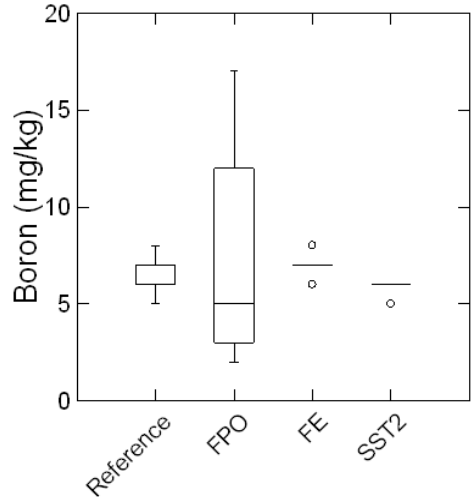
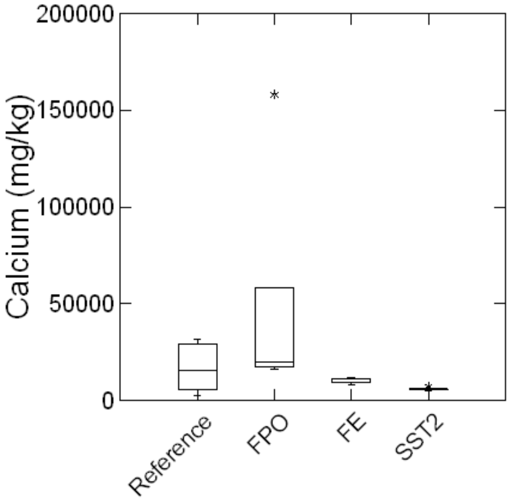
Analyte	Boxplot[a]	Dunnett's Test[b] Results (p-value)		
		FPO	FE	SST2
Boron		0.893	NA	0.915
Calcium		0.046	NA	NA

Table G -5 Results of Dunnett's Tests Comparing Reference Site Analyte Concentrations to Analyte Concentrations at Sites FPO, FE, and SST2

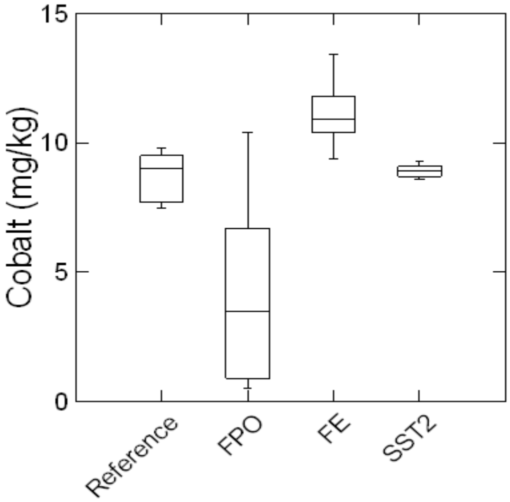
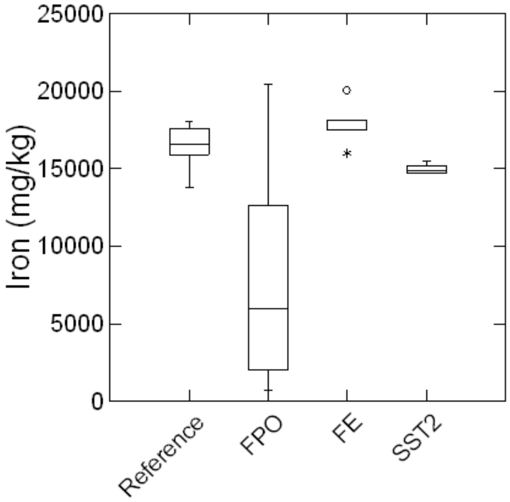
Analyte	Boxplot[a]	Dunnett's Test[b] Results (p-value)		
		FPO	FE	SST2
Cobalt		0.002	0.807	NA
Iron		0.003	0.99	NA

Table G -5 Results of Dunnett's Tests Comparing Reference Site Analyte Concentrations to Analyte Concentrations at Sites FPO, FE, and SST2

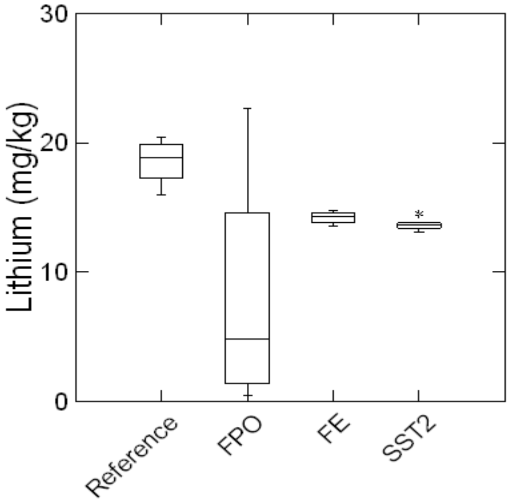
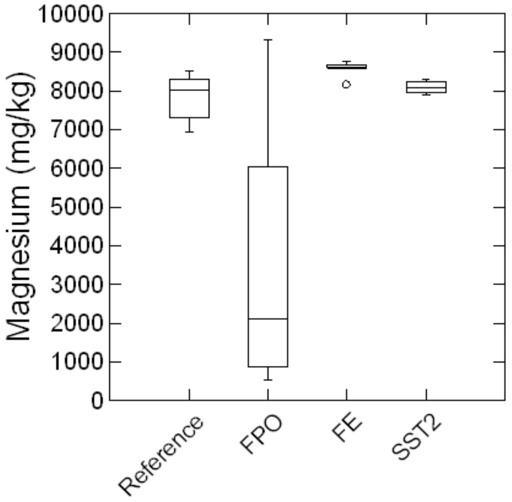
Analyte	Boxplot[a]	Dunnett's Test[b] Results (p-value)		
		FPO	FE	SST2
Lithium		0.002	0.851	NA
Magnesium		0.001	0.985	NA

Table G -5 Results of Dunnett's Tests Comparing Reference Site Analyte Concentrations to Analyte Concentrations at Sites FPO, FE, and SST2

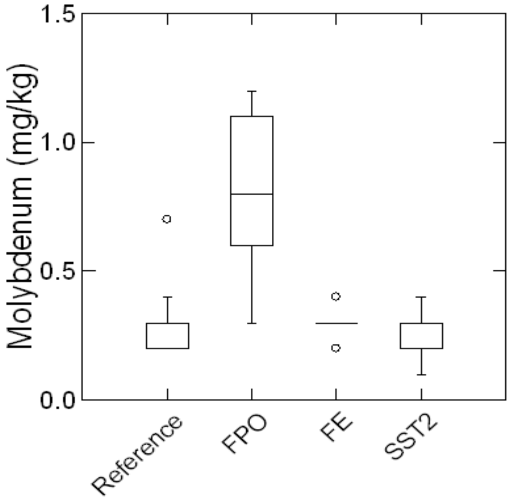
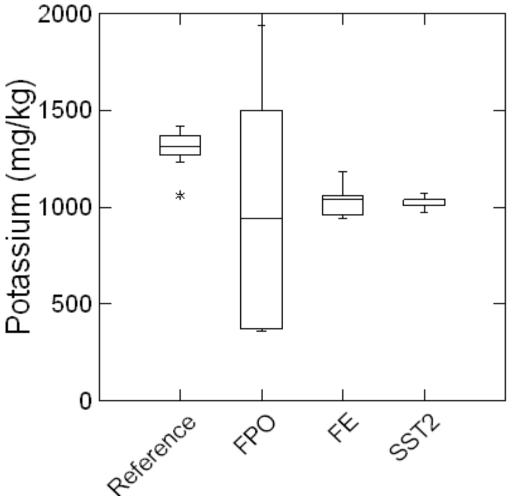
Analyte	Boxplot[a]	Dunnett's Test[b] Results (p-value)		
		FPO	FE	SST2
Molybdenum		0.004	NA	NA
Potassium		0.068	NA	NA

Table G -5 Results of Dunnett's Tests Comparing Reference Site Analyte Concentrations to Analyte Concentrations at Sites FPO, FE, and SST2

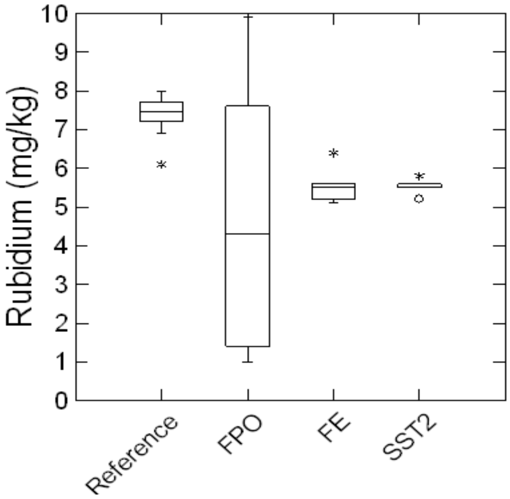
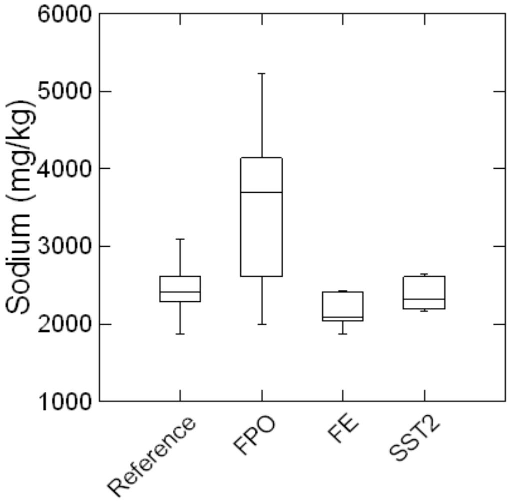
Analyte	Boxplot[a]	Dunnett's Test[b] Results (p-value)		
		FPO	FE	SST2
Rubidium		0.014	NA	NA
Sodium		0.024	NA	NA

Table G -5 Results of Dunnett's Tests Comparing Reference Site Analyte Concentrations to Analyte Concentrations at Sites FPO, FE, and SST2

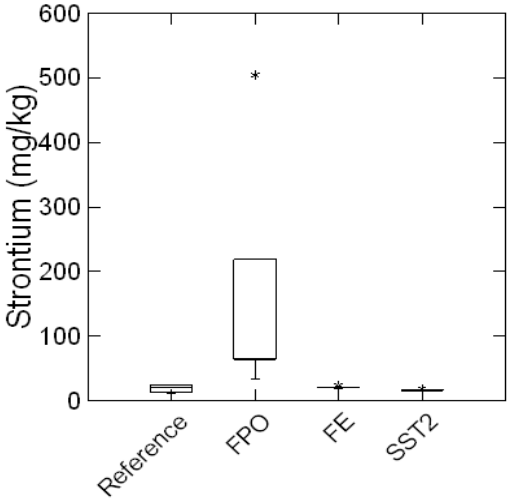
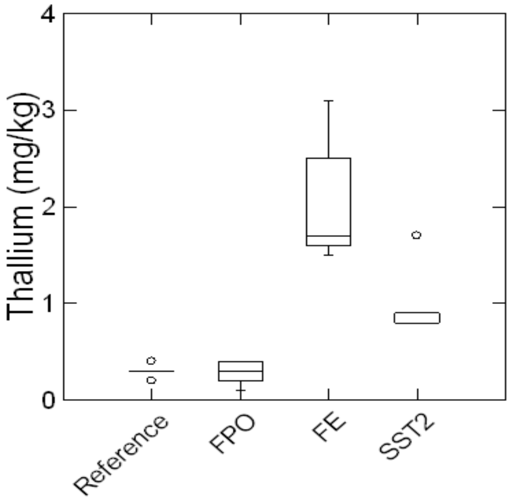
Analyte	**Boxplot**[a]	**Dunnett's Test**[b] **Results (p-value)**		
		FPO	**FE**	**SST2**
Strontium		<0.001	NA	NA
Thallium		NA	<0.001	<0.001

Table G -5 Results of Dunnett's Tests Comparing Reference Site Analyte Concentrations to Analyte Concentrations at Sites FPO, FE, and SST2

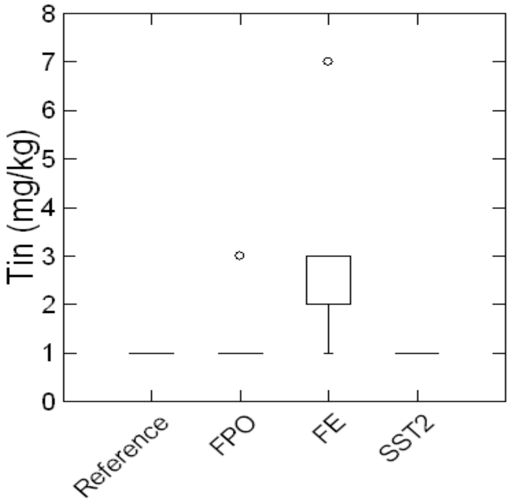
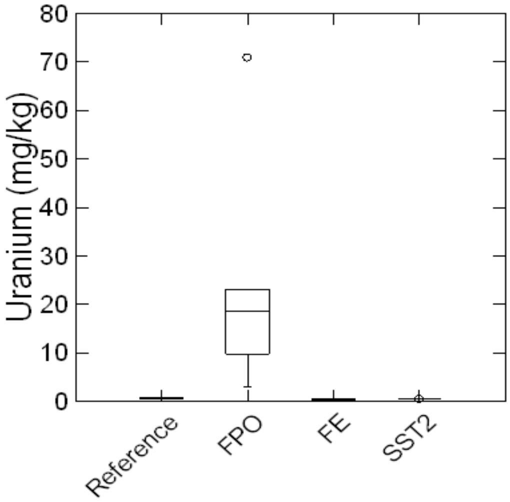
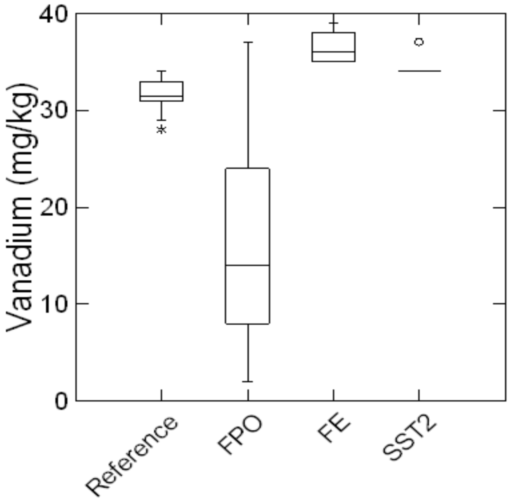
Analyte	Boxplot[a]	Dunnett's Test[b] Results (p-value)		
		FPO	FE	SST2
Tin		NP	NP	NA
Uranium		<0.001	NA	NA

Table G -5 Results of Dunnett's Tests Comparing Reference Site Analyte Concentrations to Analyte Concentrations at Sites FPO, FE, and SST2

Analyte	Boxplot[a]	Dunnett's Test[b] Results (p-value)		
		FPO	FE	SST2
Vanadium		0.004	0.915	0.976

Notes:

NP = Not performed; Statistical analysis not performed due to lack of detected data from the reference site. See discussion of results in text.

NA = Not applicable; Chemical not carried forward for statistical evaluation in this area (See Table B-4)

a The top and bottom of each box indicate the 75th and 25th percentiles of the data, respectively. The middle line in each box indicates the median (50th percentile). The whiskers indicate the lowest datum that is within 1.5 times the interquartile range (IQR, which equals the 75th percentile minus the 25th percentile) from the bottom of the box and the highest datum that is within 1.5 IQR from the top of the box. Values that are greater than 1.5 IQR but less than or equal to 3 IQR from the box are indicated with asterisks. Values that are more than 3 IQR from the box are indicated by empty circles.

b Data were log-transformed prior to analysis to improve data normality

Table G-6 Summary of Statistical Comparison Results for Analytes that did not Exceed the Selected Guideline Value (or for which no Suitable Guideline was Identified)

Analyte	Significantly Different from Reference Site ($p<0.05$)?			Notes
	FPO	FE	SST2	
Aluminum	Y*	NA	NA	*Site FPO significantly lower than Reference
Antimony	NP	NP	NP	Antimony was not detected in 8 of 10 reference samples (detection limit of 0.1 mg/kg) and present in the two detected samples at 0.1 mg/kg. As such, statistical analysis could not be performed. Antimony was detected in all samples at FPO (range = 0.1 mg/kg to 1.1 mg/kg) and FE (range = 0.2 mg/kg to 1 mg/kg). As such, antimony was carried forward for further assessment in FPO and FE sediments. At SST2, four of the five samples were detected at concentrations of 0.1, 0.1, 0.2 and 0.2 mg/kg. Given four of the five samples were detected at concentrations similar to the detection limit and similar to those in the reference area, antimony at SST2 was not carried forward for further assessment.
Barium	NA	N	N	
Bismuth	NA	NP	NA	Bismuth was not detected in the reference area (detection limit of <1 mg/kg) and as such, statistical analysis could not be performed. Bismuth was detected in FE sediment at concentrations ranging from <1 to 4 mg/kg. Given four of the five FE samples were detected and at concentration greater than those in the reference area, bismuth was carried forward for assessment in FE sediments.
Boron	N	NA	N	
Calcium	Y	NA	N	
Cobalt	Y*	N	NA	*Site FPO significantly lower than Reference
Iron	Y*	N	NA	*Site FPO significantly lower than Reference
Lithium	Y*	N	NA	*Site FPO significantly lower than Reference
Magnesium	Y*	N	NA	*Site FPO significantly lower than Reference
Molybdenum	Y	NA	NA	
Potassium	N	NA	NA	
Rubidium	Y*	NA	NA	*Site FPO significantly lower than Reference
Sodium	Y	NA	NA	
Strontium	Y	NA	NA	
Thallium	NA	Y	Y	
Tin	NP	NP	NA	Tin was not detected in any reference area samples

Table G-6	**Summary of Statistical Comparison Results for Analytes that did not Exceed the Selected Guideline Value (or for which no Suitable Guideline was Identified)**			
Analyte	**Significantly Different from Reference Site (p<0.05)?**			**Notes**
	FPO	**FE**	**SST2**	
				(detection limit of <1 mg/kg) and as such, statistical analysis could not be performed. Tin was detected in only 1 of 5 FPO samples at a concentration of 3 mg/kg. As such, tin was not carried forward for assessment in FPO. In FE tin was detected in 4 of the 5 samples with concentrations ranging from <1 to 7 mg/kg. Given four of the five FE samples were detected and at concentration greater than those in the reference area, tin was carried forward for assessment in FE sediments.
Uranium	Y	NA	NA	
Vanadium	Y*	N	N	*Site FPO significantly lower than Reference

Notes:
N = No statistical difference, analyte not carried forward; Y = Yes a statistical difference, analyte carried forward; NP = not performed; NA = not applicable as analytic not carried forward for statistical evaluation in this area; * = significantly lower than reference
Analytes with study area concentrations significantly higher than those in the reference area and as such were carried forward for further evaluation in addition to analytes carried forward for additional evaluation based on qualitative considerations are shaded.

G-1.3 Glencore Bivalve Tissue Residue Statistical Evaluation

Boxplots were generated in order to compare metal concentrations in mussels from the reference area (sites R1 and R2, combined) with those collected from the smelter exposed area (sites S1, S2, S3, and S4) (see Table G-7). Additionally, for each analyte, a Dunnett's multiple comparison test was performed to compare the concentrations from the smelter exposed mussels from each of the sample sites back to the concentrations from the reference mussels (see Table G-7). Note, for the purpose of all graphs and statistical comparisons, all concentrations reported as less than the detection limit were replaced with the full detection limit. Additionally, data were log transformed prior to analysis to improve data normality. Table G-8 provides a summary, and statistics comparing various caged areas within the study area to each other are provided at the end of the file for cadmium, lead and zinc.

For Antimony, Thallium, Tin, and Uranium, statistical analysis was not possible as there were few to no detected concentrations of these chemicals in the reference site samples (i.e., <4 total detected values or <20% detected values). Therefore, the comparison between reference site and study area for these analytes were made qualitatively based on the observed data, see details below.

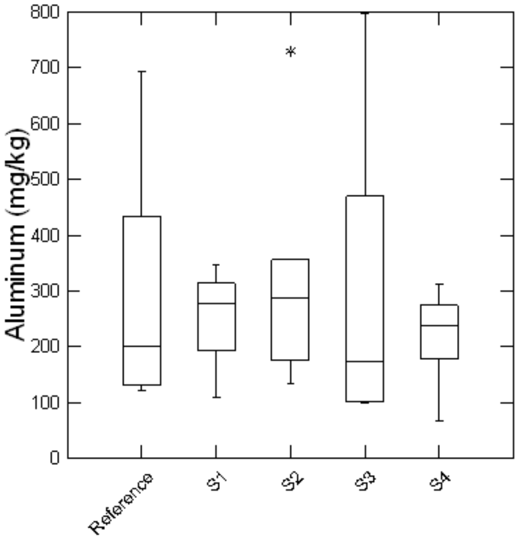
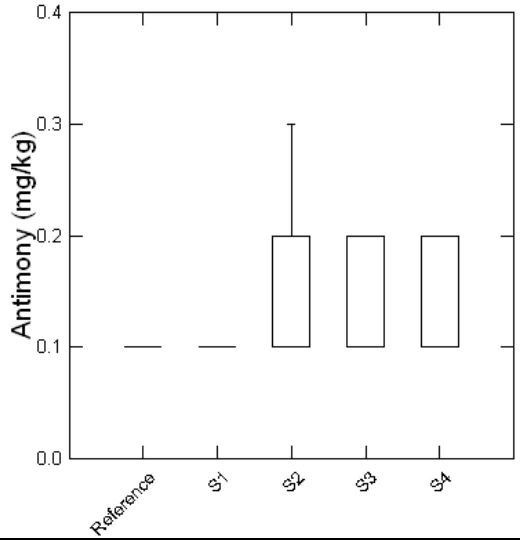
Table G-7	**Results of Dunnett's Tests Comparing Reference Site Analyte Concentrations to Analyte Concentrations at Sites S1, S2, S3, and S4**				
Analyte	**Boxplot**[a]	**Dunnett's Test**[b] **Results (p-value)**			
		S1	**S2**	**S3**	**S4**
Aluminum		0.999	0.993	0.999	0.902
Antimony		NA	NA	NA	NA

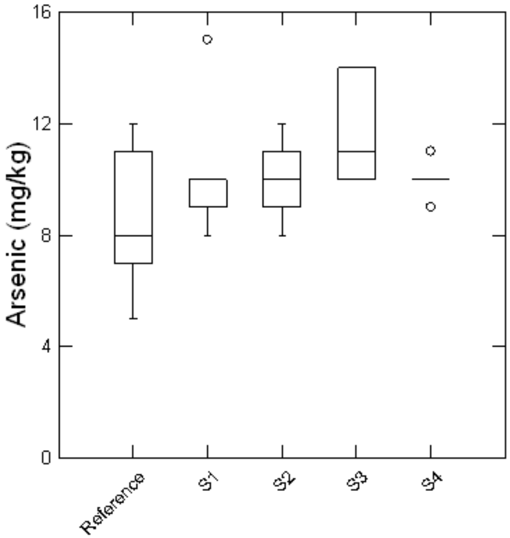
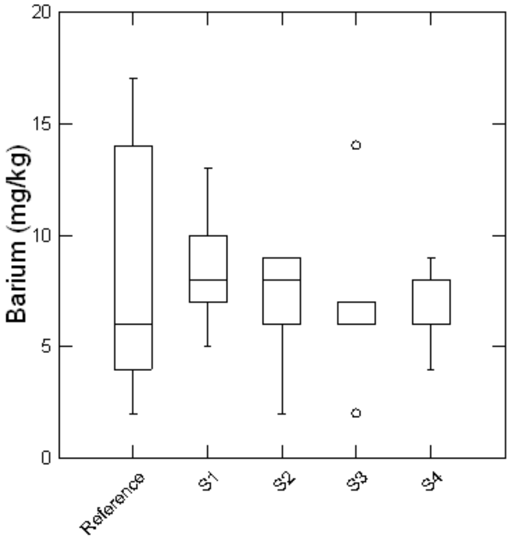
Table G-7	**Results of Dunnett's Tests Comparing Reference Site Analyte Concentrations to Analyte Concentrations at Sites S1, S2, S3, and S4**				
Analyte	**Boxplot**[a]	**Dunnett's Test**[b] **Results (p-value)**			
		S1	**S2**	**S3**	**S4**
Arsenic		0.311	0.33	**0.021**	0.296
Barium		0.815	>0.999	>0.999	0.995

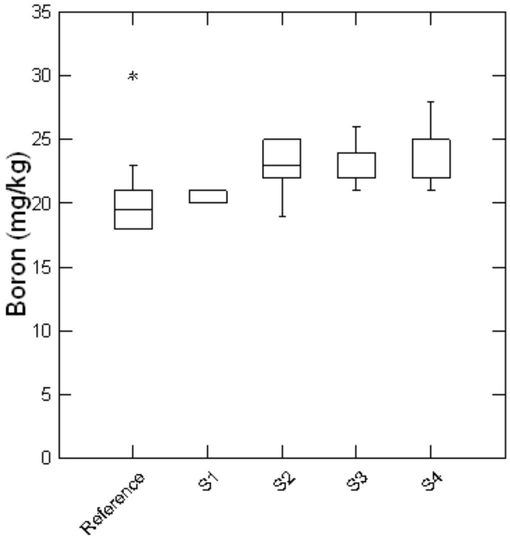
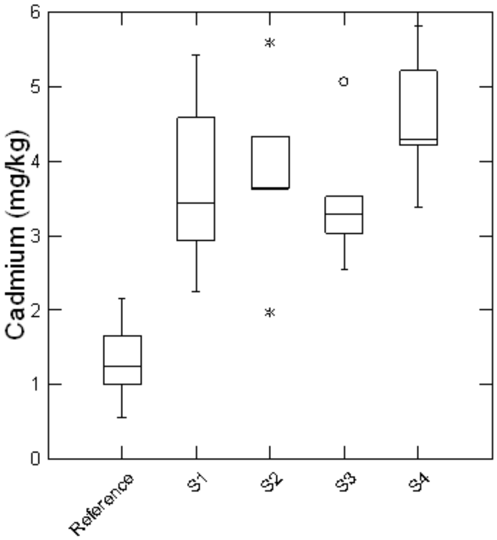
Table G-7	**Results of Dunnett's Tests Comparing Reference Site Analyte Concentrations to Analyte Concentrations at Sites S1, S2, S3, and S4**				
Analyte	**Boxplot**[a]	**Dunnett's Test**[b] **Results (p-value)**			
		S1	**S2**	**S3**	**S4**
Boron		0.999	0.335	0.256	0.06
Cadmium		**<0.001**	**<0.001**	**<0.001**	**<0.001**

Table G-7 Results of Dunnett's Tests Comparing Reference Site Analyte Concentrations to Analyte Concentrations at Sites S1, S2, S3, and S4

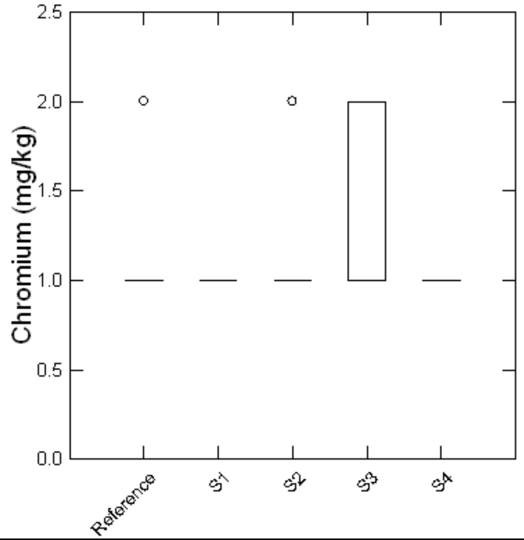
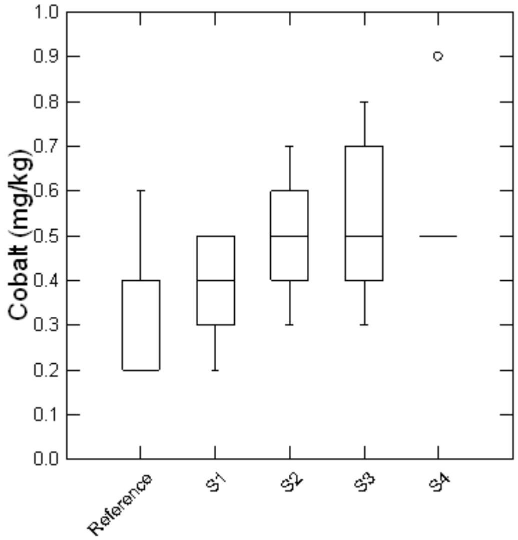
Analyte	Boxplot[a]	Dunnett's Test[b] Results (p-value)			
		S1	S2	S3	S4
Chromium		0.964	0.964	0.361	0.964
Cobalt		0.994	0.288	0.174	0.062

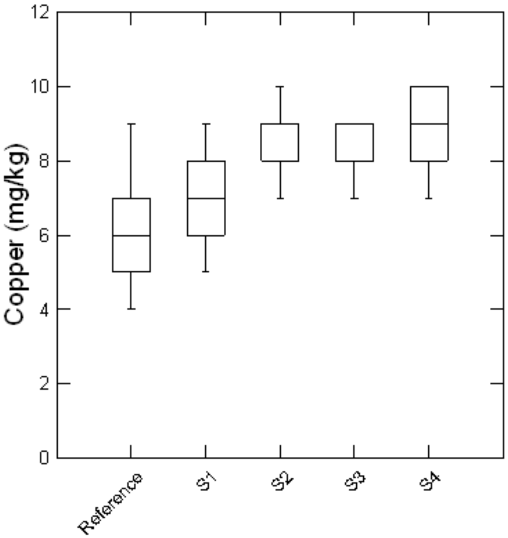
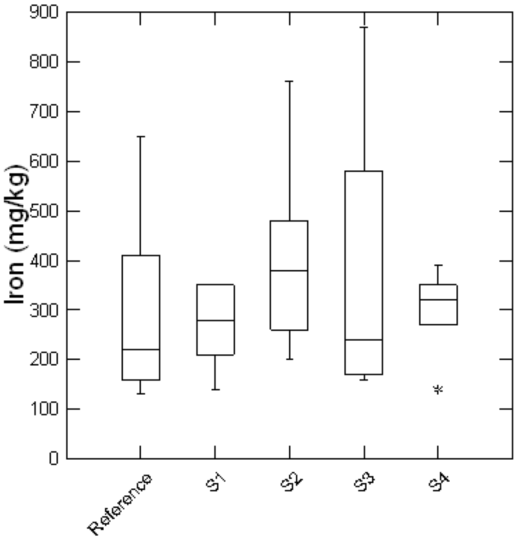
Table G-7	**Results of Dunnett's Tests Comparing Reference Site Analyte Concentrations to Analyte Concentrations at Sites S1, S2, S3, and S4**				
Analyte	**Boxplot**[a]	**Dunnett's Test**[b] **Results (p-value)**			
		S1	**S2**	**S3**	**S4**
Copper		0.419	**0.009**	**0.008**	**0.003**
Iron		>0.999	0.57	0.892	0.997

Table G-7 Results of Dunnett's Tests Comparing Reference Site Analyte Concentrations to Analyte Concentrations at Sites S1, S2, S3, and S4

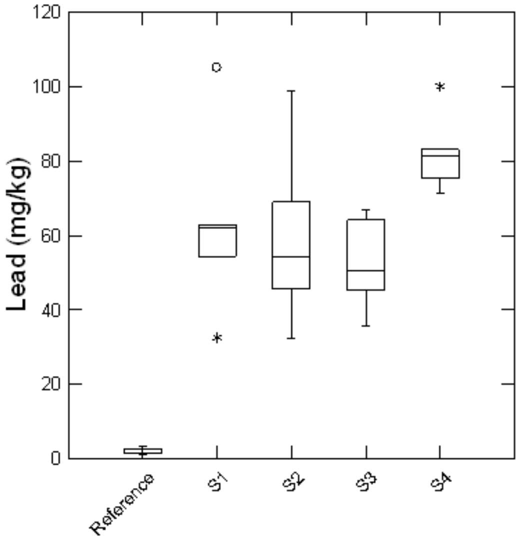
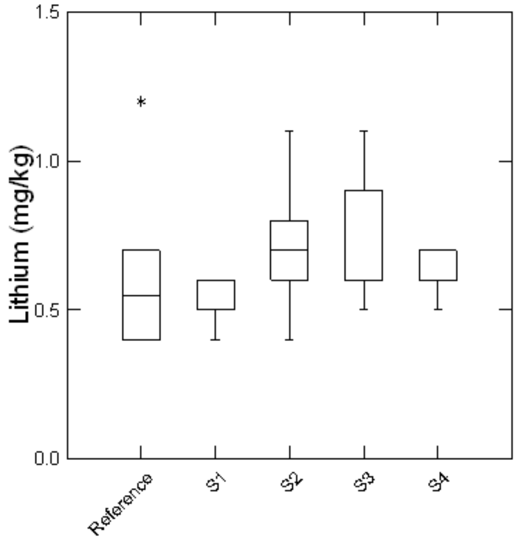
Analyte	Boxplot[a]	Dunnett's Test[b] Results (p-value)			
		S1	S2	S3	S4
Lead		**<0.001**	**<0.001**	**<0.001**	**<0.001**
Lithium		0.991	0.665	0.512	0.915

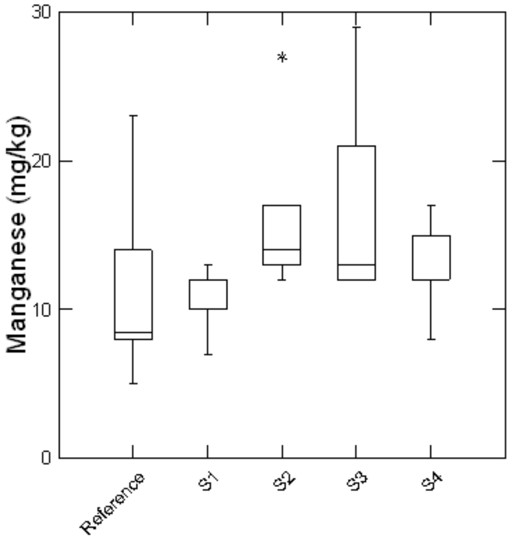
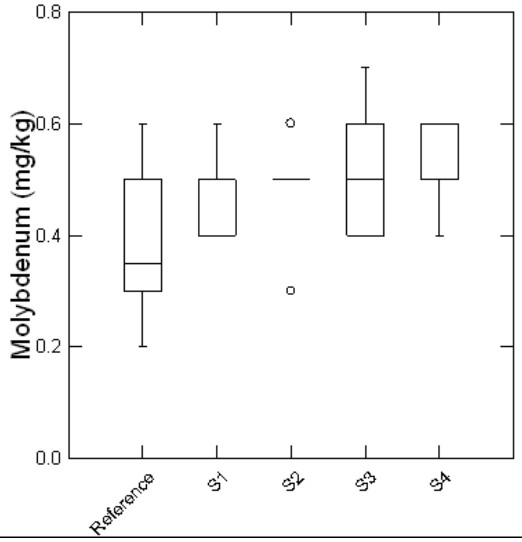
Table G-7	**Results of Dunnett's Tests Comparing Reference Site Analyte Concentrations to Analyte Concentrations at Sites S1, S2, S3, and S4**				
Analyte	**Boxplot**[a]	**Dunnett's Test**[b] **Results (p-value)**			
		S1	**S2**	**S3**	**S4**
Manganese		>0.999	0.122	0.095	0.741
Molybdenum		0.329	0.376	0.148	0.074

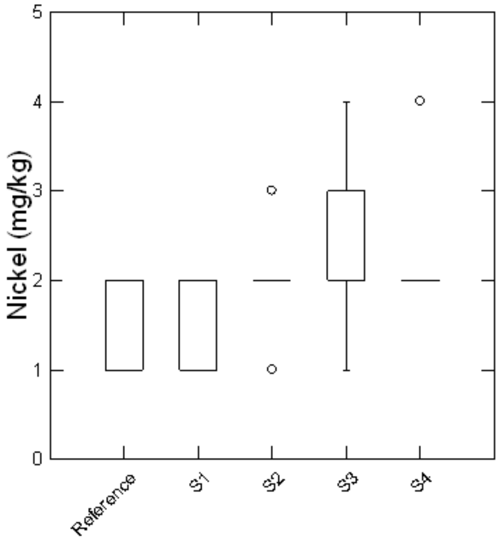
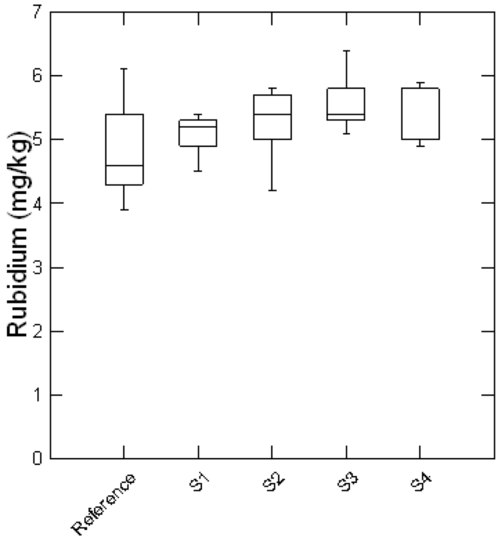
Table G-7	**Results of Dunnett's Tests Comparing Reference Site Analyte Concentrations to Analyte Concentrations at Sites S1, S2, S3, and S4**				
Analyte	**Boxplot**[a]	**Dunnett's Test**[b] **Results (p-value)**			
		S1	**S2**	**S3**	**S4**
Nickel		>0.999	0.328	0.1	0.057
Rubidium		0.825	0.551	0.072	0.146

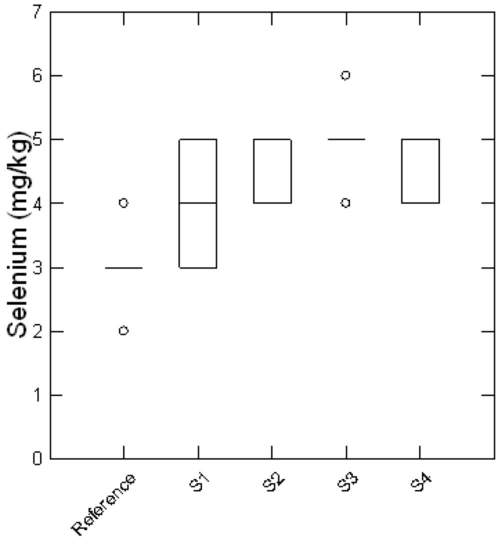
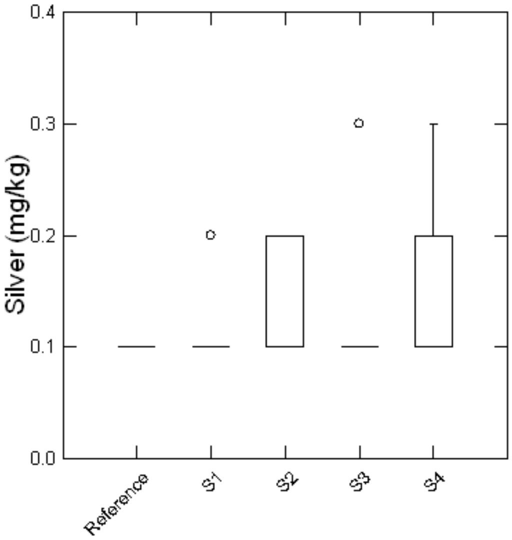
Table G-7	**Results of Dunnett's Tests Comparing Reference Site Analyte Concentrations to Analyte Concentrations at Sites S1, S2, S3, and S4**				
Analyte	**Boxplot**[a]	**Dunnett's Test**[b] **Results (p-value)**			
		S1	**S2**	**S3**	**S4**
Selenium		**0.047**	**0.004**	**<0.001**	**0.001**
Silver		0.891	0.426	0.629	**0.046**

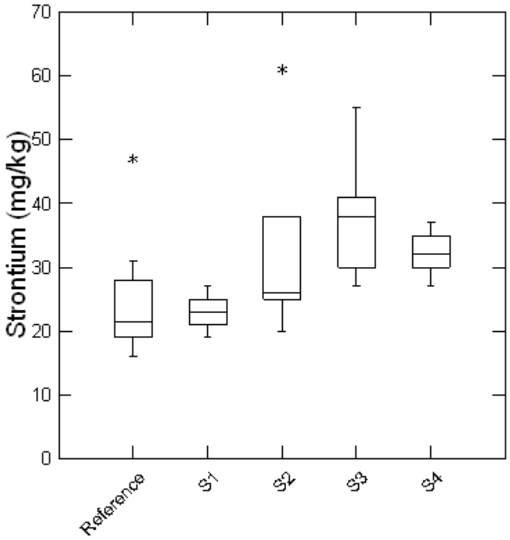
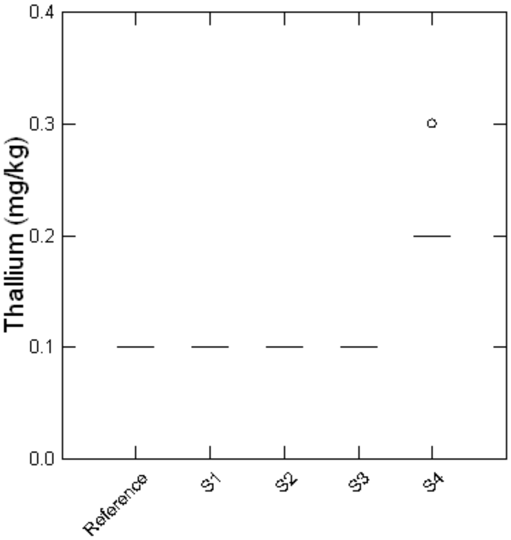
Table G-7	**Results of Dunnett's Tests Comparing Reference Site Analyte Concentrations to Analyte Concentrations at Sites S1, S2, S3, and S4**				
Analyte	**Boxplot**[a]	**Dunnett's Test**[b] **Results (p-value)**			
		S1	**S2**	**S3**	**S4**
Strontium		>0.999	0.255	**0.03**	0.201
Thallium		NA	NA	NA	NA

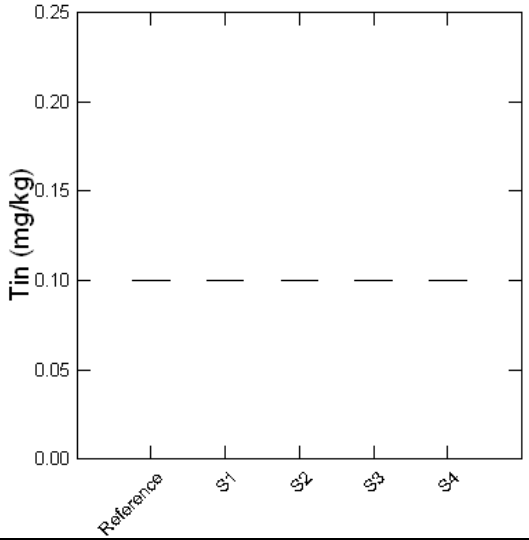
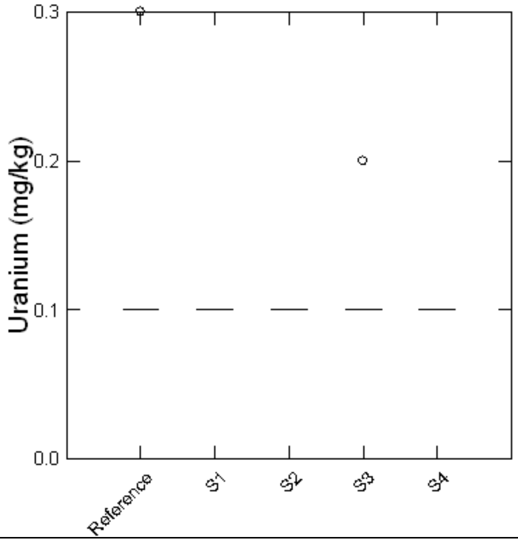
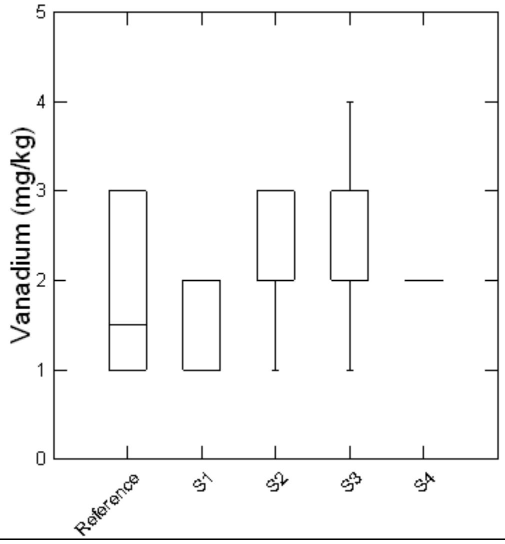
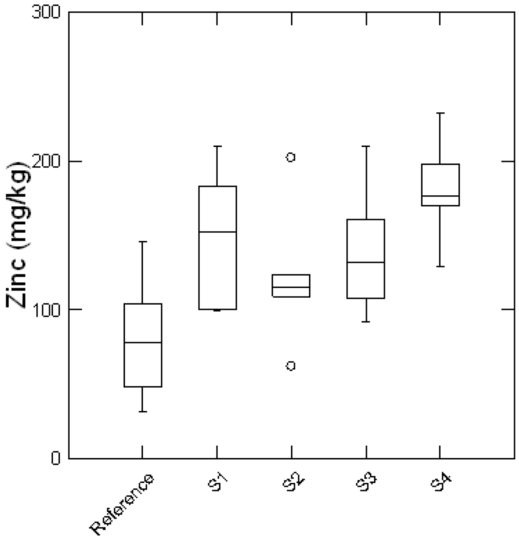
Table G-7	**Results of Dunnett's Tests Comparing Reference Site Analyte Concentrations to Analyte Concentrations at Sites S1, S2, S3, and S4**				
Analyte	**Boxplot**[a]	**Dunnett's Test**[b] **Results (p-value)**			
		S1	**S2**	**S3**	**S4**
Tin		NA	NA	NA	NA
Uranium		NA	NA	NA	NA

Table G-7 Results of Dunnett's Tests Comparing Reference Site Analyte Concentrations to Analyte Concentrations at Sites S1, S2, S3, and S4

Analyte	Boxplot[a]	Dunnett's Test[b] Results (p-value)			
		S1	S2	S3	S4
Vanadium		0.872	0.734	0.574	0.795
Zinc		**0.015**	0.132	**0.026**	**0.001**

Notes –

[a] The top and bottom of each box indicate the 75th and 25th percentiles of the data, respectively. The middle line in each box indicates the median (50th percentile). The whiskers indicate the lowest datum that is within 1.5 times the interquartile range (IQR, which equals the 75th percentile minus the 25th percentile) from the bottom of the box and the highest datum that is within 1.5 IQR from the top of the box. Values that are greater than 1.5 IQR but less than or equal to 3 IQR from the box are indicated with asterisks. Values that are more than 3 IQR from the box are indicated by empty circles.

[b] Data were log-transformed prior to analysis to improve data normality

[c] Statistical comparisons were not preformed when there were less than four samples (or <20% of samples) from sampling location were greater than detection limit.

Table G-8 Summary of Dunnett's Tests Comparing Reference Site Analyte Concentrations to Analyte Concentrations at Sites S1, S2, S3, and S4

Analyte	Significantly Different from Reference Site ($p<0.05$)?				Notes
	S1	S2	S3	S4	
Aluminum	N	N	N	N	
Antimony	NA	NA	NA	NA	Only 1 sample in the reference location was detected, it was equal to the detection limit (9/10). S1 had 2 detected values, both equal to the detection limit. All other sampling locations had detected values at or near detection limit.
Arsenic	N	N	Y	N	
Barium	N	N	N	N	
Boron	N	N	N	N	
Cadmium	Y	Y	Y	Y	
Chromium	N	N	N	N	
Cobalt	N	N	N	N	
Copper	N	Y	Y	Y	
Iron	N	N	N	N	
Lead	Y	Y	Y	Y	
Lithium	N	N	N	N	
Magnesium	N	N	N	N	
Molybdenum	N	N	N	N	
Nickel	N	N	N	N	
Rubidium	N	N	N	N	
Selenium	Y	Y	Y	Y	
Silver	N	N	N	Y	
Strontium	Y	N	N	N	
Thallium	NA	NA	NA	NA	All samples were less than the detection limit in the reference location (10/10), as well as at S1, S2 and S4 (5/5). S3 had 1 detected value, equal to the detection limit.
Tin	NA	NA	NA	NA	All samples were less than the detection limit in the reference location (10/10), as well as at S1 and S4 (5/5). S2 and S3 each had 1 detected value, equal to the detection limit.
Uranium	NA	NA	NA	NA	Of the 2 detected samples in the reference location, 1 was equal to detection limit. All other samples were below detection limit (8/10). S1 had 1 detection value, S2 had 2 detected values, each equal to the detection limit. S3 had 2 detected values, 1 was equal to detection limit. S4 also had 2 detected values, both were equal to detection limit.
Vanadium	N	N	N	N	
Zinc	Y	N	Y	Y	

Notes – Sites for which analyte concentrations were significantly higher than those at the reference site are shaded

Tukey's Honestly-Significant-Difference Test for Cadmium		
CATEGORY(i)	CATEGORY(j)	p-Value
Reference	S1	**<0.001**
Reference	S2	**<0.001**
Reference	S3	**<0.001**
Reference	S4	**<0.001**
S1	S2	>0.999
S1	S3	>0.999
S1	S4	0.801
S2	S3	0.998
S2	S4	0.854
S3	S4	0.685

Tukey's Honestly-Significant-Difference Test for Lead		
CATEGORY(i)	CATEGORY(j)	p-Value
Reference	S1	**<0.001**
Reference	S2	**<0.001**
Reference	S3	**<0.001**
Reference	S4	**<0.001**
S1	S2	0.999
S1	S3	0.959
S1	S4	0.573
S2	S3	0.993
S2	S4	0.418
S3	S4	0.221

Tukey's Honestly-Significant-Difference Test for Zinc		
CATEGORY(i)	CATEGORY(j)	p-Value
Reference	S1	**0.029**
Reference	S2	0.22
Reference	S3	**0.05**
Reference	S4	**0.002**
S1	S2	0.906
S1	S3	>0.999
S1	S4	0.897
S2	S3	0.964
S2	S4	0.417
S3	S4	0.802

APPENDIX H

SUPPLEMENTARY FIELD INFORMATION (MINNOW ENVIRONMENTAL, 2014)

Table H-1: Beach sand intertidal zone sampling heights and substrate observations. Intertidal heights relative to chart datum.

Station ID	Latitude Degrees	Longitude Degrees	Sampling Date	Sampling Time	Intertidal Low Sampling Ht.	Intertidal High Sampling Ht.	Avg. Intertidal Level of Sampling	Observations
SBS-01	47.907275	65.83134	8-Oct-14	12:50	1.53	2.64	2.09	fine gravel in the low intertidal zone transitioning to fine gravel and coarse sand then to coarse sand higher in the intertidal zone; some slag dust observed in the high intertidal zone
SBS-02	47.90508	65.82990	8-Oct-14	12:35	1.45	2.51	1.98	coarse sand in low intertidal zone transitioning to medium sand then to fine sand high in the intertidal zone; slag and slag dust observed higher in the intertidal zone
SBS-03	47.90289	65.82879	8-Oct-14	12:20	1.51	2.53	2.02	coarse sand in the low intertidal zone transitioning to medium sand higher in the intertidal zone; slag and slag dust observed in the high intertidal zone
SBS-04	47.90075	65.82736	8-Oct-14	12:05	1.26	1.26	1.26	medium-coarse sand with some gravel throughout the intertidal zone; no slag observed
SBS-05	47.89925	65.82592	13-Oct-14	13:15	0.76	2.70	1.73	coarse sand in low intertidal zone transitioning to medium sand then to fine sand high in the intertidal zone; slag observed in the high intertidal zone
SBS-06	47.89797	65.82401	13-Oct-14	13:30	0.79	2.72	1.75	coarse sand in low intertidal zone transitioning to fine sand higher in the intertidal zone; some slag observed in the high intertidal zone
SBS-07	47.89649	65.82191	13-Oct-14	13:45	0.76	2.42	1.59	coarse sand in low intertidal zone transitioning to coarse-medium sand higher in the intertidal zone; some slag observed in the high intertidal zone
SBS-08	47.89554	65.81944	12-Oct-14	10:30	1.21	1.99	1.60	medium to coarse sand throughout the intertidal zone; no slag observed
SBS-09	47.89468	65.81852	12-Oct-14	10:50	1.12	2.22	1.67	fine sand in the low intertidal zone transitioning to coarse sand then to fine sand in the high intertidal zone; no slag observed

Table H-1: Beach sand intertidal zone sampling heights and substrate observations. Intertidal heights relative to chart datum.

Station ID	Latitude Degrees	Longitude Degrees	Sampling Date	Sampling Time	Intertidal Low Sampling Ht.	Intertidal High Sampling Ht.	Avg. Intertidal Level of Sampling	Observations
SBS-10	47.89344	65.81762	12-Oct-14	11:10	1.03	2.33	1.68	coarse sand and gravel at low intertidal zone transitioning to medium sand, then to a mixture of fine and coarse sand with progression to high intertidal zone; no slag observed
SBS-11	47.89232	65.81652	12-Oct-14	11:25	1.01	2.34	1.68	medium sand in the lower intertidal zone transitioning to medium-fine sand higher in the intertidal zone; no slag observed
SBS-12	47.89122	65.81534	12-Oct-14	11:40	0.81	2.69	1.75	coarse sand in low intertidal zone transitioning to fine sand higher in the intertidal zone; no slag observed
SBS-13	47.88999	65.81344	12-Oct-14	12:00	0.66	2.46	1.56	coarse sand in the low intertidal zone transitioning to fine sand higher in the intertidal zone; no slag observed
SBS-14	47.88915	65.81248	12-Oct-14	12:15	0.59	2.20	1.40	coarse sand in the lower intertidal zone transitioning to medium-fine sand higher in the intertidal zone; no slag observed
SBS-15	47.88821	65.81116	12-Oct-14	12:30	0.53	2.50	1.51	coarse sand and gravel in the low intertidal zone transitioning to coarse sand then to fine sand higher in the intertidal zone; no slag observed
SBS-16	47.88764	65.81030	12-Oct-14	12:45	0.59	2.54	1.57	fine sand in the low intertidal zone transitioning to fine sand with gravel higher in the intertidal zone; no slag observed
SBS-17	47.88677	65.80891	12-Oct-14	13:00	0.74	2.31	1.52	medium-fine sand in the low intertidal zone transitioning to fine sand higher in the intertidal zone; no slag observed
SBS-18	47.88595	65.80744	12-Oct-14	13:15	0.91	2.56	1.74	fine sand throughout the intertidal zone; no slag observed
SBS-19	47.88510	65.80575	12-Oct-14	13:30	0.83	2.43	1.63	coarse sand mixed with mud (anoxic sediments below the surface) low in the intertidal zone transitioning to fine-coarse sand higher in the intertidal zone; no slag observed

Table H-1: Beach sand intertidal zone sampling heights and substrate observations. Intertidal heights relative to chart datum.

Station ID	Latitude Degrees	Longitude Degrees	Sampling Date	Sampling Time	Intertidal Low Sampling Ht.	Intertidal High Sampling Ht.	Avg. Intertidal Level of Sampling	Observations
SBS-20	47.88386	65.80389	12-Oct-14	13:45	0.85	2.24	1.55	coarse sand in the low intertidal zone transitioning to coarse sand and gravel, then to fine sand in the high intertidal zone; no slag observed
SBS-21	47.88311	65.80096	12-Oct-14	14:05	0.94	2.63	1.78	coarse sand low in the intertidal zone transitioning to fine sand higher in the intertidal zone; no slag observed
RBS-01	47.91786	65.93151	13-Oct-14	12:35	0.81	2.36	1.59	coarse sand in the low intertidal zone transitioning to fine sand then to fine-coarse sand higher in the intertidal zone; no slag observed
RBS-02	47.91830	65.92963	13-Oct-14	12:20	0.97	2.45	1.71	coarse sand in the low intertidal zone transitioning to fine sand higher in the intertidal zone; no slag observed
RBS-03	47.91842	65.92788	13-Oct-14	11:35	1.14	2.42	1.78	medium sand throughout the intertidal zone; no slag observed
RBS-04	47.91902	65.92509	13-Oct-14	12:00	0.99	2.64	1.81	coarse sand in the low intertidal zone transitioning to medium sand with gravel, then to fine sand with gravel higher in the intertidal zone; no slag observed
RBS-05	47.91953	65.90265	13-Oct-14	15:00	1.05	1.81	1.43	fine sand throughout the intertidal zone; no slag observed
RBS-06	47.92057	65.90584	13-Oct-14	15:15	1.15	2.00	1.57	fine-medium sand in the low intertidal zone transitioning to fine sand, then to fine sand with some gravel higher in the intertidal zone; no slag observed

Table H-2: Beach invertebrate sampling station details and invertebrate composition (by mass).

Station ID	Latitude Degrees	Longitude Degrees	Sampling Date	Invertebrate Type and Mass (g) per Sample				
				Amphipods	Isopods	Mysidacea	Polychaetes	Total Mass
SBS-01[a]	47.90728	65.83134	-	-	-	-	-	0.000
SBS-02[a]	47.90508	65.82990	-	-	-	-	-	0.000
SBS-03[a]	47.90289	65.82879	-	-	-	-	-	0.000
SBS-04	47.90075	65.82736	13-Oct-14	1.566	0.049	0.706	-	2.321
SBS-05	47.89925	65.82592	13-Oct-14	2.834	-	0.087	0.103	3.024
SBS-06	47.89797	65.82401	13-Oct-14	1.590	-	0.683	0.170	2.443
SBS-07	47.89649	65.82191	13-Oct-14	2.852	-	-	-	2.852
SBS-08	47.89554	65.81944	12-Oct-14	2.904	-	-	0.048	2.952
SBS-09	47.89468	65.81852	12-Oct-14	2.998	0.160	-	-	3.158
SBS-10	47.89344	65.81762	12-Oct-14	0.538	-	1.320	-	1.858
SBS-11	47.89232	65.81652	12-Oct-14	0.302	-	3.909	-	4.211
SBS-12	47.89122	65.81534	12-Oct-14	1.950	0.074	-	-	2.024
SBS-13	47.88999	65.81344	12-Oct-14	1.824	-	-	-	1.824
SBS-14	47.88915	65.81248	12-Oct-14	3.240	0.070	-	-	3.310
SBS-15	47.88821	65.81116	12-Oct-14	2.165	0.148	-	-	2.313
SBS-16	47.88764	65.81030	12-Oct-14	3.269	-	0.360	-	3.629
SBS-17	47.88677	65.80891	12-Oct-14	2.345	0.041	-	-	2.386
SBS-18	47.88595	65.80744	12-Oct-14	2.271	-	-	-	2.271
SBS-19	47.88510	65.80575	12-Oct-14	1.746	0.036	0.049	0.074	1.905
SBS-20	47.88386	65.80389	12-Oct-14	2.250	0.021	-	-	2.271
SBS-21	47.88311	65.80096	12-Oct-14	1.085	0.528	0.636	0.140	2.389
RBS-01	47.91786	65.93151	13-Oct-14	5.108	0.089	-	0.145	5.342
RBS-02	47.91830	65.92963	13-Oct-14	1.892	-	0.729	-	2.621
RBS-03	47.91842	65.92788	13-Oct-14	2.530	-	-	-	2.530
RBS-04	47.91902	65.92509	13-Oct-14	2.517	-	-	-	2.517
RBS-05	47.91953	65.90265	13-Oct-14	2.953	-	-	-	2.953
RBS-06	47.92057	65.90584	13-Oct-14	3.956	-	0.289	-	4.245

[a] No sample was collected due to lack of suitable habitat for capture of intertidal benthic invertebrates of sufficient mass for sample collection in timely manner.

Table H-3: Summary of surface and bottom field-based water quality measures at mussel cage stations, Brunswick Smelter ERA, August and October 2014.

Timing and Cage ID		Date Sampled	Coordinates (UTM)	Profile Depth	Temp. (°C)	Dissolved Oxygen		Salinity (ppt)	pH (units)
						(mg/L)	(% sat.)		
August (Deployment)	S1	05-Aug-14	5309913	surface	20.83	8.35	108.7	26.12	8.00
			288583	bottom					
	S2	05-Aug-14	5309305	surface	21.32	9.02	112.1	26.08	8.12
			288814	bottom					
	S3	05-Aug-14	5308809	surface	19.51	8.44	107.3	26.32	8.13
			289339	bottom					
	S4	05-Aug-14	5308312	surface	20.20	8.41	114.4	26.29	8.16
			289749	bottom					
	R1	06-Aug-14	5311809	surface	19.94	7.70	100.5	25.67	8.09
			283163	bottom	19.10	8.12	101.8	25.92	8.08
	R2	06-Aug-14	5311372	surface	20.36	7.99	100.7	25.66	8.09
			283929	bottom	18.82	7.90	99.2	25.98	8.07
October (Retrieval)	S1	07-Oct-14	5309913	surface	12.49	8.99	100.1	27.27	7.84
			288583	bottom	12.49	8.97	99.8	27.20	7.84
	S2	07-Oct-14	5309305	surface	12.35	9.12	101.2	27.26	7.85
			288814	bottom	12.34	9.07	100.6	27.26	7.84
	S3	07-Oct-14	5308809	surface	12.44	9.14	101.6	27.30	7.85
			289339	bottom	12.42	9.11	101.3	27.31	7.85
	S4	07-Oct-14	5308312	surface	12.41	9.22	102.5	27.29	7.85
			289749	bottom	12.41	9.21	102.3	27.29	7.85
	R1	07-Oct-14	5311809	surface	12.69	9.16	102.3	27.24	7.86
			283163	bottom	12.61	9.14	102.0	27.25	7.86
	R2	07-Oct-14	5311372	surface	12.72	9.02	100.9	27.30	7.86
			283929	bottom	12.67	8.97	100.2	27.30	7.86
	S1	09-Oct-14	5309913	surface	12.38	8.69	96.6	27.35	7.85
			288583	bottom	12.37	8.68	96.5	27.36	7.85
	S2	09-Oct-14	5309305	surface	12.39	8.92	99.0	27.30	7.86
			288814	bottom	12.37	8.80	97.5	27.32	7.85
	S3	09-Oct-14	5308809	surface	12.43	9.01	100.2	27.31	7.86
			289339	bottom	12.40	8.92	99.1	27.33	7.86
	S4	09-Oct-14	5308312	surface	12.43	8.93	99.4	27.21	7.85
			289749	bottom	12.46	9.25	102.8	27.22	7.88
	R1	09-Oct-14	5311809	surface	12.17	9.01	99.6	27.24	7.88
			283163	bottom	12.15	8.99	99.3	27.20	7.88
	R2	09-Oct-14	5311372	surface	12.23	9.25	101.9	26.60	7.90
			283929	bottom	12.27	9.26	102.7	27.28	7.90
	S1	11-Oct-14	5309913	surface	12.15	8.77	97.3	27.79	7.89
			288583	bottom					
	S2	11-Oct-14	5309305	surface	12.07	8.91	98.4	27.32	7.88
			288814	bottom					
	S3	11-Oct-14	5308809	surface	12.02	8.98	98.9	27.31	7.88
			289339	bottom					
	S4	11-Oct-14	5308312	surface	11.81	9.68	106.2	27.30	7.93
			289749	bottom					
	R1	11-Oct-14	5311809	surface	11.38	9.38	101.4	26.61	7.92
			283163	bottom					
	R2	11-Oct-14	5311372	surface	11.58	9.10	98.8	26.83	7.90
			283929	bottom					

Table H-4: In-situ water quality profile data collected at Smelter-Exposed mussel cage locations at time of cage deployment, Brunswick Smelter ERA, August 2014.

Mussel Cage ID	Depth (m)	Temperature	Dissolved Oxygen		pH	Specific Conductance	Salinity
		(˚C)	(mg/L)	(% sat)	(pH units)	(µS/cm)	(ppt)
S1	0.5	19.91	8.35	106.9	7.71	40,155	25.70
	1.0	19.78	8.26	105.5	7.92	40,275	25.79
	1.5	19.36	8.43	106.9	7.96	40,402	25.87
	2.0	18.83	8.79	110.5	7.99	40,580	25.98
	2.5	18.36	8.96	111.3	8.00	40,683	26.09
	3.0	18.00	9.11	112.4	8.00	40,726	26.11
	3.5	17.96	9.09	112.2	8.01	40,725	26.11
	4.0	17.82	9.09	111.8	8.01	40,754	26.13
	4.5	17.65	9.08	111.3	8.01	40,777	26.15
	5.0	17.55	9.07	110.9	8.01	40,802	26.16
S2	0.5	19.14	8.92	112.5	8.03	40,506	25.95
	1.0	19.12	8.84	111.4	8.04	40,505	25.95
	1.5	19.12	8.82	111.1	8.05	40,507	25.95
	2.0	19.09	8.80	110.9	8.05	40,512	25.96
	2.5	19.00	8.80	110.6	8.05	40,532	25.97
	3.0	18.92	8.77	110.2	8.05	40,543	25.98
	3.5	18.67	8.79	109.8	8.05	40,606	26.03
	4.0	16.97	9.01	109.0	8.04	40,913	26.24
	4.5	16.42	8.85	106.0	8.02	41,008	26.30
S3	0.5	19.38	8.20	103.9	8.04	40,480	25.93
	1.0	19.26	8.23	104.1	8.05	40,514	25.96
	1.5	19.03	8.40	105.6	8.05	40,534	25.97
	2.0	18.84	8.47	106.2	8.05	40,572	26.00
	2.5	18.63	8.52	106.4	8.05	40,597	26.02
	3.0	18.31	8.56	106.3	8.05	40,663	26.07
	3.5	17.29	8.60	104.8	8.03	40,835	26.20
	4.0	16.03	8.70	103.4	8.02	41,120	26.38
S4	0.5	19.42	8.12	102.8	8.04	40,409	25.89
	1.0	19.37	8.12	102.9	8.04	40,476	25.94
	1.5	19.36	8.21	104.2	8.05	40,542	25.97
	2.0	19.37	8.35	106.2	8.07	40,589	26.01
	2.5	19.34	8.52	108.1	8.08	40,609	26.03
	3.0	19.31	8.62	109.3	8.08	40,622	26.03
	3.5	19.04	8.72	109.8	8.08	40,661	26.07
	4.0	17.85	9.29	115.4	8.11	40,873	26.20
	4.5	16.92	9.54	114.7	8.07	40,986	26.29

Table H-5: Atlantic herring (*Clupea harengus*) measurement data for Smelter-Exposed (EXP) area samples submitted for tissue metals analysis, Brunswick Smelter ERA, August 2014.

Sample ID	Composite Sample Info.	Measurements	
		Total Length (mm)	Whole Wet Weight (g)
EXP-AH-01	1	49.25	0.916
	2	51.88	0.955
	3	43.70	0.546
	4	42.61	0.485
	5	40.57	0.410
	6	44.36	0.560
	7	44.34	0.567
	8	46.99	0.642
	Average	45.46	0.635
	SD	3.69	0.197
EXP-AH-02	1	38.19	0.350
	2	39.60	0.386
	3	42.14	0.493
	4	43.46	0.516
	5	48.82	0.782
	6	45.63	0.619
	7	47.50	0.636
	8	49.49	0.702
	Average	44.35	0.561
	SD	4.21	0.151
EXP-AH-03	1	47.03	0.620
	2	46.13	0.560
	3	49.09	0.755
	4	43.17	0.502
	5	46.44	0.662
	6	43.08	0.544
	7	51.27	0.937
	8	44.01	0.541
	Average	46.28	0.640
	SD	2.89	0.145
EXP-AH-04	1	58.06	1.330
	2	44.52	0.535
	3	39.94	0.381
	4	40.52	0.409
	5	50.01	0.899
	6	46.52	0.670
	7	44.68	0.575
	8	43.51	0.600
	Average	45.97	0.675
	SD	5.84	0.310
EXP-AH-05	1	47.67	0.716
	2	45.51	0.664
	3	45.00	0.645
	4	50.74	0.855
	5	40.19	0.413
	6	41.18	0.435
	7	42.89	0.483
	8	48.03	0.754
	Average	45.15	0.621
	SD	3.62	0.161
EXP-AH-06	1	47.93	0.738
	2	38.36	0.335
	3	44.66	0.567
	4	42.99	0.534
	5	41.04	0.478
	6	42.87	0.502
	7	43.95	0.575
	8	48.16	0.691
	Average	43.75	0.553
	SD	3.28	0.125

Table H-5: Atlantic herring (*Clupea harengus*) measurement data for Smelter-Exposed (EXP) area samples submitted for tissue metals analysis, Brunswick Smelter ERA, August 2014.

Sample ID	**Composite Sample Info.**	**Measurements**	
		Total Length (mm)	**Whole Wet Weight (g)**
EXP-AH-07	1	50.03	0.791
	2	45.22	0.659
	3	43.39	0.511
	4	45.49	0.605
	5	51.94	0.893
	6	41.20	0.419
	7	42.88	0.539
	8	44.05	0.552
	Average	45.53	0.621
	SD	3.66	0.155
EXP-AH-08	1	50.66	0.926
	2	52.79	0.980
	3	41.81	0.461
	4	51.33	0.919
	5	45.25	0.529
	6	42.92	0.502
	7	48.15	0.671
	8	45.05	0.565
	Average	47.25	0.694
	SD	4.09	0.214
EXP-AH-09	1	45.93	0.652
	2	44.93	0.585
	3	45.65	0.633
	4	46.61	0.656
	5	53.77	1.077
	6	45.62	0.584
	7	45.09	0.558
	8	48.37	0.694
	Average	47.00	0.680
	SD	2.94	0.167
EXP-AH-10	1	42.69	0.505
	2	47.33	0.628
	3	46.31	0.608
	4	62.10	1.928
	5	44.29	0.623
	6	52.04	0.860
	7	41.53	0.481
	8	46.53	0.688
	Average	47.85	0.790
	SD	6.59	0.474

Table H-6: Atlantic herring (*Clupea harengus*) measurement data for Reference area (REF) samples submitted for tissue metals analysis, Brunswick Smelter ERA, August 2014.

Sample ID	Composite Sample Info.	Measurements	
		Total Length (mm)	Whole Wet Weight (g)
REF-AH-01	1	83.62	4.125
	2	53.13	1.123
	Average	68.38	2.624
	SD	21.56	2.123
REF-AH-02	1	66.74	2.070
	2	57.52	1.132
	3	59.30	1.346
	4	50.30	0.786
	Average	58.47	1.334
	SD	6.75	0.543
REF-AH-03	1	81.76	3.756
	2	54.20	0.973
	Average	67.98	2.365
	SD	19.49	1.968
REF-AH-04	1	63.31	1.616
	2	78.40	3.460
	Average	70.86	2.538
	SD	10.67	1.304
REF-AH-05	1	48.00	0.727
	2	59.96	1.530
	3	63.85	1.810
	4	42.87	0.498
	5	64.00	1.637
	Average	55.74	1.240
	SD	9.71	0.587

Table H-7: Sand lance (*Ammodytes* sp.) measurement data for Smelter-Exposed (EXP) area samples submitted for tissue metals analysis, Brunswick Smelter ERA, August 2014.

Sample ID	Composite Sample Info.	Measurements	
		Total Length (mm)	Whole Wet Weight (g)
EXP-SL-01	1	79.83	1.438
	2	56.13	0.480
	3	54.62	0.528
	4	55.69	0.508
	5	53.23	0.426
	6	50.95	0.408
	Average	58.41	0.631
	SD	10.66	0.398
EXP-SL-02	1	55.88	0.560
	2	47.19	0.307
	3	59.06	0.585
	4	62.13	0.730
	5	49.63	0.374
	6	54.12	0.478
	7	45.34	0.279
	8	46.13	0.318
	9	47.89	0.329
	10	46.97	0.273
	Average	51.43	0.423
	SD	5.95	0.157
EXP-SL-03	1	65.74	0.754
	2	64.96	0.770
	3	62.56	0.678
	4	48.46	0.364
	5	45.50	0.262
	6	64.52	0.898
	7	47.56	0.338
	8	54.08	0.419
	Average	56.67	0.560
	SD	8.69	0.241
EXP-SL-04	1	52.94	0.405
	2	58.42	0.640
	3	57.30	0.504
	4	50.65	0.362
	5	43.14	0.250
	6	55.15	0.536
	7	53.24	0.414
	8	39.46	0.192
	9	55.21	0.539
	10	51.00	0.383
	11	50.40	0.380
	12	54.16	0.525
	Average	51.76	0.428
	SD	5.54	0.128
EXP-SL-05	1	50.62	0.408
	2	49.89	0.372
	3	50.35	0.350
	4	47.84	0.336
	5	57.84	0.520
	6	47.92	0.309
	7	58.97	0.526
	8	45.14	0.312
	9	49.69	0.325
	10	50.28	0.331
	11	54.26	0.537
	12	55.19	0.528
	Average	51.50	0.405
	SD	4.19	0.095
EXP-SL-06	1	48.46	0.311
	2	60.10	0.654
	3	50.60	0.347
	4	45.64	0.309
	5	48.68	0.331
	6	55.11	0.501
	7	56.75	0.491
	8	46.16	0.252
	9	59.39	0.551
	10	55.13	0.512
	11	44.78	0.249
	12	53.48	0.467
	13	50.79	0.368
	Average	51.93	0.411
	SD	5.15	0.126

Table H-8: Sand lance (*Ammodytes* sp.) measurement data for Reference area (REF) samples submitted for tissue metals analysis, Brunswick Smelter ERA, August 2014.

Sample ID	Composite Sample Info.	Measurements	
		Total Length (mm)	Whole Wet Weight (g)
REF-SL-01	1	62.90	0.877
	2	72.36	1.342
	3	71.65	1.183
	4	70.97	1.129
	5	67.27	0.959
	Average	69.03	1.098
	SD	3.95	0.184
REF-SL-02	1	66.16	0.965
	2	66.54	1.088
	3	77.80	1.773
	4	74.93	1.453
	5	75.19	1.368
	Average	72.12	1.329
	SD	5.39	0.318
REF-SL-03	1	80.64	1.880
	2	100.53	2.884
	3	74.87	1.402
	Average	85.35	2.055
	SD	13.46	0.756
REF-SL-04	1	80.12	1.634
	2	113.43	4.013
	Average	96.78	2.824
	SD	23.55	1.682
REF-SL-05	1	76.22	1.541
	2	87.15	2.138
	3	76.43	1.618
	Average	79.93	1.766
	SD	6.25	0.325
REF-SL-06	1	73.39	1.374
	2	90.30	2.612
	3	79.45	1.886
	Average	81.05	1.957
	SD	8.57	0.622
REF-SL-07	1	69.86	1.177
	2	70.88	1.178
	3	62.63	0.913
	4	67.65	1.074
	5	61.56	0.856
	Average	66.52	1.040
	SD	4.22	0.149
REF-SL-08	1	73.38	1.100
	2	58.23	0.648
	3	83.71	2.152
	4	59.98	0.807
	5	87.78	2.385
	Average	72.62	1.418
	SD	13.42	0.797
REF-SL-09	1	61.75	0.728
	2	58.28	0.634
	3	66.47	0.917
	4	80.60	1.909
	5	77.81	1.612
	Average	68.98	1.160
	SD	9.82	0.567
REF-SL-10	1	83.27	1.810
	2	87.30	2.359
	3	86.01	2.168
	Average	85.53	2.112
	SD	2.06	0.279

Table H-9: Blue mussel (*Mytilus edulis*) measurement data for samples submitted for soft (soma) tissue metals analysis at initiation (T0) of caged mussel study, Brunswick Smelter ERA, August 2014.

Sample ID	Composite Sample Info.	Mussel Measures at Deployment (T_0; August)				
		Length (mm)	Width (mm)	Height (mm)	Whole Wet Weight (g)	Soma Wet Weight (g)
BM-T0-01	1	34.02	12.11	20.06	3.889	1.474
	2	29.13	10.51	15.85	2.237	0.779
	3	33.59	12.26	18.66	3.566	1.217
	4	31.24	11.36	17.42	2.697	1.081
	5	32.06	13.47	18.92	4.017	1.352
	Average	32.01	11.94	18.18	3.281	1.181
	SD	1.96	1.10	1.61	0.778	0.268
BM-T0-02	1	37.50	12.95	19.37	3.991	1.619
	2	33.74	12.77	19.02	4.035	1.555
	3	32.83	11.91	18.28	3.180	1.078
	4	33.24	11.32	17.75	3.442	1.175
	Average	34.33	12.24	18.61	3.662	1.357
	SD	2.15	0.76	0.73	0.420	0.270
BM-T0-03	1	35.07	12.27	19.24	3.673	1.352
	2	35.83	12.87	19.97	4.186	1.854
	3	31.44	12.11	17.79	2.739	1.131
	4	31.42	12.90	19.25	3.726	1.559
	Average	33.44	12.54	19.06	3.581	1.474
	SD	2.34	0.41	0.91	0.607	0.308
BM-T0-04	1	33.49	10.81	19.97	3.172	1.175
	2	34.24	12.32	18.31	3.287	1.363
	3	35.23	12.21	18.95	3.877	1.522
	4	30.60	12.24	17.75	2.994	1.256
	Average	33.39	11.90	18.75	3.333	1.329
	SD	1.99	0.72	0.95	0.382	0.150
BM-T0-05	1	30.65	12.20	17.38	2.853	1.107
	2	31.58	11.13	17.89	2.654	0.997
	3	32.80	12.32	17.36	3.154	1.168
	4	33.17	11.74	18.31	2.766	1.138
	Average	32.05	11.85	17.74	2.857	1.103
	SD	1.15	0.54	0.46	0.214	0.075
BM-T0-06	1	32.94	12.02	19.01	3.172	1.138
	2	32.68	12.09	17.66	3.172	1.273
	3	30.31	12.52	17.44	3.616	1.343
	4	33.76	12.62	19.07	3.835	1.571
	Average	32.42	12.31	18.30	3.449	1.331
	SD	1.48	0.30	0.87	0.332	0.181
BM-T0-07	1	35.54	13.28	18.24	4.221	1.975
	2	32.90	10.61	19.34	3.099	1.348
	3	30.89	10.93	16.59	2.383	0.926
	4	34.79	12.31	17.36	3.690	1.604
	Average	33.53	11.78	17.88	3.348	1.463
	SD	2.08	1.24	1.18	0.790	0.441
BM-T0-08	1	32.61	11.19	17.88	2.635	1.036
	2	31.97	11.77	19.92	3.654	1.375
	3	34.10	12.00	19.33	3.142	1.458
	4	34.78	11.80	20.43	3.799	1.537
	Average	33.37	11.69	19.39	3.308	1.352
	SD	1.30	0.35	1.10	0.530	0.220
BM-T0-09	1	35.30	12.66	18.36	3.575	1.435
	2	33.51	12.06	20.01	3.563	1.459
	3	35.44	12.27	19.21	3.969	1.672
	4	33.25	12.16	18.36	3.123	1.212
	Average	34.38	12.29	18.99	3.558	1.445
	SD	1.16	0.26	0.79	0.346	0.188
BM-T0-10	1	35.17	11.94	19.93	3.914	1.610
	2	33.35	12.34	18.35	3.695	1.418
	3	34.06	12.47	18.09	3.978	1.510
	4	33.60	12.50	18.13	4.094	1.784
	Average	34.05	12.31	18.63	3.920	1.581
	SD	0.81	0.26	0.88	0.168	0.157

APPENDIX I

CHEMICALS OF POTENTIAL CONCERN SCREENING FOR AVIAN RECEPTORS

I-1.0 CHEMICALS OF POTENTIAL CONCERN SCREENING FOR AVIAN RECEPTORS

This appendix provides a description of the methods used to determine the chemicals of potential concern (COPCs) for avian receptors quantitatively evaluated in the ecological risk assessment (ERA) (i.e., spotted sandpiper, common tern and black crowned night heron). Beach sand sampling was conducted by Minnow Environmental during the fall of 2014, on Belledune Point and along the eastern portion of the coast and within references areas. Analytical results are provided in Appendix B. Concentrations reported as less than the analytical detection limit were replaced with the full detection limit for the purpose of calculating summary statistics, graphing data, or performing statistical analyses. Additionally, field duplicate samples were combined such that the higher concentration between sample and duplicate sample was selected for each chemical.

To determine COPCs, beach sand sampling results were screened by comparing maximum site concentrations to relevant ecological-health based guidelines and to the 95th percentile reference area concentrations. Results of screening against guidelines and the 95th percentile of reference area concentrations are provided in Section I-1.1. For chemicals with no applicable guidelines with maximum concentrations greater than the 95th percentile of reference, an additional comparison between reference and site concentrations is provided in Section I-1.2. The final COPCs for receptors quantitatively modelled in the ERA are provided in Section I-1.3.

I-1.1 Beach Sand Screening Against Guidelines and 95th Percentile of Reference

Beach sand samples were collected along the shore of Belledune Point, to the east of Belledune Point (the western shoreline of Belledune Point has been filled in), and in reference areas to the west of Belledune Point (close to Little Belledune Point). The areas in which these samples were collected were divided into three “study areas” and one reference area. The three study areas were:

- Area 1: Data collected on Belledune Point, which is owned by Glencore and has been industrially altered with cleared trees, etc. (i.e., samples SBS-1 to SBS-7);
- Area 2: Data from areas that are owned by Glencore but not industrially altered (i.e., samples SBS-8 to SBS-14); and
- Area 3: Data collected from areas that are not industrially altered and not owned by Glencore (i.e., samples SBS-15 to SBS-21).

The maximum chemical concentration from within each of these three areas was determined and then compared to both the applicable ecological health-based guidelines (industrial guidelines for Area 1 and residential guidelines for Areas 2 and 3) and to the 95th percentile reference concentration (i.e., 95th percentile of samples RBS-1 to RBS-6). Calcium, magnesium, potassium and sodium are essential nutrients (NRC, 2005) and no soil quality guidelines were available for these elements; as such, they were excluded from further evaluation. While iron is also an essential nutrient, it was evaluated as it could be associated with smelter activities.

At each site, chemicals were carried forward as COPCs for use in quantitative modelling when the maximum concentration at that site exceeded both the applicable guideline and the 95th percentile reference concentration. If no applicable guideline was available, and the maximum site concentration exceeded the 95th percentile reference concentration, further statistical analyses were carried out to determine whether significant differences existed between the study areas and the reference area (see Section I-1.2).

Chemicals which may potentially bioaccumulate (e.g., cadmium, lead, mercury, selenium and thallium) that exceeded reference concentrations and guidelines were carried forward for quantitative modelling (See Tables I-1 to I-3). Soil quality guidelines however, are not protective of exposures via foodchain accumulation (with the exception in some cases where agricultural exposures for livestock have been considered). As such, even if a bioaccumulative chemical does not exceed a guideline, it could lead to potential effects if concentrations accumulate to levels associated with toxicity. Given this, further statistical analyses were applied to bioaccumulative chemicals that did not exceed soil quality guidelines, but which had detectable site concentrations greater than the detection limit. Bioaccumulative chemicals that did not exceed guidelines and for which the majority of samples were not detected and / or were only present at concentrations equal to or similar to the detection limit, were not carried forward for statistical analyses.

Results of the beach sand screening for Areas 1, 2 and 3 are presented in Tables I-1, I-2 and I-3, respectively. Table I-4 provides a summary of chemicals that were selected for further evaluation based on exceedance over the guideline and reference area concentrations; exceedance over reference and no guideline available; and potential for bioaccumulation and number of samples with detectable concentrations.

Table I-1 Comparison of Beach Sand Sampling Results for Area 1 to Industrial Land Use Ecological Health-Based Soil Quality Guidelines and to 95th Percentile of Reference

	Area 1 (N=7)				95%ILE of Reference	SQG_E Industrial	
Analyte	**Min**	**Mean**	**95%ILE**	**Max**			**Source**
Aluminum	12500	14043	15200	15200	9110	NGA	NA
Antimony	3.1	8.2	12.3	12.3	0.18	0.27	US EPA, 2005
Arsenic	76	220	378	400	5	26	CCME, 1997
Barium	38	123	205	209	16	2000	US EPA, 2005
Beryllium	0.5	0.6	0.7	0.7	0.5	21	US EPA, 2005
Bismuth	1	8	24	30	<1	NGA	NA
Boron	6	9	13	14	4	120	OMOE, 2011
Cadmium	5.32	12.03	20.38	20.8	0.08	3.8	CCME, 1999
Chromium	37	46	55	57	18	87	CCME, 1997
Cobalt	25.1	56.0	88.0	89.9	7.0	120	US EPA, 2005
Copper	168	611	977	999	9	91	CCME, 1999
Iron	36300	67986	100380	102000	13950	NGA	NA
Lead	1830	7500	16519	19600	7	70	CCME, 1999
Lithium	16.1	18.4	20.6	20.7	16.4	NGA	NA
Manganese	403	508	594	597	274	4000	US EPA, 2007
Mercury *	<0.01	0.02	0.027	0.03	<0.01	50	CCME, 1999
Molybdenum	1.9	7.4	13.2	13.7	0.2	74	OMOE, 2011
Nickel	25	32	37	38	21	50	CCME, 1999
Rubidium	4.7	6.7	7.7	7.7	6.5	NGA	NA
Selenium	<1	2	4	4	<1	2.9	CCME, 2009
Silver	0.2	1.0	1.9	2	<0.1	4.2	US EPA, 2005
Strontium	22	43	60	61	28	NGA	NA
Tellurium	<0.1	0.3	0.8	0.9	<0.1	NGA	NA
Thallium	2	9	27	33	<0.1	1	CCME, 1999
Tin	20	90	159	164	<1	300	AENV, 2010
Uranium	0.4	0.7	1	1	0.5	2000	CCME, 2007
Vanadium	47	52	59	61	26	130	CCME, 1997
Zinc	5570	21096	36370	36700	36	360	CCME, 1999

Notes:

Units in mg/kg; 95%ILE = 95th percentile; < = analyte not detected, number provided is detection limit; NGA = no guideline available, NA = not applicable; SQG_E = ecological health-based soil quality guideline

Shaded cell indicates maximum site concentration was greater than the 95th percentile of reference soil concentration and greater than ecological health-based soil quality guideline (where available).

Bold and Italicized cell indicates no guideline available and maximum site is concentration greater than 95th percentile reference concentrations; chemical carried forward for statistical evaluation.

* Indicates chemical did not screen based on guideline / reference area comparison, but was carried forward for statistical evaluation due to potential bioaccumulative nature and number of detected samples.

Table I-2 Comparison of Beach Sand Sampling Results for Area 2 to Industrial Land Use Ecological Health-Based Soil Quality Guidelines and to 95th Percentile of Reference

Analyte	Area 2 (N=7)				95%ILE of Reference	SQG$_E$ Residential	Source
	Min	Mean	95%ILE	Max			
Aluminum	12100	14371	15840	16200	9110	NGA	NA
Antimony	<0.1	0.1	0.2	0.2	0.2	0.27	US EPA, 2005
Arsenic	11	16	24	25	5	17	CCME, 1997
Barium	11	19	31	35	16	2000	US EPA, 2005
Beryllium	0.4	0.4	0.4	0.4	0.5	21	US EPA, 2005
Bismuth	<1	NC	NC	<1	<1	NGA	NA
Boron	4	5	5	5	4	120	OMOE, 2011
Cadmium *	0.23	0.30	0.43	0.47	0.08	3.8	CCME, 1999
Chromium	34	43	52	53	18	64	CCME, 1997
Cobalt	11	13	15	15	7	120	US EPA, 2005
Copper	12	15	18	18	9	63	CCME, 1999
Iron	18300	22200	24780	24900	13950	NGA	NA
Lead	37.3	56.3	82.6	90.2	7	70	CCME, 1999
Lithium	16	18	19	19	16	NGA	NA
Manganese	301	362	411	426	274	4000	US EPA, 2007
Mercury	<0.01	0.01	0.01	0.01	<0.01	12	CCME, 1999
Molybdenum	<0.1	0.1	0.2	0.2	0.2	6.9	OMOE, 2011
Nickel	30	36	42	43	21	50	CCME, 1999
Rubidium	3.8	4.3	5.0	5.1	6.5	NGA	NA
Selenium	<1	NC	NC	<1	<1	1	CCME, 2009
Silver	<0.1	NC	NC	<0.1	<0.1	4.2	US EPA, 2005
Strontium	32	37	41	41	28	NGA	NA
Tellurium	<0.1	NC	NC	<0.1	<0.1	NGA	NA
Thallium *	0.5	0.6	0.8	0.9	<0.1	1	CCME, 1999
Tin	<1	NC	NC	<1	<1	5	AENV, 2010
Uranium	0.2	0.3	0.3	0.3	0.5	500	CCME, 2007
Vanadium	46	53	62	63	26	130	CCME, 1997
Zinc	77	116	205	246	36	200	CCME, 1999

Notes:
Units in mg/kg; 95%ILE = 95th percentile; < = analyte not detected, number provided is detection limit; NGA = no guideline available, NA = not applicable; SQG$_E$ = ecological health-based soil quality guideline
Shaded cell indicates maximum site concentration was greater than the 95th percentile of reference soil concentration and greater than ecological health-based soil quality guideline (where available).
Bold and Italicized cell indicates no guideline available and maximum site is concentration greater than 95th percentile reference concentrations; chemical carried forward for statistical evaluation.
* Indicates chemical did not screen based on guideline / reference area comparison, but was carried forward for statistical evaluation due to potential bioaccumulative nature and number of detected samples.

Table I-3 Comparison of Beach Sand Sampling Results for Area 3 to Industrial Land Use Ecological Health-Based Soil Quality Guidelines and to 95th Percentile of Reference

Analyte	Area 3 (N=7)				95%ILE of Reference	SQG_E Residential	Source
	Min	Mean	95%ILE	Max			
Aluminum	14200	16157	18230	18500	9110	NGA	NA
Antimony	<0.1	0.2	0.3	0.4	0.2	0.27	US EPA, 2005
Arsenic	12	20	28	28	5	17	CCME, 1997
Barium	15	71	201	251	16	2000	US EPA, 2005
Beryllium	0.3	0.4	0.4	0.4	0.5	21	US EPA, 2005
Bismuth	<1	NC	NC	<1	<1	NGA	NA
Boron	5	7	12	14	4	120	OMOE, 2011
Cadmium *	0.28	0.59	1.18	1.35	0.08	3.8	CCME, 1999
Chromium	46	52	61.1	62	18	64	CCME, 1997
Cobalt	14.6	16.0	17.8	18.1	7.0	120	US EPA, 2005
Copper	14	21	27.7	28	9	63	CCME, 1999
Iron	23400	25300	26890	27100	13950	NGA	NA
Lead	34.7	81.3	149.1	165	7	70	CCME, 1999
Lithium	15.5	18.5	20.57	20.6	16.4	NGA	NA
Manganese	373	408	451	458	274	4000	US EPA, 2007
Mercury *	<0.01	0.01	0.02	0.02	<0.01	12	CCME, 1999
Molybdenum	<0.1	0.1	0.27	0.3	0.2	6.9	OMOE, 2011
Nickel	34	40	44	45	21	50	CCME, 1999
Rubidium	3.3	3.9	4.4	4.5	6.5	NGA	NA
Selenium	<1	NC	NC	<1	<1	1	CCME, 2009
Silver	<0.1	NC	NC	<0.1	<0.1	4.2	US EPA, 2005
Strontium	29	49	65	65	28	NGA	NA
Tellurium	<0.1	NC	NC	<0.1	<0.1	NGA	NA
Thallium *	0.3	0.5	0.8	0.8	0.1	1	CCME, 1999
Tin	<1	NC	NC	<1	<1	5	AENV, 2010
Uranium	0.2	0.3	0.3	0.3	0.5	500	CCME, 2007
Vanadium	54	62	73	74	26	130	CCME, 1997
Zinc	92	219	474	564	36	200	CCME, 1999

Notes:

Units in mg/kg; 95%ILE = 95th percentile; < = analyte not detected, number provided is detection limit; NGA = no guideline available, NA = not applicable; SQG_E = ecological health-based soil quality guideline

Shaded cell indicates maximum site concentration was greater than the 95th percentile of reference soil concentration and greater than ecological health-based soil quality guideline (where available).

Bold and Italicized cell indicates no guideline available and maximum site is concentration greater than 95th percentile reference concentrations; chemical carried forward for statistical evaluation.

* Indicates chemical did not screen based on guideline / reference area comparison, but was carried forward for statistical evaluation due to potential bioaccumulative nature and number of detected samples.

Table I-4 List of Chemicals Carried for Further Evaluation

	Area 1			Area 2			Area 3		
	>95th%ILE Reference and > Guideline^1	**NGA & > 95th%ILE Reference^2**	**Bioaccumulation Potential and # of ND^2**	**>95th%ILE Reference and > Guideline^1**	**NGA & > 95th%ILE Reference^2**	**Bioaccumulation Potential and # of ND^2**	**>95th%ILE Reference and > Guideline^1**	**NGA & > 95th%ILE Reference^2**	**Bioaccumulation Potential and # of ND^2**
Aluminum		√			√			√	
Antimony	√						√		
Arsenic	√			√			√		
Bismuth		√							
Cadmium	√					√			√
Copper	√								
Iron		√			√			√	
Lead	√			√			√		
Lithium		√			√			√	
Mercury			√						√
Rubidium		√							
Selenium	√								
Strontium		√			√			√	
Tellurium		√							
Thallium	√					√			√
Zinc	√			√			√		

Notes:

95th%ILE – 95th percentile; Ref = reference; NGA = no guideline available; ND = non-detects; √ = indicates chemical was carried forward for further evaluation

1. Chemical carried forward for quantitative modelling
2. Chemical carried forward for further statistical evaluation

I-1.2 Additional Statistical Analyses to Determine Whether Study Areas and the Reference Area Concentrations were Statistically Different

Based on the results presented in Tables I-1 to I-3, as well as the considerations with respect to bioaccumulation described above, the following chemicals were carried forward for further statistical analysis based on exceedance of reference and no available guideline to determine whether differences existed between the study areas and the reference area: aluminum, bismuth, iron, lithium, rubidium, strontium and tellurium (See Table I-4). Cadmium (in Areas 2 and 3), mercury (in Areas 1 and 3) and thallium (in Areas 2 and 3) did not exceed guidelines (See Table I-4), but are potentially bioaccumulative, and were generally detected in these areas, and as such, were carried forward for further statistical evaluation.

For each of these chemicals, boxplots were generated to provide a visual comparison between the reference site and each of the study areas (Table I-5). For bismuth, mercury, selenium, tellurium, and thallium, statistical analysis was not possible since there were no detected concentrations of these chemicals in the reference area beach sand samples. Therefore, comparisons between sites for these chemicals are discussed on a case-by-case basis, below. For the remaining chemicals, Dunnett's multiple comparison tests were performed to compare the beach sand concentrations at each study area to the beach sand concentrations from the reference site (Table I-5). Data were log transformed prior to analysis to improve data normality. Results of the statistical comparison are summarized in Table I-6. For bismuth, selenium, and tellurium, reported concentrations in beach sand were below detection limit for all samples from the reference site (n=6) as well as for all samples from Area 2 (n=7) and Area 3 (n=7) (Table I-6). Therefore, these chemicals were not carried forward as COPCs for Areas 2 and 3 (Table I-7). However, beach sand concentrations of bismuth, selenium, and tellurium from Area 1 were above detection limit for the majority of samples (n=7), with maximum concentrations that were 4 to 9 times higher than the detection limits for these samples (Table I-5). Therefore, these chemicals were carried forward as COPCs for Area 1 (Table I-7).

Table I-5 Results of Dunnett's Tests Comparing Reference Site Analyte Concentrations to Analyte Concentrations at Areas 1, 2, and 3

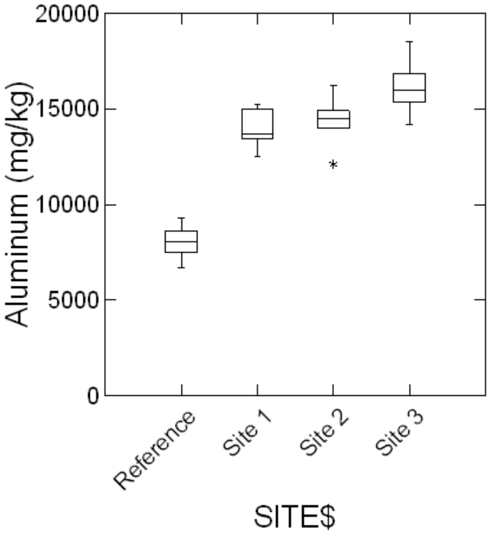
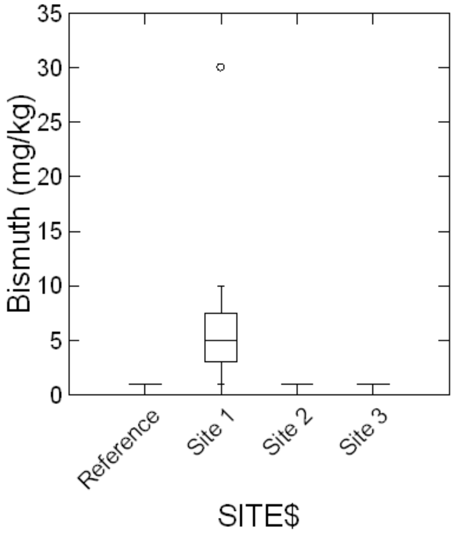
<table>
<tr><th rowspan="2">Analyte</th><th rowspan="2">Boxplot[a]</th><th colspan="3">Dunnett's Test[b] Results (p-value)</th></tr>
<tr><th>Area 1</th><th>Area 2</th><th>Area 3</th></tr>
<tr><td>Aluminum</td><td> </td><td><0.001</td><td><0.001</td><td><0.001</td></tr>
<tr><td>Bismuth</td><td> </td><td>NP</td><td>NA</td><td>NA</td></tr>
</table>

Table I-5 Results of Dunnett's Tests Comparing Reference Site Analyte Concentrations to Analyte Concentrations at Areas 1, 2, and 3

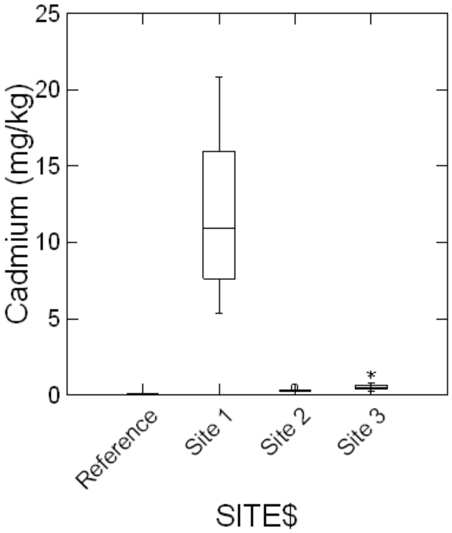
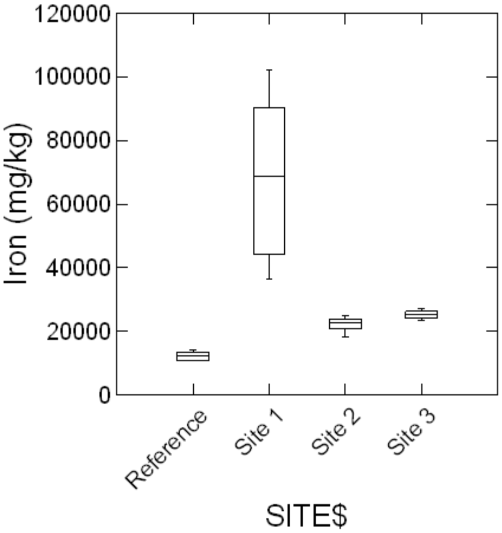
Analyte	Boxplot[a]	Dunnett's Test[b] Results (p-value)		
		Area 1	Area 2	Area 3
Cadmium		NA	<0.001	<0.001
Iron		<0.001	<0.001	<0.001

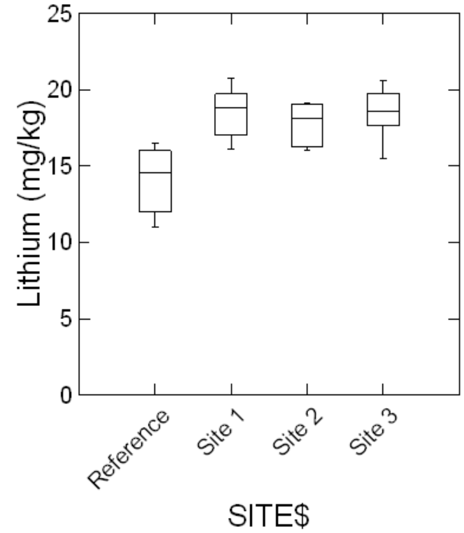
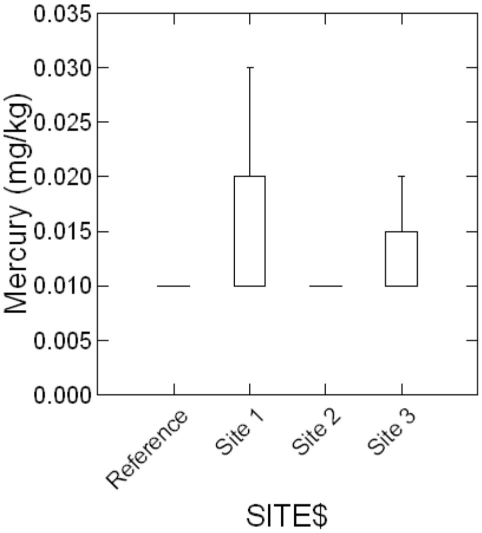
Table I-5	**Results of Dunnett's Tests Comparing Reference Site Analyte Concentrations to Analyte Concentrations at Areas 1, 2, and 3**			
Analyte	**Boxplot[a]**	**Dunnett's Test[b] Results (p-value)**		
		Area 1	**Area 2**	**Area 3**
Lithium		0.001	0.003	0.001
Mercury		NP	NA	NP

Table I-5 Results of Dunnett's Tests Comparing Reference Site Analyte Concentrations to Analyte Concentrations at Areas 1, 2, and 3

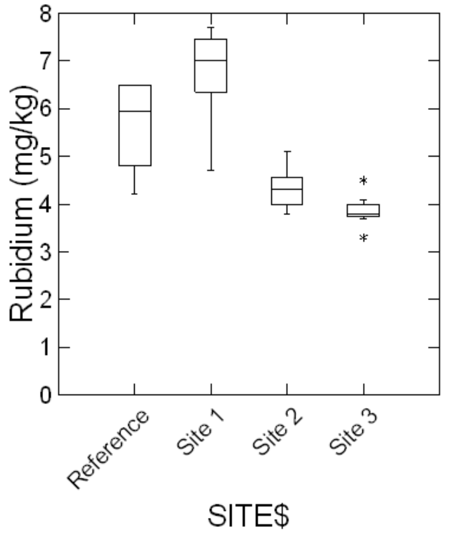
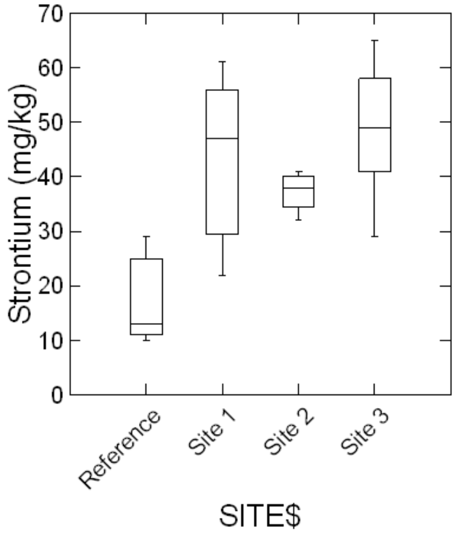
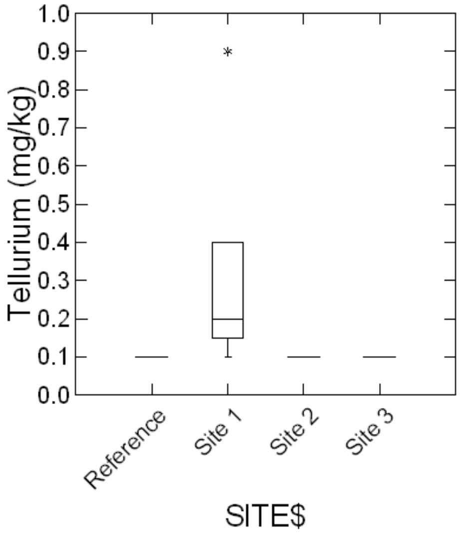
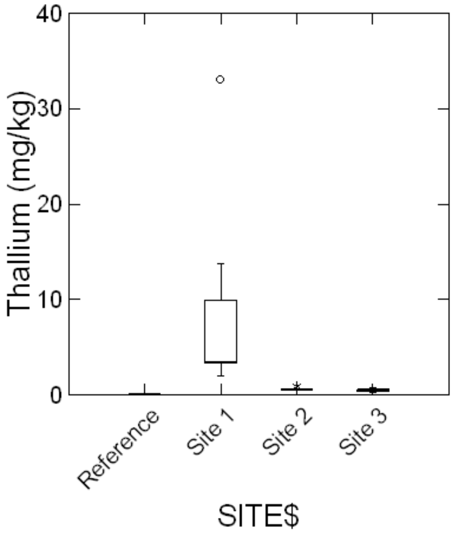
Analyte	Boxplot[a]	Dunnett's Test[b] Results (p-value)		
		Area 1	Area 2	Area 3
Rubidium		0.095	NA	NA
Strontium		<0.001	<0.001	<0.001

Table I-5 Results of Dunnett's Tests Comparing Reference Site Analyte Concentrations to Analyte Concentrations at Areas 1, 2, and 3

Analyte	Boxplot[a]	Dunnett's Test[b] Results (p-value)		
		Area 1	Area 2	Area 3
Tellurium		NP	NA	NA
Thallium		NA	NP	NP

Notes:

NP = Not performed; Statistical analysis not performed due to lack of detected data from the reference site. See discussion of results in text.

NA = Not applicable; Chemical not carried forward for statistical evaluation in this area (See Table B-4)

a The top and bottom of each box indicate the 75th and 25th percentiles of the data, respectively. The middle line in each box indicates the median (50th percentile). The whiskers indicate the lowest datum that is within 1.5 times the interquartile range (IQR, which equals the 75th percentile minus the 25th percentile) from the bottom of the box and the highest datum that is within 1.5 IQR from the top of the box. Values that are greater than 1.5 IQR but less than or equal to 3 IQR from the box are indicated with asterisks. Values that are more than 3 IQR from the box are indicated by empty circles.

b Data were log-transformed prior to analysis to improve data normality

Table I-6 Summary of Statistical Comparison Results for Potentially Bioaccumulative Analytes or Analytes for Which No Guideline Was Identified

Analyte	Significantly Different from Reference Site (p<0.05)?			Notes
	Area 1	Area 2	Area 3	
Aluminum	Y	Y	Y	
Bismuth	Y	NA	NA	All samples were non-detect in reference and in Areas 2 and 3; Bismuth in Area 1carried forward based on all samples in Area 1 had detectable concentrations.
Cadmium	NA	Y	Y	Cadmium not carried forward for statistical evaluation in Area 1; it screened on in Area 1 given it exceeded the guideline and reference area concentrations
Iron	Y	Y	Y	
Lithium	Y	Y	Y	
Mercury	Y	NA	Y	No detectable concentrations of Hg in reference (n=6) and only one value reported at the detection limit for samples from Area 2 (n=7) (Table B-4). Therefore, Hg not carried forward in Area 2 (Table B-6). Hg exceeded the detection limit for the majority of samples from Areas 1 and 3 (n=7) and was therefore carried forward in these Areas (Table B-6).
Rubidium	N	NA	NA	Rubidium not carried forward for statistical evaluation in Areas 2 and 3 as they were lower than the 95th percentile reference area concentration (See Table B-4)
Strontium	Y	Y	Y	
Tellurium	Y	NA	NA	All samples were non-detect in reference and Areas 2 and 3; Tellurium in Area 1 carried forward based on 6 of 7 samples having detectable concentrations.
Thallium	NA	Y	Y	Thallium not carried forward for statistical evaluation in Area 1; it screened on in Area 1 given it exceeded the guideline and reference area concentrations. All samples were non-detect in reference; Thallium carried forward in Areas 2 and 3 based on these areas having all samples with detectable concentrations.

Notes:
N = not statistically different from reference
Y = statistically different from reference
NA = not applicable; chemical was not carried forward for statistical evaluation in this area
Areas for which analyte concentrations were significantly higher than those at the reference are shaded

I-1.3 COPCs for Avian Receptors Quantitatively Modelled in the ERA

Based on the results of the comparison to guidelines and to the 95th percentile of reference area concentrations (i.e., Tables I-1 to I-3) in addition to the statistical comparison between site and reference (Table I-6), the COPCs carried forward for quantitative modelling were identified (See Table I-7).

Table I-7 COPCs Selected for Quantitative Modelling in Each Area

COPC	Area 1	Area 2	Area 3
Aluminum	Yes	Yes	Yes
Antimony	Yes	No	Yes
Arsenic	Yes	Yes	Yes
Bismuth	Yes	No	No
Cadmium	Yes	Yes	Yes
Copper	Yes	No	No
Iron	Yes	Yes	Yes
Lead	Yes	Yes	Yes
Lithium	Yes	Yes	Yes
Mercury	Yes	No	Yes
Selenium	Yes	No	No
Strontium	Yes	Yes	Yes
Tellurium	Yes	No	No
Thallium	Yes	Yes	Yes
Zinc	Yes	Yes	Yes

While antimony concentrations in Areas 1 and 3 were greater than the available soil quality guideline (Tables I-1 and I-3), no avian TRV could be identified for antimony and as such it could not be assessed. This is an uncertainty in the assessment; however given the toxicity of other COPCs, antimony concentrations would not be driving overall risk conclusions. No soil quality guidelines were available for bismuth or tellurium and concentrations in Area 1 were significantly difference from reference (neither bismuth or tellurium were detected in Areas 2 or 3); however there is a paucity of toxicity data for bismuth and tellurium in birds and as such, potential risks to avian species form bismuth and tellurium could not be assessed. Similar to antimony, bismuth and tellurium would not be driving overall risk conclusions.

For mercury, both fish tissue and shoreline invertebrate tissues were less than tissue residue guidelines established to protect upper trophic level fish-eating species. These comparisons are present in the main report (Section 5), and as a result, mercury was not modelled for avian receptors. In addition, egg and chick tissue concentrations were used to assess potential mercury exposures, as an additional line of evidence (See main report, Section 5).

As such the resulting COPCs were quantitatively modelled:

- Aluminum

- Arsenic
- Cadmium
- Copper (Area 1 only)
- Iron
- Lead
- Lithium
- Mercury (fish tissue and chick and egg tissues)
- Selenium (Area 1 only)
- Strontium
- Thallium
- Zinc

I-2.0 REFERENCES

NRC (National Research Council). 2005. Mineral Tolerance of Domestic Animals. Second Edition. National Academies Press, Washington, D.C.

APPENDIX J

MODEL APPROACH, WORKED EXAMPLE AND MODEL WORKSHEETS

J-1.0 AVIAN SPECIES ASSESSMENT

The methods used to estimate daily intake (EDI) of COPC were based on food and sand exposures in each area of interest. The following equation was used to estimate EDI for each receptor and area of interest (GoC 2012; US EPA 1996):

$$EDI = (C_{soil} \times SIR \times BA_{soil}) + \sum_{1}^{j} \frac{C_j \times P_j \times FMR \times BA_j}{ME_j}$$

Where
EDI = Total daily intake of COPC by receptor (mg/day)
C_{soil} = Concentration of chemical in sand (mg/kg)
SIR = Sand ingestion rate (kg/day)
BA_{soil} = Bio-accessibility of COPC in sand (Unitless; %)
C_j = Concentration of chemical in food item j (mg/kg-dw)
P_j = Proportion of food item j in diet (Unitless; %)
FMR = Free-living metabolic rate (FMR) (kcal/day)
BA_j = Bio-accessibility of food item j in diet (Unitless; %)
ME_j = Metabolizable energy of the food item j in diet (kcal/kg-DW)

The free-living metabolic rate (FMR) is defined as the total daily energy requirement for an animal in the wild and includes energy costs of basal metabolic rate (BMR), resting metabolic rate (RMR), thermoregulation, locomotion, feeding, predator avoidance, alertness, posture, and other energy expenditures to meet daily energy requirements. Combined with the metabolizable energy (ME) that is available in the receptor's forage or prey the EDI can be predicted.

Predicted EDI values were normalized to the receptor body weight based on the following equation:

$$TDI = \frac{EDI}{BW}$$

Where
TDI = Total daily intake of COPC by receptor (mg/kg/day)
EDI = Estimated daily intake (mg/day)
BW = Body weight (kg)

The EDI was predicted for each area of interest, receptor and COPC on a probabilistic basis. Probabilistic assessment methods use a modelling technique called Monte Carlo simulation where parameter values are drawn at random from defined input probability distributions, combined according to a model equation, and the process repeated iteratively until a relatively smooth distribution of outcomes are predicted. Probabilistic rather than a deterministic (fixed parameter value) assessment was selected to provide a more informative assessment that incorporates spatial variability in exposure media and biological attributes of wildlife (e.g., body weight, feeding rate, diet). The result of a probabilistic assessment is a distribution of possible outcomes are calculated based on distributions of important biological, chemical, physical, and environmental parameters that are linked through mathematical equations. As such the natural variability in parameters can be acknowledged, characterized and incorporated with the avian exposure model. Probabilistic methods in this assessment provide more information on the range and likelihood of potential outcomes among individuals in a population from exposure to each area of interest. The model did not include correlation among variables as it was unnecessary. Exposures were assumed to be random in each area of interest and receptor ingestion rate was automatically correlated with body weight through the equation used to predict FMR.

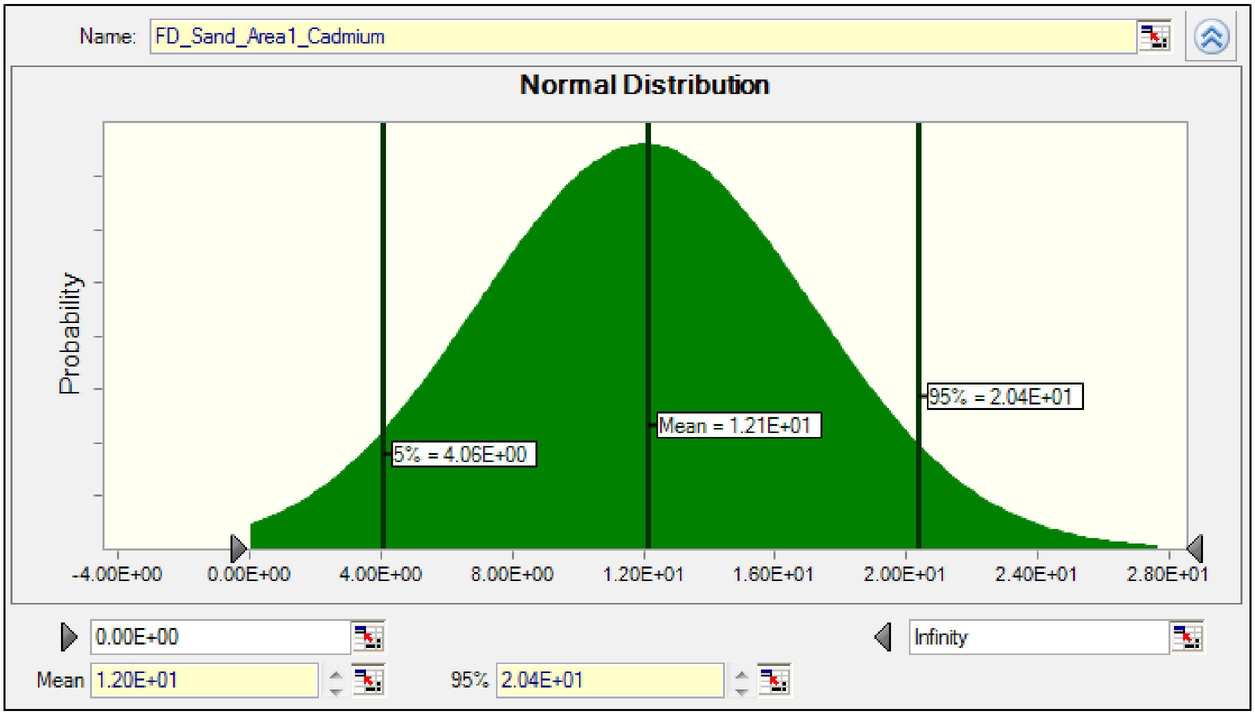
The wildlife exposure modelling relied on the use of a EDI model. The primary focus of the model is on ingestion of prey, and soil/sediment, which are generally the most important exposure pathways for wildlife (Moore and Caux, 1997; Moore et al., 1999). Thus, the avian exposure model did not include the dermal or inhalation routes of exposure in the model calculations (Suter et al. 2000). In addition, the avian exposure model excluded water ingestion, as it is typically not a dominant pathway.

This section provides a description of the model input parameters used in the avian exposure model based on the following components:

1. Media concentrations;
2. Bio-accessibility;
3. Sand ingestion rates;
4. Receptor variables;
5. Free-living metabolic rate (FMR);
6. Dietary apportionment;
7. Miscellaneous variables; and
8. Model Precision and Uncertainty.

J-1.1 Media Concentrations

Measured concentrations of COPCs in sand and aquatic invertebrates (i.e., scuds, amphipods and small shrimp; see Appendix H) were available from the 4 areas of interest (i.e., Reference and Area 1 to 3). Marine fish concentrations were not sampled by area of interest but sampled from the reference area and the smelter exposed fishing area where the highest impacts are predicted from the smelter (see Figure 2-3, main report). Sample sizes within each area of interest were less than 10; therefore, the confidence interval (i.e., 95% upper confidence limit on the mean) could not be estimated with reliability (GoC, 2012). Most input assumptions for media concentrations in the probabilistic exposure model were assumed to follow a normal distribution defined by the mean and 95th percentile. In some circumstances, the model input assumptions for media concentrations were assumed to follow a log-normal distribution defined by the mean and 95th percentile. Log-normal distribution models were assumed when the normal distribution resulted in a large quantity of values below zero (i.e., negative values). Table J4 in model attachments to this appendix presents the distribution models that were assumed for COPC media concentrations in each area of interest. Figure J-1 presents an example of the distribution model that was assumed for Area 1 concentrations of cadmium in sand (5th percentile=4.1, Mean=12 and 95th percentile=20 mg/kg).



Name: FD_Sand_Area1_Cadmium

0.00E+00

Infinity

Mean 1.20E+01

95% 2.04E+01

Figure J-1 Assumed Distribution of Area 1 Cadmium Concentrations in Sand [mg/kg]

In some circumstances, insufficient data were available to assign a distribution model and a fixed value was assumed instead. Selenium and thallium concentrations in certain media and areas of interest were all below the limit of analytical quantification (i.e., less than method detection limit). In this case the exposure model assumed a fixed value equivalent to the method detection limit to be conservative.

The exposure model did not predict any media concentrations based on uptake factors where food chain concentrations were missing. Uptake factors are used to extrapolate contaminant concentrations from a single abiotic exposure medium (e.g., soil or sand) to a tissue concentration in an organism (e.g., forage or prey). Several types of uptake factors exist, including bio-concentration factors (BCF), bio-accumulation factors (BAF), and regression models. None of these types of uptake factors were used because all media concentration data used in the exposure model was based on measured concentrations to reduce the uncertainty in food chain modelling.

Finally, the EDI model predicted exposures for each receptor and COPC in the following areas of interest:

- Reference;
- Area#1;
- Area#2;
- Area#3; and
- Area#1 to #3 combined.

Exposures in the Reference, Area#1, Area#2 and Area#3 were based on the full distribution of measured concentrations due the limited sample size (i.e., <10) within each area of interest. However, sufficient data were available to calculate exposures based on the confidence interval for Area #1 to #3 combined. Table J4 in the model attachment files in this appendix presents the distribution models that were assumed for COPC media concentrations in each area of interest.

J-1.2 Bio-accessibility

Bio-accessibility parameters in the exposure model assumed a fixed value of 100% for each COPC and media (e.g., food) with the exception of beach sand for which site-specific bioaccessibility data were available.

This is considered a conservative assumption because the media concentrations are reported as total concentrations and did not consider the various forms (e.g., bound to sulphides) and speciation (e.g., ionic state) that chemicals can exist in media. Table J6 in the model attachment file to this appendix presents the bio-accessibility factors that were assumed for each COPC and media in the exposure model.

J-1.3 Sand Ingestion Rates

Sand ingestion rates were assumed to be similar to soil ingestion rates. Soil ingestion rates were based on an estimated fraction of incidental ingestion during foraging activities (i.e., mass of food consumed on a daily basis) and based on the following equation.

$$SIR = F_s \times FIR$$

Where
SIR = Sand ingestion rate (kg/day)
F_s = Fraction of sand in total diet (Unitless; %)
FIR = Food ingestion rate (kg-DW/day)

The fraction of sand (F_s) in the total diet for each receptor is presented in Table J7 of the model attachment file to this appendix. Insufficient information is available to assign a distribution with a central tendency; therefore, the probabilistic exposure model conservatively assumed uniform distributions for F_s in the diet for each receptor. Uniform distributions randomly select values with equal probability within the assigned range. The calculation of the sand ingestion rate (SIR) was based on combined variability in the F_s and FIR parameters. These two parameters were assumed to behave independently and the FIR was based on variability in the following parameters that are used to calculate the mass of food consumed on a daily basis:

- FMR;
- Dietary composition for each receptor; and
- Variability in the metabolizable energy that is available in food items.

Table J8 in the model attachment file to this appendix presents how all these parameters are combined to calculate the SIR and FIR. Figure J-2 and Figure J-3 present an example of the distribution of predicted sandpiper FIR and SIR.

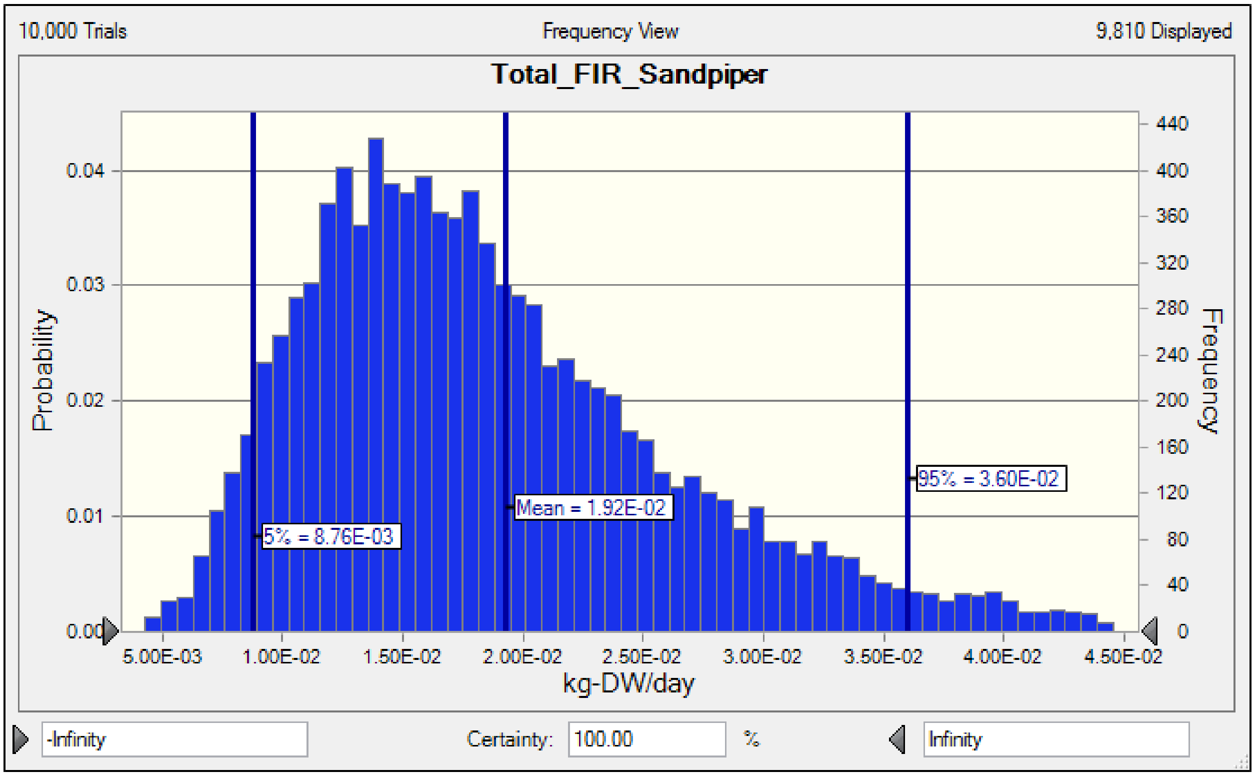
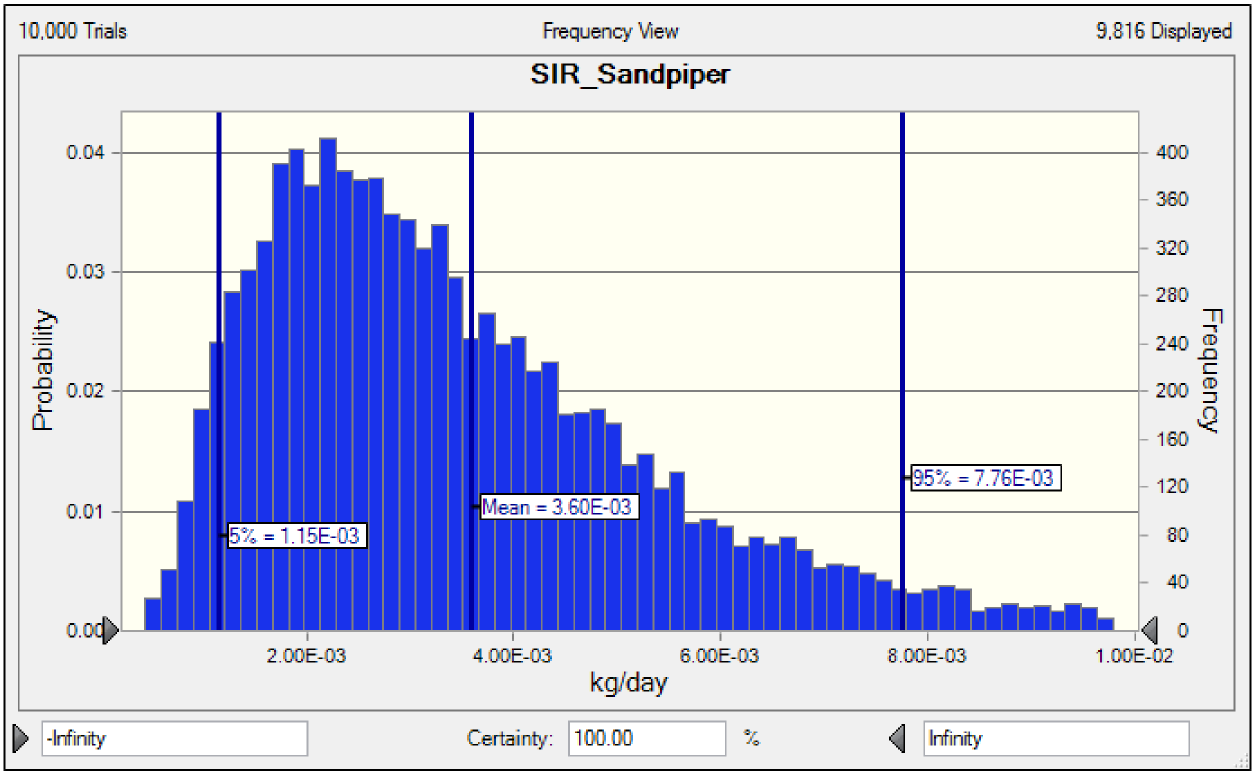


Figure J-2 Example Distribution of Predicted Sandpiper Food Ingestion Rates [kg-DW-day]



-Infinity

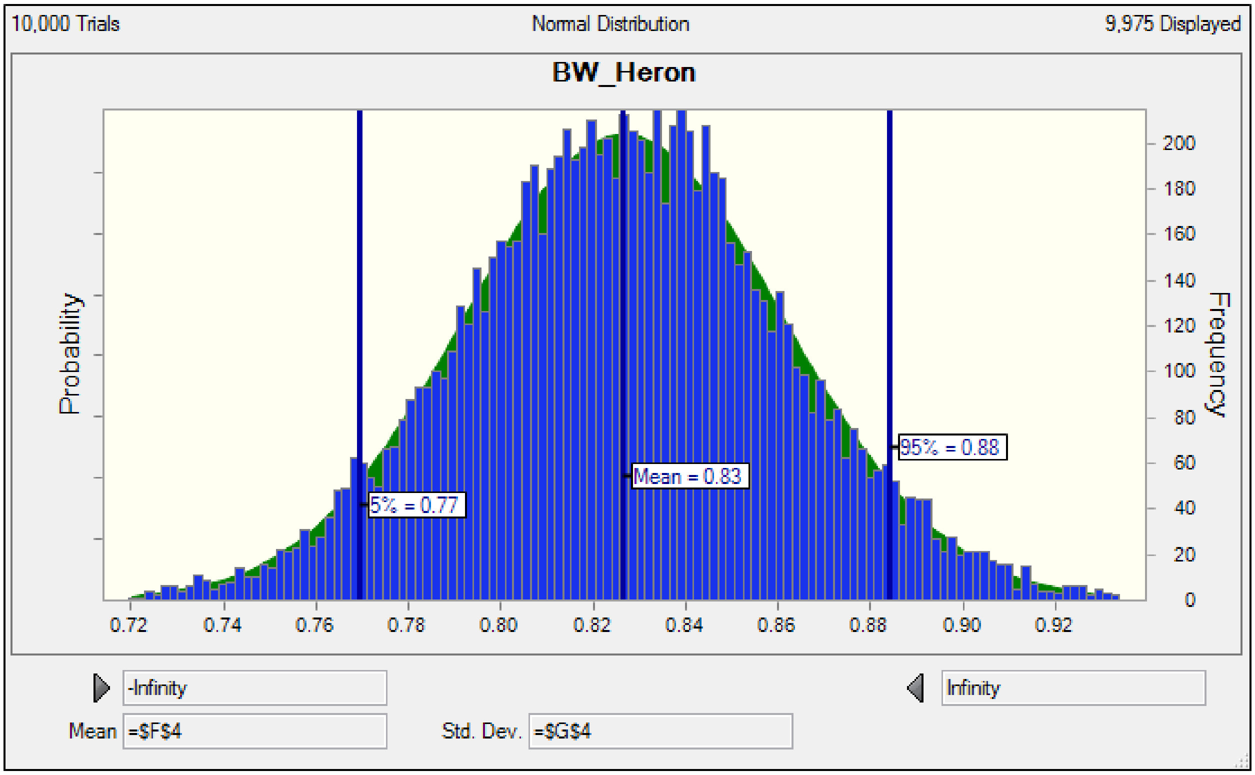
Certainty: 100.00 %

Infinity

Figure J-3 Example Distribution of Predicted Sandpiper Sand Ingestion Rates [kg/day]

J-1.4 Receptor Variables

The body weight is an important variable that is critical to estimating the FMR and FIR. Table J7 in the model attachment file to this appendix presents the body weights that were assumed for each receptor in the exposure model. Body weights are fairly well known for wildlife species and can be assigned normal distributions. Figure J-4 presents the distribution of body weights that were assigned to the adult Heron. Adult body weights are used in the exposure model to predict exposures during reproductive periods.



-Infinity

Infinity

Mean =$F$4

Std. Dev. =$G$4

Figure J-4 Distribution of Body Weight for the Heron [kg]

J-1.5 Free-living Metabolic Rates

The food ingestion rate is influenced by a number of factors, such as the energy requirements and metabolic rate of the organism, the available energy in food items and composition of the diet. The rate of food consumption that an animal must achieve to meet its metabolic needs can be calculated by dividing its free-living (or field) metabolic rate (FMR) by the metabolizable energy in its food (US EPA 1993; Nagy 1987).

Metabolizable energy (ME) is the gross energy (GE) in a unit of food consumed minus the energy lost in feces and urine (US EPA 1993). Assimilation efficiency (AE) equals the ratio of metabolizable energy to gross energy, or the fraction of gross energy that is metabolizable (US EPA 1993). Thus, the metabolizable energy for dietary items can be calculated as follows:

$$ME = GE \times AE$$

Where:

ME = metabolizable energy of dietary item (kcal/kg)
GE = gross energy of dietary item (kcal/kg DW)
AE = assimilation efficiency of dietary item (%)

The gross energy and assimilation efficiency values for the different dietary items were provided by the US EPA (1993) and are presented in Table J12 and J13, respectively in the Model attachment of this appendix. Sufficient information is available to assign normal distributions to the GE and AE parameters for each dietary item and receptor. Figure J-5 presents the distribution of predicted ME values that were assumed for aquatic invertebrates.

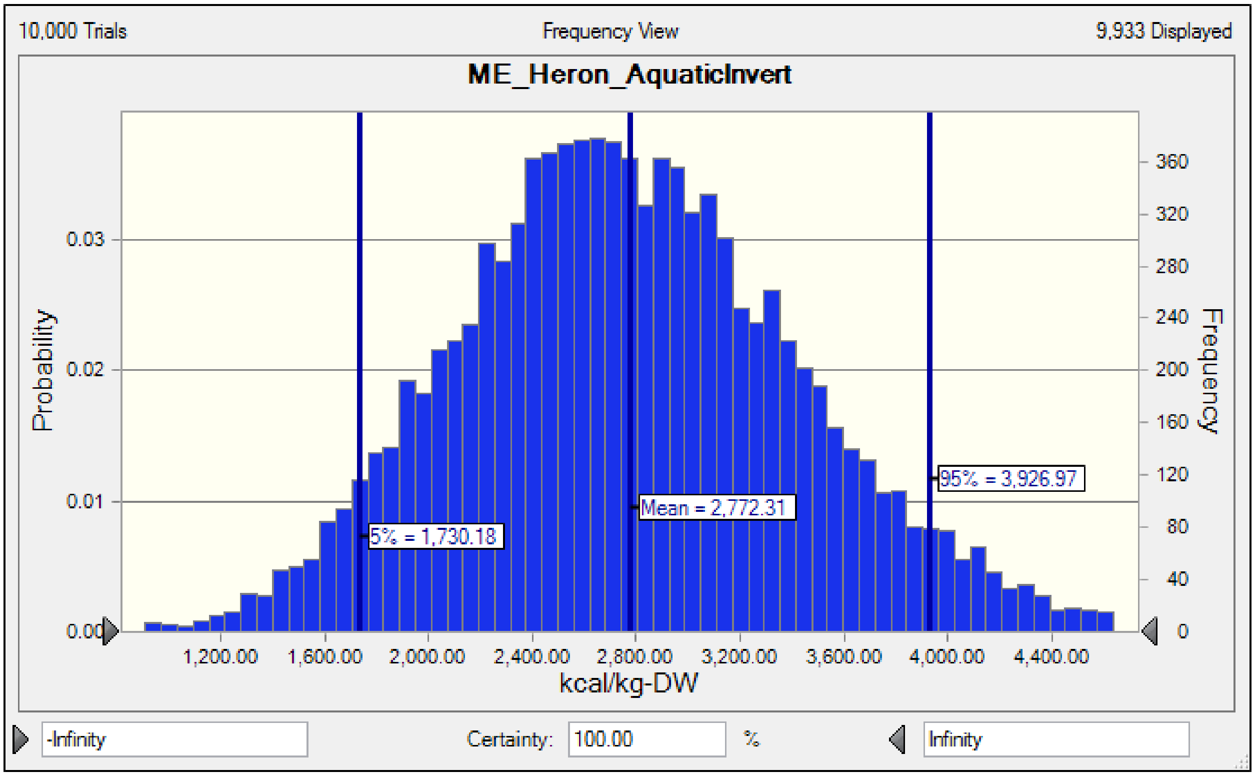


Figure J-5 Distribution of ME Predicted for Aquatic Invertebrates [kcal/kg-DW]

Nagy et al. (1999) provides raw data to calculate FMR equations based on doubly-labelled water measurements of CO_2 production in free-living animals (US EPA 1993). The data provided by Nagy et al. (1999) was used to develop the following allometric equation (i.e., based on a power function) based on five bird species that are common to the area of interest (i.e., Common sandpiper, Ringed plover, Arctic tern, Common tern and Sooty tern):

$$FMR = a \times BW^{b}$$

$$FMR = 47.587 \times BW^{0.3712}$$

Where:

FMR = free-living metabolic rate (kcal/d)

a = slope of the allometric equation for the FMR (unitless)

BW = body weight (g)

b = y-intercept of the allometric equation for the FMR (unitless)

The FMR data was log-transformed to complete linear regression analysis and estimate the standard error based on the following equation:

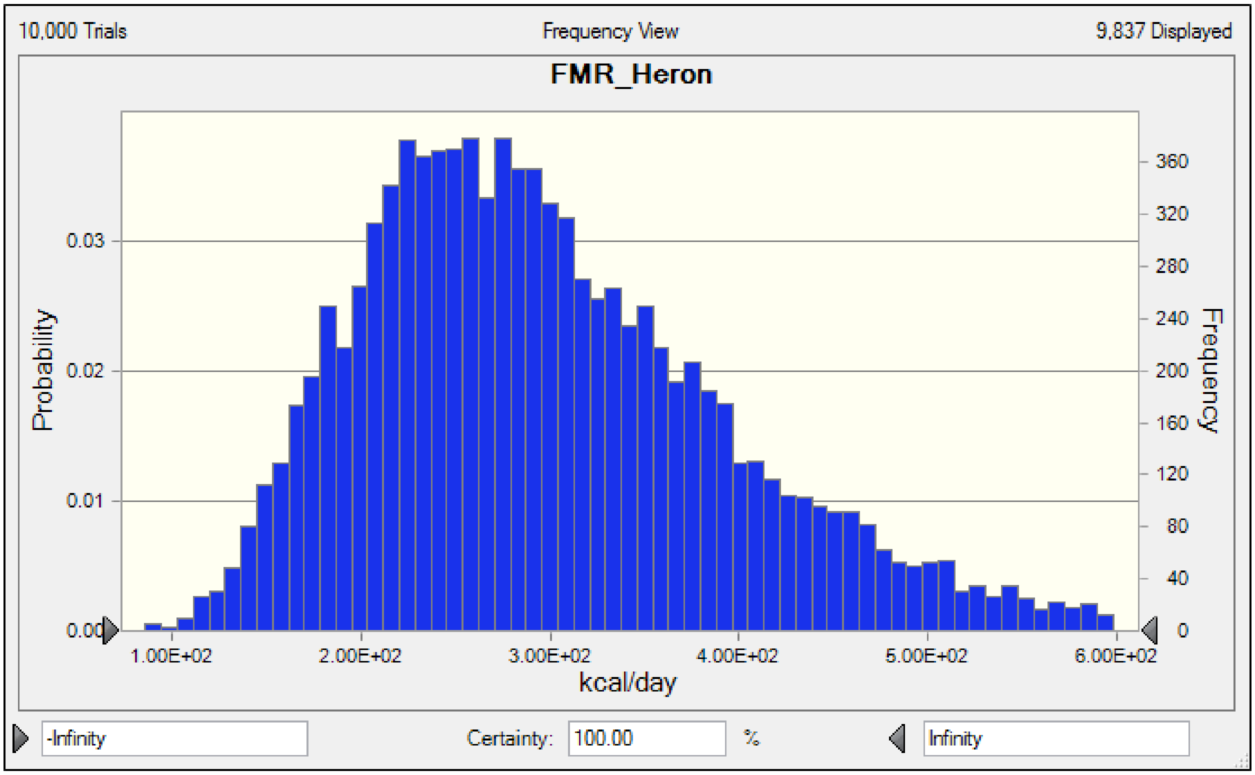
$$\log FMR = a + \log BW + E$$

The equation can be re-arranged as follows:

$$FMR = 10^{1.677} + BW^{0.3712} + E^{0.1522}$$

where:
FMR = free metabolic rate (kcal/day)
BW = body weight (grams)
E = Standard error of the regression model or root mean square error (kcal/day)

The standard error in the FMR regression model was assumed to be normally distributed and was parameterized with a mean of zero and standard deviation of 0.1522. The standard error represents the variability in FMR for a given body weight value and defines the error between what is observed and predicted in the regression model. Figure J-6 presents the distribution of FMR that was predicted for the Heron.



-Infinity
Certainty: 100.00 %
Infinity

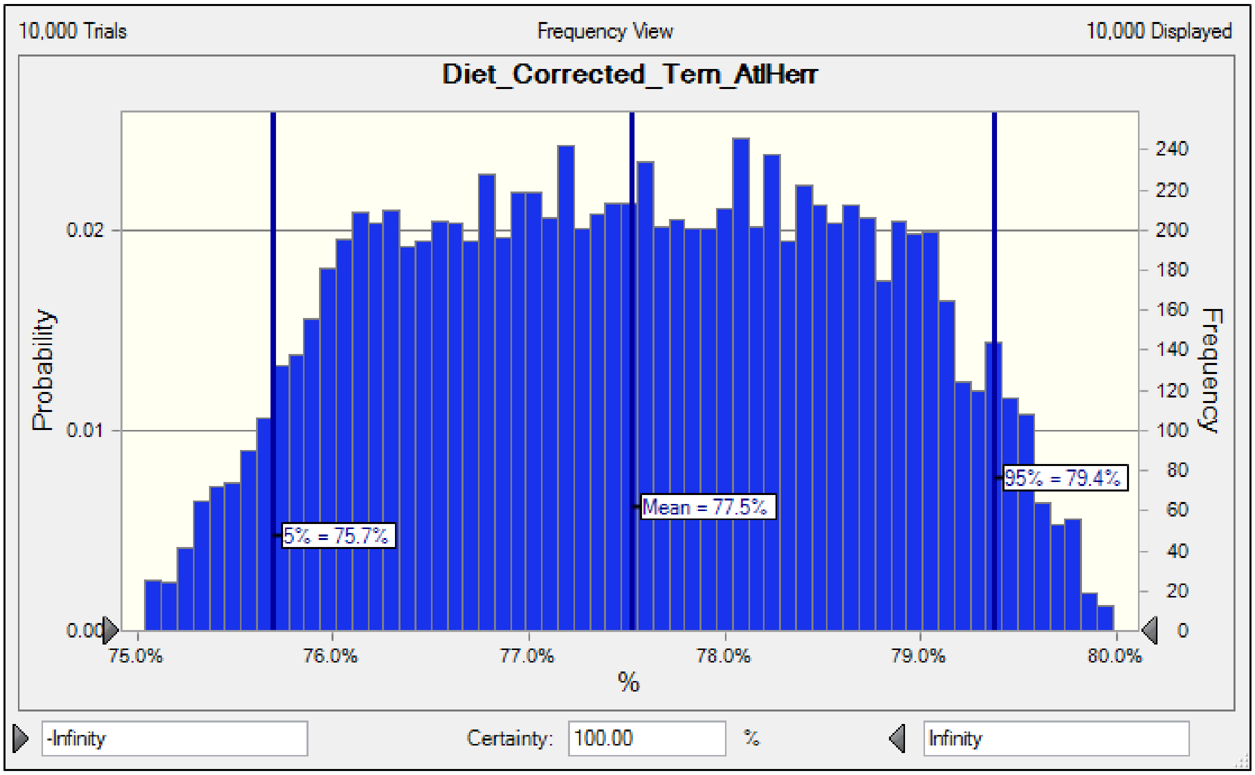
Figure J-6 Example Distribution of FMR Assumed for the Heron [kcal/day]

J-1.6 Dietary Apportionment

Wildlife receptors were assumed to consume a variety of marine and beach foods, including aquatic invertebrates, sand lance and Atlantic herring. The assumed proportion of each food type consumed by wildlife was presented in Table J10 in model attachment to this appendix. The proportion of each food item in the diet of avian receptors was assigned a probabilistic distribution defined by a uniform distribution. Probabilistic distributions were assigned to the diet to acknowledge that dietary proportions are not fixed but vary with availability of food. Due to the added variability, the proportion used in the probabilistic exposure model was auto-corrected to ensure the sum of the percentages of each diet item was 100%. The distribution of dietary items assigned to each receptor was based on the following:

- Literature reviews of biological reports and text books;
- Professional judgement.

Figure J-7, J-8 and J-9 present the distribution of dietary proportions of Atlantic herring, sand lance and aquatic invertebrates assumed for the Tern in the probabilistic exposure model, respectively.



-Infinity

Certainty: 100.00 %

Infinity

Figure J-7 Distribution of Dietary Proportion for the Atlantic Herring [%]

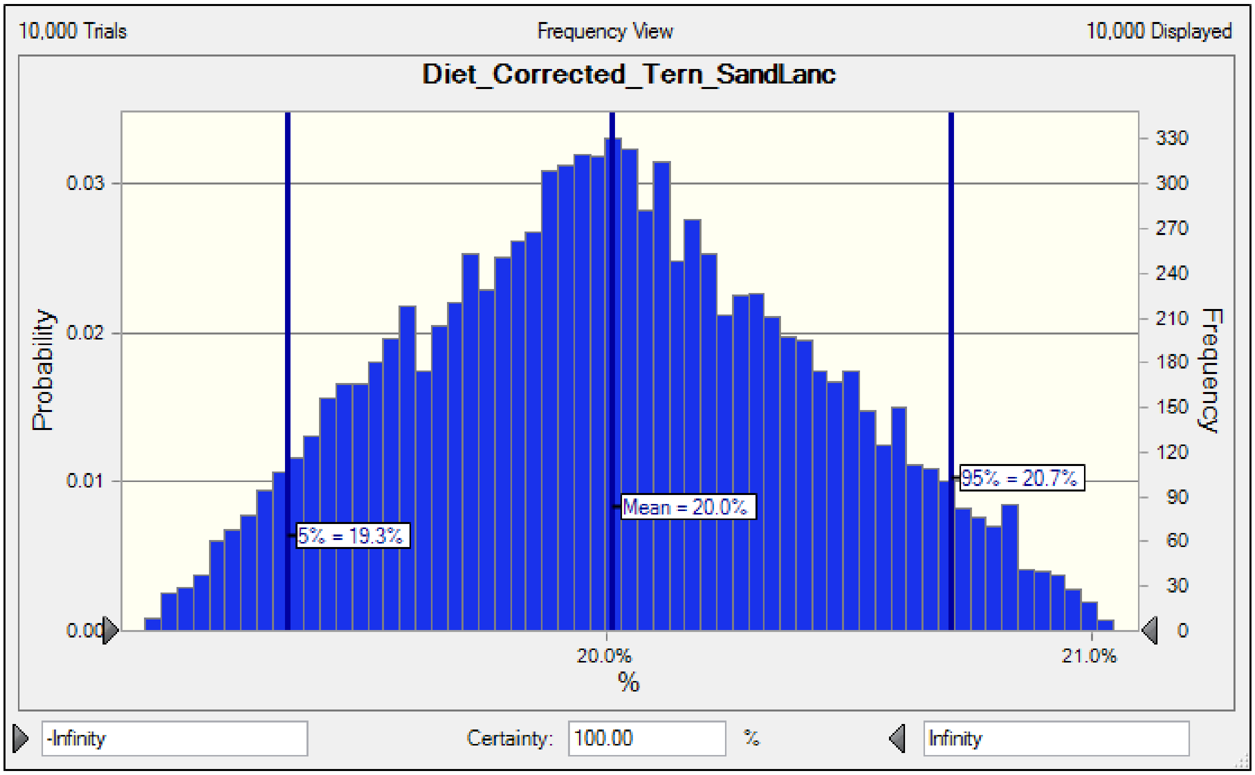


Figure J-8 Distribution of Dietary Proportion for the Sand Lance [%]

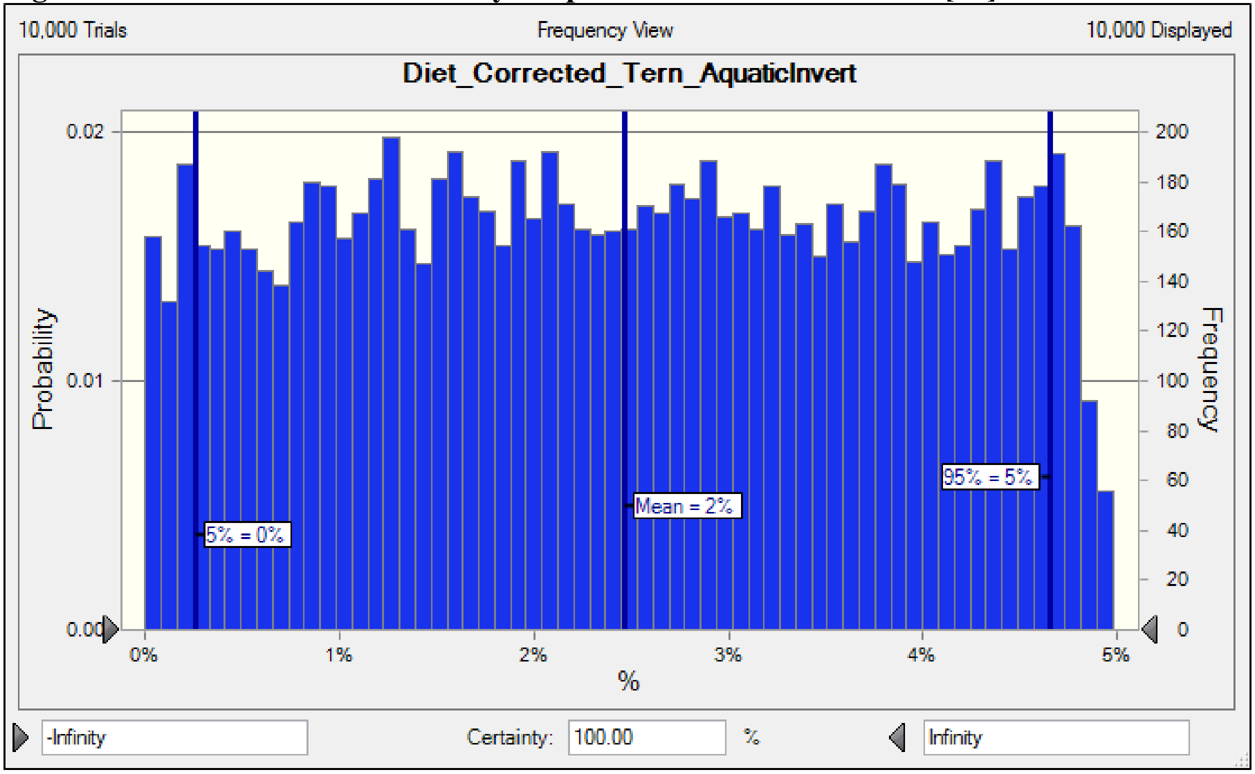


Figure J-9 Distribution of Dietary Proportion for the Aquatic Invertebrate [%]

J-1.7 Miscellaneous Variables

The exposure model required media concentrations in dry weight; therefore, the moisture content of aquatic invertebrates and marine fish were used to convert the reported wet weight concentrations into dry weight. The following equation was used to convert wet weight sample data to dry weight in the exposure model.

$$C_{DW} = \frac{C_{WW}}{(100 - MC)}$$

Where
C_{DW} = Concentration in dry weight (mg/kg-DW)
C_{WW} = Concentration in wet weight (mg/kg-WW)
MC = Moisture content (Unitless; %)

Table J14 in the model attachment to this appendix presents the distribution of moisture content that was assumed for dietary items.

J-1.8 Model Precision and Uncertainty

J-1.8.1 Model Precision

The outcomes of the probabilistic exposure model can be evaluated for precision. The assessment of precision is important as it determines if the Monte Carlo simulation sampled each assumption sufficiently to capture the full range of possible outcomes. Table J-1 demonstrates how repeated runs of the Monte Carlo simulation (i.e., 10,000 iterations) produced very similar lead and zinc HQ values at the 5th and 95th percentile for the tern in Area#1. Therefore, 10,000 iterations are sufficient to capture the full distribution of model outcomes and indicate the probabilistic exposure model is:

- Robust; and
- Reproducible.

Table J-1 Precision Analysis

Trial	5th and 95th Percentile HQ Values for Tern in Area#1	
	Lead	Zinc
#1	0.18 and 1.3	0.15 and 0.74
#2	0.19 and 1.3	0.15 and 0.74
#3	0.19 and 1.3	0.15 and 0.74

J-1.8.2 Uncertainty

Uncertainty in the probabilistic exposure model should not be confused with variability. Uncertainty derives from a lack of knowledge. Alternatively, variability in the model describes differences in parameter values such as metal concentrations at different parts of the study area, or differences in body weight or food intake rates for individual animals (i.e., population heterogeneity). 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, 2001):

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

J-1.8.2.1 Parameter Uncertainty

One of the difficult issues in assessing ecological risks is the establishment of a priori performance criteria for model results (Moore and Bartell, 2000). The risk assessment need only be certain that risks are not under-predicted and that the model will rarely predict the absence of risk when there is a risk (i.e., avoid a false negative). Therefore, the objective of the analysis of uncertainty for the model input parameters is to demonstrate the following:

- Model input variables accurately reflect the natural variability in the environment with minimal uncertainty; and,
- Model input variables assume conservative values in the face of uncertainty (lack of knowledge).

A useful question to ask when attempting to identify uncertainty and define variability in a particular model input parameter is:

“Will the collection of more information dramatically improve the understanding of the variability of an input variable?”

At some point, the collection of additional data will reach the point of diminishing returns. When the variability in a measured parameter is well characterized for a particular area, uncertainty has been reduced to an acceptable level and no further data collection is required. Variability is characterized by sample size, repeated measures and area of coverage. Uncertainty is characterized by the degree of missing information from the parameter estimate or model structure. Table J-2 presents the variability and uncertainty for each parameter in the probabilistic exposure model.

Table J-2 Evaluation of Exposure Model Variability and Uncertainty

Parameter	Variability	Uncertainty
Pathways of Exposure	Not applicable	With the exception of water ingestion, inhalation and dermal contact, all pathways of exposure included. Excluded pathways are expected to have low impact on predicted risks. Uncertainty judged to be low.
Media Concentrations	Sampling number is relatively high or adequate for the area of coverage, includes multiple species or groups. Judged to be well characterized.	Collection of additional data unlikely to improve understanding of existing Distributions. Uncertainty judged to be low.
Bio-accessibility	Not applicable	Model assumed most conservative value. Uncertainty judged to be low.
Sand Ingestion Rates	Sand ingestion rates based on empirical studies with similar wildlife.	Model assumed most conservative value. Uncertainty judged to be low.
Receptor Variables	The variability in wildlife exposure variables is required in the model to account for individual, geographic and seasonal differences in body weights. Extensive literature searches were conducted to locate data and information on the exposure variables for each receptor. Given the extensive literature review and use of relatively large data sets, the variability in exposure variables is judged to be well characterized.	Uncertainty in wildlife exposure variables is judged to be low. No site-specific data were available for the derivation of exposure variables, but significant population or geographical differences between similar wildlife species are not expected.
Free-living Metabolic Rates (FMR)	The variability in FMR is required in the model to account for individual, geographic and seasonal differences in food ingestion rates. Extensive literature searches were conducted to locate data and information on free-living receptor energy requirements. Given the extensive literature review and use of empirical data	Uncertainty judged to be low.

Table J-2 Evaluation of Exposure Model Variability and Uncertainty

Parameter	Variability	Uncertainty
	sets (Naggy et al 1999), the variability in FMR is judged to be well characterized.	
Dietary Apportionment	Variability accounts for difference in individual, geographic and seasonal; differences. Literature searches were consulted. Judged to be well characterized.	Uncertainty judged to be low.
Toxicity Reference Values	Variability was accounted for through evaluation of toxicity data from a number of different species, where data was available. Selection of conservative value.	Uncertainty is moderate, as species-specific data was not available for the 3 receptors of interest.

J-1.8.2.2 Model Uncertainty

Uncertainty in the exposure model has been characterized and the likelihood of underestimating risks is considered to be low to negligible. This is due to the availability of site-specific data as well as the use of conservative assumptions where appropriate. The exposure model predicts exposures on an 'individual animal' basis. The exposure model did not explicitly incorporate habitat quality or suitability information into risk estimates. This is a very critical factor that determines the media and concentrations a wildlife will be exposed to in their home range. However, the use of probabilistic methods with consideration of appropriate spatial averaging (i.e., confidence intervals) and full distribution of exposure point concentrations for each receptor is considered adequate and appropriate.

The exposure model is based on the assumption that the entire study area is suitable habitat for each receptor, because wildlife was assumed to be exposed to the full distribution of measured concentrations in each area of interest. This assumption ensures that risk estimates are considered for areas with the highest concentrations even if a particular receptor has no preference for that particular area of interest. This assumption also provides an estimate of future risks to receptors if areas of poor habitat quality are improved through remediation or rehabilitation.

J-1.8.2.3 Scenario Uncertainty

Scenario uncertainty is defined as uncertainty regarding missing or incomplete information that would fully define exposure (U.S. EPA 2001). The exposure model provides an estimate of risks to wildlife from a spatial perspective, but does not address the variability in exposures that would occur over time (i.e., in the future or year after year). Metal concentrations in media (e.g., aquatic invertebrates and marine fish) 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 level. 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. The ERA exposure model was not designed to account for these factors, but indirectly addressed this issue by assuming probabilistic exposures to metal concentrations that included maximum foreseeable chemical concentrations over time.

J-1.9 References

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J-2.0 WORKED EXAMPLE FOR HERON EXPOSURE TO LEAD IN AREA 1

J-2.1 Introduction

This example provides a description of the rationale, methods, detailed calculations and results that were used to estimate heron exposures and risks to lead in Area #1. The heron exposed to lead was selected for this worked example because predicted exposures were based on a diverse diet (i.e., mixture of fish and aquatic invertebrates).

The example represents a single iteration of the probabilistic model for demonstration purposes using lead exposures to the heron. The example calculations are provided for a single iteration, but the results of the ecological risk assessment (ERA) were based on fully probabilistic exposure modelling involving 10,000 iterations. Similar methods were applied to other avian receptors and chemicals of concern evaluated in the assessment.

Table J-3: Heron Exposure Variables

Variable	Abbreviation	Units	Value	Reference
Toxicity reference value for lead	TRV	mg/kg bw/d	9.9E+00	Table J5 Toxicity Reference Values for Wildlife
Bio-accessibility food	BA	%	100	Table J6 Bio-accessibility Assumed for Food
Bio-accessibility sand	BA	%	5.7	Table J6 Bio-accessibility Assumed for Media
Body Weight	BW	kg	8.3E-01	Table J7 Receptor Exposure Variables
Percent sand ingestion	P_{sand}	%	2.0E+00	Table J7 Receptor Exposure Variables
Free-living metabolic rate	FMR	kcal/day	2.8E+02	Table J9 Free-living (Field) Metabolic Rate (FMR)
Dietary Apportionment of: Atlantic Herring	P_{AH}	%	30	Table J10 Dietary Apportionment for Wildlife Receptors
Sand Lance	P_{SL}	%	30	
Aquatic Invertebrates	P_{AI}	%	40	
Metabolizable Energy of: Atlantic Herring	ME_{AH}	kcal/kg-DW food	7.4E+03	Table J11 Metabolizable Energy (ME) of Dietary Items
Sand Lance	ME_{SL}	kcal/kg-DW food	5.3E+03	
Aquatic Invertebrates	ME_{AI}	kcal/kg-DW food	2.8E+03	
Moisture Content of: Atlantic Herring	MC_{AH}	%	80	Table J14 Moisture Content

Sand Lance	MC_{SL}	%	77	
Aquatic Invertebrates	MC_{AI}	%	80	

J-2.2 Heron Exposure Calculations

J-2.2.1 Food Ingestion Rates

The food ingestion rate is influenced by a number of factors, such as the metabolic rate and composition of the diet. The rate of food consumption that an animal must achieve to meet its metabolic needs can be calculated by dividing its free-living (or field) metabolic rate (FMR) by the metabolizable energy in its food (Nagy 1999; U.S. EPA 1993).

The food ingestion rates were calculated as follows:

$$FIR = \sum_i \frac{FMR \ \times P_i}{ME_i}$$

Where:

FIR = food ingestion rate (kg-DW/day)

FMR = free-living metabolic rate (kcal/d)

P_i = dietary apportionment of the i^{th} food items (%)

ME = metabolizable energy of the i^{th} dietary item (kcal/kg)

Example:

$$FIR_{total} = \frac{2.8E+02 \ \times 0.3}{7.4E+03} + \frac{2.8E+02 \times 0.3}{5.3E+03} + \frac{2.8E+02 \times 0.4}{2.8E+03}$$

$$FIR = 6.9E-02 \ kg/d$$

J-2.2.2 Sand Ingestion Rates

The sand ingestion rates were calculated as a percentage of the total estimated food ingestion rate for all dietary items.

The sand ingestion rates were calculated as follows:

$$SIR = P_{sand} \times FIR_{total}$$

Where:

SIR = sand ingestion rate (kg/d)

P_{sand} = percent of sand in diet (%)

FIR_{total} = total food ingestion rate of chemical for all dietary items (kg-DW/d)

Example:

$$SIR = 0.02 \times 6.9E - 02$$
$$SIR = 1.4E - 03\ kg/d$$

J-2.2.3 Estimated Daily Intake of Chemicals in Herons Via all Media

J-2.2.3.1 Sand Exposure

The estimated daily intake of lead through incidental ingestion of sand by herons was calculated by applying the sand ingestion rate to the chemical concentration in the sand.

$$EDI_{sand} = C_{sand} \times SIR \times BA$$

Where:

EDI_{sand}=	estimated daily intake of lead from sand ingestion (mg/d)	
C_{sand}	=	lead concentration in sand (mg/kg)
SIR	=	sand ingestion rate (kg/d)
BA	=	bio-accessibility of lead (%)

Example:

$$EDI_{sand} = (7.5E + 03) \times (1.4E - 03) \times 5.7E - 02$$

$$EDI_{sand} = 5.9E - 01\ mg/d$$

J-2.2.3.2 Atlantic Herring Exposure

The estimated daily intake of lead through consumption of Atlantic herring was calculated as follows:

$$EDI_{AH} = \frac{FMR \times P_{AH} \times C_{lead} \times BA}{ME_{AH} \times (1 - MC_{AH})}$$

Where:

EDI_{AH}	=	estimated daily intake of lead from Atlantic herring ingestion (mg/d)
FMR	=	free-living metabolic rate (kcal/d)
P_{AH}	=	portion of diet consisting of Atlantic herring (%)
C_{lead}	=	concentration of lead in Atlantic herring (mg/kg)
BA	=	Bio-accessibility of lead (%)
ME_{AH}	=	metabolizable energy of Atlantic herring (kcal/kg)
MC_{AH}	=	moisture content of Atlantic herring (%)

Example:

$$EDI_{AH} = \frac{(2.8E + 02) \times (0.3) \times (1.3E + 00) \times 1}{(7.4E + 03) \times (1 - 0.8)}$$
$$EDI_{AH} = 7.2E - 02\ mg/d$$

J-2.2.3.3 Sand Lance Exposure

The estimated daily intake of lead through consumption of sand lance was calculated as follows:

$$EDI_{SL} = \frac{FMR \times P_{SL} \times C_{lead} \times BA}{ME_{SL} \times (1 - MC_{SL})}$$

Where:

EDI_{SL} = estimated daily intake of lead from sand lance ingestion (mg/d)
FMR = free-living metabolic rate (kcal/d)
P_{SL} = portion of diet consisting of sand lance (%)
C_{lead} = concentration of lead in sand lance (mg/kg)
BA = bio-accessibility of lead (%)
ME_{SL} = metabolizable energy of sand lance (kcal/kg)
MC_{SL} = moisture content of sand lance (%)

Example:

$$EDI_{SL} = \frac{(2.8E+02) \times (0.3) \times (2.6E+01) \times 1}{(5.3E+03) \times (1 - 0.77)}$$
$$EDI_{SL} = 1.9E+00\ mg/d$$

J-2.2.3.4 Aquatic Invertebrate Exposure

The estimated daily intake of lead through consumption of aquatic invertebrates was calculated as follows:

$$EDI_{AI} = \frac{FMR \times P_{AI} \times C_{lead} \times BA}{ME_{AI} \times (1 - MC_{AI})}$$

Where:

EDI_{AI} = estimated daily intake of lead from aquatic invertebrates (mg/d)
FMR = free-living metabolic rate (kcal/d)
P_{AI} = portion of diet consisting of aquatic invertebrates (%)
C_{lead} = concentration of lead in aquatic invertebrates (mg/kg)
BA = bio-accessibility of lead (%)
ME_{AI} = metabolizable energy of aquatic invertebrates (kcal/kg)
MC_{AI} = moisture content of aquatic invertebrates (%)

Example:

$$EDI_{AI} = \frac{(2.8E+02) \times (0.4) \times (2.3E+01) \times 1}{(2.8E+03) \times (1 - 0.8)}$$
$$EDI_{AI} = 4.7E+00\ mg/d$$

J-2.2.3.5 Estimated Daily Intake

The estimated daily intake of lead for herons from all potential pathways of exposure was calculated as follows:

$$EDI_{total} = EDI_{sand} + EDI_{AH} + EDI_{SL} + EDI_{AI}$$

Where:

EDI_{total}= estimated daily intake of lead via all routes of exposure (mg/d)

EDI_{sand}= estimated daily intake of lead from ingestion of sand (mg/d)

EDI_{AH} = estimated daily intake of lead from consumption of Atlantic herring (mg/d)

EDI_{SL} = estimated daily intake of lead from consumption of sand lance (mg/d)

EDI_{AI} = estimated daily intake of lead from consumption of aquatic invertebrates (mg/d)

Example:

$$EDI_{total} = (5.9E - 01) + (7.2E - 02) + (1.9E + 00) + (4.7E + 00)$$

$$EDI_{total} = 7.2E + 00\ mg/d$$

J-2.2.3.6 Estimated Total Daily Intake

The estimated total daily intake of lead for herons from all potential pathways of exposure was calculated as follows:

$$TDI = \frac{EDI_{total}}{BW}$$

Where:

TDI = estimated total daily intake of lead per kg body weight (mg/kg bw/d)

EDI_{total}= estimated daily intake of lead via all routes of exposure (kg/d)

BW = heron body weight (kg)

Example:

$$TDI = \frac{1.7E + 00}{8.3E - 01}$$

$$TDI = 8.8E + 00 mg/kg\ bw/d$$

J-2.3 Risk Characterization

The hazard quotient (HQ) is the ratio of the estimated total daily intake (TDI) to the toxicity reference value (TRV) and was calculated as follows:

$$HQ = \frac{TDI}{TRV}$$

where:

HQ = hazard quotient (unitless)
TDI = estimated total daily intake of lead (mg/kg bw/d)
TRV = toxicity reference value (mg/kg bw/d)

Example:

$$HQ = \frac{8.8E + 00}{9.9E + 00}$$
$$HQ = 8.8E - 01$$

J-2.4 References

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Appendix J
Avian Exposure Model

Table J1 Summary of Area and Chemical Specific HQ Values for Ecological Receptors
(Based on MTL Values)

		FD	FD	FD	FD	UCLM
Receptor	**Chemical**	**Reference**	**Area1**	**Area2**	**Area3**	**Area1to3**
Heron	Iron	1.1E+00	2.1E+00	1.9E+00	1.7E+00	1.9E+00
Heron	Lithium	5.1E-02	6.4E-02	6.0E-02	6.1E-02	6.2E-02
Heron	Strontium	3.8E-01	6.4E-01	5.1E-01	4.6E-01	5.3E-01
Sandpiper	Iron	7.5E+00	1.3E+01	6.3E+00	5.0E+00	9.4E+00
Sandpiper	Lithium	7.5E-01	9.5E-01	8.9E-01	9.3E-01	9.2E-01
Sandpiper	Strontium	2.6E+00	4.6E+00	3.6E+00	3.3E+00	3.7E+00
Tern	Iron	3.9E-01	1.5E+00	1.5E+00	1.4E+00	1.5E+00
Tern	Lithium	1.9E-02	2.9E-02	2.9E-02	2.9E-02	2.9E-02
Tern	Strontium	1.1E-01	1.8E-01	1.5E-01	1.4E-01	1.5E-01

HQ>10

HQ>1

FD: Full Distribution

UCLM: Upper Confidence Limit on Mean

Table J2 Summary of Area and Chemical Specific HQ Values for Ecological Receptors

		FD	FD	FD	FD	UCLM
Receptor	Chemical	Reference	Area1	Area2	Area3	Area1to3
Heron	Aluminum	2.1E-01	2.2E-01	2.0E-01	1.7E-01	2.0E-01
Heron	Arsenic	2.0E-02	4.8E-02	3.6E-02	3.3E-02	3.8E-02
Heron	Cadmium	9.1E-03	9.9E-02	3.4E-02	2.0E-02	4.8E-02
Heron	Copper	8.1E-02	4.7E-01	2.4E-01	2.0E-01	2.9E-01
Heron	Lead	1.4E-02	8.8E-01	3.8E-01	3.5E-01	8.1E-01
Heron	Selenium	3.2E-01	4.9E-01	4.1E-01	3.9E-01	4.2E-01
Heron	Thallium	9.9E-03	6.2E-01	2.4E-01	2.0E-01	3.4E-01
Heron	Zinc	8.0E-02	3.4E-01	2.4E-01	2.3E-01	3.1E-01
Sandpiper	Aluminum	1.5E+00	1.3E+00	1.1E+00	8.8E-01	1.1E+00
Sandpiper	Arsenic	9.2E-02	3.3E-01	1.7E-01	1.5E-01	2.2E-01
Sandpiper	Cadmium	3.5E-02	6.9E-01	2.0E-01	1.0E-01	3.8E-01
Sandpiper	Copper	5.3E-01	3.3E+00	1.5E+00	1.2E+00	2.1E+00
Sandpiper	Lead	9.8E-02	7.1E+00	1.1E+00	1.2E+00	1.5E+01
Sandpiper	Selenium	9.2E-01	2.3E+00	1.5E+00	1.3E+00	1.7E+00
Sandpiper	Thallium	7.1E-02	3.4E+00	5.5E-01	2.5E-01	1.4E+00
Sandpiper	Zinc	1.8E-01	2.5E+00	4.2E-01	3.6E-01	2.9E+00
Tern	Aluminum	4.7E-02	1.0E-01	1.0E-01	9.5E-02	1.0E-01
Tern	Arsenic	1.9E-02	3.0E-02	2.7E-02	2.6E-02	2.8E-02
Tern	Cadmium	1.2E-02	3.4E-02	2.1E-02	1.8E-02	2.4E-02
Tern	Copper	3.9E-02	1.5E-01	9.7E-02	8.9E-02	1.1E-01
Tern	Lead	5.7E-03	4.2E-01	3.2E-01	3.1E-01	4.3E-01
Tern	Selenium	4.9E-01	5.7E-01	5.6E-01	5.5E-01	5.6E-01
Tern	Thallium	7.1E-03	4.5E-01	3.8E-01	3.7E-01	3.9E-01
Tern	Zinc	1.3E-01	3.1E-01	2.8E-01	2.8E-01	3.0E-01

HQ>10

HQ>1

FD: Full Distribution

UCLM: Upper Confidence Limit on Mean

Table J3 Predicted Chemical Exposure for Each Wildlife Receptor and Exposure Area

				Sand	AtlHerr	SandLanc	AquaticInvert	EDI	TDI	HQ	Percent Contribution				
Scenario	Receptor	Area	Chemical	mg/day	mg/day	mg/day	mg/day	mg/day	mg/kg/day	Unitless	Sand	ArcHerr	SandLanc	AquaticInvert	Total
FD	Heron	Area1	Aluminum	1.6E-01	6.3E-01	6.3E+00	2.2E+01	2.9E+01	3.6E+01	2.2E-01	0.6%	2.1%	21.4%	75.9%	100%
FD	Heron	Area1	Arsenic	2.7E-02	3.1E-02	1.2E-01	3.8E-01	5.5E-01	6.7E-01	4.8E-02	4.9%	5.5%	21.5%	68.1%	100%
FD	Heron	Area1	Cadmium	1.3E-03	4.8E-03	9.5E-03	1.8E-01	1.9E-01	2.3E-01	9.9E-02	0.7%	2.5%	4.9%	91.9%	100%
FD	Heron	Area1	Copper	3.8E-02	5.1E-02	3.0E-01	4.3E+00	4.7E+00	5.7E+00	4.7E-01	0.8%	1.1%	6.4%	91.7%	100%
FD	Heron	Area1	Iron	4.7E+00	1.7E+00	2.9E+01	2.9E+01	6.5E+01	7.8E+01	2.1E+00	7.2%	2.6%	45.6%	44.5%	100%
FD	Heron	Area1	Lead	5.9E-01	7.2E-02	1.9E+00	4.7E+00	7.2E+00	8.8E+00	8.8E-01	8.1%	1.0%	25.7%	65.2%	100%
FD	Heron	Area1	Lithium	2.5E-02	3.7E-03	9.3E-03	5.9E-02	9.8E-02	1.2E-01	6.4E-02	26.0%	3.8%	9.5%	60.7%	100%
FD	Heron	Area1	Selenium	3.1E-03	2.7E-02	4.1E-02	7.9E-02	1.5E-01	1.8E-01	4.9E-01	2.1%	18.1%	27.5%	52.3%	100%
FD	Heron	Area1	Strontium	5.9E-02	1.0E+00	1.6E+00	7.5E+01	7.8E+01	9.4E+01	6.4E-01	0.1%	1.3%	2.1%	96.6%	100%
FD	Heron	Area1	Thallium	2.6E-04	1.7E-02	3.2E-02	1.3E-01	1.8E-01	2.2E-01	6.2E-01	0.1%	9.2%	17.7%	72.9%	100%
FD	Heron	Area1	Zinc	2.7E+00	1.4E+00	1.0E+01	7.5E+00	2.2E+01	2.6E+01	3.4E-01	12.2%	6.4%	47.2%	34.2%	100%
UCLM	Heron	Area1to3	Aluminum	1.7E-01	6.3E-01	6.3E+00	1.9E+01	2.6E+01	3.2E+01	2.0E-01	0.7%	2.4%	23.8%	73.1%	100%
UCLM	Heron	Area1to3	Arsenic	1.3E-02	3.1E-02	1.2E-01	2.8E-01	4.4E-01	5.4E-01	3.8E-02	2.9%	6.9%	26.8%	63.4%	100%
UCLM	Heron	Area1to3	Cadmium	4.6E-03	4.8E-03	9.5E-03	7.6E-02	9.5E-02	1.1E-01	4.8E-02	4.8%	5.0%	10.0%	80.1%	100%
UCLM	Heron	Area1to3	Copper	7.4E-02	5.1E-02	3.0E-01	2.5E+00	2.9E+00	3.5E+00	2.9E-01	2.5%	1.7%	10.4%	85.3%	100%
UCLM	Heron	Area1to3	Iron	2.6E+00	1.7E+00	2.9E+01	2.5E+01	5.8E+01	7.1E+01	1.9E+00	4.5%	2.9%	50.4%	42.2%	100%
UCLM	Heron	Area1to3	Lead	2.7E+00	7.2E-02	1.9E+00	2.0E+00	6.7E+00	8.1E+00	8.1E-01	40.5%	1.1%	27.9%	30.5%	100%
UCLM	Heron	Area1to3	Lithium	2.5E-02	3.7E-03	9.3E-03	5.6E-02	9.4E-02	1.1E-01	6.2E-02	26.7%	4.0%	9.9%	59.5%	100%
UCLM	Heron	Area1to3	Selenium	2.0E-03	2.7E-02	4.1E-02	5.9E-02	1.3E-01	1.6E-01	4.2E-01	1.5%	21.1%	32.0%	45.4%	100%
UCLM	Heron	Area1to3	Strontium	5.9E-02	1.0E+00	1.6E+00	6.2E+01	6.4E+01	7.8E+01	5.3E-01	0.1%	1.6%	2.5%	95.8%	100%
UCLM	Heron	Area1to3	Thallium	1.7E-03	1.7E-02	3.2E-02	4.7E-02	9.7E-02	1.2E-01	3.4E-01	1.8%	17.2%	33.0%	48.0%	100%
UCLM	Heron	Area1to3	Zinc	3.8E+00	1.4E+00	1.0E+01	4.2E+00	2.0E+01	2.4E+01	3.1E-01	19.4%	7.1%	52.4%	21.1%	100%
FD	Heron	Area2	Aluminum	2.8E-02	6.3E-01	6.3E+00	2.0E+01	2.7E+01	3.3E+01	2.0E-01	0.1%	2.3%	23.2%	74.4%	100%
FD	Heron	Area2	Arsenic	2.4E-03	3.1E-02	1.2E-01	2.6E-01	4.1E-01	5.0E-01	3.6E-02	0.6%	7.5%	28.9%	63.1%	100%
FD	Heron	Area2	Cadmium	2.5E-04	4.8E-03	9.5E-03	5.1E-02	6.6E-02	7.9E-02	3.4E-02	0.4%	7.3%	14.5%	77.9%	100%
FD	Heron	Area2	Copper	5.1E-03	5.1E-02	3.0E-01	2.0E+00	2.4E+00	2.9E+00	2.4E-01	0.2%	2.2%	12.8%	84.9%	100%
FD	Heron	Area2	Iron	2.7E-02	1.7E+00	2.9E+01	2.6E+01	5.7E+01	6.9E+01	1.9E+00	0.0%	3.0%	51.6%	45.4%	100%
FD	Heron	Area2	Lead	1.5E-02	7.2E-02	1.9E+00	1.2E+00	3.1E+00	3.8E+00	3.8E-01	0.5%	2.3%	59.1%	38.1%	100%
FD	Heron	Area2	Lithium	2.4E-02	3.7E-03	9.3E-03	5.4E-02	9.1E-02	1.1E-01	6.0E-02	26.6%	4.1%	10.1%	59.3%	100%
FD	Heron	Area2	Selenium	1.4E-03	2.7E-02	4.1E-02	5.4E-02	1.2E-01	1.5E-01	4.1E-01	1.1%	22.0%	33.4%	43.5%	100%

Table J3 Predicted Chemical Exposure for Each Wildlife Receptor and Exposure Area

				Sand	AtlHerr	SandLanc	AquaticInvert	EDI	TDI	HQ	Percent Contribution				
Scenario	**Receptor**	**Area**	**Chemical**	**mg/day**	**mg/day**	**mg/day**	**mg/day**	**mg/day**	**mg/kg/day**	**Unitless**	**Sand**	**ArcHerr**	**SandLanc**	**AquaticInvert**	**Total**
FD	Heron	Area2	Strontium	5.1E-02	1.0E+00	1.6E+00	5.9E+01	6.2E+01	7.5E+01	5.1E-01	0.1%	1.6%	2.6%	95.7%	100%
FD	Heron	Area2	Thallium	1.9E-04	1.7E-02	3.2E-02	2.1E-02	7.0E-02	8.4E-02	2.4E-01	0.3%	23.9%	45.9%	29.9%	100%
FD	Heron	Area2	Zinc	5.4E-02	1.4E+00	1.0E+01	3.3E+00	1.5E+01	1.8E+01	2.4E-01	0.4%	9.3%	68.4%	22.0%	100%
FD	Heron	Area3	Aluminum	4.0E-02	6.3E-01	6.3E+00	1.6E+01	2.3E+01	2.8E+01	1.7E-01	0.2%	2.7%	27.3%	69.8%	100%
FD	Heron	Area3	Arsenic	2.3E-03	3.1E-02	1.2E-01	2.3E-01	3.8E-01	4.6E-01	3.3E-02	0.6%	8.0%	31.0%	60.4%	100%
FD	Heron	Area3	Cadmium	6.2E-04	4.8E-03	9.5E-03	2.5E-02	4.0E-02	4.8E-02	2.0E-02	1.6%	12.1%	24.0%	62.3%	100%
FD	Heron	Area3	Copper	7.1E-03	5.1E-02	3.0E-01	1.6E+00	2.0E+00	2.4E+00	2.0E-01	0.4%	2.6%	15.4%	81.7%	100%
FD	Heron	Area3	Iron	9.7E-02	1.7E+00	2.9E+01	2.0E+01	5.1E+01	6.2E+01	1.7E+00	0.2%	3.3%	57.2%	39.3%	100%
FD	Heron	Area3	Lead	8.6E-02	7.2E-02	1.9E+00	8.4E-01	2.9E+00	3.5E+00	3.5E-01	3.0%	2.5%	65.0%	29.5%	100%
FD	Heron	Area3	Lithium	2.5E-02	3.7E-03	9.3E-03	5.5E-02	9.3E-02	1.1E-01	6.1E-02	27.3%	4.0%	10.0%	58.8%	100%
FD	Heron	Area3	Selenium	1.4E-03	2.7E-02	4.1E-02	4.9E-02	1.2E-01	1.4E-01	3.9E-01	1.2%	22.9%	34.9%	41.0%	100%
FD	Heron	Area3	Strontium	6.7E-02	1.0E+00	1.6E+00	5.4E+01	5.6E+01	6.8E+01	4.6E-01	0.1%	1.8%	2.9%	95.2%	100%
FD	Heron	Area3	Thallium	2.5E-04	1.7E-02	3.2E-02	8.5E-03	5.7E-02	6.9E-02	2.0E-01	0.4%	29.1%	55.7%	14.8%	100%
FD	Heron	Area3	Zinc	1.2E-01	1.4E+00	1.0E+01	2.5E+00	1.4E+01	1.7E+01	2.3E-01	0.8%	9.8%	72.0%	17.5%	100%
FD	Heron	Reference	Aluminum	1.3E-02	1.2E-01	1.3E-01	2.8E+01	2.8E+01	3.4E+01	2.1E-01	0.0%	0.4%	0.5%	99.1%	100%
FD	Heron	Reference	Arsenic	3.4E-04	3.1E-02	5.8E-02	1.4E-01	2.3E-01	2.8E-01	2.0E-02	0.1%	13.2%	24.9%	61.8%	100%
FD	Heron	Reference	Cadmium	7.3E-05	3.8E-03	5.1E-03	8.9E-03	1.8E-02	2.2E-02	9.1E-03	0.4%	21.2%	28.4%	49.9%	100%
FD	Heron	Reference	Copper	1.0E-03	4.3E-02	5.1E-02	7.1E-01	8.0E-01	9.7E-01	8.1E-02	0.1%	5.4%	6.4%	88.1%	100%
FD	Heron	Reference	Iron	2.0E-03	1.0E+00	1.3E+00	3.1E+01	3.3E+01	4.0E+01	1.1E+00	0.0%	3.0%	4.0%	93.0%	100%
FD	Heron	Reference	Lead	6.1E-04	5.5E-03	1.9E-03	1.1E-01	1.1E-01	1.4E-01	1.4E-02	0.5%	4.8%	1.6%	93.0%	100%
FD	Heron	Reference	Lithium	1.9E-02	2.2E-03	4.1E-03	5.1E-02	7.7E-02	9.3E-02	5.1E-02	25.1%	2.8%	5.4%	66.7%	100%
FD	Heron	Reference	Selenium	1.4E-03	2.4E-02	4.1E-02	3.1E-02	9.7E-02	1.2E-01	3.2E-01	1.4%	24.7%	42.2%	31.7%	100%
FD	Heron	Reference	Strontium	2.3E-02	7.7E-01	1.2E+00	4.4E+01	4.6E+01	5.5E+01	3.8E-01	0.1%	1.7%	2.7%	95.6%	100%
FD	Heron	Reference	Thallium	1.4E-04	2.9E-04	3.7E-04	2.1E-03	2.9E-03	3.4E-03	9.9E-03	4.8%	10.1%	13.0%	72.1%	100%
FD	Heron	Reference	Zinc	2.4E-03	1.4E+00	2.1E+00	1.6E+00	5.1E+00	6.2E+00	8.0E-02	0.0%	27.0%	41.9%	31.0%	100%
FD	Sandpiper	Area1	Aluminum	3.6E-01	0.0E+00	0.0E+00	9.3E+00	9.7E+00	2.1E+02	1.3E+00	3.8%	0.0%	0.0%	96.2%	100%
FD	Sandpiper	Area1	Arsenic	6.1E-02	0.0E+00	0.0E+00	1.6E-01	2.2E-01	4.6E+00	3.3E-01	28.0%	0.0%	0.0%	72.0%	100%
FD	Sandpiper	Area1	Cadmium	2.9E-03	0.0E+00	0.0E+00	7.4E-02	7.7E-02	1.6E+00	6.9E-01	3.8%	0.0%	0.0%	96.2%	100%
FD	Sandpiper	Area1	Copper	8.5E-02	0.0E+00	0.0E+00	1.8E+00	1.9E+00	4.0E+01	3.3E+00	4.5%	0.0%	0.0%	95.5%	100%
FD	Sandpiper	Area1	Iron	1.0E+01	0.0E+00	0.0E+00	1.2E+01	2.2E+01	4.8E+02	1.3E+01	46.7%	0.0%	0.0%	53.3%	100%

Table J3 Predicted Chemical Exposure for Each Wildlife Receptor and Exposure Area

				Sand	AtlHerr	SandLanc	AquaticInvert	EDI	TDI	HQ	Percent Contribution				
Scenario	Receptor	Area	Chemical	mg/day	mg/day	mg/day	mg/day	mg/day	mg/kg/day	Unitless	Sand	ArcHerr	SandLanc	AquaticInvert	Total
FD	Sandpiper	Area1	Lead	1.3E+00	0.0E+00	0.0E+00	2.0E+00	3.3E+00	7.0E+01	7.1E+00	40.1%	0.0%	0.0%	59.9%	100%
FD	Sandpiper	Area1	Lithium	5.7E-02	0.0E+00	0.0E+00	2.5E-02	8.2E-02	1.7E+00	9.5E-01	69.7%	0.0%	0.0%	30.3%	100%
FD	Sandpiper	Area1	Selenium	7.0E-03	0.0E+00	0.0E+00	3.3E-02	4.0E-02	8.5E-01	2.3E+00	17.7%	0.0%	0.0%	82.3%	100%
FD	Sandpiper	Area1	Strontium	1.3E-01	0.0E+00	0.0E+00	3.1E+01	3.2E+01	6.7E+02	4.6E+00	0.4%	0.0%	0.0%	99.6%	100%
FD	Sandpiper	Area1	Thallium	5.7E-04	0.0E+00	0.0E+00	5.5E-02	5.5E-02	1.2E+00	3.4E+00	1.0%	0.0%	0.0%	99.0%	100%
FD	Sandpiper	Area1	Zinc	6.0E+00	0.0E+00	0.0E+00	3.1E+00	9.1E+00	1.9E+02	2.5E+00	65.7%	0.0%	0.0%	34.3%	100%
UCLM	Sandpiper	Area1to3	Aluminum	3.8E-01	0.0E+00	0.0E+00	8.0E+00	8.4E+00	1.8E+02	1.1E+00	4.6%	0.0%	0.0%	95.4%	100%
UCLM	Sandpiper	Area1to3	Arsenic	2.9E-02	0.0E+00	0.0E+00	1.2E-01	1.5E-01	3.1E+00	2.2E-01	19.8%	0.0%	0.0%	80.2%	100%
UCLM	Sandpiper	Area1to3	Cadmium	1.0E-02	0.0E+00	0.0E+00	3.2E-02	4.2E-02	8.9E-01	3.8E-01	24.4%	0.0%	0.0%	75.6%	100%
UCLM	Sandpiper	Area1to3	Copper	1.7E-01	0.0E+00	0.0E+00	1.0E+00	1.2E+00	2.6E+01	2.1E+00	13.8%	0.0%	0.0%	86.2%	100%
UCLM	Sandpiper	Area1to3	Iron	5.9E+00	0.0E+00	0.0E+00	1.0E+01	1.6E+01	3.4E+02	9.4E+00	36.6%	0.0%	0.0%	63.4%	100%
UCLM	Sandpiper	Area1to3	Lead	6.0E+00	0.0E+00	0.0E+00	8.5E-01	6.9E+00	1.5E+02	1.5E+01	87.7%	0.0%	0.0%	12.3%	100%
UCLM	Sandpiper	Area1to3	Lithium	5.6E-02	0.0E+00	0.0E+00	2.3E-02	7.9E-02	1.7E+00	9.2E-01	70.7%	0.0%	0.0%	29.3%	100%
UCLM	Sandpiper	Area1to3	Selenium	4.4E-03	0.0E+00	0.0E+00	2.5E-02	2.9E-02	6.2E-01	1.7E+00	15.2%	0.0%	0.0%	84.8%	100%
UCLM	Sandpiper	Area1to3	Strontium	1.3E-01	0.0E+00	0.0E+00	2.6E+01	2.6E+01	5.5E+02	3.7E+00	0.5%	0.0%	0.0%	99.5%	100%
UCLM	Sandpiper	Area1to3	Thallium	3.8E-03	0.0E+00	0.0E+00	1.9E-02	2.3E-02	4.9E-01	1.4E+00	16.6%	0.0%	0.0%	83.4%	100%
UCLM	Sandpiper	Area1to3	Zinc	8.6E+00	0.0E+00	0.0E+00	1.7E+00	1.0E+01	2.2E+02	2.9E+00	83.2%	0.0%	0.0%	16.8%	100%
FD	Sandpiper	Area2	Aluminum	6.2E-02	0.0E+00	0.0E+00	8.4E+00	8.5E+00	1.8E+02	1.1E+00	0.7%	0.0%	0.0%	99.3%	100%
FD	Sandpiper	Area2	Arsenic	5.4E-03	0.0E+00	0.0E+00	1.1E-01	1.1E-01	2.4E+00	1.7E-01	4.8%	0.0%	0.0%	95.2%	100%
FD	Sandpiper	Area2	Cadmium	5.7E-04	0.0E+00	0.0E+00	2.1E-02	2.2E-02	4.7E-01	2.0E-01	2.6%	0.0%	0.0%	97.4%	100%
FD	Sandpiper	Area2	Copper	1.1E-02	0.0E+00	0.0E+00	8.4E-01	8.5E-01	1.8E+01	1.5E+00	1.3%	0.0%	0.0%	98.7%	100%
FD	Sandpiper	Area2	Iron	6.2E-02	0.0E+00	0.0E+00	1.1E+01	1.1E+01	2.3E+02	6.3E+00	0.6%	0.0%	0.0%	99.4%	100%
FD	Sandpiper	Area2	Lead	3.5E-02	0.0E+00	0.0E+00	5.0E-01	5.3E-01	1.1E+01	1.1E+00	6.5%	0.0%	0.0%	93.5%	100%
FD	Sandpiper	Area2	Lithium	5.4E-02	0.0E+00	0.0E+00	2.3E-02	7.7E-02	1.6E+00	8.9E-01	70.7%	0.0%	0.0%	29.3%	100%
FD	Sandpiper	Area2	Selenium	3.1E-03	0.0E+00	0.0E+00	2.2E-02	2.6E-02	5.4E-01	1.5E+00	12.1%	0.0%	0.0%	87.9%	100%
FD	Sandpiper	Area2	Strontium	1.1E-01	0.0E+00	0.0E+00	2.5E+01	2.5E+01	5.3E+02	3.6E+00	0.5%	0.0%	0.0%	99.5%	100%
FD	Sandpiper	Area2	Thallium	4.3E-04	0.0E+00	0.0E+00	8.7E-03	9.1E-03	1.9E-01	5.5E-01	4.7%	0.0%	0.0%	95.3%	100%
FD	Sandpiper	Area2	Zinc	1.2E-01	0.0E+00	0.0E+00	1.4E+00	1.5E+00	3.2E+01	4.2E-01	8.1%	0.0%	0.0%	91.9%	100%
FD	Sandpiper	Area3	Aluminum	9.0E-02	0.0E+00	0.0E+00	6.7E+00	6.8E+00	1.4E+02	8.8E-01	1.3%	0.0%	0.0%	98.7%	100%
FD	Sandpiper	Area3	Arsenic	5.1E-03	0.0E+00	0.0E+00	9.6E-02	1.0E-01	2.2E+00	1.5E-01	5.0%	0.0%	0.0%	95.0%	100%
FD	Sandpiper	Area3	Cadmium	1.4E-03	0.0E+00	0.0E+00	1.0E-02	1.2E-02	2.5E-01	1.0E-01	11.9%	0.0%	0.0%	88.1%	100%

Table J3 Predicted Chemical Exposure for Each Wildlife Receptor and Exposure Area

				Sand	AtlHerr	SandLanc	AquaticInvert	EDI	TDI	HQ	Percent Contribution				
Scenario	Receptor	Area	Chemical	mg/day	mg/day	mg/day	mg/day	mg/day	mg/kg/day	Unitless	Sand	ArcHerr	SandLanc	AquaticInvert	Total
FD	Sandpiper	Area3	Copper	1.6E-02	0.0E+00	0.0E+00	6.7E-01	6.9E-01	1.5E+01	1.2E+00	2.3%	0.0%	0.0%	97.7%	100%
FD	Sandpiper	Area3	Iron	2.2E-01	0.0E+00	0.0E+00	8.4E+00	8.7E+00	1.8E+02	5.0E+00	2.5%	0.0%	0.0%	97.5%	100%
FD	Sandpiper	Area3	Lead	1.9E-01	0.0E+00	0.0E+00	3.5E-01	5.4E-01	1.2E+01	1.2E+00	35.4%	0.0%	0.0%	64.6%	100%
FD	Sandpiper	Area3	Lithium	5.7E-02	0.0E+00	0.0E+00	2.3E-02	8.0E-02	1.7E+00	9.3E-01	71.4%	0.0%	0.0%	28.6%	100%
FD	Sandpiper	Area3	Selenium	3.1E-03	0.0E+00	0.0E+00	2.0E-02	2.3E-02	5.0E-01	1.3E+00	13.2%	0.0%	0.0%	86.8%	100%
FD	Sandpiper	Area3	Strontium	1.5E-01	0.0E+00	0.0E+00	2.2E+01	2.3E+01	4.8E+02	3.3E+00	0.7%	0.0%	0.0%	99.3%	100%
FD	Sandpiper	Area3	Thallium	5.7E-04	0.0E+00	0.0E+00	3.5E-03	4.1E-03	8.7E-02	2.5E-01	13.9%	0.0%	0.0%	86.1%	100%
FD	Sandpiper	Area3	Zinc	2.6E-01	0.0E+00	0.0E+00	1.0E+00	1.3E+00	2.8E+01	3.6E-01	20.1%	0.0%	0.0%	79.9%	100%
FD	Sandpiper	Reference	Aluminum	3.0E-02	0.0E+00	0.0E+00	1.1E+01	1.1E+01	2.4E+02	1.5E+00	0.3%	0.0%	0.0%	99.7%	100%
FD	Sandpiper	Reference	Arsenic	7.6E-04	0.0E+00	0.0E+00	6.0E-02	6.1E-02	1.3E+00	9.2E-02	1.3%	0.0%	0.0%	98.7%	100%
FD	Sandpiper	Reference	Cadmium	1.6E-04	0.0E+00	0.0E+00	3.7E-03	3.9E-03	8.2E-02	3.5E-02	4.2%	0.0%	0.0%	95.8%	100%
FD	Sandpiper	Reference	Copper	2.3E-03	0.0E+00	0.0E+00	3.0E-01	3.0E-01	6.3E+00	5.3E-01	0.8%	0.0%	0.0%	99.2%	100%
FD	Sandpiper	Reference	Iron	4.5E-03	0.0E+00	0.0E+00	1.3E+01	1.3E+01	2.7E+02	7.5E+00	0.0%	0.0%	0.0%	100.0%	100%
FD	Sandpiper	Reference	Lead	1.4E-03	0.0E+00	0.0E+00	4.4E-02	4.6E-02	9.7E-01	9.8E-02	3.0%	0.0%	0.0%	97.0%	100%
FD	Sandpiper	Reference	Lithium	4.3E-02	0.0E+00	0.0E+00	2.1E-02	6.5E-02	1.4E+00	7.5E-01	67.0%	0.0%	0.0%	33.0%	100%
FD	Sandpiper	Reference	Selenium	3.1E-03	0.0E+00	0.0E+00	1.3E-02	1.6E-02	3.4E-01	9.2E-01	19.3%	0.0%	0.0%	80.7%	100%
FD	Sandpiper	Reference	Strontium	5.2E-02	0.0E+00	0.0E+00	1.8E+01	1.8E+01	3.9E+02	2.6E+00	0.3%	0.0%	0.0%	99.7%	100%
FD	Sandpiper	Reference	Thallium	3.1E-04	0.0E+00	0.0E+00	8.6E-04	1.2E-03	2.5E-02	7.1E-02	26.5%	0.0%	0.0%	73.5%	100%
FD	Sandpiper	Reference	Zinc	5.5E-03	0.0E+00	0.0E+00	6.6E-01	6.7E-01	1.4E+01	1.8E-01	0.8%	0.0%	0.0%	99.2%	100%
FD	Tern	Area1	Aluminum	6.2E-03	3.7E-01	9.8E-01	6.5E-01	2.0E+00	1.7E+01	1.0E-01	0.3%	18.4%	48.9%	32.5%	100%
FD	Tern	Area1	Arsenic	1.0E-03	1.8E-02	1.9E-02	1.1E-02	4.8E-02	4.1E-01	3.0E-02	2.1%	37.0%	38.2%	22.7%	100%
FD	Tern	Area1	Cadmium	5.0E-05	2.8E-03	1.5E-03	5.2E-03	9.5E-03	8.1E-02	3.4E-02	0.5%	29.4%	15.5%	54.6%	100%
FD	Tern	Area1	Copper	1.4E-03	3.0E-02	4.7E-02	1.3E-01	2.0E-01	1.7E+00	1.5E-01	0.7%	14.6%	23.1%	61.6%	100%
FD	Tern	Area1	Iron	1.8E-01	1.0E+00	4.6E+00	8.4E-01	6.6E+00	5.6E+01	1.5E+00	2.7%	15.1%	69.5%	12.7%	100%
FD	Tern	Area1	Lead	2.2E-02	4.2E-02	2.9E-01	1.4E-01	4.9E-01	4.2E+00	4.2E-01	4.5%	8.6%	58.9%	28.0%	100%
FD	Tern	Area1	Lithium	9.6E-04	2.2E-03	1.4E-03	1.7E-03	6.3E-03	5.4E-02	2.9E-02	15.3%	34.4%	22.9%	27.5%	100%
FD	Tern	Area1	Selenium	1.2E-04	1.6E-02	6.5E-03	2.3E-03	2.5E-02	2.1E-01	5.7E-01	0.5%	64.2%	26.0%	9.3%	100%
FD	Tern	Area1	Strontium	2.2E-03	5.9E-01	2.5E-01	2.2E+00	3.1E+00	2.6E+01	1.8E-01	0.1%	19.5%	8.2%	72.2%	100%
FD	Tern	Area1	Thallium	9.7E-06	9.8E-03	5.0E-03	3.8E-03	1.9E-02	1.6E-01	4.5E-01	0.1%	52.5%	26.8%	20.7%	100%
FD	Tern	Area1	Zinc	1.0E-01	8.2E-01	1.6E+00	2.2E-01	2.8E+00	2.4E+01	3.1E-01	3.7%	29.8%	58.6%	7.9%	100%
UCLM	Tern	Area1to3	Aluminum	6.5E-03	3.7E-01	9.8E-01	5.6E-01	1.9E+00	1.6E+01	1.0E-01	0.3%	19.2%	51.1%	29.4%	100%

Table J3 Predicted Chemical Exposure for Each Wildlife Receptor and Exposure Area

				Sand	AtlHerr	SandLanc	AquaticInvert	EDI	TDI	HQ	Percent Contribution				
Scenario	Receptor	Area	Chemical	mg/day	mg/day	mg/day	mg/day	mg/day	mg/kg/day	Unitless	Sand	ArcHerr	SandLanc	AquaticInvert	Total
UCLM	Tern	Area1to3	Arsenic	4.9E-04	1.8E-02	1.9E-02	8.2E-03	4.5E-02	3.9E-01	2.8E-02	1.1%	39.7%	41.0%	18.2%	100%
UCLM	Tern	Area1to3	Cadmium	1.7E-04	2.8E-03	1.5E-03	2.2E-03	6.7E-03	5.7E-02	2.4E-02	2.6%	41.9%	22.2%	33.3%	100%
UCLM	Tern	Area1to3	Copper	2.8E-03	3.0E-02	4.7E-02	7.3E-02	1.5E-01	1.3E+00	1.1E-01	1.8%	19.5%	30.9%	47.7%	100%
UCLM	Tern	Area1to3	Iron	1.0E-01	1.0E+00	4.6E+00	7.2E-01	6.4E+00	5.5E+01	1.5E+00	1.6%	15.6%	71.6%	11.2%	100%
UCLM	Tern	Area1to3	Lead	1.0E-01	4.2E-02	2.9E-01	5.9E-02	4.9E-01	4.2E+00	4.3E-01	20.7%	8.6%	58.7%	12.0%	100%
UCLM	Tern	Area1to3	Lithium	9.5E-04	2.2E-03	1.4E-03	1.6E-03	6.2E-03	5.3E-02	2.9E-02	15.3%	35.0%	23.3%	26.3%	100%
UCLM	Tern	Area1to3	Selenium	7.5E-05	1.6E-02	6.5E-03	1.7E-03	2.4E-02	2.1E-01	5.6E-01	0.3%	65.9%	26.7%	7.1%	100%
UCLM	Tern	Area1to3	Strontium	2.2E-03	5.9E-01	2.5E-01	1.8E+00	2.7E+00	2.3E+01	1.5E-01	0.1%	22.4%	9.5%	68.0%	100%
UCLM	Tern	Area1to3	Thallium	6.5E-05	9.8E-03	5.0E-03	1.4E-03	1.6E-02	1.4E-01	3.9E-01	0.4%	60.3%	30.9%	8.4%	100%
UCLM	Tern	Area1to3	Zinc	1.5E-01	8.2E-01	1.6E+00	1.2E-01	2.7E+00	2.3E+01	3.0E-01	5.4%	30.4%	59.7%	4.5%	100%
FD	Tern	Area2	Aluminum	1.1E-03	3.7E-01	9.8E-01	5.9E-01	1.9E+00	1.7E+01	1.0E-01	0.1%	19.0%	50.5%	30.4%	100%
FD	Tern	Area2	Arsenic	9.2E-05	1.8E-02	1.9E-02	7.6E-03	4.4E-02	3.8E-01	2.7E-02	0.2%	40.6%	42.0%	17.2%	100%
FD	Tern	Area2	Cadmium	9.7E-06	2.8E-03	1.5E-03	1.5E-03	5.8E-03	4.9E-02	2.1E-02	0.2%	48.4%	25.6%	25.8%	100%
FD	Tern	Area2	Copper	1.9E-04	3.0E-02	4.7E-02	5.9E-02	1.4E-01	1.2E+00	9.7E-02	0.1%	21.9%	34.7%	43.3%	100%
FD	Tern	Area2	Iron	1.0E-03	1.0E+00	4.6E+00	7.6E-01	6.3E+00	5.4E+01	1.5E+00	0.0%	15.7%	72.3%	11.9%	100%
FD	Tern	Area2	Lead	5.9E-04	4.2E-02	2.9E-01	3.5E-02	3.7E-01	3.1E+00	3.2E-01	0.2%	11.5%	78.8%	9.5%	100%
FD	Tern	Area2	Lithium	9.2E-04	2.2E-03	1.4E-03	1.6E-03	6.1E-03	5.2E-02	2.9E-02	15.1%	35.4%	23.6%	25.9%	100%
FD	Tern	Area2	Selenium	5.2E-05	1.6E-02	6.5E-03	1.6E-03	2.4E-02	2.1E-01	5.6E-01	0.2%	66.3%	26.9%	6.6%	100%
FD	Tern	Area2	Strontium	1.9E-03	5.9E-01	2.5E-01	1.7E+00	2.6E+00	2.2E+01	1.5E-01	0.1%	23.0%	9.7%	67.2%	100%
FD	Tern	Area2	Thallium	7.2E-06	9.8E-03	5.0E-03	6.1E-04	1.5E-02	1.3E-01	3.8E-01	0.0%	63.5%	32.5%	4.0%	100%
FD	Tern	Area2	Zinc	2.1E-03	8.2E-01	1.6E+00	9.7E-02	2.5E+00	2.2E+01	2.8E-01	0.1%	32.4%	63.7%	3.8%	100%
FD	Tern	Area3	Aluminum	1.5E-03	3.7E-01	9.8E-01	4.7E-01	1.8E+00	1.6E+01	9.5E-02	0.1%	20.2%	53.8%	25.9%	100%
FD	Tern	Area3	Arsenic	8.6E-05	1.8E-02	1.9E-02	6.8E-03	4.3E-02	3.7E-01	2.6E-02	0.2%	41.4%	42.8%	15.6%	100%
FD	Tern	Area3	Cadmium	2.4E-05	2.8E-03	1.5E-03	7.2E-04	5.0E-03	4.3E-02	1.8E-02	0.5%	55.7%	29.5%	14.3%	100%
FD	Tern	Area3	Copper	2.7E-04	3.0E-02	4.7E-02	4.7E-02	1.2E-01	1.1E+00	8.9E-02	0.2%	24.0%	38.0%	37.8%	100%
FD	Tern	Area3	Iron	3.7E-03	1.0E+00	4.6E+00	5.9E-01	6.2E+00	5.3E+01	1.4E+00	0.1%	16.1%	74.2%	9.6%	100%
FD	Tern	Area3	Lead	3.3E-03	4.2E-02	2.9E-01	2.5E-02	3.6E-01	3.1E+00	3.1E-01	0.9%	11.7%	80.5%	6.8%	100%
FD	Tern	Area3	Lithium	9.7E-04	2.2E-03	1.4E-03	1.6E-03	6.2E-03	5.3E-02	2.9E-02	15.6%	35.1%	23.4%	25.9%	100%
FD	Tern	Area3	Selenium	5.2E-05	1.6E-02	6.5E-03	1.4E-03	2.4E-02	2.0E-01	5.5E-01	0.2%	66.8%	27.1%	6.0%	100%
FD	Tern	Area3	Strontium	2.5E-03	5.9E-01	2.5E-01	1.6E+00	2.4E+00	2.1E+01	1.4E-01	0.1%	24.6%	10.4%	64.9%	100%
FD	Tern	Area3	Thallium	9.7E-06	9.8E-03	5.0E-03	2.5E-04	1.5E-02	1.3E-01	3.7E-01	0.1%	65.0%	33.3%	1.7%	100%

Table J3 Predicted Chemical Exposure for Each Wildlife Receptor and Exposure Area

				Sand	AtlHerr	SandLanc	AquaticInvert	EDI	TDI	HQ	Percent Contribution				
Scenario	**Receptor**	**Area**	**Chemical**	**mg/day**	**mg/day**	**mg/day**	**mg/day**	**mg/day**	**mg/kg/day**	**Unitless**	**Sand**	**ArcHerr**	**SandLanc**	**AquaticInvert**	**Total**
FD	Tern	Area3	Zinc	4.5E-03	8.2E-01	1.6E+00	7.3E-02	2.5E+00	2.1E+01	2.8E-01	0.2%	32.7%	64.2%	2.9%	100%
FD	Tern	Reference	Aluminum	5.0E-04	6.9E-02	2.1E-02	8.0E-01	8.9E-01	7.6E+00	4.7E-02	0.1%	7.7%	2.3%	90.0%	100%
FD	Tern	Reference	Arsenic	1.3E-05	1.8E-02	9.0E-03	4.2E-03	3.1E-02	2.7E-01	1.9E-02	0.0%	57.5%	29.0%	13.5%	100%
FD	Tern	Reference	Cadmium	2.8E-06	2.2E-03	7.9E-04	2.6E-04	3.3E-03	2.8E-02	1.2E-02	0.1%	67.8%	24.2%	8.0%	100%
FD	Tern	Reference	Copper	3.9E-05	2.5E-02	8.0E-03	2.1E-02	5.4E-02	4.6E-01	3.9E-02	0.1%	46.8%	14.8%	38.3%	100%
FD	Tern	Reference	Iron	7.7E-05	5.9E-01	2.1E-01	9.0E-01	1.7E+00	1.4E+01	3.9E-01	0.0%	34.5%	12.2%	53.2%	100%
FD	Tern	Reference	Lead	2.3E-05	3.2E-03	2.9E-04	3.1E-03	6.6E-03	5.7E-02	5.7E-03	0.3%	48.5%	4.4%	46.8%	100%
FD	Tern	Reference	Lithium	7.4E-04	1.3E-03	6.4E-04	1.5E-03	4.2E-03	3.5E-02	1.9E-02	17.7%	30.6%	15.5%	36.2%	100%
FD	Tern	Reference	Selenium	5.2E-05	1.4E-02	6.4E-03	9.0E-04	2.1E-02	1.8E-01	4.9E-01	0.2%	65.6%	29.9%	4.2%	100%
FD	Tern	Reference	Strontium	8.8E-04	4.5E-01	1.9E-01	1.3E+00	1.9E+00	1.6E+01	1.1E-01	0.0%	23.4%	10.0%	66.6%	100%
FD	Tern	Reference	Thallium	5.2E-06	1.7E-04	5.8E-05	6.0E-05	2.9E-04	2.5E-03	7.1E-03	1.8%	57.7%	19.9%	20.6%	100%
FD	Tern	Reference	Zinc	9.3E-05	8.1E-01	3.3E-01	4.6E-02	1.2E+00	1.0E+01	1.3E-01	0.0%	67.9%	28.2%	3.9%	100%

Table J4 Summary of Exposure Point Concentrations (EPC) Used in the Ecological Risk Assessment Model

Scenario	Media	Area	Chemical	Value	Units	Distribution	Parameter1	Parameter2	Comment
FD	Sand	Reference	Aluminum	8.03E+03	mg/kg	N(Mean, 95th)	8.03E+03	9.11E+03	
FD	Sand	Reference	Arsenic	3.33E+00	mg/kg	N(Mean, 95th)	3.33E+00	4.75E+00	
FD	Sand	Reference	Cadmium	5.33E-02	mg/kg	N(Mean, 95th)	5.33E-02	8.25E-02	
FD	Sand	Reference	Copper	6.83E+00	mg/kg	N(Mean, 95th)	6.83E+00	8.75E+00	
FD	Sand	Reference	Iron	1.23E+04	mg/kg	N(Mean, 95th)	1.23E+04	1.40E+04	
FD	Sand	Reference	Lead	6.12E+00	mg/kg	N(Mean, 95th)	6.12E+00	7.00E+00	
FD	Sand	Reference	Selenium	1.00E+00	mg/kg	Fixed	1.00E+00	1.00E+00	Equal to detection limit
FD	Sand	Reference	Thallium	1.00E-01	mg/kg	Fixed	1.00E-01	1.00E-01	Equal to detection limit
FD	Sand	Reference	Zinc	3.17E+01	mg/kg	N(Mean, 95th)	3.17E+01	3.60E+01	
FD	Sand	Reference	Lithium	1.41E+01	mg/kg	N(Mean, 95th)	1.41E+01	1.64E+01	
FD	Sand	Reference	Strontium	1.68E+01	mg/kg	N(Mean, 95th)	1.68E+01	2.80E+01	
FD	Sand	Area1	Aluminum	1.40E+04	mg/kg	N(Mean, 95th)	1.40E+04	1.52E+04	
FD	Sand	Area1	Arsenic	2.20E+02	mg/kg	N(Mean, 95th)	2.20E+02	3.78E+02	
FD	Sand	Area1	Cadmium	1.20E+01	mg/kg	N(Mean, 95th)	1.20E+01	2.04E+01	
FD	Sand	Area1	Copper	6.11E+02	mg/kg	N(Mean, 95th)	6.11E+02	9.77E+02	
FD	Sand	Area1	Iron	6.80E+04	mg/kg	N(Mean, 95th)	6.80E+04	1.00E+05	
FD	Sand	Area1	Lead	7.50E+03	mg/kg	N(Mean, 95th)	7.50E+03	1.65E+04	
FD	Sand	Area1	Selenium	2.29E+00	mg/kg	N(Mean, 95th)	2.29E+00	4.00E+00	
FD	Sand	Area1	Thallium	9.29E+00	mg/kg	N(Mean, 95th)	9.29E+00	2.72E+01	
FD	Sand	Area1	Zinc	2.11E+04	mg/kg	N(Mean, 95th)	2.11E+04	3.64E+04	
FD	Sand	Area1	Lithium	1.84E+01	mg/kg	N(Mean, 95th)	1.84E+01	2.06E+01	
FD	Sand	Area1	Strontium	4.30E+01	mg/kg	N(Mean, 95th)	4.30E+01	6.04E+01	
FD	Sand	Area2	Aluminum	1.44E+04	mg/kg	N(Mean, 95th)	1.44E+04	1.58E+04	
FD	Sand	Area2	Arsenic	1.60E+01	mg/kg	N(Mean, 95th)	1.60E+01	2.35E+01	
FD	Sand	Area2	Cadmium	2.99E-01	mg/kg	N(Mean, 95th)	2.99E-01	4.28E-01	
FD	Sand	Area2	Copper	1.49E+01	mg/kg	N(Mean, 95th)	1.49E+01	1.77E+01	
FD	Sand	Area2	Iron	2.22E+04	mg/kg	N(Mean, 95th)	2.22E+04	2.48E+04	
FD	Sand	Area2	Lead	5.63E+01	mg/kg	N(Mean, 95th)	5.63E+01	8.26E+01	
FD	Sand	Area2	Selenium	1.00E+00	mg/kg	Fixed	1.00E+00	1.00E+00	Equal to detection limit
FD	Sand	Area2	Thallium	6.00E-01	mg/kg	N(Mean, 95th)	6.00E-01	8.40E-01	
FD	Sand	Area2	Zinc	1.16E+02	mg/kg	N(Mean, 95th)	1.16E+02	2.05E+02	
FD	Sand	Area2	Lithium	1.77E+01	mg/kg	N(Mean, 95th)	1.77E+01	1.91E+01	

Table J4 Summary of Exposure Point Concentrations (EPC) Used in the Ecological Risk Assessment Model

Scenario	Media	Area	Chemical	Value	Units	Distribution	Parameter1	Parameter2	Comment
FD	Sand	Area2	Strontium	3.71E+01	mg/kg	N(Mean, 95th)	3.71E+01	4.07E+01	
FD	Sand	Area3	Aluminum	1.62E+04	mg/kg	N(Mean, 95th)	1.62E+04	1.82E+04	
FD	Sand	Area3	Arsenic	1.99E+01	mg/kg	N(Mean, 95th)	1.99E+01	2.77E+01	
FD	Sand	Area3	Cadmium	5.87E-01	mg/kg	N(Mean, 95th)	5.87E-01	1.18E+00	
FD	Sand	Area3	Copper	2.14E+01	mg/kg	N(Mean, 95th)	2.14E+01	2.77E+01	
FD	Sand	Area3	Iron	2.53E+04	mg/kg	N(Mean, 95th)	2.53E+04	2.69E+04	
FD	Sand	Area3	Lead	8.13E+01	mg/kg	N(Mean, 95th)	8.13E+01	1.49E+02	
FD	Sand	Area3	Selenium	1.00E+00	mg/kg	Fixed	1.00E+00	1.00E+00	Equal to detection limit
FD	Sand	Area3	Thallium	5.14E-01	mg/kg	N(Mean, 95th)	5.14E-01	7.70E-01	
FD	Sand	Area3	Zinc	2.19E+02	mg/kg	N(Mean, 95th)	2.19E+02	4.74E+02	
FD	Sand	Area3	Lithium	1.85E+01	mg/kg	N(Mean, 95th)	1.85E+01	2.06E+01	
FD	Sand	Area3	Strontium	4.87E+01	mg/kg	N(Mean, 95th)	4.87E+01	6.47E+01	
UCLM	Sand	Area1to3	Aluminum	1.49E+04	mg/kg	N(Mean, 95th)	1.49E+04	1.54E+04	
UCLM	Sand	Area1to3	Arsenic	8.53E+01	mg/kg	LN(Mean, 95th)	8.53E+01	1.98E+02	
UCLM	Sand	Area1to3	Cadmium	4.30E+00	mg/kg	LN(Mean, 95th)	4.30E+00	1.05E+01	
UCLM	Sand	Area1to3	Copper	2.16E+02	mg/kg	LN(Mean, 95th)	2.16E+02	5.46E+02	
UCLM	Sand	Area1to3	Iron	3.85E+04	mg/kg	N(Mean, 95th)	3.85E+04	6.33E+04	
UCLM	Sand	Area1to3	Lead	2.55E+03	mg/kg	LN(Mean, 95th)	2.55E+03	9.31E+03	
UCLM	Sand	Area1to3	Selenium	1.43E+00	mg/kg	N(Mean, 95th)	1.43E+00	1.80E+00	
UCLM	Sand	Area1to3	Thallium	3.47E+00	mg/kg	LN(Mean, 95th)	3.47E+00	1.05E+01	
UCLM	Sand	Area1to3	Zinc	7.14E+03	mg/kg	LN(Mean, 95th)	7.14E+03	2.41E+04	
UCLM	Sand	Area1to3	Lithium	1.82E+01	mg/kg	N(Mean, 95th)	1.82E+01	1.88E+01	
UCLM	Sand	Area1to3	Strontium	4.30E+01	mg/kg	N(Mean, 95th)	4.30E+01	4.76E+01	
FD	AquaticInvert	Reference	Aluminum	1.34E+02	mg/kg-WW	N(Mean, 95th)	1.34E+02	2.20E+02	
FD	AquaticInvert	Reference	Arsenic	7.00E-01	mg/kg-WW	N(Mean, 95th)	7.00E-01	8.00E-01	
FD	AquaticInvert	Reference	Cadmium	4.33E-02	mg/kg-WW	N(Mean, 95th)	4.33E-02	6.20E-02	
FD	AquaticInvert	Reference	Copper	3.45E+00	mg/kg-WW	N(Mean, 95th)	3.45E+00	5.30E+00	
FD	AquaticInvert	Reference	Iron	1.50E+02	mg/kg-WW	N(Mean, 95th)	1.50E+02	2.20E+02	
FD	AquaticInvert	Reference	Lead	5.17E-01	mg/kg-WW	N(Mean, 95th)	5.17E-01	7.90E-01	
FD	AquaticInvert	Reference	Selenium	1.50E-01	mg/kg-WW	N(Mean, 95th)	1.50E-01	2.00E-01	
FD	AquaticInvert	Reference	Thallium	1.00E-02	mg/kg-WW	Fixed	1.00E-02	1.00E-02	Equal to detection limit
FD	AquaticInvert	Reference	Zinc	7.73E+00	mg/kg-WW	N(Mean, 95th)	7.73E+00	1.01E+01	
FD	AquaticInvert	Reference	Lithium	2.50E-01	mg/kg-WW	N(Mean, 95th)	2.50E-01	3.25E-01	

Table J4 Summary of Exposure Point Concentrations (EPC) Used in the Ecological Risk Assessment Model

Scenario	Media	Area	Chemical	Value	Units	Distribution	Parameter1	Parameter2	Comment
FD	AquaticInvert	Reference	Strontium	2.13E+02	mg/kg-WW	N(Mean, 95th)	2.13E+02	2.27E+02	
FD	AquaticInvert	Area1	Aluminum	1.08E+02	mg/kg-WW	N(Mean, 95th)	1.08E+02	1.53E+02	
FD	AquaticInvert	Area1	Arsenic	1.83E+00	mg/kg-WW	N(Mean, 95th)	1.83E+00	3.43E+00	
FD	AquaticInvert	Area1	Cadmium	8.66E-01	mg/kg-WW	N(Mean, 95th)	8.66E-01	1.92E+00	
FD	AquaticInvert	Area1	Copper	2.10E+01	mg/kg-WW	N(Mean, 95th)	2.10E+01	4.45E+01	
FD	AquaticInvert	Area1	Iron	1.40E+02	mg/kg-WW	N(Mean, 95th)	1.40E+02	1.85E+02	
FD	AquaticInvert	Area1	Lead	2.30E+01	mg/kg-WW	N(Mean, 95th)	2.30E+01	3.62E+01	
FD	AquaticInvert	Area1	Selenium	3.83E-01	mg/kg-WW	N(Mean, 95th)	3.83E-01	7.00E-01	
FD	AquaticInvert	Area1	Thallium	6.40E-01	mg/kg-WW	N(Mean, 95th)	6.40E-01	1.43E+00	
FD	AquaticInvert	Area1	Zinc	3.64E+01	mg/kg-WW	N(Mean, 95th)	3.64E+01	5.90E+01	
FD	AquaticInvert	Area1	Lithium	2.88E-01	mg/kg-WW	N(Mean, 95th)	2.88E-01	3.35E-01	
FD	AquaticInvert	Area1	Strontium	3.67E+02	mg/kg-WW	N(Mean, 95th)	3.67E+02	6.95E+02	
FD	AquaticInvert	Area2	Aluminum	9.83E+01	mg/kg-WW	N(Mean, 95th)	9.83E+01	3.09E+02	
FD	AquaticInvert	Area2	Arsenic	1.26E+00	mg/kg-WW	N(Mean, 95th)	1.26E+00	2.47E+00	
FD	AquaticInvert	Area2	Cadmium	2.49E-01	mg/kg-WW	N(Mean, 95th)	2.49E-01	6.29E-01	
FD	AquaticInvert	Area2	Copper	9.81E+00	mg/kg-WW	N(Mean, 95th)	9.81E+00	1.82E+01	
FD	AquaticInvert	Area2	Iron	1.26E+02	mg/kg-WW	N(Mean, 95th)	1.26E+02	3.94E+02	
FD	AquaticInvert	Area2	Lead	5.83E+00	mg/kg-WW	N(Mean, 95th)	5.83E+00	1.66E+01	
FD	AquaticInvert	Area2	Selenium	2.63E-01	mg/kg-WW	N(Mean, 95th)	2.63E-01	5.60E-01	
FD	AquaticInvert	Area2	Thallium	1.01E-01	mg/kg-WW	N(Mean, 95th)	1.01E-01	2.66E-01	
FD	AquaticInvert	Area2	Zinc	1.62E+01	mg/kg-WW	N(Mean, 95th)	1.62E+01	3.54E+01	
FD	AquaticInvert	Area2	Lithium	2.64E-01	mg/kg-WW	N(Mean, 95th)	2.64E-01	5.91E-01	
FD	AquaticInvert	Area2	Strontium	2.89E+02	mg/kg-WW	N(Mean, 95th)	2.89E+02	5.63E+02	
FD	AquaticInvert	Area3	Aluminum	7.84E+01	mg/kg-WW	N(Mean, 95th)	7.84E+01	1.28E+02	
FD	AquaticInvert	Area3	Arsenic	1.13E+00	mg/kg-WW	N(Mean, 95th)	1.13E+00	2.64E+00	
FD	AquaticInvert	Area3	Cadmium	1.20E-01	mg/kg-WW	N(Mean, 95th)	1.20E-01	2.12E-01	
FD	AquaticInvert	Area3	Copper	7.83E+00	mg/kg-WW	N(Mean, 95th)	7.83E+00	2.02E+01	
FD	AquaticInvert	Area3	Iron	9.85E+01	mg/kg-WW	N(Mean, 95th)	9.85E+01	1.68E+02	
FD	AquaticInvert	Area3	Lead	4.11E+00	mg/kg-WW	N(Mean, 95th)	4.11E+00	6.43E+00	
FD	AquaticInvert	Area3	Selenium	2.38E-01	mg/kg-WW	N(Mean, 95th)	2.38E-01	5.60E-01	
FD	AquaticInvert	Area3	Thallium	4.13E-02	mg/kg-WW	N(Mean, 95th)	4.13E-02	7.95E-02	
FD	AquaticInvert	Area3	Zinc	1.22E+01	mg/kg-WW	N(Mean, 95th)	1.22E+01	2.63E+01	
FD	AquaticInvert	Area3	Lithium	2.66E-01	mg/kg-WW	N(Mean, 95th)	2.66E-01	3.48E-01	

Table J4 Summary of Exposure Point Concentrations (EPC) Used in the Ecological Risk Assessment Model

Scenario	Media	Area	Chemical	Value	Units	Distribution	Parameter1	Parameter2	Comment
FD	AquaticInvert	Area3	Strontium	2.61E+02	mg/kg-WW	N(Mean, 95th)	2.61E+02	5.10E+02	
UCLM	AquaticInvert	Area1to3	Aluminum	9.38E+01	mg/kg-WW	N(Mean, 95th)	9.38E+01	1.26E+02	
UCLM	AquaticInvert	Area1to3	Arsenic	1.37E+00	mg/kg-WW	N(Mean, 95th)	1.37E+00	2.24E+00	
UCLM	AquaticInvert	Area1to3	Cadmium	3.70E-01	mg/kg-WW	N(Mean, 95th)	3.70E-01	5.64E-01	
UCLM	AquaticInvert	Area1to3	Copper	1.21E+01	mg/kg-WW	N(Mean, 95th)	1.21E+01	1.67E+01	
UCLM	AquaticInvert	Area1to3	Iron	1.20E+02	mg/kg-WW	N(Mean, 95th)	1.20E+02	1.59E+02	
UCLM	AquaticInvert	Area1to3	Lead	9.87E+00	mg/kg-WW	N(Mean, 95th)	9.87E+00	1.65E+01	
UCLM	AquaticInvert	Area1to3	Selenium	2.86E-01	mg/kg-WW	N(Mean, 95th)	2.86E-01	4.84E-01	
UCLM	AquaticInvert	Area1to3	Thallium	2.26E-01	mg/kg-WW	LN(Mean, 95th)	2.26E-01	5.80E-01	
UCLM	AquaticInvert	Area1to3	Zinc	2.02E+01	mg/kg-WW	N(Mean, 95th)	2.02E+01	2.78E+01	
UCLM	AquaticInvert	Area1to3	Lithium	2.71E-01	mg/kg-WW	N(Mean, 95th)	2.71E-01	3.20E-01	
UCLM	AquaticInvert	Area1to3	Strontium	3.00E+02	mg/kg-WW	N(Mean, 95th)	3.00E+02	3.70E+02	Modified-t UCL
FD	SandLanc	Reference	Aluminum	1.85E+00	mg/kg-WW	N(Mean, 95th)	1.85E+00	2.30E+00	
FD	SandLanc	Reference	Arsenic	8.09E-01	mg/kg-WW	N(Mean, 95th)	8.09E-01	1.07E+00	
FD	SandLanc	Reference	Cadmium	7.09E-02	mg/kg-WW	N(Mean, 95th)	7.09E-02	9.64E-02	
FD	SandLanc	Reference	Copper	7.19E-01	mg/kg-WW	N(Mean, 95th)	7.19E-01	7.70E-01	
FD	SandLanc	Reference	Iron	1.86E+01	mg/kg-WW	N(Mean, 95th)	1.86E+01	2.30E+01	
FD	SandLanc	Reference	Lead	2.60E-02	mg/kg-WW	N(Mean, 95th)	2.60E-02	3.77E-02	
FD	SandLanc	Reference	Selenium	5.75E-01	mg/kg-WW	N(Mean, 95th)	5.75E-01	6.10E-01	
FD	SandLanc	Reference	Thallium	5.20E-03	mg/kg-WW	U(Min, Max)	5.00E-03	7.00E-03	Minimum equal to detection limit
FD	SandLanc	Reference	Zinc	3.00E+01	mg/kg-WW	N(Mean, 95th)	3.00E+01	3.52E+01	
FD	SandLanc	Reference	Lithium	5.78E-02	mg/kg-WW	N(Mean, 95th)	5.78E-02	8.07E-02	
FD	SandLanc	Reference	Strontium	1.71E+01	mg/kg-WW	N(Mean, 95th)	1.71E+01	2.11E+01	
FD	SandLanc	Area1	Aluminum	8.80E+01	mg/kg-WW	N(Mean, 95th)	8.80E+01	2.39E+02	
FD	SandLanc	Area1	Arsenic	1.66E+00	mg/kg-WW	N(Mean, 95th)	1.66E+00	3.16E+00	
FD	SandLanc	Area1	Cadmium	1.33E-01	mg/kg-WW	N(Mean, 95th)	1.33E-01	2.04E-01	
FD	SandLanc	Area1	Copper	4.24E+00	mg/kg-WW	N(Mean, 95th)	4.24E+00	7.96E+00	
FD	SandLanc	Area1	Iron	4.12E+02	mg/kg-WW	N(Mean, 95th)	4.12E+02	9.52E+02	
FD	SandLanc	Area1	Lead	2.60E+01	mg/kg-WW	N(Mean, 95th)	2.60E+01	5.82E+01	
FD	SandLanc	Area1	Selenium	5.80E-01	mg/kg-WW	N(Mean, 95th)	5.80E-01	6.15E-01	
FD	SandLanc	Area1	Thallium	4.48E-01	mg/kg-WW	N(Mean, 95th)	4.48E-01	5.42E-01	
FD	SandLanc	Area1	Zinc	1.45E+02	mg/kg-WW	N(Mean, 95th)	1.45E+02	2.86E+02	
FD	SandLanc	Area1	Lithium	1.30E-01	mg/kg-WW	N(Mean, 95th)	1.30E-01	2.75E-01	

Table J4 Summary of Exposure Point Concentrations (EPC) Used in the Ecological Risk Assessment Model

Scenario	Media	Area	Chemical	Value	Units	Distribution	Parameter1	Parameter2	Comment
FD	SandLanc	Area1	Strontium	2.26E+01	mg/kg-WW	N(Mean, 95th)	2.26E+01	2.37E+01	
FD	SandLanc	Area2	Aluminum	8.80E+01	mg/kg-WW	N(Mean, 95th)	8.80E+01	2.39E+02	
FD	SandLanc	Area2	Arsenic	1.66E+00	mg/kg-WW	N(Mean, 95th)	1.66E+00	3.16E+00	
FD	SandLanc	Area2	Cadmium	1.33E-01	mg/kg-WW	N(Mean, 95th)	1.33E-01	2.04E-01	
FD	SandLanc	Area2	Copper	4.24E+00	mg/kg-WW	N(Mean, 95th)	4.24E+00	7.96E+00	
FD	SandLanc	Area2	Iron	4.12E+02	mg/kg-WW	N(Mean, 95th)	4.12E+02	9.52E+02	
FD	SandLanc	Area2	Lead	2.60E+01	mg/kg-WW	N(Mean, 95th)	2.60E+01	5.82E+01	
FD	SandLanc	Area2	Selenium	5.80E-01	mg/kg-WW	N(Mean, 95th)	5.80E-01	6.15E-01	
FD	SandLanc	Area2	Thallium	4.48E-01	mg/kg-WW	N(Mean, 95th)	4.48E-01	5.42E-01	
FD	SandLanc	Area2	Zinc	1.45E+02	mg/kg-WW	N(Mean, 95th)	1.45E+02	2.86E+02	
FD	SandLanc	Area2	Lithium	1.30E-01	mg/kg-WW	N(Mean, 95th)	1.30E-01	2.75E-01	
FD	SandLanc	Area2	Strontium	2.26E+01	mg/kg-WW	N(Mean, 95th)	2.26E+01	2.37E+01	
FD	SandLanc	Area3	Aluminum	8.80E+01	mg/kg-WW	N(Mean, 95th)	8.80E+01	2.39E+02	
FD	SandLanc	Area3	Arsenic	1.66E+00	mg/kg-WW	N(Mean, 95th)	1.66E+00	3.16E+00	
FD	SandLanc	Area3	Cadmium	1.33E-01	mg/kg-WW	N(Mean, 95th)	1.33E-01	2.04E-01	
FD	SandLanc	Area3	Copper	4.24E+00	mg/kg-WW	N(Mean, 95th)	4.24E+00	7.96E+00	
FD	SandLanc	Area3	Iron	4.12E+02	mg/kg-WW	N(Mean, 95th)	4.12E+02	9.52E+02	
FD	SandLanc	Area3	Lead	2.60E+01	mg/kg-WW	N(Mean, 95th)	2.60E+01	5.82E+01	
FD	SandLanc	Area3	Selenium	5.80E-01	mg/kg-WW	N(Mean, 95th)	5.80E-01	6.15E-01	
FD	SandLanc	Area3	Thallium	4.48E-01	mg/kg-WW	N(Mean, 95th)	4.48E-01	5.42E-01	
FD	SandLanc	Area3	Zinc	1.45E+02	mg/kg-WW	N(Mean, 95th)	1.45E+02	2.86E+02	
FD	SandLanc	Area3	Lithium	1.30E-01	mg/kg-WW	N(Mean, 95th)	1.30E-01	2.75E-01	
FD	SandLanc	Area3	Strontium	2.26E+01	mg/kg-WW	N(Mean, 95th)	2.26E+01	2.37E+01	
UCLM	SandLanc	Area1to3	Aluminum	8.80E+01	mg/kg-WW	N(Mean, 95th)	8.80E+01	1.73E+02	
UCLM	SandLanc	Area1to3	Arsenic	1.66E+00	mg/kg-WW	N(Mean, 95th)	1.66E+00	2.60E+00	
UCLM	SandLanc	Area1to3	Cadmium	1.33E-01	mg/kg-WW	N(Mean, 95th)	1.33E-01	1.80E-01	
UCLM	SandLanc	Area1to3	Copper	4.24E+00	mg/kg-WW	N(Mean, 95th)	4.24E+00	6.74E+00	
UCLM	SandLanc	Area1to3	Iron	4.12E+02	mg/kg-WW	N(Mean, 95th)	4.12E+02	7.37E+02	
UCLM	SandLanc	Area1to3	Lead	2.60E+01	mg/kg-WW	N(Mean, 95th)	2.60E+01	4.75E+01	
UCLM	SandLanc	Area1to3	Selenium	5.80E-01	mg/kg-WW	N(Mean, 95th)	5.80E-01	6.01E-01	
UCLM	SandLanc	Area1to3	Thallium	4.48E-01	mg/kg-WW	N(Mean, 95th)	4.48E-01	5.12E-01	
UCLM	SandLanc	Area1to3	Zinc	1.45E+02	mg/kg-WW	N(Mean, 95th)	1.45E+02	2.36E+02	
UCLM	SandLanc	Area1to3	Lithium	1.30E-01	mg/kg-WW	N(Mean, 95th)	1.30E-01	2.10E-01	

Table J4 Summary of Exposure Point Concentrations (EPC) Used in the Ecological Risk Assessment Model

Scenario	Media	Area	Chemical	Value	Units	Distribution	Parameter1	Parameter2	Comment
UCLM	SandLanc	Area1to3	Strontium	2.26E+01	mg/kg-WW	N(Mean, 95th)	2.26E+01	2.34E+01	
FD	AtlHerr	Reference	Aluminum	2.04E+00	mg/kg-WW	N(Mean, 95th)	2.04E+00	3.24E+00	
FD	AtlHerr	Reference	Arsenic	5.32E-01	mg/kg-WW	N(Mean, 95th)	5.32E-01	5.94E-01	
FD	AtlHerr	Reference	Cadmium	6.58E-02	mg/kg-WW	N(Mean, 95th)	6.58E-02	9.27E-02	
FD	AtlHerr	Reference	Copper	7.54E-01	mg/kg-WW	N(Mean, 95th)	7.54E-01	8.70E-01	
FD	AtlHerr	Reference	Iron	1.74E+01	mg/kg-WW	N(Mean, 95th)	1.74E+01	2.08E+01	
FD	AtlHerr	Reference	Lead	9.56E-02	mg/kg-WW	N(Mean, 95th)	9.56E-02	1.63E-01	
FD	AtlHerr	Reference	Selenium	4.18E-01	mg/kg-WW	N(Mean, 95th)	4.18E-01	4.88E-01	
FD	AtlHerr	Reference	Thallium	5.00E-03	mg/kg-WW	Fixed	5.00E-03	5.00E-03	Equal to detection limit
FD	AtlHerr	Reference	Zinc	2.40E+01	mg/kg-WW	N(Mean, 95th)	2.40E+01	2.86E+01	
FD	AtlHerr	Reference	Lithium	3.78E-02	mg/kg-WW	N(Mean, 95th)	3.78E-02	4.28E-02	
FD	AtlHerr	Reference	Strontium	1.33E+01	mg/kg-WW	N(Mean, 95th)	1.33E+01	1.60E+01	
FD	AtlHerr	Area1	Aluminum	1.10E+01	mg/kg-WW	N(Mean, 95th)	1.10E+01	3.12E+01	
FD	AtlHerr	Area1	Arsenic	5.33E-01	mg/kg-WW	N(Mean, 95th)	5.33E-01	5.88E-01	
FD	AtlHerr	Area1	Cadmium	8.32E-02	mg/kg-WW	N(Mean, 95th)	8.32E-02	1.01E-01	
FD	AtlHerr	Area1	Copper	8.88E-01	mg/kg-WW	N(Mean, 95th)	8.88E-01	9.98E-01	
FD	AtlHerr	Area1	Iron	2.96E+01	mg/kg-WW	N(Mean, 95th)	2.96E+01	5.62E+01	
FD	AtlHerr	Area1	Lead	1.26E+00	mg/kg-WW	N(Mean, 95th)	1.26E+00	1.67E+00	
FD	AtlHerr	Area1	Selenium	4.74E-01	mg/kg-WW	N(Mean, 95th)	4.74E-01	4.90E-01	
FD	AtlHerr	Area1	Thallium	2.90E-01	mg/kg-WW	N(Mean, 95th)	2.90E-01	3.56E-01	
FD	AtlHerr	Area1	Zinc	2.44E+01	mg/kg-WW	N(Mean, 95th)	2.44E+01	2.66E+01	
FD	AtlHerr	Area1	Lithium	6.44E-02	mg/kg-WW	N(Mean, 95th)	6.44E-02	9.03E-02	
FD	AtlHerr	Area1	Strontium	1.77E+01	mg/kg-WW	N(Mean, 95th)	1.77E+01	2.03E+01	
FD	AtlHerr	Area2	Aluminum	1.10E+01	mg/kg-WW	N(Mean, 95th)	1.10E+01	3.12E+01	
FD	AtlHerr	Area2	Arsenic	5.33E-01	mg/kg-WW	N(Mean, 95th)	5.33E-01	5.88E-01	
FD	AtlHerr	Area2	Cadmium	8.32E-02	mg/kg-WW	N(Mean, 95th)	8.32E-02	1.01E-01	
FD	AtlHerr	Area2	Copper	8.88E-01	mg/kg-WW	N(Mean, 95th)	8.88E-01	9.98E-01	
FD	AtlHerr	Area2	Iron	2.96E+01	mg/kg-WW	N(Mean, 95th)	2.96E+01	5.62E+01	
FD	AtlHerr	Area2	Lead	1.26E+00	mg/kg-WW	N(Mean, 95th)	1.26E+00	1.67E+00	
FD	AtlHerr	Area2	Selenium	4.74E-01	mg/kg-WW	N(Mean, 95th)	4.74E-01	4.90E-01	
FD	AtlHerr	Area2	Thallium	2.90E-01	mg/kg-WW	N(Mean, 95th)	2.90E-01	3.56E-01	
FD	AtlHerr	Area2	Zinc	2.44E+01	mg/kg-WW	N(Mean, 95th)	2.44E+01	2.66E+01	
FD	AtlHerr	Area2	Lithium	6.44E-02	mg/kg-WW	N(Mean, 95th)	6.44E-02	9.03E-02	

Table J4 Summary of Exposure Point Concentrations (EPC) Used in the Ecological Risk Assessment Model

Scenario	Media	Area	Chemical	Value	Units	Distribution	Parameter1	Parameter2	Comment
FD	AtlHerr	Area2	Strontium	1.77E+01	mg/kg-WW	N(Mean, 95th)	1.77E+01	2.03E+01	
FD	AtlHerr	Area3	Aluminum	1.10E+01	mg/kg-WW	N(Mean, 95th)	1.10E+01	3.12E+01	
FD	AtlHerr	Area3	Arsenic	5.33E-01	mg/kg-WW	N(Mean, 95th)	5.33E-01	5.88E-01	
FD	AtlHerr	Area3	Cadmium	8.32E-02	mg/kg-WW	N(Mean, 95th)	8.32E-02	1.01E-01	
FD	AtlHerr	Area3	Copper	8.88E-01	mg/kg-WW	N(Mean, 95th)	8.88E-01	9.98E-01	
FD	AtlHerr	Area3	Iron	2.96E+01	mg/kg-WW	N(Mean, 95th)	2.96E+01	5.62E+01	
FD	AtlHerr	Area3	Lead	1.26E+00	mg/kg-WW	N(Mean, 95th)	1.26E+00	1.67E+00	
FD	AtlHerr	Area3	Selenium	4.74E-01	mg/kg-WW	N(Mean, 95th)	4.74E-01	4.90E-01	
FD	AtlHerr	Area3	Thallium	2.90E-01	mg/kg-WW	N(Mean, 95th)	2.90E-01	3.56E-01	
FD	AtlHerr	Area3	Zinc	2.44E+01	mg/kg-WW	N(Mean, 95th)	2.44E+01	2.66E+01	
FD	AtlHerr	Area3	Lithium	6.44E-02	mg/kg-WW	N(Mean, 95th)	6.44E-02	9.03E-02	
FD	AtlHerr	Area3	Strontium	1.77E+01	mg/kg-WW	N(Mean, 95th)	1.77E+01	2.03E+01	
UCLM	AtlHerr	Area1to3	Aluminum	1.10E+01	mg/kg-WW	N(Mean, 95th)	1.10E+01	2.20E+01	
UCLM	AtlHerr	Area1to3	Arsenic	5.33E-01	mg/kg-WW	N(Mean, 95th)	5.33E-01	5.53E-01	
UCLM	AtlHerr	Area1to3	Cadmium	8.32E-02	mg/kg-WW	N(Mean, 95th)	8.32E-02	9.06E-02	
UCLM	AtlHerr	Area1to3	Copper	8.88E-01	mg/kg-WW	N(Mean, 95th)	8.88E-01	9.27E-01	
UCLM	AtlHerr	Area1to3	Iron	2.96E+01	mg/kg-WW	N(Mean, 95th)	2.96E+01	3.87E+01	
UCLM	AtlHerr	Area1to3	Lead	1.26E+00	mg/kg-WW	N(Mean, 95th)	1.26E+00	1.42E+00	
UCLM	AtlHerr	Area1to3	Selenium	4.74E-01	mg/kg-WW	N(Mean, 95th)	4.74E-01	4.82E-01	
UCLM	AtlHerr	Area1to3	Thallium	2.90E-01	mg/kg-WW	N(Mean, 95th)	2.90E-01	3.16E-01	
UCLM	AtlHerr	Area1to3	Zinc	2.44E+01	mg/kg-WW	N(Mean, 95th)	2.44E+01	2.53E+01	
UCLM	AtlHerr	Area1to3	Lithium	6.44E-02	mg/kg-WW	N(Mean, 95th)	6.44E-02	7.30E-02	
UCLM	AtlHerr	Area1to3	Strontium	1.77E+01	mg/kg-WW	N(Mean, 95th)	1.77E+01	1.86E+01	

Notes:

FD - Full Distribution

CI - Confidence Interval

SL - Sand Lance

AH - Atlantic Heron

N(Mean, 95th) Normal distribution assumed where mean equal to parameter1 and 95th percentile equal to parameter2

LN(Mean, 95th) Log-normal distribution assumed where mean equal to parameter1 and 95UCLM equal to parameter2

FD: Exposure scenario based on full distribution

UCLM: Exposure scenario based on confidence interval on the mean

Table J5 Toxicity Reference Values for Wildlife [mg/kg/day]

Receptor	Chemical	LOAEL	MTL	Reference / Comment
Heron	Aluminum	NA	164	Carrier et al 1985; Based tolerable level of 1500 mg/kg-food and on 0.166kg body weight (Carriere et al 1985) and 0.0181kg/day consumption rate for ringed turtle-dove (US EPA 1993; Equation 3-3)
Heron	Arsenic	14	NA	US EPA 2001; EC20
Heron	Cadmium	2.37	NA	US EPA 2005; Lowest bounded reproductive LOAEL
Heron	Copper	12	NA	US EPA 2007; Lowest bounded reproductive LOAEL
Heron	Iron	NA	37	NAS 2005; Based tolerable level of 500 mg/kg-food and on 1.5kg body weight and 0.11kg/day consumption rate for poultry Sample et al. 1996
Heron	Lead	9.9	NA	US EPA 2005; EC20
Heron	Lithium	NA	2	NAS 2005; Based tolerable level of 25 mg/kg-food and on 1.5kg body weight and 0.11kg/day consumption rate for poultry Sample et al. 1996
Heron	Selenium	0.37	NA	US EPA 2007; Lowest bounded LOAEL
Heron	Strontium	NA	147	NAS 2005; Based tolerable level of 2000 mg/kg-food and on 1.5kg body weight and 0.11kg/day consumption rate for poultry Sample et al. 1996
Heron	Thallium	0.35	NA	US EPA 1999; Acute LD50 with 0.01 uncertainty factor applied
Heron	Zinc	77	NA	US EPA 2007; Lowest LOAEL
Sandpiper	Aluminum	NA	164	Carrier et al 1985; Based tolerable level of 1500 mg/kg-food and on 0.166kg body weight (Carriere et al 1985) and 0.0181kg/day consumption rate for ringed turtle-dove (US EPA 1993; Equation 3-3)
Sandpiper	Arsenic	14	NA	US EPA 2001; EC20
Sandpiper	Cadmium	2.37	NA	US EPA 2005; Lowest bounded reproductive LOAEL
Sandpiper	Copper	12	NA	US EPA 2007; Lowest bounded reproductive LOAEL
Sandpiper	Iron	NA	37	NAS 2005; Based tolerable level of 500 mg/kg-food and on 1.5kg body weight and 0.11kg/day consumption rate for poultry Sample et al. 1996
Sandpiper	Lead	9.9	NA	US EPA 2005; EC20
Sandpiper	Lithium	NA	2	NAS 2005; Based tolerable level of 25 mg/kg-food and on 1.5kg body weight and 0.11kg/day consumption rate for poultry Sample et al. 1996
Sandpiper	Selenium	0.37	NA	US EPA 2007; Lowest bounded LOAEL
Sandpiper	Strontium	NA	147	NAS 2005; Based tolerable level of 2000 mg/kg-food and on 1.5kg body weight and 0.11kg/day consumption rate for poultry Sample et al. 1996
Sandpiper	Thallium	0.35	NA	US EPA 1999; Acute LD50 with 0.01 uncertainty factor applied
Sandpiper	Zinc	77	NA	US EPA 2007; Lowest LOAEL
Tern	Aluminum	NA	164	Carrier et al 1985; Based tolerable level of 1500 mg/kg-food and on 0.166kg body weight (Carriere et al 1985) and 0.0181kg/day consumption rate for ringed turtle-dove (US EPA 1993; Equation 3-3)
Tern	Arsenic	14	NA	US EPA 2001; EC20
Tern	Cadmium	2.37	NA	US EPA 2005; Lowest bounded reproductive LOAEL
Tern	Copper	12	NA	US EPA 2007; Lowest bounded reproductive LOAEL

Table J5 Toxicity Reference Values for Wildlife [mg/kg/day]				
Receptor	**Chemical**	**LOAEL**	**MTL**	**Reference / Comment**
Tern	Iron	NA	37	NAS 2005; Based tolerable level of 500 mg/kg-food and on 1.5kg body weight and 0.11kg/day consumption rate for poultry Sample et al. 1996
Tern	Lead	9.9	NA	US EPA 2005; EC20
Tern	Lithium	NA	2	NAS 2005; Based tolerable level of 25 mg/kg-food and on 1.5kg body weight and 0.11kg/day consumption rate for poultry Sample et al. 1996
Tern	Selenium	0.37	NA	US EPA 2007; Lowest bounded LOAEL
Tern	Strontium	NA	147	NAS 2005; Based tolerable level of 2000 mg/kg-food and on 1.5kg body weight and 0.11kg/day consumption rate for poultry Sample et al. 1996
Tern	Thallium	0.35	NA	US EPA 1999; Acute LD50 with 0.01 uncertainty factor applied
Tern	Zinc	77	NA	US EPA 2007; Lowest LOAEL

LOAEL: Lowest observable adverse effect level
MTL: Maximum tolerable limit

Table J6 Bio-accessibility Assumed for Food and Media [%]							
Site	**Media/Food**	**Chemical**	**Value**	**Distribution**	**Parameter1**	**Parameter2**	**Reference / Comment**
Reference	AquaticInvert	Aluminum	1.00E+00	Fixed			Assumed most conservative value
Reference	AquaticInvert	Arsenic	1.00E+00	Fixed			Assumed most conservative value
Reference	AquaticInvert	Cadmium	1.00E+00	Fixed			Assumed most conservative value
Reference	AquaticInvert	Copper	1.00E+00	Fixed			Assumed most conservative value
Reference	AquaticInvert	Iron	1.00E+00	Fixed			Assumed most conservative value
Reference	AquaticInvert	Lead	1.00E+00	Fixed			Assumed most conservative value
Reference	AquaticInvert	Lithium	1.00E+00	Fixed			Assumed most conservative value
Reference	AquaticInvert	Selenium	1.00E+00	Fixed			Assumed most conservative value
Reference	AquaticInvert	Strontium	1.00E+00	Fixed			Assumed most conservative value
Reference	AquaticInvert	Thallium	1.00E+00	Fixed			Assumed most conservative value
Reference	AquaticInvert	Zinc	1.00E+00	Fixed			Assumed most conservative value
Reference	AtlHerr	Aluminum	1.00E+00	Fixed			Assumed most conservative value
Reference	AtlHerr	Arsenic	1.00E+00	Fixed			Assumed most conservative value
Reference	AtlHerr	Cadmium	1.00E+00	Fixed			Assumed most conservative value
Reference	AtlHerr	Copper	1.00E+00	Fixed			Assumed most conservative value
Reference	AtlHerr	Iron	1.00E+00	Fixed			Assumed most conservative value
Reference	AtlHerr	Lead	1.00E+00	Fixed			Assumed most conservative value
Reference	AtlHerr	Lithium	1.00E+00	Fixed			Assumed most conservative value
Reference	AtlHerr	Selenium	1.00E+00	Fixed			Assumed most conservative value
Reference	AtlHerr	Strontium	1.00E+00	Fixed			Assumed most conservative value
Reference	AtlHerr	Thallium	1.00E+00	Fixed			Assumed most conservative value
Reference	AtlHerr	Zinc	1.00E+00	Fixed			Assumed most conservative value
Reference	Sand	Aluminum	1.20E-03	Fixed			Based on highest detection limit value from bioaccessibility
Reference	Sand	Arsenic	7.40E-02	Fixed			Based on highest detection limit value from bioaccessibility
Reference	Sand	Cadmium	1.00E+00	Fixed			Not calculated; Assumed most conservative value
Reference	Sand	Copper	1.10E-01	Fixed			Based on highest measured value from bioaccessibility
Reference	Sand	Iron	1.20E-04	Fixed			Based on highest measured value from bioaccessibility
Reference	Sand	Lead	7.20E-02	Fixed			Based on highest measured value from bioaccessibility
Reference	Sand	Lithium	1.00E+00	Fixed			Not calculated; Assumed most conservative value
Reference	Sand	Selenium	1.00E+00	Fixed			Not calculated; Assumed most conservative value
Reference	Sand	Strontium	1.00E+00	Fixed			Not calculated; Assumed most conservative value
Reference	Sand	Thallium	1.00E+00	Fixed			Not calculated; Assumed most conservative value
Reference	Sand	Zinc	5.60E-02	Fixed			Based on highest measured value from bioaccessibility
Reference	SandLanc	Aluminum	1.00E+00	Fixed			Assumed most conservative value
Reference	SandLanc	Arsenic	1.00E+00	Fixed			Assumed most conservative value
Reference	SandLanc	Cadmium	1.00E+00	Fixed			Assumed most conservative value
Reference	SandLanc	Copper	1.00E+00	Fixed			Assumed most conservative value
Reference	SandLanc	Iron	1.00E+00	Fixed			Assumed most conservative value
Reference	SandLanc	Lead	1.00E+00	Fixed			Assumed most conservative value
Reference	SandLanc	Lithium	1.00E+00	Fixed			Assumed most conservative value
Reference	SandLanc	Selenium	1.00E+00	Fixed			Assumed most conservative value
Reference	SandLanc	Strontium	1.00E+00	Fixed			Assumed most conservative value
Reference	SandLanc	Thallium	1.00E+00	Fixed			Assumed most conservative value
Reference	SandLanc	Zinc	1.00E+00	Fixed			Assumed most conservative value
Area1	AquaticInvert	Aluminum	1.00E+00	Fixed			Assumed most conservative value
Area1	AquaticInvert	Arsenic	1.00E+00	Fixed			Assumed most conservative value
Area1	AquaticInvert	Cadmium	1.00E+00	Fixed			Assumed most conservative value

Table J6 Bio-accessibility Assumed for Food and Media [%]

Site	Media/Food	Chemical	Value	Distribution	Parameter1	Parameter2	Reference / Comment
Area1	AquaticInvert	Copper	1.00E+00	Fixed			Assumed most conservative value
Area1	AquaticInvert	Iron	1.00E+00	Fixed			Assumed most conservative value
Area1	AquaticInvert	Lead	1.00E+00	Fixed			Assumed most conservative value
Area1	AquaticInvert	Lithium	1.00E+00	Fixed			Assumed most conservative value
Area1	AquaticInvert	Selenium	1.00E+00	Fixed			Assumed most conservative value
Area1	AquaticInvert	Strontium	1.00E+00	Fixed			Assumed most conservative value
Area1	AquaticInvert	Thallium	1.00E+00	Fixed			Assumed most conservative value
Area1	AquaticInvert	Zinc	1.00E+00	Fixed			Assumed most conservative value
Area1	AtlHerr	Aluminum	1.00E+00	Fixed			Assumed most conservative value
Area1	AtlHerr	Arsenic	1.00E+00	Fixed			Assumed most conservative value
Area1	AtlHerr	Cadmium	1.00E+00	Fixed			Assumed most conservative value
Area1	AtlHerr	Copper	1.00E+00	Fixed			Assumed most conservative value
Area1	AtlHerr	Iron	1.00E+00	Fixed			Assumed most conservative value
Area1	AtlHerr	Lead	1.00E+00	Fixed			Assumed most conservative value
Area1	AtlHerr	Lithium	1.00E+00	Fixed			Assumed most conservative value
Area1	AtlHerr	Selenium	1.00E+00	Fixed			Assumed most conservative value
Area1	AtlHerr	Strontium	1.00E+00	Fixed			Assumed most conservative value
Area1	AtlHerr	Thallium	1.00E+00	Fixed			Assumed most conservative value
Area1	AtlHerr	Zinc	1.00E+00	Fixed			Assumed most conservative value
Area1	Sand	Aluminum	8.40E-03	Uniform	0.0064	0.0084	Range from Phase 1 bioaccessibility
Area1	Sand	Arsenic	9.00E-02	Uniform	0.066	0.09	Range from Phase 1 & 2 bioaccessibility
Area1	Sand	Cadmium	7.90E-02	Uniform	0.05	0.079	Range from Phase 1 & 2 bioaccessibility
Area1	Sand	Copper	4.50E-02	Uniform	0.0014	0.045	Range from Phase 1 & 2 bioaccessibility
Area1	Sand	Iron	5.00E-02	Uniform	0.0031	0.05	Range from Phase 1 & 2 bioaccessibility
Area1	Sand	Lead	5.70E-02	Uniform	0.0018	0.057	Range from Phase 1 & 2 bioaccessibility
Area1	Sand	Lithium	1.00E+00	Fixed			Not calculated; Assumed most conservative value
Area1	Sand	Selenium	1.00E+00	Fixed			Not calculated; Assumed most conservative value
Area1	Sand	Strontium	1.00E+00	Fixed			Not calculated; Assumed most conservative value
Area1	Sand	Thallium	2.00E-02	Uniform	0.12	0.2	Range from Phase 1 & 2 bioaccessibility
Area1	Sand	Zinc	9.20E-02	Uniform	0.038	0.092	Range from Phase 1 & 2 bioaccessibility
Area1	SandLanc	Aluminum	1.00E+00	Fixed			Assumed most conservative value
Area1	SandLanc	Arsenic	1.00E+00	Fixed			Assumed most conservative value
Area1	SandLanc	Cadmium	1.00E+00	Fixed			Assumed most conservative value
Area1	SandLanc	Copper	1.00E+00	Fixed			Assumed most conservative value
Area1	SandLanc	Iron	1.00E+00	Fixed			Assumed most conservative value
Area1	SandLanc	Lead	1.00E+00	Fixed			Assumed most conservative value
Area1	SandLanc	Lithium	1.00E+00	Fixed			Assumed most conservative value
Area1	SandLanc	Selenium	1.00E+00	Fixed			Assumed most conservative value
Area1	SandLanc	Strontium	1.00E+00	Fixed			Assumed most conservative value
Area1	SandLanc	Thallium	1.00E+00	Fixed			Assumed most conservative value
Area1	SandLanc	Zinc	1.00E+00	Fixed			Assumed most conservative value
Area2	AquaticInvert	Aluminum	1.00E+00	Fixed			Assumed most conservative value
Area2	AquaticInvert	Arsenic	1.00E+00	Fixed			Assumed most conservative value
Area2	AquaticInvert	Cadmium	1.00E+00	Fixed			Assumed most conservative value
Area2	AquaticInvert	Copper	1.00E+00	Fixed			Assumed most conservative value
Area2	AquaticInvert	Iron	1.00E+00	Fixed			Assumed most conservative value
Area2	AquaticInvert	Lead	1.00E+00	Fixed			Assumed most conservative value
Area2	AquaticInvert	Lithium	1.00E+00	Fixed			Assumed most conservative value
Area2	AquaticInvert	Selenium	1.00E+00	Fixed			Assumed most conservative value

Table J6 Bio-accessibility Assumed for Food and Media [%]							
Site	Media/Food	Chemical	Value	Distribution	Parameter1	Parameter2	Reference / Comment
Area2	AquaticInvert	Strontium	1.00E+00	Fixed			Assumed most conservative value
Area2	AquaticInvert	Thallium	1.00E+00	Fixed			Assumed most conservative value
Area2	AquaticInvert	Zinc	1.00E+00	Fixed			Assumed most conservative value
Area2	AtlHerr	Aluminum	1.00E+00	Fixed			Assumed most conservative value
Area2	AtlHerr	Arsenic	1.00E+00	Fixed			Assumed most conservative value
Area2	AtlHerr	Cadmium	1.00E+00	Fixed			Assumed most conservative value
Area2	AtlHerr	Copper	1.00E+00	Fixed			Assumed most conservative value
Area2	AtlHerr	Iron	1.00E+00	Fixed			Assumed most conservative value
Area2	AtlHerr	Lead	1.00E+00	Fixed			Assumed most conservative value
Area2	AtlHerr	Lithium	1.00E+00	Fixed			Assumed most conservative value
Area2	AtlHerr	Selenium	1.00E+00	Fixed			Assumed most conservative value
Area2	AtlHerr	Strontium	1.00E+00	Fixed			Assumed most conservative value
Area2	AtlHerr	Thallium	1.00E+00	Fixed			Assumed most conservative value
Area2	AtlHerr	Zinc	1.00E+00	Fixed			Assumed most conservative value
Area2	Sand	Aluminum	1.40E-03	Uniform	0.00044	0.0014	Range from Phase 1 bioaccessibility
Area2	Sand	Arsenic	1.10E-01	Uniform	0.022	0.11	Range from Phase 1 & 2 bioaccessibility
Area2	Sand	Cadmium	6.20E-01	Uniform	0.28	0.62	Range from Phase 1 & 2 bioaccessibility
Area2	Sand	Copper	2.50E-01	Uniform	0.062	0.25	Range from Phase 1 & 2 bioaccessibility
Area2	Sand	Iron	9.00E-04	Uniform	0.00016	0.0009	Range from Phase 1 & 2 bioaccessibility
Area2	Sand	Lead	2.00E-01	Uniform	0.035	0.2	Range from Phase 1 & 2 bioaccessibility
Area2	Sand	Lithium	1.00E+00	Fixed			Not calculated; Assumed most conservative value
Area2	Sand	Selenium	1.00E+00	Fixed			Not calculated; Assumed most conservative value
Area2	Sand	Strontium	1.00E+00	Fixed			Not calculated; Assumed most conservative value
Area2	Sand	Thallium	2.30E-01	Uniform	0.19	0.23	Range from Phase 1 & 2 bioaccessibility
Area2	Sand	Zinc	3.40E-01	Uniform	0.025	0.34	Range from Phase 1 & 2 bioaccessibility
Area2	SandLanc	Aluminum	1.00E+00	Fixed			Assumed most conservative value
Area2	SandLanc	Arsenic	1.00E+00	Fixed			Assumed most conservative value
Area2	SandLanc	Cadmium	1.00E+00	Fixed			Assumed most conservative value
Area2	SandLanc	Copper	1.00E+00	Fixed			Assumed most conservative value
Area2	SandLanc	Iron	1.00E+00	Fixed			Assumed most conservative value
Area2	SandLanc	Lead	1.00E+00	Fixed			Assumed most conservative value
Area2	SandLanc	Lithium	1.00E+00	Fixed			Assumed most conservative value
Area2	SandLanc	Selenium	1.00E+00	Fixed			Assumed most conservative value
Area2	SandLanc	Strontium	1.00E+00	Fixed			Assumed most conservative value
Area2	SandLanc	Thallium	1.00E+00	Fixed			Assumed most conservative value
Area2	SandLanc	Zinc	1.00E+00	Fixed			Assumed most conservative value
Area3	AquaticInvert	Aluminum	1.00E+00	Fixed			Assumed most conservative value
Area3	AquaticInvert	Arsenic	1.00E+00	Fixed			Assumed most conservative value
Area3	AquaticInvert	Cadmium	1.00E+00	Fixed			Assumed most conservative value
Area3	AquaticInvert	Copper	1.00E+00	Fixed			Assumed most conservative value
Area3	AquaticInvert	Iron	1.00E+00	Fixed			Assumed most conservative value
Area3	AquaticInvert	Lead	1.00E+00	Fixed			Assumed most conservative value
Area3	AquaticInvert	Lithium	1.00E+00	Fixed			Assumed most conservative value
Area3	AquaticInvert	Selenium	1.00E+00	Fixed			Assumed most conservative value
Area3	AquaticInvert	Strontium	1.00E+00	Fixed			Assumed most conservative value
Area3	AquaticInvert	Thallium	1.00E+00	Fixed			Assumed most conservative value
Area3	AquaticInvert	Zinc	1.00E+00	Fixed			Assumed most conservative value
Area3	AtlHerr	Aluminum	1.00E+00	Fixed			Assumed most conservative value
Area3	AtlHerr	Arsenic	1.00E+00	Fixed			Assumed most conservative value

Table J6 Bio-accessibility Assumed for Food and Media [%]

Site	Media/Food	Chemical	Value	Distribution	Parameter1	Parameter2	Reference / Comment
Area3	AtlHerr	Cadmium	1.00E+00	Fixed			Assumed most conservative value
Area3	AtlHerr	Copper	1.00E+00	Fixed			Assumed most conservative value
Area3	AtlHerr	Iron	1.00E+00	Fixed			Assumed most conservative value
Area3	AtlHerr	Lead	1.00E+00	Fixed			Assumed most conservative value
Area3	AtlHerr	Lithium	1.00E+00	Fixed			Assumed most conservative value
Area3	AtlHerr	Selenium	1.00E+00	Fixed			Assumed most conservative value
Area3	AtlHerr	Strontium	1.00E+00	Fixed			Assumed most conservative value
Area3	AtlHerr	Thallium	1.00E+00	Fixed			Assumed most conservative value
Area3	AtlHerr	Zinc	1.00E+00	Fixed			Assumed most conservative value
Area3	Sand	Aluminum	1.80E-03	Uniform	0.00073	0.0018	Range from Phase 1 & 2 bioaccessibility
Area3	Sand	Arsenic	8.30E-02	Uniform	0.037	0.083	Range from Phase 1 & 2 bioaccessibility
Area3	Sand	Cadmium	7.70E-01	Uniform	0.13	0.77	Range from Phase 1 & 2 bioaccessibility
Area3	Sand	Copper	2.40E-01	Uniform	0.018	0.24	Range from Phase 1 & 2 bioaccessibility
Area3	Sand	Iron	2.80E-03	Uniform	0.0012	0.0028	Range from Phase 1 & 2 bioaccessibility
Area3	Sand	Lead	7.70E-01	Uniform	0.023	0.77	Range from Phase 1 & 2 bioaccessibility
Area3	Sand	Lithium	1.00E+00	Fixed			Not calculated; Assumed most conservative value
Area3	Sand	Selenium	1.00E+00	Fixed			Not calculated; Assumed most conservative value
Area3	Sand	Strontium	1.00E+00	Fixed			Not calculated; Assumed most conservative value
Area3	Sand	Thallium	3.60E-01	Uniform	0.15	0.36	Range from Phase 1 & 2 bioaccessibility
Area3	Sand	Zinc	3.90E-01	Uniform	0.35	0.39	Range from Phase 1 & 2 bioaccessibility
Area3	SandLanc	Aluminum	1.00E+00	Fixed			Assumed most conservative value
Area3	SandLanc	Arsenic	1.00E+00	Fixed			Assumed most conservative value
Area3	SandLanc	Cadmium	1.00E+00	Fixed			Assumed most conservative value
Area3	SandLanc	Copper	1.00E+00	Fixed			Assumed most conservative value
Area3	SandLanc	Iron	1.00E+00	Fixed			Assumed most conservative value
Area3	SandLanc	Lead	1.00E+00	Fixed			Assumed most conservative value
Area3	SandLanc	Lithium	1.00E+00	Fixed			Assumed most conservative value
Area3	SandLanc	Selenium	1.00E+00	Fixed			Assumed most conservative value
Area3	SandLanc	Strontium	1.00E+00	Fixed			Assumed most conservative value
Area3	SandLanc	Thallium	1.00E+00	Fixed			Assumed most conservative value
Area3	SandLanc	Zinc	1.00E+00	Fixed			Assumed most conservative value
Area1to3	AquaticInvert	Aluminum	1.00E+00	Fixed			Assumed most conservative value
Area1to3	AquaticInvert	Arsenic	1.00E+00	Fixed			Assumed most conservative value
Area1to3	AquaticInvert	Cadmium	1.00E+00	Fixed			Assumed most conservative value
Area1to3	AquaticInvert	Copper	1.00E+00	Fixed			Assumed most conservative value
Area1to3	AquaticInvert	Iron	1.00E+00	Fixed			Assumed most conservative value
Area1to3	AquaticInvert	Lead	1.00E+00	Fixed			Assumed most conservative value
Area1to3	AquaticInvert	Lithium	1.00E+00	Fixed			Assumed most conservative value
Area1to3	AquaticInvert	Selenium	1.00E+00	Fixed			Assumed most conservative value
Area1to3	AquaticInvert	Strontium	1.00E+00	Fixed			Assumed most conservative value
Area1to3	AquaticInvert	Thallium	1.00E+00	Fixed			Assumed most conservative value
Area1to3	AquaticInvert	Zinc	1.00E+00	Fixed			Assumed most conservative value
Area1to3	AtlHerr	Aluminum	1.00E+00	Fixed			Assumed most conservative value
Area1to3	AtlHerr	Arsenic	1.00E+00	Fixed			Assumed most conservative value
Area1to3	AtlHerr	Cadmium	1.00E+00	Fixed			Assumed most conservative value
Area1to3	AtlHerr	Copper	1.00E+00	Fixed			Assumed most conservative value
Area1to3	AtlHerr	Iron	1.00E+00	Fixed			Assumed most conservative value
Area1to3	AtlHerr	Lead	1.00E+00	Fixed			Assumed most conservative value
Area1to3	AtlHerr	Lithium	1.00E+00	Fixed			Assumed most conservative value

Table J6 Bio-accessibility Assumed for Food and Media [%]

Site	Media/Food	Chemical	Value	Distribution	Parameter1	Parameter2	Reference / Comment
Area1to3	AtlHerr	Selenium	1.00E+00	Fixed			Assumed most conservative value
Area1to3	AtlHerr	Strontium	1.00E+00	Fixed			Assumed most conservative value
Area1to3	AtlHerr	Thallium	1.00E+00	Fixed			Assumed most conservative value
Area1to3	AtlHerr	Zinc	1.00E+00	Fixed			Assumed most conservative value
Area1to3	Sand	Aluminum	8.40E-03	Uniform	0.00044	0.0084	Range from Phase 1 & 2 bioaccessibility
Area1to3	Sand	Arsenic	1.10E-01	Uniform	0.022	0.11	Range from Phase 1 & 2 bioaccessibility
Area1to3	Sand	Cadmium	7.70E-01	Uniform	0.05	0.77	Range from Phase 1 & 2 bioaccessibility
Area1to3	Sand	Copper	2.50E-01	Uniform	0.0014	0.25	Range from Phase 1 & 2 bioaccessibility
Area1to3	Sand	Iron	5.00E-02	Uniform	0.00016	0.05	Range from Phase 1 & 2 bioaccessibility
Area1to3	Sand	Lead	7.70E-01	Uniform	0.0018	0.77	Range from Phase 1 & 2 bioaccessibility
Area1to3	Sand	Lithium	1.00E+00	Fixed			Not calculated; Assumed most conservative value
Area1to3	Sand	Selenium	1.00E+00	Fixed			Not calculated; Assumed most conservative value
Area1to3	Sand	Strontium	1.00E+00	Fixed			Not calculated; Assumed most conservative value
Area1to3	Sand	Thallium	3.60E-01	Uniform	0.12	0.36	Range from Phase 1 & 2 bioaccessibility
Area1to3	Sand	Zinc	3.90E-01	Uniform	0.025	0.39	Range from Phase 1 & 2 bioaccessibility
Area1to3	SandLanc	Aluminum	1.00E+00	Fixed			Assumed most conservative value
Area1to3	SandLanc	Arsenic	1.00E+00	Fixed			Assumed most conservative value
Area1to3	SandLanc	Cadmium	1.00E+00	Fixed			Assumed most conservative value
Area1to3	SandLanc	Copper	1.00E+00	Fixed			Assumed most conservative value
Area1to3	SandLanc	Iron	1.00E+00	Fixed			Assumed most conservative value
Area1to3	SandLanc	Lead	1.00E+00	Fixed			Assumed most conservative value
Area1to3	SandLanc	Lithium	1.00E+00	Fixed			Assumed most conservative value
Area1to3	SandLanc	Selenium	1.00E+00	Fixed			Assumed most conservative value
Area1to3	SandLanc	Strontium	1.00E+00	Fixed			Assumed most conservative value
Area1to3	SandLanc	Thallium	1.00E+00	Fixed			Assumed most conservative value
Area1to3	SandLanc	Zinc	1.00E+00	Fixed			Assumed most conservative value

Table J7 Receptor Exposure Variables

Variable	Receptor	Value	Distribution	Parameter1	Parameter2	Units	Reference/Comments
BW	Tern	0.117	N(Mean, StDev)	0.117	0.0079	kg-WW	Coulter 1986; Adult female; The Birds of North America
BW	Heron	0.8266	N(Mean, StDev)	0.8266	0.0347	kg-WW	Gross 1923; Adult females; The Birds of North America
BW	Sandpiper	0.047	N(Mean, 95UCLM)	0.0471	0.05	kg-WW	US EPA 1993; Adult Female
Per_Sand	Tern	0.5%	U(Min, Max)	0%	0.5%	%	Assumed
Per_Sand	Heron	2%	U(Min, Max)	0%	2%	%	Assumed
Per_Sand	Sandpiper	18%	U(Min, Max)	7.3%	30.0%	%	US EPA 1993; Beyer et al. 1994; n=4

Table J8 Predicted Sand Ingestion Rates for Wildlife [kg/day]

	Sand Ingestion Rate			Diet [%]				Food Ingestion Rate [kg-DW/day]			
Receptor	**[kg/day]**	**Per_Sand**	**FMR [kcal/day]**	**AtlHerr**	**SandLanc**	**AquaticInvert**	**Total**	**AtlHerr**	**SandLanc**	**AquaticInvert**	**Total**
Tern	5.22E-05	0.5%	6.66E+01	75%	20%	5%	100%	6.72E-03	2.52E-03	1.20E-03	1.04E-02
Heron	1.37E-03	2.0%	2.85E+02	30%	30%	40%	100%	1.15E-02	1.61E-02	4.11E-02	6.87E-02
Sandpiper	3.08E-03	18%	4.74E+01	0%	0%	100%	100%	0.00E+00	0.00E+00	1.71E-02	1.71E-02

Table J9 Free-living (Field) Metabolic Rate (FMR) [kcal/kg bw/day]

Receptor	NFMR [kcal/kg/day]	FMR [kcal/day]	FMR [kJ/day]	Body Weight [grams]	Constant	Slope	Error	Avg	StDev	Reference / Comments
Tern	5.69E-01	6.66E+01	2.79E+02	117	4.76E+01	3.71E-01	0	0	1.52E-01	Nagy et al. 1999; Five marine birds
Heron	3.44E-01	2.85E+02	1.19E+03	826.6	1.43E+01	6.59E-01	0	0	1.47E-01	Nagy et al. 1999; All marine birds
Sandpiper	1.01E+00	4.74E+01	1.99E+02	47	4.76E+01	3.71E-01	0	0	1.52E-01	Nagy et al. 1999; Five marine birds

Notes:

A) NFMR = Normalized Free Metabolic Rate = FMR / BW

B) Conversion factor 4.1875 kJ/Calorie

Five marine birds include: Common sandpiper, Ringed plover, Arctic tern, Common tern and Sooty tern

Table J10 Dietary Apportionment for Wildlife Receptors [%]

Receptor	Diet	Value Corrected	Value	Distribution	Parameter1	Parameter2	Parameter3	Reference / Comment
Tern	AtlHerr	75.0%	75%	U(Min, Max)	75.0%	80.0%	Not Used	Assumed
Tern	SandLanc	20.0%	20%	U(Min, Max)	20.0%	25.0%	Not Used	Assumed
Tern	AquaticInvert	5%	5%	U(Min, Max)	0.0%	5.0%	Not Used	Assumed
Heron	AtlHerr	30.0%	30%	U(Min, Max)	20.0%	30.0%	Not Used	Assumed
Heron	SandLanc	30.0%	30%	U(Min, Max)	20.0%	30.0%	Not Used	Assumed
Heron	AquaticInvert	40.0%	40%	U(Min, Max)	30.0%	40.0%	Not Used	Assumed
Sandpiper	AtlHerr	0%	0%	U(Min, Max)	0.0%	2.5%	Not Used	Assumed
Sandpiper	SandLanc	0%	0%	U(Min, Max)	0.0%	2.5%	Not Used	Assumed
Sandpiper	AquaticInvert	100%	100%	U(Min, Max)	95.0%	100.0%	Not Used	Assumed

Table J11 Metabolizable Energy (ME) of Dietary Items [kcal/kg-DW]				
Receptor	**Diet**	**Variable**	**Value**	**Reference / Comment**
Tern	AtlHerr	Tern_AtlHerr	7426	US EPA 1993; ME = GE x AE
Tern	SandLanc	Tern_SandLanc	5293	US EPA 1993; ME = GE x AE
Tern	AquaticInvert	Tern_AquaticInvert	2772	US EPA 1993; ME = GE x AE
Heron	AtlHerr	Heron_AtlHerr	7426	US EPA 1993; ME = GE x AE
Heron	SandLanc	Heron_SandLanc	5293	US EPA 1993; ME = GE x AE
Heron	AquaticInvert	Heron_AquaticInvert	2772	US EPA 1993; ME = GE x AE
Sandpiper	AtlHerr	Sandpiper_AtlHerr	7426	US EPA 1993; ME = GE x AE
Sandpiper	SandLanc	Sandpiper_SandLanc	5293	US EPA 1993; ME = GE x AE
Sandpiper	AquaticInvert	Sandpiper_AquaticInvert	2772	US EPA 1993; ME = GE x AE

Table J12 Gross Energy (GE) of Dietary Items [kcal/kg-dw]

Receptor	Diet	Value	Distribution	Parameter1	Parameter2	Reference / Comment
Tern	AtlHerr	9400	N(Mean, Stdev)	9400	500	US EPA 1993; Table 4-1 & 4-2, and Tully 1999 Table 9; based on pacific herring
Tern	SandLanc	6700	N(Mean, Stdev)	6700	500	US EPA 1993; Table 4-1 & 4-2, and Tully 1999 Table 9; based on sand lance
Tern	AquaticInvert	3600	N(Mean, Stdev)	3600	780	US EPA 1993; Table 4-1 & 4-2, based on isopods and amphipods
Heron	AtlHerr	9400	N(Mean, Stdev)	9400	500	US EPA 1993; Table 4-1 & 4-2, and Tully 1999 Table 9; based on pacific herring
Heron	SandLanc	6700	N(Mean, Stdev)	6700	500	US EPA 1993; Table 4-1 & 4-2, and Tully 1999 Table 9; based on sand lance
Heron	AquaticInvert	3600	N(Mean, Stdev)	3600	780	US EPA 1993; Table 4-1 & 4-2, based on crabs with shell
Sandpiper	AtlHerr	9400	N(Mean, Stdev)	9400	500	US EPA 1993; Table 4-1 & 4-2, and Tully 1999 Table 9; based on pacific herring
Sandpiper	SandLanc	6700	N(Mean, Stdev)	6700	500	US EPA 1993; Table 4-1 & 4-2, and Tully 1999 Table 9; based on sand lance
Sandpiper	AquaticInvert	3600	N(Mean, Stdev)	3600	780	US EPA 1993; Table 4-1 & 4-2, based on crabs with shell

Table J13 Assimilation Efficiency (AE) of Dietary Items [Percent% Efficiency]						
Receptor	**Diet**	**Value**	**Distribution**	**Parameter1**	**Parameter2**	**Reference / Comment**
Tern	AtlHerr	79%	N(Mean, Stdev)	79%	4.5%	US EPA 1993; Table 4-3
Tern	SandLanc	79%	N(Mean, Stdev)	79%	4.5%	US EPA 1993; Table 4-3
Tern	AquaticInvert	77%	N(Mean, Stdev)	77%	8.4%	US EPA 1993; Table 4-3
Heron	AtlHerr	79%	N(Mean, Stdev)	79%	4.5%	US EPA 1993; Table 4-3
Heron	SandLanc	79%	N(Mean, Stdev)	79%	4.5%	US EPA 1993; Table 4-3
Heron	AquaticInvert	77%	N(Mean, Stdev)	77%	8.4%	US EPA 1993; Table 4-3
Sandpiper	AtlHerr	79%	N(Mean, Stdev)	79%	4.5%	US EPA 1993; Table 4-3
Sandpiper	SandLanc	79%	N(Mean, Stdev)	79%	4.5%	US EPA 1993; Table 4-3
Sandpiper	AquaticInvert	77%	N(Mean, Stdev)	77%	8.4%	US EPA 1993; Table 4-3

Table J14 Moisture Content [%]					
Food	**Value**	**Distribution**	**Parameter1**	**Parameter2**	**Reference / Comment**
AtlHerr	80%	N(Mean,StDev)	80%	0.68%	Site-specific
SandLanc	77%	N(Mean,StDev)	77%	0.89%	Site-specific
AquaticInvert	80%	U(Min, Max)	71%	80%	Suter et al. 2000

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APPENDIX K

BIOACCESSIBILITY OF BEACH SAND (RMC, 2014)

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REPORT OF ANALYSIS

ASU #: 15345

Report I.D.: ASU 15345 Intrinsik

Client: Intrinsik Environmental Sciences Inc.
5121 Sackville Street, Suite 506
Halifax NS
B3J 1K1

Date Submitted: 25 February 2015

Date Reported: 23 March 2015

Matrix: Sediment

Report to follow in attached documents.

Results relate only to the items tested.

Prepared by Paula Whitley.

Authorization:

ANALYTICAL SCIENCES DIVISION

Environmental
Sciences
Group

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ANALYSIS REPORT COVER NOTE

Report Number: ASD15345
Report Date: 20 March 2015
Sample(s) reported: 10
Issue Status: Final
Analysis commenced on: 27 February 2015

The following data are reported in this final report: total aluminium, arsenic, cadmium, copper, iron, lead, selenium, thallium and zinc; bioaccessible extracted aluminium, arsenic, cadmium, copper, iron, lead, selenium, thallium and zinc; and percent bioaccessibility, for 10 sediment samples.

Methods

All samples were received in good condition. Samples arrived dried and sieved and were used as received for the bioaccessibility extraction and total analysis.

To obtain the bioaccessible aluminium, arsenic, cadmium, copper, iron, lead, selenium, thallium and zinc for the avian receptor, the ESG Avian method was employed. The ESG Avian bioaccessibility method is based on estimates of mallard duck sediment ingestion rates. The ESG Avian bioaccessibility method uses a liquid-to-(dry) solid ratio of 200:1 and includes two phases (stomach and intestine, or gastric and gastric + intestine). Dried samples were weighed into 150 mL extraction vessels and then the gastric (stomach) conditions were simulated by extracting the sediments at avian body temperature (42 °C) with simulated gastric solution (1M NaCl, 10 g/L pepsin) at pH 2.6 for 1 hour. After 1 hour, a portion was removed for analysis. To simulate gastric + intestinal conditions the above samples were adjusted to pH 6.2 with saturated $NaHCO_3$. Bile (0.35%) and pancreatin (0.035%) were then added. The extraction continued at these conditions for 2 hours.

The extracts were filtered (0.45 µm) and analyzed for total aluminium, arsenic, cadmium, copper, iron, lead, selenium, thallium and zinc by ICP-MS, and the total concentrations for these elements in sediment samples was obtained by aqua regia digestion and analysis using ICP-MS and ICP-OES (at ASU, CALA accredited for specific tests listed in their scope of accreditation).

Quality Assurance and Quality Control

Blanks were carried through the bioaccessbility extraction procedure, and detectable concentrations of all measured elements, except for thallium, were obtained in phase 1 (P1), and copper, iron, lead, selenium and zinc were detected in phase 2 (P2). The source of the inorganic elements in the blanks has not been determined; it could be from the reagents used, or carry over from high concentration samples (e.g., when adjusting pH). For samples with percent levels of analytes (e.g., lead and zinc) it is not unexpected to have µg/L levels of sample cross-contamination. Previously run blanks using this method contained arsenic and lead in low but variable concentrations, with negligible or non-detectable concentrations of thallium and cadmium; thus the possibility of contamination from reagents cannot be discounted. The other elements in the present study (aluminum, copper, iron, selenium and zinc) were not measured in blanks previously. A method detection limit for the avian bioaccessibility method has not been established. Signal enhancement of selenium by elevated concentrations of the sodium in the matrix (such as the NaCl used in the avian gastrointestinal model fluid) is a known phenomenon. Given these considerations, the measured concentrations for the detectable elements in the blanks were subtracted from extract concentrations.

Blanks fortified with known concentrations of the elements of interest (blank spikes) were included in the analysis to monitor recovery. When blank subtraction was applied as described above, recoveries ranged from 82 to 134% in P1, and 55 to 142% in P2. The P1 results were considered to be acceptable as they were approximately within 30% of the known values. The P2 results were lower than 70% for copper, lead and zinc; this has been seen in other bioaccessibility studies because of the instability of these elements in solution at the higher pH of the intestinal phase. Recoveries for other elements were considered acceptable. These results confirmed that blank subtraction was appropriate for this study.

The bioaccessibility of two standard reference materials, NIST 2710 and 2711, were measured at the same time as the samples, using the ESG Avian ratio of 200:1, and results were compared to preliminary control limits obtained during method development in our laboratory. The results were outside the preliminary control limits for the following: arsenic P1 and P2 values in NIST 2710, thallium P1 and P2 values in NIST 2710, and cadmium P2 in NIST 2711. The preliminary control limits are based on limited replicate analyses of the control samples and thus the comparison is semi-quantitative. The consistency of the arsenic values for NIST 2711 and lead values in both materials with preliminary control limits indicates that the bioaccessibility extraction proceeded as expected for this method. Control limits were not available for aluminum, copper, iron, selenium and zinc. Updated and more robust limits are currently being compiled for an extended suite of elements.

Precision was acceptable for all results from P1 with relative percent difference (RPDs) less than 30% with the exception of the RPD for copper (38 %). The precision was acceptable for all results from P2 with RPDs less than 30 % with the exception of cadmium (34 %), copper (74 %) and thallium (32 %). For copper results the relative percent differences were inflated because blank subtraction was used.

The QC results were reviewed for report ASU 15345 (aluminium, arsenic, cadmium, copper, iron, lead, selenium, thallium and zinc in sediments and extracts). The results for duplicates, blanks, water and Mess-3 controls were all acceptable.

Data Interpretation and Limitations

The detection limit for selenium in sediments was raised due to interferences in the ICP-MS analysis. As mentioned previously the selenium values in extracts were caused by interference from sodium, and after the blank subtraction only one sample had a detectable concentration of selenium. This result is not considered reliable and selenium should be considered to be not detectable in these samples.

To calculate % bioaccessibility (% BA), the following equation was used:

$$\%\ \text{Bioaccessibility} = \frac{\text{Bioaccessible concentration}\ \ (\text{mg/kg})}{\text{Total concentration}\ \ (\text{mg/kg})} \times 100\%$$

Equation 1

The maximum % BAs obtained were for cadmium and lead (77% in P1). The maximum P1 %BAs for copper (24 %), thallium (36 %) and zinc ranged (40 %) from 20 to 40%. For arsenic the maximum P1 % BA was 13 % and for iron the maximum was 5 %. Aluminum had the lowest % BA, 0.84 %. Generally the P1 % BA values were higher than the P2 % BA although differences were not great for some elements (e.g., arsenic, copper, thallium). The bioaccessibility in P1 may be higher than P2 because the increase in P2 can cause many elements to precipitate out of solution.

Because of limitations with the current software used for reporting data, the number of significant figures quoted in the attached table may not be representative of the actual uncertainty. Data should be considered accurate to no more than two significant figures.

The Environmental Sciences Group does not accept responsibility for the validity of procedures used to obtain or preserve the samples provided to the laboratory and does not accept any liability for the consequences of any acts taken or omissions made on the basis of the analysis or advice or interpretation provided. The results given relate only to the items tested.

Report authorised by:

Iris Koch, Senior Analytical and Arsenic Research Manager, ESG

A. Rutter

Allison Rutter, Director, ASU

Date: 23 Mar 2015

ESG Bioaccessibility Report

Report ID: ASD15345
Date: 20-Mar-15
Extraction Method: Avian bioaccessibility extraction
Analytical Method: Total elements by ICP-MS
 # Samples: 10

Concentrations in mg/kg, based on DRY WEIGHT, unless otherwise indicated
BA conc = bioacessible concentration (mg/kg); %BA = percent bioaccessibility
Blank subtraction applied to all elements (except for Tl) in P1
Blank subtraction applied to Cu, Fe, Pb, Se, Zn in P2

	Aluminum (Al)			Arsenic (As)			Cadmium (Cd)			Copper (Cu)			Iron (Fe)			Lead (Pb)			Selenium (Se)			Thallium (Tl)			Zinc (Zn)		
Sample	**BA conc**	**Sediment conc**	**%BA**	**BA conc**	**Sediment conc**	**%BA**	**BA conc**	**Sediment conc**	**%BA**	**BA conc**	**Sediment conc**	**%BA**	**BA conc**	**Sediment conc**	**%BA**	**BA conc**	**Sediment conc**	**%BA**	**BA conc**	**Sediment conc**	**%BA**	**BA conc**	**Sediment conc**	**%BA**	**BA conc**	**Sediment conc**	**%BA**
PHASE 1																											
180551-02	102	16000	0.64	26	360	7.1	0.75	14	5.4	1.0	710	0.14	3956	92000	4.3	261	7500	3.5	BS-0	<2.5	NC	0.28	2.3	12	1948	24000	8.1
180551-05	150	18000	0.84	32	400	7.9	1.4	21	6.6	15	950	1.5	5555	110000	5.0	541	12000	4.5	BS-0	<2.5	NC	1.5	8.8	17	2747	30000	9.2
180551-06	125	19000	0.66	18	280	6.6	0.87	11	7.9	27	600	4.5	3554	84000	4.2	401	7100	5.7	BS-0	<2.5	NC	0.66	5.4	12	1948	21000	9.3
180551-09	6.1	14000	0.044	0.51	23	2.2	0.11	0.33	34	2.9	24	12	18	25000	0.073	26	150	17	BS-0	<2.5	NC	0.11	0.58	19	8.2	320	2.5
180551-11	20	14000	0.14	1.3	19	6.8	0.13	0.32	40	2.4	13	19	BS-0	24000	(<0.04)	24	63	38	BS-0	<2.5	NC	0.10	0.53	19	4.0	120	3.4
180551-13	10	13000	0.079	1.0	15	6.7	0.30	0.48	62	2.2	14	16	22	25000	0.090	26	53	49	BS-0	<2.5	NC	0.18	0.85	22	12	91	13
180551-16	21	16000	0.13	2.7	21	13	0.75	0.98	77	5.0	21	24	83	29000	0.28	70	91	77	BS-0	<2.5	NC	0.31	0.89	35	66	170	39
180551-17	BS-0	16000	(<0.06)	1.7	45	3.7	0.11	0.81	13	0.85	46	1.8	53	45000	0.12	17	270	6.5	BS-0	<2.5	NC	0.063	0.42	15	34	790	4.3
180551-24	BS-0	8600	(<0.12)	<0.4	5.4	<7.4	BS-0	< 0.05	NC	1.0	9.3	11	2.1	17000	0.012	0.60	8.4	7.2	BS-0	<2.5	NC	<0.02	<0.025	NC	BS-0	37	(<5.4)
* 180551-19	27	15000	0.18	2.2	27	8.3	0.81	1.7	48	2.6	28	9.1	83	31000	0.27	70	140	50	2.0	<2.5	NC	0.31	0.85	36	62	240	26
PHASE 2																											
180551-02	<10	16000	<0.06	26	360	7.3	0.70	14	5.0	5.2	710	0.74	289	92000	0.31	14	7500	0.18	BS-0	<2.5	NC	0.28	2.3	12	922	24000	3.8
180551-05	<10	18000	<0.06	36	400	9.0	1.3	21	6.4	17	950	1.8	610	110000	0.55	30	12000	0.25	BS-0	<2.5	NC	1.7	8.8	20	1622	30000	5.4
180551-06	<10	19000	<0.05	19	280	6.7	0.70	11	6.4	17	600	2.9	390	84000	0.46	32	7100	0.45	BS-0	<2.5	NC	0.76	5.4	14	841	21000	4.0
180551-09	<10	14000	<0.07	0.88	23	3.8	0.094	0.33	28	BS-0	24	(<4)	BS-0	25000	(<0.04)	8.7	150	5.8	BS-0	<2.5	NC	0.11	0.58	19	12	320	3.8
180551-11	14	14000	0.10	1.4	19	7.4	0.12	0.32	37	0.81	13	6.2	BS-0	24000	(<0.04)	12	63	19	BS-0	<2.5	NC	0.12	0.53	22	26	120	22
180551-13	13	13000	0.10	1.6	15	11	0.27	0.48	55	3.5	14	25	4.1	25000	0.016	11	53	20	BS-0	<2.5	NC	0.19	0.85	23	31	91	34
180551-16	<10	16000	<0.06	1.5	21	7.2	0.50	0.98	51	3.5	21	17	2.1	29000	0.007	14	91	15	BS-0	<2.5	NC	0.25	0.89	28	27	170	16
180551-17	<10	16000	<0.06	1.8	45	3.9	0.10	0.81	13	0.85	46	1.8	23	45000	0.052	6.3	270	2.3	BS-0	<2.5	NC	0.074	0.42	18	28	790	3.5
180551-24	<10	8600	<0.12	<0.4	5.4	<7.4	<0.02	< 0.05	NC	BS-0	9.3	(<11)	BS-0	17000	(<0.06)	0.10	8.4	1.2	BS-0	<2.5	NC	<0.02	<0.025	NC	2.1	37	5.6
* 180551-19	11	15000	0.073	1.8	27	6.8	0.52	1.7	31	1.6	28	5.8	BS-0	31000	(<0.03)	13	140	9.0	BS-0	<2.5	NC	0.25	0.85	29	31	240	13

* Average of duplicate extractions, except for Se P1 and Al P2, where the detectable value is shown.
BS-0 indicates that blank subtraction gave zero or negative number
NC = could not be calculated
(<#) indicates less than an approximate percent bioaccessibility, calculated from detection limit and total concentration

QA/QC for Bioaccessibility Extractions

Blanks (mg/L)

Blank	Aluminium	Arsenic	Cadmium	Copper	Iron	Lead	Selenium	Thallium	Zinc
Extraction Blank P1	0.11	0.0021	0.00015	0.067	0.30	0.0023	0.18	< 0.0001	0.30
Extraction Blank P2	< 0.05	< 0.002	< 0.0001	0.074	0.16	0.0023	0.20	< 0.0001	0.11
Analytical Blank	< 0.05	< 0.002	< 0.0001	< 0.005	< 0.05	< 0.0002	< 0.01	< 0.0001	< 0.01

Duplicates

Extraction Duplicates	Aluminum (Al)		Arsenic (As)		Cadmium (Cd)		Copper (Cu)		Iron (Fe)		Lead (Pb)		Selenium (Se)		Thallium (Tl)		Zinc (Zn)	
	BA conc (ppm)	%BA	BA conc (ppm)	%BA	BA conc (ppm)	%BA	BA conc (ppm)	%BA	BA conc (ppm)	%BA	BA conc (ppm)	%BA	BA conc (ppm)	%BA	BA conc (ppm)	%BA	BA conc (ppm)	%BA
180551-19 P1	28	0.19	2.4	9.0	0.88	52	3.0	11	89	0.29	79	56	2.0	NC	0.35	41	69	29
180551-19 P1 DUP	25	0.17	2.0	7.6	0.73	43	2.1	7.4	76	0.25	61	44	BS-0	NC	0.27	32	56	23
Average	27	0.18	2.2	8.3	0.81	48	2.6	9.1	83	0.27	70	50	2.0	NC	0.31	36	62	26
RPD (%)	14	14	17	17	19	19	38	38	16	16	25	25	1 nd	NC	25	25	21	21
180551-19 P2	< 10	<0.07	2.0	7.5	0.61	36	2.2	8.0	BS-0	NC	14	9.8	BS-0	NC	0.28	33	35	14
180551-19 P2 DUP	11	0.073	1.7	6.1	0.43	26	1.0	3.7	BS-0	NC	12	8.2	BS-0	NC	0.21	24	27	11
Average	1 nd	1 nd	1.8	6.8	0.52	31	1.6	5.8	NC	NC	13	9.0	NC	NC	0.25	29	31	13
RPD (%)	1 nd	1 nd	21	21	34	34	74	74	NC	NC	18	18	NC	NC	32	32	25	25

Analytical Duplicates	Aluminium	Arsenic	Cadmium	Copper	Iron	Lead	Selenium	Thallium	Zinc
180551-02 P1	610	130	3.9	60	20000	1300	120	1.3	10000
180551-02 P1 DUP	640	130	3.9	85	20000	1300	150	1.4	10000
Average	625	130	3.9	73	20000	1300	135	1.4	10000
RPD (%)	4.8	0	0	34	0	0	22	7.4	0
180551-02 P2	< 0.05	140	3.7	110	1700	75	200	1.5	5300
180551-02 P2 DUP	< 0.05	120	3.3	94	1500	65	180	1.4	4100
Average	both nd	130	3.5	102	1600	70	190	1.5	4700
RPD (%)	both nd	15	11	16	13	14	11	6.9	26

Blank Spikes

	% Recovery								
	Aluminium	Arsenic	Cadmium	Copper	Iron	Lead	Selenium	Thallium	Zinc
Spike P1	118	103	82	82	115	97	134	104	115
Spike P2	142	103	81	69	77	55	96	89	57

Control Samples for Bioaccessibility Extraction

	% BA			
	Arsenic	Cadmium	Lead	Thallium
NIST 2710 P1	28	69	63	25
ESG Control Limits P1*	11.7-21	40-74	59.7-63.7	6.9-10
NIST 2711 P1	55	86	88	23.0
ESG Control Limits P1**	11.6-63	64-115	68-106	1.0-34
NIST 2710 P2	20	48	4	11.0
ESG Control Limits P2*	12.0-16	28-77	1.0-9	16-21
NIST 2711 P2	29	43	6	14.0
ESG Control Limits P2**	25-38	55-90	8.3-12	0-40

* From 5 replicates over 2 days

** From 13 replicates over 3 days

QA/QC for Total Elements in Sediments

Blanks

	Aluminium	Arsenic	Cadmium	Copper	Iron	Lead	Selenium	Thallium	Zinc
Blank 1	<50	<0.5	<0.05	<2.0	<20	<0.5	<2.5	<0.025	<5.0

Duplicates

	Aluminium	Arsenic	Cadmium	Copper	Iron	Lead	Selenium	Thallium	Zinc
180551-05	18	0.39	0.020	0.92	110	13	< 0.0025	0.0085	28
180551-05 DUP	17	0.41	0.021	0.98	110	10	< 0.0025	0.0090	32
Average	18	0.40	0.021	0.95	110	12	< 0.0025	0.0088	30
RPD (%)	5.7	5.0	4.9	6.3	0	26	NC	5.7	13

CRM

	% Recovery								
	Aluminium	Arsenic	Cadmium	Copper	Iron	Lead	Selenium	Thallium	Zinc
MESS 3	22000	21	0.22	34	32000	18	<2.5	0.087	140
MESS 3 Target	20000	19	0.24	31	35000	19	-	-	130
% Recovery	110	110	92	110	91	95	NC	NC	108

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ASU #	**15345**		Report ID:	ASU 15345 ESG Intrinsik-Extract1
Client:	**Intrinsik**		Date Submitted:	3-Mar-15
			Date Tested:	12-Mar-15
Site: ESG			Date:	19-Mar-15
Technique:	**ICP-OES and ICP-MS**		Matrix: Ex	tracts
Report of Analysis: all results in ng/ml				
Results relate only to the items tested				
	P1 180551-02 *	**P1 180551-05**	**P1 180551-06**	**P1 180551-09**
Aluminium	620	860	730	140
Arsenic	130	160	94	4.6
Cadmium	3.9	6.9	4.5	0.70
Copper	72	140	200	81
Iron	20000	28000	18000	390
Lead	1300	2700	2000	130
Selenium***	140	150	160	170
Thallium	1.4	7.3	3.3	0.53
Zinc	10000	14000	10000	340
	P1 180551-11	**P1 180551-13**	**P1 180551-16**	**P1 180551-17**
Aluminium	210	160	210	100
Arsenic	8.5	7.0	15	10
Cadmium	0.78	1.6	3.8	0.66
Copper	79	78	91	71
Iron	300	410	700	550
Lead	120	130	340	85
Selenium***	170	170	170	170
Thallium	0.50	0.90	1.5	0.30
Zinc	320	360	620	460
	P1 180551-19	**P1 180551-24**	**P1 180551-19 DUP**	**P1 Blank**
Aluminium	250	110	230	110
Arsenic	14	<2.0	12	2.1
Cadmium	4.5	0.11	3.7	0.15
Copper	82	72	77	67
Iron	740	310	670	300
Lead	390	5.2	300	2.3
Selenium***	190	180	180	180
Thallium	1.7	<0.1	1.3	<0.1
Zinc	640	290	570	300

	P1 SPIKE	**P1 SRM 2710**	**P1 SRM 2711**	**P2 180551-02 ***
Aluminium	130	1700	3600	<50
Arsenic	64	850	270	130
Cadmium	54	73	190	3.5
Copper	110	6600	190	100
Iron	360	950	1800	1600
Lead	53	17000	4800	70
Selenium***	250	180	200	190
Thallium	56	1.6	2.7	1.4
Zinc	360	7100	630	4700
	P2 180551-05	**P2 180551-06**	**P2 180551-09**	**P2 180551-11**
Aluminium	<50	<50	<50	70
Arsenic	180	94	4.3	7.0
Cadmium	6.5	3.5	0.46	0.59
Copper	160	160	59	78
Iron	3200	2100	150	140
Lead	150	160	45	62
Selenium***	200	180	170	160
Thallium	8.7	3.8	0.54	0.57
Zinc	8200	4300	170	240
	P2 180551-13	**P2 180551-16**	**P2 180551-17**	**P2 180551-19**
Aluminium	66	<50	<50	<50
Arsenic	7.8	7.3	8.3	10
Cadmium	1.3	2.4	0.49	3.0
Copper	91	91	78	85
Iron	180	170	270	150
Lead	54	70	32	70
Selenium***	180	160	170	180
Thallium	0.95	1.2	0.35	1.4
Zinc	260	240	240	280

	P2 180551-24	**P2 180551-19 DUP**	**P2 Blank**	**P2 SPIKE**
Aluminium	<50	53	<50	74
Arsenic	<2.0	8.0	<2.0	54
Cadmium	<0.1	2.1	<0.1	42
Copper	73	79	74	110
Iron	110	150	160	200
Lead	2.8	58	2.3	31
Selenium***	160	160	200	250
Thallium	<0.1	1.0	<0.1	48
Zinc	120	240	110	140
	P2 SRM 2710	**P2 SRM 2711**		
Aluminium	<50	<50		
Arsenic	610	140		
Cadmium	51	94		
Copper	5400	160		
Iron	140	80		
Lead	960	310		
Selenium***	200	180		
Thallium	0.72	1.6		
Zinc	830	95		
Laboratory QA/QC				
	Blank	**Reporting Limit ****		
Aluminium	<50	<50		
Arsenic	<2.0	<2.0		
Cadmium ***	<0.1	<0.1		
Copper	<5.0	<5.0		
Iron	<50	<50		
Lead	<0.2	<0.2		
Selenium ***	<10	<10		
Thallium	<0.1	<0.1		
Zinc	<10	<10		

	Control 1	**Control 1 Target**	**EU-H-4 Control**	**EU-H-4 Target**
Aluminium	26	25	410	420
Arsenic	24	25	780	780
Cadmium	26	25	270	260
Copper	24	25	730	740
Iron	26	25	620	580
Lead	27	25	670	610
Selenium***	25	25	140	140
Thallium	24	25	390	390
Zinc	24	25	880	870
	P1 180551-02	**P1 180551-02**	**P2 180551-02**	**P2 180551-02**
Aluminium	610	640	<50	<50
Arsenic	130	130	140	120
Cadmium	3.9	3.9	3.7	3.3
Copper	60	85	110	94
Iron	20000	20000	1700	1500
Lead	1300	1300	75	65
Selenium***	120	150	200	180
Thallium	1.3	1.4	1.5	1.4
Zinc	10000	10000	5300	4100
NOTES:	Scandium, Indium and Bismith were used as internal standards. Gas dilution (HMI) used: N.			
	* Averaged result of duplicate analyses; All extracts diluted x 10 prior to analysis			
	** Reporting limits factored from neat water analysis x 10;			
	***78 Se used instead of 82 Se due to matrix effects.		*** detection limits raised due to interferences.	
	Recommend blank subtraction of results			
Prepared by:	Paula Whitley		Authorized by:	A. Rutter

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ASU #	15345		**Report ID:**	ASU 15345 ESG Intrinsik-S1
Client:	ESG		**Date Submitted:**	3-Mar-15
			Date tested:	10-Mar-15
Site:	Intrinsik		**Date:**	19-Mar-15
			Matrix:	Soil
Report of Analysis of Metals by ICP-OES and ICPMS				
Results relate only to the items tested: Results in ug/g				
Sample	**180551-2**	**180551-5 ***	**180551-6**	**180551-9**
Aluminium **	16000	18000	19000	14000
Arsenic	360	400	280	23
Cadmium	14	21	11	0.33
Copper	710	950	600	24
Iron	92000	110000	84000	25000
Lead	7500	12000	7100	150
Selenium **	<2.5	<2.5	<2.5	<2.5
Thallium	2.3	8.8	5.4	0.58
Zinc	24000	30000	21000	320
Sample	**180551-11**	**180551-13**	**180551-16**	**180551-17**
Aluminium **	14000	13000	16000	16000
Arsenic	19	15	21	45
Cadmium	0.32	0.48	0.98	0.81
Copper	13	14	21	46
Iron	24000	25000	29000	45000
Lead	63	53	91	270
Selenium **	<2.5	<2.5	<2.5	<2.5
Thallium	0.53	0.85	0.89	0.42
Zinc	120	91	170	790
Prepared by:	Paula Whitley		Authorization :	A. Rutter

Sample	**180551-19**	**180551-24**		
Aluminium **	15000	8600		
Arsenic	27	5.4		
Cadmium	1.7	<0.05		
Copper	28	9.3		
Iron	31000	17000		
Lead	140	8.4		
Selenium **	<2.5	<2.5		
Thallium	0.85	<0.025		
Zinc	240	37		
Laboratory QA/QC				
Sample	**Blank**	**Mess-3 *** **	**Mess-3 Target**	
Aluminium **	<50	22000	20000	
Arsenic	<0.5	21	19	
Cadmium	<0.05	0.22	0.24	
Copper	<2.0	34	31	
Iron	<20	32000	35000	
Lead	<0.5	18	19	
Selenium **	<2.5	<2.5	-	
Thallium	<0.025	0.087	-	
Zinc	<5.0	140	130	
Sample	**180551-5**	**180551-5**		
Aluminium **	18000	17000		
Arsenic	390	410		
Cadmium	20	21		
Copper	920	980		
Iron	110000	110000		
Lead	13000	10000		
Selenium **	<2.5	<2.5		
Thallium	8.5	9.0		
Zinc	28000	32000		

Scandium, Indium and Bismith were used as internal standards. Gas dilution (HMI) used: Y (Med); * Averaged result of duplicate analyses

** Detection limits raised due to interferences. *** ICPMS Limits are being compiled on an extended suite of elements (partial extract).

APPENDIX L

CANADIAN WILDLIFE SERVICE TISSUE ANALYSIS OF CHICK LIVERS

Environment Canada Environnement Canada

Laboratory Services Report: CHEM-MET-11-03

National Wildlife Research Centre
Ecotoxicology and Wildlife Health Division
Science and Technology Branch
Environment Canada
Ottawa, Ontario
K1A 0H3

E&WHD Study 1128NB07

Study Leader: Neil Burgess

Determination of total mercury in liver samples by AMA-254 advanced mercury analyzer and metals: Mn, Cu, Zn, As, Se, Rb, Cd and Pb by ICP-MS, Elan-9000

Original signed by:

France Maisonneuve
Biomarker Lab. Biochemist
Tel.: 613-998-8088

June 2011

Study Number: **1128NB07**

Study Title: **Wildlife Toxicology Activities in Atlantic Region**

Study Leader: **N. Burgess**

Test Method: **MET-CHEM-AA-03 H (July 2009) and EPA Method 200.8** and **MET-CHEM-ICP-01A (under review)** – Available upon request

Analysts: **Ewa Neugebauer/Robyn Lima**

General Information

Tissues analyzed:	individual livers (n=7)
Collection dates:	July 2010
Dates received at NWRC:	2010-09-30
Condition upon arrival at NWRC:	liver samples were received frozen and were kept at -40 deg C until being processed
Date of processing by TP Lab:	2011-04-27
Date issued to Metals Lab:	2011-05-03 (Outgoing Report # 2111)
Analysis:	May 2011

Sample Preparation and Method of Analysis

Sample Preparation by Tissue Preparation Lab: Upon arrival all livers were stored at -40ºC until processing, afterwards at -20 deg C until being issued. Liver samples were not homogenized but samples from K11-28229 and K11-28233 were minced with scissors and two separate aliquots for each sample were issued to Metals Lab. All samples were small; from 0.3 to 3.9 g wet weight.

Sample Preparation for Hg Analyses in Metals Lab: as described in test method MET-CHEM-AA-03H. Liver samples were accurately weighed out into plastic, acid washed vials then freeze-dried. The dry masses were recorded and moisture content calculated. For mercury measurements, dry samples were homogenized using spatula and weighed onto tared sample boats.

Analysis (Hg) and Quantification: As described in MET-CHEM-AA-03H. In brief, the sample is thermally and chemically decomposed within the decomposition furnace of the AMA-254. The products are carried by flowing oxygen to the catalytic section of the furnace. Oxidation is completed and halogens and nitrogen/sulfur oxides are trapped. The remaining decomposition products are carried to an amalgamator that selectively traps mercury. After the system is flushed with oxygen, the amalgamator is rapidly heated releasing mercury vapor which is carried through absorbance cells positioned in the light path of an atomic absorption spectrometer (253.7 nm).

The AMA-254 software calculates directly a concentration of mercury in sample, based on calibration curve and specific weight of the sample. Results are reported in µg/g dry weight.

Sample Preparation for ICP-MS Analyses in Metals Lab: as described in MET-CHEM-ICP-01A (under review/development). The procedure used, is based on EPA Method 200.8 with modifications for biological samples. Samples were weighed out into plastic, acid washed test tubes. Then samples were digested: 1.0 mL of 70% nitric acid was added to each sample. The samples sat overnight at room temperature. The next day they were heated, loosely capped, at 100ºC in dry heating blocks for 4 hours. The cool, digested samples were diluted with ROP water to 3 mL except two very small samples K11-28234 and K11-28235 diluted to 2 mL (the weight of the dry sample for ICP analyses was about 50 mg) in glass test tubes and stored at room temperature until analyses were performed. Before analysis original digest were diluted 20 times with ROP water and Internal Standard containing Sc, Ga, Ge, Rh, In, Tb, and Ta was added (to compensate for fluctuation of the instrument stability), to all solutions including calibration blanks and standards (prepared fresh each day of analysis), samples and quality control samples and standards.

Analysis and Quantification: as described in MET-CHEM-ICP-01A. In brief, the digests of biological samples are nebulized into a spray chamber where a stream of argon carries the sample aerosol through a quartz torch and injects it into an RF plasma. There the sample is decomposed and desolvated. The ions produced are entrained in the plasma gas and by means of a cooled, differentially pumped interface, introduced into a high vacuum chamber and a quadropole mass spectrometer. The ions are sorted according to theirs mass-to-charge ratio and measured with a detector. The standard operating procedure for method which was used is in the stage of preparation. Method used based on EPA Method 200.8 with modifications for biological samples. Concentrations of metals were measure in samples using ELAN 9000, ICP-MS from Perkin Elmer. All calculations are based on measurement for isotopes listed in Table 4 on page 6 of the report.
Results are reported in µg/g dry weight.

Quality Control

- ***System performance and calibration –*** instrument's AMA-254 mercury analyzer performance was evaluated, before the samples were analyzed, using certified reference materials (CRM's) – for Daily Calibration Validation.

  ELAN- 9000 ICP-MS performance was evaluated, before the samples were analyzed, using certified reference materials (CRM) and Daily Calibration Check Standards.

- ***Accuracy –*** the accuracy of the mercury method was demonstrated by analyzing the concentration of certified reference materials Dolt-3 and Tort-2 from NRC and Oyster Tissue 1566b from NIST. Standards used for validation of calibration are from Institute for Reference Materials and Measurements: ERM®-CE278 Mussel Tissue and BCR®-463 Tuna Fish.

The accuracy of the ICP-MS method for analyzed elements : Mn, As, Cu, Zn, Se, Rb, Cd and Pb was demonstrated by analyzing the concentration of certified reference materials Dolt-3 and Tort-2 from NRC.

- ***Replicates –*** to check for the homogeneity of the samples, two (2) random liver samples were analyzed in duplicate for mercury. One(1) random liver sample was digested and analyzed in duplicate by ICP-MS. Duplicates of the certified reference material were also analyzed to check calibration of the instrument, the within-run precision and the reproducibility of the method.
- ***Mercury analyzer AMA-254 practical detection limit –*** 0.12 ng Hg which corresponds to 0.006 µg/g in the average 0.020 g dry mass sample.
- ***ELAN-9000 ICP-MS practical detection limit –*** Theoretical (DL) and Practical (PDL) detection limits were establish for all elements determined in the sample, expressed in [µg/L] as measured in digested samples and in µg/g dry wt. in the egg sample, see **Table 4** for details.
- ***Contamination in Hg method-****"empty boats"* blanks were used to detect possible contamination for mercury determinations.
- ***Contamination*** in ICP-MS**–** blank samples were digested to check for contamination
- ***Data verification*** – the data were verified to ensure that all the criteria listed in the Quality Control Section of the test method were met. Please see the QA/QC Notes below for details.

Results and Comments

QC data are reported in **Tables 1, 2, 5, 6 and 8.** Concentrations of mercury measured by AMA-254 are in **Table 3** and concentrations of analytes measured by ICP-MS found in the liver samples are in **Table 7.** Field collection data are in **Table 9.**

QA/QC Notes:

- ICP-MS Inductively Coupled Plasma Mass Spectrometer ELAN 9000 was used to determine concentration of metals in liver samples. Recoveries of analytes from CRM samples ranged from 70.6 % 124.2% see **Tables 5 and 6.** The lowest recovery was observed for lead in Tort-2, (73.5%) and in Dolt-3 (70.6 %). Concentration of lead in both CRM's is very low (0.35 and 0.32 µg/g respectively) with Practical Detection Limit for lead equal to 0.15µg/g.
- Standard deviations for replicate readings for all analyzed metals in duplicate liver samples were between 0.6 and 4.7 % see **Table 8.**

- Recoveries of mercury for the daily calibration check standards (certified reference materials) ranged from 94.0 to 116.3 % (**Table 1**). Values obtained were within the acceptable limits.
- Standard deviations for all replicate mercury readings in random liver samples and CRM samples were between 3.2 to 8.9 % (**Table 1 and 2**).

Note: The results relate only to the items tested.

Index of Tables

Original signed by:

Ewa Neugebauer
Metals Chemistry Technologist
Tel.: 613-998-6908

Table 1. Recoveries of total mercury from CRM samples

Sample ID	Certified Value [µg/g]	Experimental Value [µg/g]	n	SD	% RSD	% Recovery
OT 1566 b	0.0371 ± 0.0013	0.0349	1	NA	NA	94.0
DOLT-3	3.37 ± 0.14	3.364	3	0.107	3.2	99.8
TORT-2	0.27 ± 0.06	0.314	1	NA	NA	116.3
CE278	0.196 ± 0.009	0.203	1	NA	NA	103.4
BCR-463	2.85 ± 0.16	2.908	1	NA	NA	102.0

Table 2. Results of replicate determinations of mercury in random liver samples [µg/g dry wt]

Sample ID	Replicate 1 Hg [µg/g]	Replicate 2 Hg [µg/g]	Mean [µg/g]	SD [µg/g]	% RSD
28230	0.781	0.828	0.804	0.034	4.2
28234	0.654	0.741	0.698	0.062	8.9

Table 3. Results of total mercury concentration in Common Tern liver samples [µg/g dry wt]

Sample ID	Specimen	Moisture [%]	Total Hg [µg/g] dry wt.
K11-28229-00-00	BS-COTE-10	71.3	0.133
K11-28230-00-00**	BS-COTE-2	71.6	0.804
K11-28233-00-00	BS-COTE-5	75.5	0.342
K11-28234-00-00**	BS-COTE-6	76.5	0.698
K11-28235-00-00	BS-COTE-7	74.7	1.262
K11-28236-00-00	BS-COTE-8	69.4	0.278
K11-28237-00-00	BS-COTE-9	73.5	0.268

(**) sample was analysed in duplicate and average value from duplicate readings is reported in this table. For individual results see Table 2

Table 4. Detection Limits for ICP-MS analyses

Analyte Symbol	a.mass amu	DL(3xSD) µg/L	PDL(5xDL) µg/L	PDL(5xDL) µg/g
Mn	55	0.008	0.04	0.024
Cu	63	0.06	0.3	0.18
Zn	67	1.1	5.5	3.3
As	75	0.05	0.25	0.15
Se	82	0.1	0.5	0.3
Rb	87	0.05	0.25	0.15
Cd	111	0.001	0.005	0.003
Pb	208	0.05	0.25	0.15

PDL(5xDL) µg/g in sample calculated for average dry wt=0.1g
and vol 60 ml for 20x diluted samples

Table 5. Recoveries of analytes from CRM TORT-2

TORT-2 Analyte	Experimental value [µg/g]	Certified value [µg/g]	Certif. SD [µg/g]	Recovery [%]
Mn	12.0	13.6	1.2	88.0
Cu	97.2	106	10	91.7
Zn	199.9	180	6	111.1
As	23.6	21.6	1.8	109.4
Se	6.994	5.63	0.67	124.2
Rb	2.5	NC	NC	NC
Cd	27.9	26.7	0.6	104.6
Pb	0.257	0.35	0.13	73.5

Table 6. Recoveries of analytes from CRM DOLT-3

DOLT-3 Analyte	Experimental value [µg/g]	SD [µg/g]	RSD [%]	n	Certified value [µg/g]	Certif. SD [µg/g]	Recovery [%]
Mn	9.2	0.20	2.2	2	NC	NC	NA
Cu	30.9	0.25	0.8	2	31.2	1.00	99.0
Zn	100.5	0.97	1.0	2	86.6	2.40	116.1
As	10.3	0.34	3.3	2	10.2	0.50	100.5
Se	8.33	0.34	4.1	2	7.06	0.48	118.0
Rb	3.36	0.10	2.9	2	NC	NC	NA
Cd	19.7	0.11	0.6	2	19.4	0.60	101.7
Pb	0.226	NA	NA	1	0.32	0.05	70.6

NC= not certified
NA= not available

Table 7. Concentration of metals analysed by ICP-MS in liver samples in µg/g dry weight.

Analyte	Cd	Mn	Cu	Zn	As	Se	Rb	Pb
a.mass	**111**	**55**	**63**	**67**	**75**	**82**	**87**	**208**
USOX #	[µg/g]	[µg/g]	[µg/g]	[µg/g]	[µg/g]	[µg/g]	[µg/g]	[µg/g]
K11-28229-00-00	2.56	16.91	17.2	87.9	2.21	5.58	6.43	3.42
K11-28230-00-00	0.96	8.34	13.0	98.9	4.70	3.94	3.58	36.15
K11-28233-00-00	0.05	10.60	61.6	71.1	1.30	5.02	4.65	0.48
K11-28234-00-00	1.45	7.86	37.4	239.0	5.56	5.47	3.51	107.88
K11-28235-00-00	0.31	9.89	16.7	153.1	1.78	3.63	2.60	15.23
K11-28236-00-00	2.92	15.42	63.9	323.3	1.68	6.25	6.08	13.60
K11-28237-00-00	4.80	12.85	23.6	188.2	2.15	5.32	5.00	7.87

Note: all calculations are based on measurement for isotopes listed in Table 4.

Table- 8 Results of duplicate determinations of metals in random liver sample K11-28233

Analyte	Result-1 [µg/g]	Result-2 [µg/g]	Average [µg/g]	SD [µg/g]	RSD [%]
Cd	0.053	0.050	0.051	0.0024	4.7
Mn	10.6	11.3	10.93	0.467	4.3
Cu	61.6	60.7	61.12	0.647	1.1
Zn	71.1	70.7	70.94	0.271	0.4
As	1.299	1.311	1.31	0.009	0.7
Se	5.02	5.12	5.07	0.071	1.4
Rb	4.65	4.75	4.70	0.072	1.5
Pb	0.483	0.434	0.459	0.035	7.5

1128NB07 - 9 COTE chick liver samples to Ewa for ICP-MS and Hg analysis

Sample processing informatio SOP-TP-PROC-06C, tissues not homogenized but samples from K11-28229 and K11-28233 were minced with scissors.

Sample storage information: Samples were shipped frozen and were stored at -40C or -20C until being processed. Aliquots were stored at -20C until being issued.

USOX	Specimen number	Species	Location	Province	Coll Date (mm/dd/yyy)	Coll Cond	Sample wt (g)	Tissue State	Processing Method	Storage Container	Lab	Date Received (mm/dd/yyy)	Date Prepared (mm/dd/yyy)	Condition
K11-28229-00-00	BS-COTE-10	Tern, Common	Belledune Smelter	New Brunswick	July 2010	Normal	2.9	N	Dissectio	Linear Polyprop Vial	NWRC Metals	9/30/10	4/27/11	Normal
K11-28229-00-01	BS-COTE-10	Tern, Common	Belledune Smelter	New Brunswick	July 2010	Normal	2.9	N	Dissectio	Linear Polyprop Vial	NWRC Metals	9/30/10	4/27/11	Normal
K11-28230-00-00	BS-COTE-2	Tern, Common	Belledune Smelter	New Brunswick	July 2010	Normal	1	N	Dissectio	Linear Polyprop Vial	NWRC Metals	9/30/10	4/27/11	Normal
K11-28233-00-00	BS-COTE-5	Tern, Common	Belledune Smelter	New Brunswick	July 2010	Normal	3.9	N	Dissectio	Linear Polyprop Vial	NWRC Metals	9/30/10	4/27/11	Normal
K11-28233-00-01	BS-COTE-5	Tern, Common	Belledune Smelter	New Brunswick	July 2010	Normal	3.9	N	Dissectio	Linear Polyprop Vial	NWRC Metals	9/30/10	4/27/11	Normal
K11-28234-00-00	BS-COTE-6	Tern, Common	Belledune Smelter	New Brunswick	July 2010	Normal	0.3	N	Dissectio	Linear Polyprop Vial	NWRC Metals	9/30/10	4/27/11	Normal
K11-28235-00-00	BS-COTE-7	Tern, Common	Belledune Smelter	New Brunswick	July 2010	Normal	0.3	N	Dissectio	Linear Polyprop Vial	NWRC Metals	9/30/10	4/27/11	Normal
K11-28236-00-00	BS-COTE-8	Tern, Common	Belledune Smelter	New Brunswick	July 2010	Normal	4	N	Dissectio	Linear Polyprop Vial	NWRC Metals	9/30/10	4/27/11	Normal
K11-28237-00-00	BS-COTE-9	Tern, Common	Belledune Smelter	New Brunswick	July 2010	Normal	4	N	Dissectio	Linear Polyprop Vial	NWRC Metals	9/30/10	4/27/11	Normal

Table 9. Study 1128NB07, Field collection data for individual liver samples; analytical report CHEM-MET-11-03.

USOX	Specimen number	Study #	Species	Location	Province	Coll Date	Coll Cond	Tissue	Date Received	Date Prepared	Condition
K11-28229-00-00	BS-COTE-10	1128NB07	Tern, Common	Belledune Smelter	New Brunswick	July 2010	Normal	Liver	9/30/10	4/27/11	Normal
K11-28229-00-01	BS-COTE-10	1128NB07	Tern, Common	Belledune Smelter	New Brunswick	July 2010	Normal	Liver	9/30/10	4/27/11	Normal
K11-28230-00-00	BS-COTE-2	1128NB07	Tern, Common	Belledune Smelter	New Brunswick	July 2010	Normal	Liver	9/30/10	4/27/11	Normal
K11-28233-00-00	BS-COTE-5	1128NB07	Tern, Common	Belledune Smelter	New Brunswick	July 2010	Normal	Liver	9/30/10	4/27/11	Normal
K11-28233-00-01	BS-COTE-5	1128NB07	Tern, Common	Belledune Smelter	New Brunswick	July 2010	Normal	Liver	9/30/10	4/27/11	Normal
K11-28234-00-00	BS-COTE-6	1128NB07	Tern, Common	Belledune Smelter	New Brunswick	July 2010	Normal	Liver	9/30/10	4/27/11	Normal
K11-28235-00-00	BS-COTE-7	1128NB07	Tern, Common	Belledune Smelter	New Brunswick	July 2010	Normal	Liver	9/30/10	4/27/11	Normal
K11-28236-00-00	BS-COTE-8	1128NB07	Tern, Common	Belledune Smelter	New Brunswick	July 2010	Normal	Liver	9/30/10	4/27/11	Normal
K11-28237-00-00	BS-COTE-9	1128NB07	Tern, Common	Belledune Smelter	New Brunswick	July 2010	Normal	Liver	9/30/10	4/27/11	Normal

APPENDIX M

MINNOW (2015c) SHOREBIRD POPULATION AND NESTING SURVEY

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July 24, 2015

Mr. Bob Butler - Environmental Superintendent
Glencore Canada Corporation
Brunswick Smelter
692 Main Street
Belledune, NB E8G 2M1

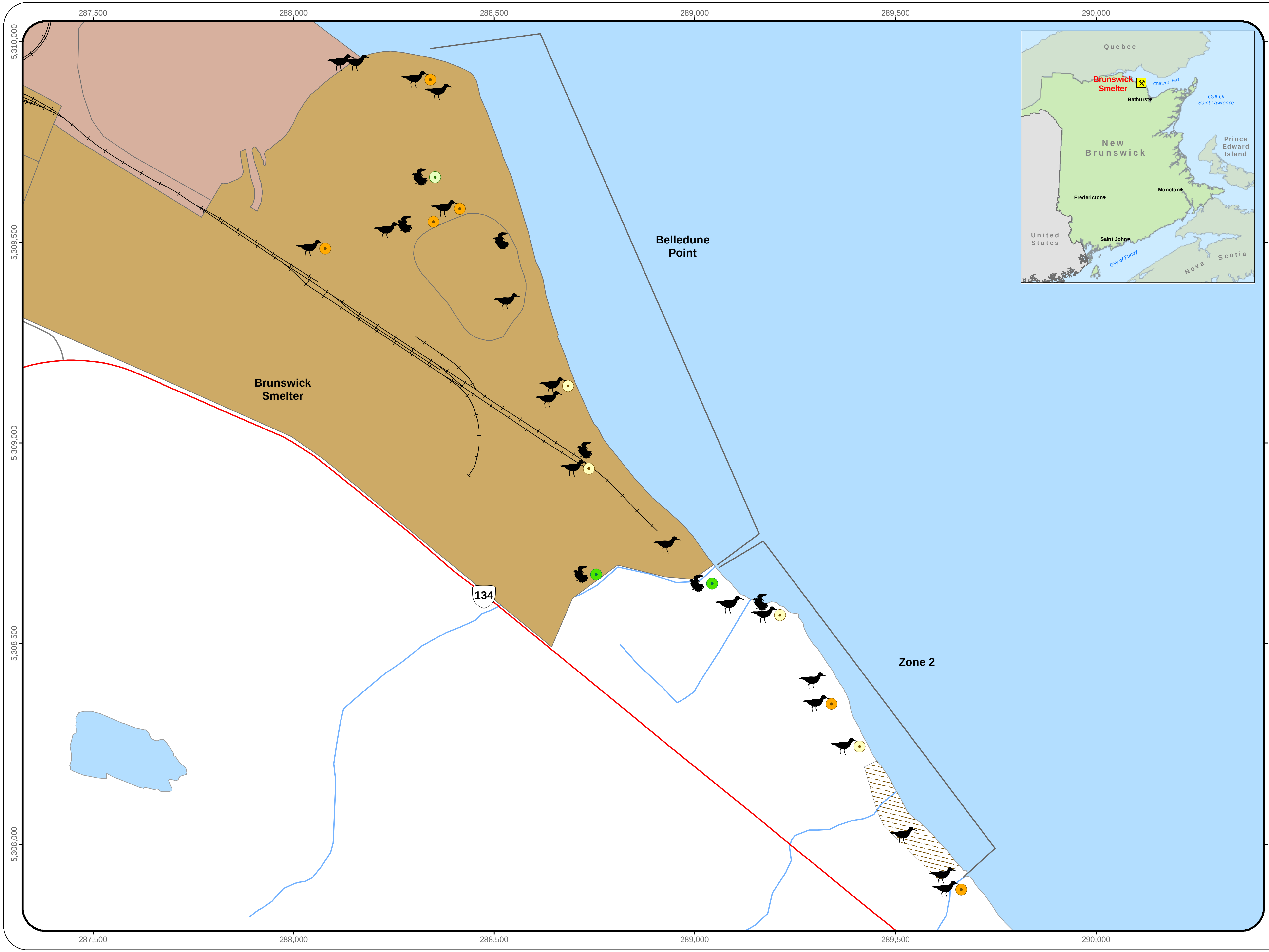
Re: Shorebird Population and Nesting Survey, 2015

Dear Mr. Butler,

Contaminant-related risks were identified for shorebirds using the Brunswick Smelter property (Belledune, NB) in a marine ecological risk assessment completed by Intrinsik (2015). Although previous bird surveys had identified the presence of shorebirds including spotted sandpipers (*Actitus macularius*) and killdeer (*Charadrius vociferous*) on the Brunswick Smelter property during the breeding season, the total number of shorebirds using the property for foraging and nesting was not quantified. Therefore, this Shorebird Population and Nesting Survey was conducted in early June 2015 to document the species and numbers of shorebirds using the Brunswick Smelter property for foraging and nesting, and to evaluate the overall suitability of the available habitat for nesting. The quantitative results obtained during this survey can be used to better understand the potential risks to shorebirds using the Brunswick Smelter property, and gain perspective on risks to the shorebird population using the general area.

Methods

The Shorebird Population and Nesting Survey was completed from June 10th to 12th, 2015 (inclusive), coinciding with the beginning of the egg incubation period for most nesting spotted sandpipers (Reed et al. 2013). The Brunswick Smelter property, extending from Belledune Point to approximately 1 km east of the smelter infrastructure (Figure 1), was surveyed twice over a period of two days (June 10th and 11th; Table 1). Three reference areas were also surveyed (one time each), including Little Belledune Point from the mouth of the Belledune River to Roherty Beach (June 11th), the mouth of the Jacquet River (June 12th) and Tetagouche Marsh (June 12th) (Table 1).



Features

Shorebird Nest Observed

- Possible Killdeer Nest
- Killdeer Nest
- Possible SPSA Nest
- SPSA Nest

Sandpiper Kildeer Sampling

- Both SPSA and Killdeer Adults
- One or More Adult SPSA
- One or More Adult Killdeer
- Highway
- Road
- Railway
- Brunswick Smelter
- Port of Belledune
- Waterbody
- Watercourse
- Marginal Nesting Habitat

N
W E
S

0 50 100 200 300 400

Metres

MAP INFORMATION
Map Projection: NAD 1983 UTM Zone 20N
Data Source:Province of New Brunswick, Service New Brunswick - GeoNB. All rights reserved.
Creation Date: September, 2015
Project No.: 2539

Figure 1: Spotted Sandpiper (SPSA) and Killdeer Observations at the Brunswick Smelter Property, June 10 and 11, 2015

minnow environmental inc.

Table 1: Overview of Brunswick Smelter Shorebird Population Nesting Survey sampling dates and effort, June 10th – 12th, 2015.

Survey Date	Study Area	Number of Observers	Time In	Time Out
June 10	Belledune Point	2	9:30	13:30
June 10	Zone 2 (East Property)	2	14:10	17:00
June 11	Belledune Point	5	8:45	11:40
June 11	Zone 2 (East Property)	4	11:50	13:30
June 11	Little Belledune Point	2	14:00	15:10
June 12	Jacquet River Mouth	2	8:50	10:15
June 12	Tetagouche Marsh	2	11:45	12:20

Surveys consisted of a minimum of two individuals walking the study areas, documenting the species and numbers of shorebirds observed, the presence of shorebird nests, and evidence of nesting activity. When nests were found, clutch size was recorded and a photograph of the nest was taken. Adult shorebird observations and nest locations (including suspected nests) were recorded in Universal Transverse Mercator (UTM) units using a handheld Global Positioning System (GPS). Finally, an evaluation of the quality of habitat for shorebird nesting was assessed by an experienced biologist.

Integrated Results and Discussion

The only shorebird species observed on the Brunswick Smelter property and nearby reference areas were spotted sandpiper and killdeer (Table 2). The presence of these two species (and lack of other species) was consistent with expected distributions of North American shorebird species during the breeding season.

Over the two day survey period, an average of 19 adult spotted sandpipers were observed each day, and a total of six confirmed and four potential nesting locations were identified on the Brunswick Smelter property between Belledune Point and the eastern border of Zone 2 as defined by Intrinsik (2015; Table 2; Figure 1). Conservatively, it can be assumed that the total number of spotted sandpiper nests in an area will be half of the adult population, and therefore the number of confirmed and potential nest locations observed during the survey (i.e., 10) was consistent with the number expected through observations of adults. This estimate does not account for the potential occurrence of polyandry (i.e., one female mating with several males) by spotted sandpipers (Oring et al. 1983), which may result in a greater number of nests per number of adults observed. Moreover, because the timing of the field survey coincided with the beginning of the spotted sandpiper nesting/egg incubation period (Reed et al. 2013), it is possible that some birds had not yet begun nesting. These factors may contribute to underestimation of the number of spotted sandpiper nests located during the survey.

On average, nine adult killdeer were observed daily on the Brunswick Smelter property, with two confirmed and one potential nesting location identified (Table 2). Killdeer tend to initiate egg laying earlier than spotted sandpipers (e.g., late April through June in northern Michigan, with most nests started during the first half of May; Powell and Cuthbert 1993), and thus were expected to be incubating at the time of the survey. Based on similar assumptions to those indicated above for spotted sandpiper (i.e., one nest for every two adults observed), the expected number of nests would be four to five (slightly higher than the number of confirmed and potential nest locations identified during the survey; Figure 1). It is possible that some killdeer nests were depredated prior to the survey, a common occurrence for ground-nesting birds and this may have accounted for the slightly lower number of potential nest sites observed.

In terms of expected nest success, previous studies of spotted sandpipers indicate that approximately 50% of nests do not survive to hatch due to depredation, abandonment and other causes (i.e., inundation by water, trampling by wildlife, etc.; Minnow 2015; Oring et al. 1983). Nest success of killdeer is similar to spotted sandpipers, ranging from 38 to 64% in previous studies (Jackson and Jackson 2000). This suggests that only half of the 10 spotted sandpiper and five killdeer nests estimated for the Brunswick Smelter property may survive to hatch under natural conditions. Assuming each nest contains a clutch of four eggs (typical for both spotted sandpipers and killdeer), and all eggs hatch from surviving nests, this would result in approximately 20 and 10 offspring, respectively. Combining these with the adult birds observed during the surveys results in a maximum of about 40 spotted sandpipers and 19 killdeer that potentially use the shoreline and/or industrially-influenced portions of the Brunswick Smelter property for foraging during the breeding season. Based on the distribution of adults observed during the survey, approximately two-thirds use Belledune Point for foraging and/or nesting, with the remaining one-third using the beach area east of the industrially-influenced portion of the property (Figure 1).

Despite its industrial nature, the Brunswick Smelter property provides relatively high quality foraging and nesting habitat for spotted sandpipers and killdeer. Spotted sandpipers typically construct their nests near water, in grasses among rocks or small shrubs (Reed at al. 2013). The prevalence of shallow ponds and water channels in proximity to grassy areas with small shrubs throughout Belledune Point provides excellent habitat for both nesting and foraging by this species. Similarly, a narrow band of grasses, small shrubs and woody debris border the pebble/gravel beach above the high tide line just east of the industrially-influenced portion of the Brunswick Smelter property (i.e., Intrinsik [2015] Zone 2) that provide good nesting habitat, with ocean beach and various creek mouths providing excellent foraging

Table 2: Nest observations and adult spotted sandpiper and killdeer sightings at the Brunswick Smelter property on June 10th and 11th, 2015.

Shorebird Species	Survey Date	Location		Description		Nest	Eggs	Adults	Comments
		Easting	Northing						
Spotted Sandpiper	10-Jun-15	288684	5309143	Belledune Point	edge of rock wall	1 possible	0	4	2 pairs; foraging in rocks and rockweed debris on ocean shoreline
		288195	5309947		cooling water channel outlet	0	0	3	foraging on ocean shoreline
		288400	5309875		beach	0	0	2	foraging on ocean shoreline
		288414	5309584		inland pond area	1	3	2	nest hidden in grasses approximately 3 m from log, on sand/gravel substrate
		289215	5308569	Zone 2 - East Property	beach	1 possible	0	1	chased adult from nest on 2 occasions
		289125	5308596		beach	0	0	4	foraging on ocean shoreline
		289212	5308571		beach	1 possible	0	1	foraging next to creek mouth
		289341	5308350		beach/wetland area	1	4	1	nest in grasses, on sandy soil
		289411	5308244		beach	1 possible	0	1	possible nest in grasses; chased adult from area on two occasions
		289559	5308022		beach	0	0	1	foraging on ocean shoreline
		289664	5307887		beach/creek mouth	1	4	1	nest hidden in grasses, next to creek
	11-Jun-15	288675	5309108	Belledune Point	beach	0	0	2	foraging among rocks and rockweed debris on ocean shoreline
		288570	5309352		inland pond	0	0	1	foraging at pond shoreline
		288341	5309906		near lighthouse	1	4	1	nest among logs / in grasses
		288155	5309948		cooling water channel outlet	0	0	2	foraging on shoreline
		288271	5309529		inland pond	0	0	3	foraging at pond shoreline
		288349	5309552		inland pond	1	1	0	nest under forbs, next to pond shoreline
		288079	5309485		inland pond	1	3	1	nest on grassy island between pond channels
		288969	5308746		beach	0	0	2	foraging in upper pond/wetland area
		288773	5308991		beach	0	0	2	foraging on ocean shoreline
		289333	5308407	Zone 2 - East Property	beach	0	0	3	foraging on ocean shoreline
Killdeer	10-Jun-15	288315	5309545	Belledune Point	inland pond	0	0	3	foraging next to industrial works
		288764	5308982		beach	0	0	2	foraging among beached seaweeds, on ocean shoreline
		289043	5308650	Zone 2 - East Property	beach	1	4	1	nest in horsetail, 8-10 m inland of open beach
		289125	5308596		beach	0	0	1	foraging on ocean shoreline
		288755	5308690		barren industrial area	0	0	2	industrial area, adjacent to parking lot
	11-Jun-15	288556	5309504	Belledune Point	beach	0	0	1	foraging on ocean shoreline
		288353	5309663		inland pond	1 possible	0	2	nest area likely near "Tern Island"
		288969	5308746		inland pond	0	0	2	foraging in upper pond/wetland area
		289333	5308407	Zone 2 - East Property	beach	0	0	2	foraging on ocean shoreline
		288754	5308673		barren industrial area	1	4	1	industrial area, adjacent to parking lot

habitat. Habitat along the eastern half of Zone 2, which primarily consists of pebble/gravel beach bordered by dense tree/shrub forest, was considered marginal for spotted sandpiper nesting, but suitable for foraging (Figure 1). Killdeer generally nest in open areas with sparse or no vegetation, and commonly use areas disturbed by humans (e.g., cultivated grounds, athletic fields, heavily grazed pastures, airports, golf courses, graveled or broken-asphalt parking lots, and graveled rooftops; Jackson and Jackson 2000). Beach areas above the high tide line, open clearings and areas disturbed through current and historical industrial activity are plentiful on Belledune Point and immediately adjacent to the Brunswick Smelter operations, providing excellent habitat for killdeer nesting. This type of habitat was less abundant in Zone 2, east of the industrially-influenced areas of the Brunswick Smelter property (Figure 1).

A greater number of spotted sandpiper and killdeer adults and nests were observed at the Brunswick Smelter property compared to the reference areas examined as part of this study, likely due to lower quality habitat at the latter. For example, although the area surveyed at Little Belledune Point was similar in expanse to Belledune Point, only five adult spotted sandpipers and a single nesting site were found (Table 3). The Little Belledune Point shoreline is sparsely vegetated, and where vegetation exists, it is typically dominated by trees or dense growth of tall grasses, which are not preferred for nesting by spotted sandpipers or killdeer. Just west of Roherty Beach on Little Belledune Point, a small wetland/lagoon is present slightly inland from the ocean shoreline where one spotted sandpiper nest was located high on the beach, on a relatively small area of dry gravel. Most of the ground surrounding the wetland was saturated, and thus would not be suitable for nesting. Recreational use of Little Belledune Point (e.g., All Terrain Vehicle use, motor homes) and maintenance of private properties may also limit shorebird use of the area.

At the mouth of the Jacquet River, six adult spotted sandpipers and two adult killdeer were observed, along with three confirmed and two potential nest sites between both species (Table 3). Shorebird habitat at the mouth of the Jacquet River was considered to be higher quality than that observed at Little Belledune Point, with sparser growth of short grasses, small shrubs and woody debris available as cover for nesting spotted sandpipers.

South of the Brunswick Smelter to Bathurst, the vast majority of the shoreline has been altered (e.g., armoured to prevent erosion, converted to lawn, etc.), thereby providing limited nesting and foraging habitat for shorebirds. At low tide, Tetagouche Marsh, located at the mouth of the Tetagouche River near the town of Bathurst, appeared to have suitable nesting and foraging habitat for spotted sandpiper and killdeer. However, at high tide Tetagouche Marsh was inundated with seawater precluding the use of this area for nesting by these bird species. No spotted sandpipers or killdeer were observed at Tetagouche Marsh during the June 2015 survey.

Table 3: Reference area observations of spotted sandpiper and killdeer on June 11th and 12th, 2015.

Area	Date	Location		Description	Spotted Sandpiper				Killdeer			
		Easting	Northing		Nest	Eggs	Adults	Comments	Nest	Eggs	Adults	Comments
Little Belledune Point	11-Jun-15	283900	5310995	to 283565, 5311353 - 5-10 m wide swath of grasses between lagoon and beach; poor habitat	0	0	3	-	0	0	0	-
		283317	5311451	beach area near lagoon	1	0	2	nest in grasses on lagoon side of beach	0	0	0	-
		282998	5311459	poor quality habitat; tall thick grass, partly flattened; no gravel	0	0	0	-	0	0	0	-
Jacquet River mouth	12-Jun-15	722742	5312409	-	1	4	1	nest in thick grasses among old logs and branches	0	0	0	-
		722705	5312389	-	0	0	0	-	1	3	2	nest among pebbles and gravel high on beach
		722336	5312289	-	0	0	1	foraging on beach	0	0	0	-
		722215	5312242	-	0	0	1	possible nest site	0	0	0	-
		722355	5312278	ATV trail; mostly dense grasses with pockets of shrubs and few areas with sparse grass suitable for nests	1	1	3	sparse grass over sand; adults observed in area away from nest, closer to shore	0	0	0	-
Tetagouche Marsh	12-Jun-15	298645	5280527	mostly grass/reed marsh (red-winged blackbirds nesting in area), limited habitat for ground nesting birds due to seawater inundation at high tide								

Summary

Two species of shorebird (spotted sandpiper and killdeer) were identified during the Shorebird Population and Nesting Survey of the Brunswick Smelter property and nearby reference areas conducted in early June 2015. The density of both species was highest at the Brunswick Smelter property, presumably due to the presence of optimal nesting and foraging habitat compared to reference areas located at Little Belledune Point, the Jacquet River mouth, and Tetagouche Marsh. Based on the number of adult birds observed and an assumed nest success rate of 50%, approximately 40 spotted sandpipers and 19 killdeer (adults and young combined) may use the Brunswick Smelter property during the breeding season, two-thirds of which would be found on Belledune Point.

If you have any questions regarding the above information, please do not hesitate to contact me at 905-873-3371, extension 229 or sweech@minnow.ca.

Sincerely,
Minnow Environmental Inc.

Shari Weech

Shari Weech, Ph.D., RP.Bio.
Senior Aquatic Toxicologist

References

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