ÉTUDE SUR LA SANTÉ DANS LA RÉGION DE

Belledune

AREA HEALTH STUDY

Belledune • Petit-Rocher • Pointe-Verte

Appendix A - Human Health Risk Assessment

Prepared for: Department of Health and Wellness, Government of New Brunswick

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Environmental & Occupational Health+Plus

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1.0 Objectives and rationale

1.1 Belledune Human Health Risk Assessment

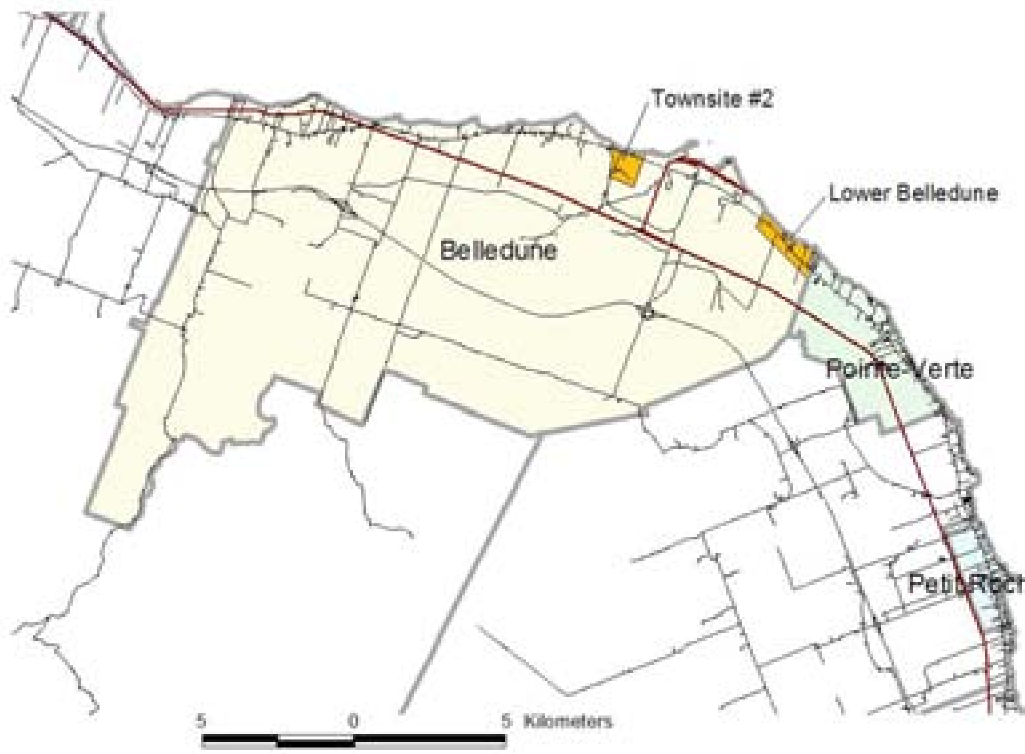
The Belledune Area Health Study was requisitioned by the Minister of Health and Wellness in the fall of 2003 in response to community concern regarding the potential impact of past and future industrial activities occurring in the Greater Belledune area on residents' health. Industrial activities occurring in the Greater Belledune Area over the last 40 years have included a lead smelter, a fertilizer plant, a battery recycling plant, a coal-fired electricity generating facility, a gypsum plant and a sawmill. Such industrial activities are typically associated with the release of chemical contaminants into the environment, and because contaminants often move around in the environment, residents can be exposed to contaminants released from industrial sources by both direct and indirect pathways of exposure.

A human health risk assessment (HHRA) was deemed an important component of the Belledune Area Health Study because it could provide estimates of the potential for risks of adverse health effects in Belledune residents that may result from exposure to the chemical contaminants released from industrial activities in the area. It is important to keep in mind that many chemicals are naturally-occurring in the environment, and human health risks from background levels sometimes occur. In order to address residents' concerns, the health risks associated with baseline levels are considered separately in order to highlight the potential for risks occurring only as a result of industrial activities (i.e. incremental risk).

This report provides the methodology, assumptions and the results from the human health risk assessment. The HHRA for the study area attempts to quantify exposures, compare them to regulatory agency-endorsed toxicity data, and provide estimates of the potential for health risks resulting from such exposures.

The study area considered in this assessment was centered on the Belledune Industrial area and included Belledune, Pointe-Verte and Petit-Rocher as seen in Figure 1.1. Within Belledune, two areas namely Townsite #2 and Lower Belledune were considered to be the most exposed areas with respect to the industrial facilities and were explicitly assessed.

Figure 1.1: Study area



1.2 Objectives of Human Health Risk Assessment

The HHRA component has been designed to address the following objectives, research questions and hypotheses as originally delineated in the terms of reference and described below:

Contribution of the HHRA Component

Designed to address...

Objective Two (O_2)
To describe and quantify the historical and current human health risks associated with past and current industrial activities in the Belledune Area.

Research Question One (Q_1)
What are the potential types and sources of contamination?

Research Question Two (Q_2)
How are residents exposed to the contamination?

Research Question Three (Q_3)
What are the potential health risks for residents as a result of the exposure to the contamination?

Hypothesis One (H_1)
There are quantifiable human health risks associated with past industrial activities in the Belledune area.

Hypothesis Two (H_2)
There are quantifiable human health risks associated with current industrial activities in the Belledune area.

And to contribute to....

Objective Four (O_4)
To produce recommendations for future studies and research based on the results of this study.

While the HHRA is a tool for determining the likelihood or risk of adverse health effects occurring, it is important to note that it does not provide an absolute statement on the experienced health effects measurable in a population. The Community Health Status Assessment (CHSA) for the Belledune area provides estimates of health effects actually experienced in the Belledune community, but does not determine the causes of such health effects. The CHSA and HHRA were conducted together in a unique, holistic and synergistic approach that was designed to provide an indication of whether or not higher-than-average adverse health effects are presently being experienced in the community of Belledune as a result of historical industrial activities.

To this end, the HHRA involved the calculation of individual risk estimates for average and maximally exposed individuals living in the study area as shown in Figure 1.1. The risks for the maximally exposed individuals were estimated using a realistic approach that was designed to provide a reasonable maximum estimate or upper bound of the risk. In addition, best estimates or average exposures in the study area were also calculated in order to provide a linkage to the CHSA. The generation of these different ranges of exposure was designed to provide a means of characterizing the potential for health effects resulting from industrial activities in the Belledune area.

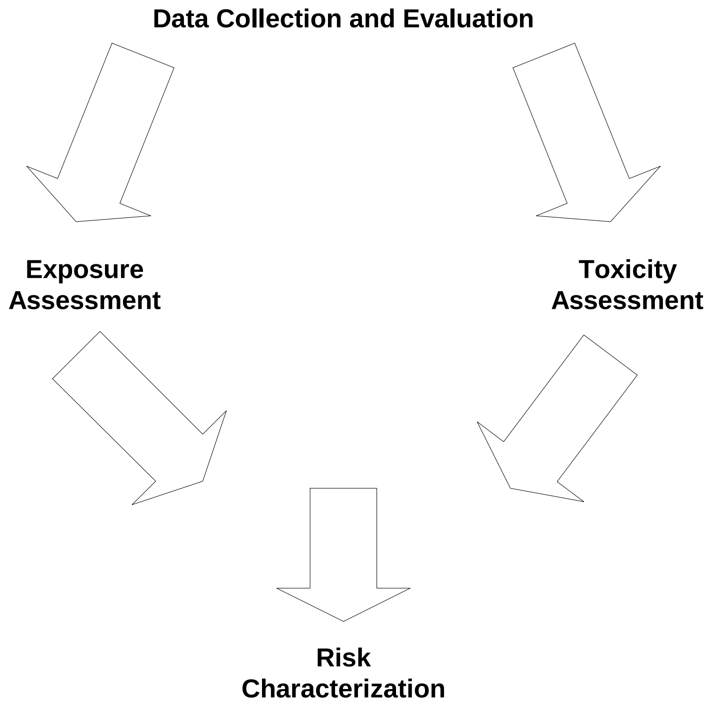
1.3 Human Health Risk Assessment framework

The human health assessment was carried out following approaches that are acceptable to regulatory agencies including Health Canada and the U.S.EPA. There are a variety of approaches to risk assessment; however, the approach used in this assessment is widely used. Such assessments often follow a stepwise process as shown in Figure 1.2 and involve:

- Data Collection and Evaluation - Involves summarizing the concentrations of chemicals in the soil, water, air, fish, garden vegetables and other environmental media.
- Estimating Exposure – Uses the data collected in the first step to calculate how much of each chemical people may be exposed to. This depends on the concentration of the chemical, who is exposed and how they are exposed.
- Determining the Toxicity – This involves the determination of which illnesses or other adverse health effects may be caused by exposure to chemicals. Toxicity reference values (TRVs) are obtained which establish at what level potential harmful effects may begin to occur.
- Characterizing the Risk – Involves the integration of the exposure and toxicity assessment to determine which chemicals are posing risks and what are the risks. It also involves a discussion of the uncertainty in the risks.

Figure 1.2: Overall steps in the Human Health Risk Assessment process

The above framework provides guidance for conducting risk assessments, which is usually based on both scientific and professional judgment. Thus, risk assessments generally rely on making inferences, assumptions and the use of models, which lead to uncertainties in the estimates. In conducting this risk assessment assumptions were selected that are more likely than not to result in overestimations of exposure.



1.4 HHRA evaluation

In order to predict the possible health effects on people in the study area and surrounding areas, the potential risks posed by carcinogenic chemicals and non-carcinogenic chemicals were assessed in the manner described below.

1.4.1 Non-carcinogens

Since non-carcinogens require exceeding a dose threshold (without consideration of a latency period) before non-carcinogenic effects can be manifested, potential adverse health effects were calculated only for the current time period (when the most complete measurement data were available). The only exception was cadmium and lead. Cadmium is considered to be a non-carcinogenic via the oral exposure pathway; however, it is considered to be a carcinogen via the inhalation pathway. Recent studies have indicated that lead is "reasonably anticipated to be a human carcinogen" (National Institute of Health, 2005); however, the epidemiological studies are studies indicate that there may be a possible effect. Based on a lack of direct evidence and the absence of a carcinogenic toxicity reference value, lead is considered to be a non-carcinogen for the purposes of this assessment.

For cadmium and lead, historical exposures and risks were calculated in order to provide a perspective on the current risks in the community since, for these chemicals, the concentrations in the past may have been higher than current concentrations due to higher historical emissions from the facilities. Since a lead smelter has been operated in the area since the early 1960's, and current exposures to lead in the environment are relatively high, lead was selected to provide a historical perspective. Cadmium exposures in the current time period are also high, and thus are mainly due to exposure to seafood, therefore cadmium was also considered from a historical perspective. Section 4 provides a discussion on the current and historical data used in the calculation of current and historical non-carcinogenic health effects.

1.4.2 Carcinogens

For carcinogenic chemicals such as arsenic, risks based on current exposure levels were calculated. In addition, since carcinogens require a latency period of up to 30 years, historical exposures were also examined to determine the potential risks when air emissions were higher than they are currently.

1.5 Uncertainty

Risk assessment is intrinsically an uncertain process with uncertainty arising not only from environmental characterization but also from exposure factors and toxicity assessment. In addition to uncertainty arising from lack of (precise) knowledge, variability inherent to the environmental systems and from person to person (inter-individual variability) also contribute to uncertainties in the risk estimates. As mentioned above, the inferences and assumptions selected in this assessment were conservative and strove to overestimate exposures and hence risk. This report discusses uncertainty throughout its various sections and provides an indication of how the uncertainty would likely affect the result.

1.6 Report structure

The report has been structured into several sections, each of which describes specific aspects of the risk assessment as shown in Exhibit 1.2 above. These aspects include:

Section 2 – Problem Formulation: Provides an overview of the risk assessment carried out for the Greater Belledune Area (GBA).

Section 3 – Chemicals of Potential Concern (COPC): Describes the selection of the key chemicals that were considered in the risk assessment.

Section 4 – Environmental Data: Provides a summary of the most pertinent information on the COPC that were used in the risk assessment from surveys of well water, fish and shellfish communities, soils, garden produce and wildlife surveys and provides a summary of the Environmental Point Concentrations (EPCs).

Section 5 – Exposure Assessment: Describes the pathways model used to assess exposure to the COPC in the environment. This section discusses the pathways of exposure of human receptors and their respective dietary characteristics.

Section 6 – Toxicity Assessment: Details the toxicity reference values for the COPC that were used in the assessment to characterize the risks of potential adverse health effects.

Section 7 – Risk Characterization: Combines the exposure assessment and toxicity assessment and provides the results of the HHRA.

Section 8 – Summary and Conclusions: Provides a synopsis of the findings of the assessment.

2.0 Problem formulation

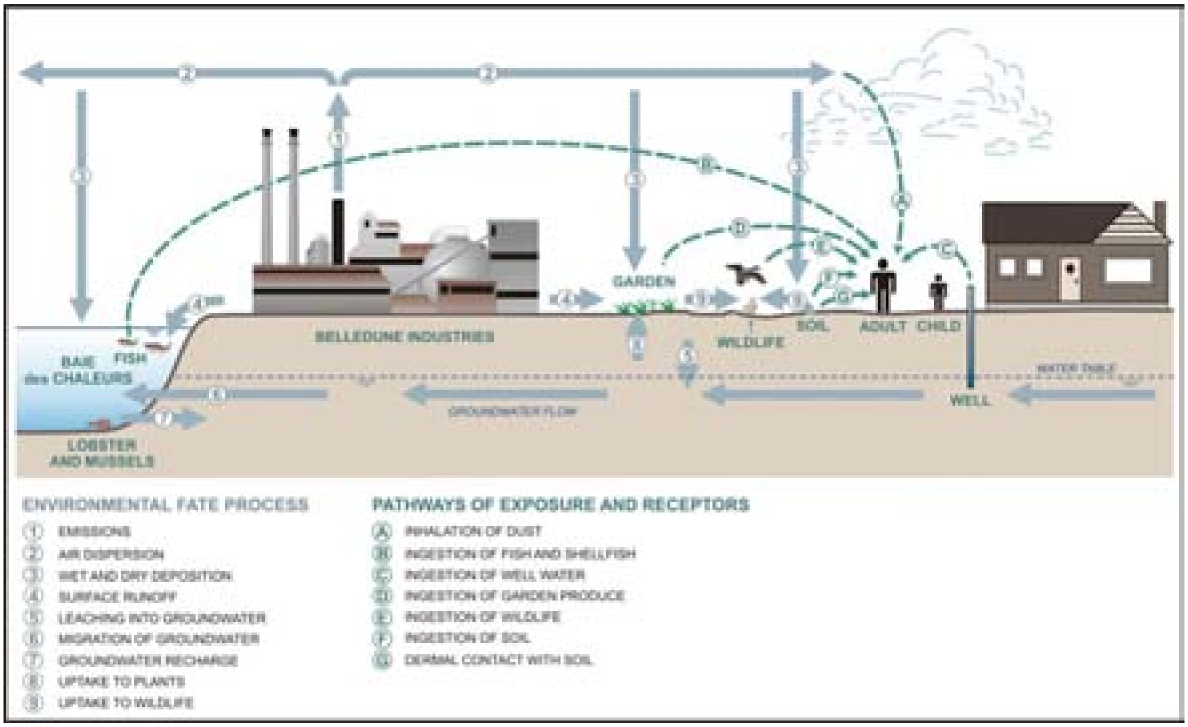
As discussed in Section 1, there have been several industrial activities operating in the Belledune area over the past four decades, which have resulted in the release of chemicals into the air and water. These chemicals have been dispersed through the environment and people living in the Belledune area have been potentially exposed to these chemicals through inhalation, ingestion and dermal contact.

Many of these chemicals also occur naturally in the environment and thus would be present in the soil and water in the absence of emissions from the Belledune industrial facilities. Exposures of this type are referred to as “background exposures.” Some chemicals also enter the environment as a result of day-to-day activities such as driving a car, heating your house and other activities. These chemicals are not as a result of the industrial facilities and are known as “baseline exposures”. In order to accurately estimate health risks to residents of the Belledune area, incremental risk from industrial exposures must be added to risk resulting from baseline exposures. Thus, chemical exposures from all sources are being considered in the HHRA and not just emissions from the industrial facilities. Furthermore, different time periods of exposure have also been assessed as historical exposures to certain chemicals may increase the likelihood of certain adverse health risks.

2.1 Conceptual model

Figure 2.1 shows the conceptual model of local chemical sources, fate and transport and human exposures associated with the industrial activities in the Belledune area. Environmental fate and transport processes are designated numerically, while human exposure pathways are labelled alphabetically. As seen from the figure, chemicals from the industrial facilities are dispersed to the air and then get carried by atmospheric processes and then are deposited on soil or vegetation. These chemicals can then be transferred to humans directly through inhalation or indirectly by the consumption of backyard produce or wildlife in the area. Discharges from the facilities also occur into water and these discharges cause increases in concentrations in the local fish, lobster and wild mussels in the area. Local, fish, lobster and wild mussels are assumed to be eaten by residents in the Greater Belledune area. Thus, this risk assessment considered the various transport processes as well as pathways of exposure.

Figure 2.1: Conceptual Model of Local Contaminant Sources, Fate and Transport and Exposure



2.2 Study area

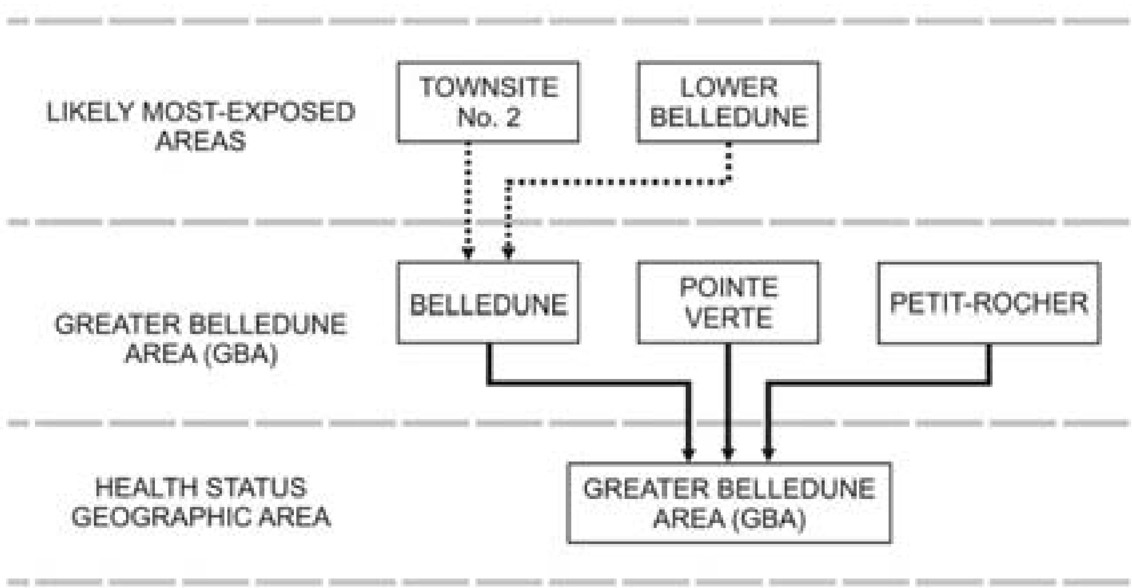
The basis for the choice of receptors included the selection of areas that were expected to be most influenced by the industrial activities in the Belledune area. Additional receptor locations were selected across the geographical extent of the study area.

2.2.1 Rationale

The geographic study area was defined in such a way that it included the source of emissions, and those areas where residents in the area potentially may have been influenced by the emissions. The geographic area selected for use in both the HHRA and the CHSA were consistent in order for the integration of their results to be possible. The geographic area used in the CHSA was defined by political boundaries as seen in Figure 1.1.

Receptors closer to the industrial facilities have been exposed to higher concentrations than receptors further away because environmental concentrations attributable to air releases typically decrease with distance from the source. The receptor locations selected for the study are illustrated in Figure 2.2. As illustrated, the areas to be considered encompass different scales; the areas that are more likely to be exposed (i.e., Townsite #2 and Lower Belledune), the core area which considers the municipalities of Belledune, Pointe-Verte and Petit-Rocher, and the overall study area.

Figure 2.2: Receptor locations selected for the assessment



2.3 Time periods

Four time periods were considered in the HHRA, which were selected to coincide either with changes to processes at the smelter or with the growth of industrial facilities likely to emit chemicals to the environment or with availability of data. Section 4 provides an in-depth rationale for the time period selection.

The time periods included: Period 1 (1967-1974), Period 2 (1975-1984), Period 3 (1985-1999) and Period 4 (2000-2003). Period 4 is referred to as the current time period. The Brunswick Mining and Smelting Corporation began operation of the Lead/Zinc smelter in Period 1 (1966), as did the Fertilizer plant and rail transport in the area. In 1970, the smelter was converted to a solely lead based smelter. Period 2 saw the installation of the Waste Water Treatment plant in 1980. In Period 3, Short Rotary Furnaces were installed at the smelter, the coal-fired Thermal Power Generating station began operations in 1993, and the Battery Recycling plant, the Canadian Gypsum Company and the Chaleur Sawmills began operating in 1996.

Both current and historical exposures were evaluated in this assessment. Current exposures were evaluated for all the COPC. Historical exposures were evaluated for arsenic, cadmium and lead as discussed in Section 1.4.1.

2.4 Receptor selection

"Receptors" refer to people who live and work in the area and can potentially be exposed to chemicals associated with the industrial facilities. In this assessment, estimates of exposure were calculated not only to those individuals with the highest risk (upper bound risks), but also for the study population as a whole (best estimate risks).

2.4.1 Receptor definition and habits

There are residential areas surrounding the Belledune industrial area and, for this reason, residential exposure was considered to occur for 100% of the time in this assessment. Different life stages of receptors were considered at all receptor locations for the assessment of non-carcinogens and composite receptors encompassing all life stages in the assessment of carcinogens (namely arsenic).

Since residential exposures are generally longer in duration than for work or school exposures, this exposure scenario was assumed to be a conservative assumption and to capture the most exposed individuals. Adults and children were assumed to be present at home 24 hours a day, 365 days a year for a 70 year lifetime.

Exposures and potential health risks from occupational exposures while working at the industries in the Belledune Industrial area were not assessed in this HHRA, as this was outside of the Terms of Reference for this study.

Table 2.1 summarizes the human receptors selected for the Belledune study area and lists assumptions made regarding their exposure.

Table 2.1: Exposure Assumptions and Receptors Selected for the Belledune Assessment

Selected Receptor	Exposure Assumptions
Infant (0 – 6 months) Toddler (7months – 4 years) Child (5 years – 11 years) Teen (12 years – 19 years) Adult (20+ years)	• Residents were assumed to be present at receptor locations 24 hours a day, 365 days per year for a lifetime of 70 years; • Residents assumed to ingest soil while indoors and outdoors. Soil ingestion via all exposure pathways is assumed to be accounted for by the soil intake rate. However, outdoor soil concentrations are used in combination with this intake rate, given that outdoor soil concentrations of the COPC in question are typically highest; • Indoor exposure to household dust was not selected as an exposure pathway since it is expected to be less than exposure to outdoor soil; • Residents assumed to spend time indoors and outdoors at the same rate as average Canadians; • Soil adheres to skin every day of the year; • Drinking water assumed to be from well water at receptor locations; • All inhaled air based on modeled concentrations at the receptor locations.

The following discussion provides the assumptions made regarding the exposure point concentrations for these different receptors, and more detail regarding their precise locations.

2.4.2 Exposure scenarios

Several exposure scenarios were selected for the HHRA. Exposure estimates depend on the media concentrations and intake rates. Best estimate and upper bound exposure scenarios were selected for residents of Townsite #2, Lower Belledune, Belledune, Pointe-Verte, Petit-Rocher and for the entire study area.

Different statistical values for media concentrations were used to estimate exposure at different receptor locations. These were termed "best estimates" and "upper bound". Section 4 provides a more detailed discussion of the statistics used for the various media and receptor locations in the assessment. Table 2.2 provides a general description of the areas where the data considered in the assessment were obtained. As described in Section 4, data were obtained from most pathways for most of the COPC. In the event data were not available for a given pathway for a given COPC, then that pathway was not evaluated. For example, data for dioxins and furans are only available for the soil and air pathways, therefore, only these pathways were assessed. For root vegetables and other vegetables, fish, lobster and mussels there are no chromium data and these pathways were not considered in the assessment of chromium. This adds to the uncertainty in the assessment. Section 4 provides a summary of the COPC and pathways that are considered in the assessment. The effect of this uncertainty on exposure is discussed in Section 7. As seen from Table 2.3, there was no available back-yard vegetable data for Petit-Rocher, thus data from the Pointe-Verte area was used for Petit-Rocher. This adds to the uncertainty in the assessment and is discussed in Section 7 in more detail.

In addition, Section 4 discusses that soil data were available from different sampling programs namely the Noranda Environmental Monitoring Program and the Conservation Council of New Brunswick. In this assessment, both sources of data were considered separately since the collection and analytical methods used for the two sampling programs are different.

Table 2.2: Geographic Source of Local Media for Belledune HHRA Exposure Scenarios

Pathway	Townsite#2	Lower Belledune	Belledune	Pointe-Verte	Petit-Rocher
Drinking Water	Well water from Belledune[1]			Well water from Pointe-Verte	Well water from Petit-Rocher
Soil	Combination of modeling and measured data from Townsite#2	Combination of modeling and measured data from Lower Belledune	Combination of modeling and measured data from Belledune	Combination of modeling and measured data from Pointe-Verte	Combination of modeling and measured data from Petit-Rocher
Backyard Produce	Townsite#2	Lower Belledune	Belledune	Pointe-Verte	Pointe-Verte[3]
Wild Game	Noranda Industrial Area				
Local Fish	Baie des Chaleurs	Baie des Chaleurs	Baie des Chaleurs	Baie des Chaleurs	Baie des Chaleurs
Local Lobster	Upper Belledune[2]	Lower Belledune	Upper and Lower Belledune	Pointe-Verte	Petit-Rocher
Wild Mussels	Upper Belledune[2]	Lower Belledune	Upper and Lower Belledune	Pointe-Verte	Petit-Rocher

Note:
1 - It has been assumed that residents in Townsite #2 obtain their drinking water from wells since the surface water supply at Jacquet River is not influenced by the industrial activities.
2 - Due to data limitations, in the case of lobster and wild mussels concentrations for Townsite #2, data from all of Upper Belledune were used. Upper Belledune was assumed to stretch from near Nash Creek from the west to mussel sampling site 1W to the east (see Figure 4.4), which is east of the Belledune River.
3 - There were no backyard produce data for Petit-Rocher and therefore, concentrations from Pointe-Verte were assumed to be applied to Petit-Rocher.

3.0 Chemicals of potential concern

This section describes the details of the process for the selection of chemicals of potential concern (COPC). Furthermore, in examining the data to determine the COPC, a perspective on the phosphogypsum present in the Baie des Chaleurs is provided within this section.

3.1 Selection of Chemicals of Potential Concern

Fairly extensive sampling programs have been carried out for the Belledune area. The data collected on soils are more extensive than other data and therefore, these data were used to select the chemicals to carry through the risk assessment evaluation. The selection of chemicals of potential concern (COPC) to be carried through to the more detailed assessment was based on a screening process called “Toxic Potential” that takes into account the toxicity of the chemical, its persistence in the environment, and/or its potential to bioaccumulate in various media. This screening process is generally acceptable to regulatory agencies such as Health Canada and the Ontario Ministry of the Environment and is described in Figure 3.1. This approach was deemed acceptable since the chemicals that were being considered were not volatile and thus exposure would occur mainly via the oral route. Therefore, the use of the oral toxicity values to assess toxicity of the chemicals was appropriate. This process ensures that chemicals that are most likely to cause the greatest risk are considered in the assessment.

Figure 3.1: Screening procedure for Chemicals of Potential Concern

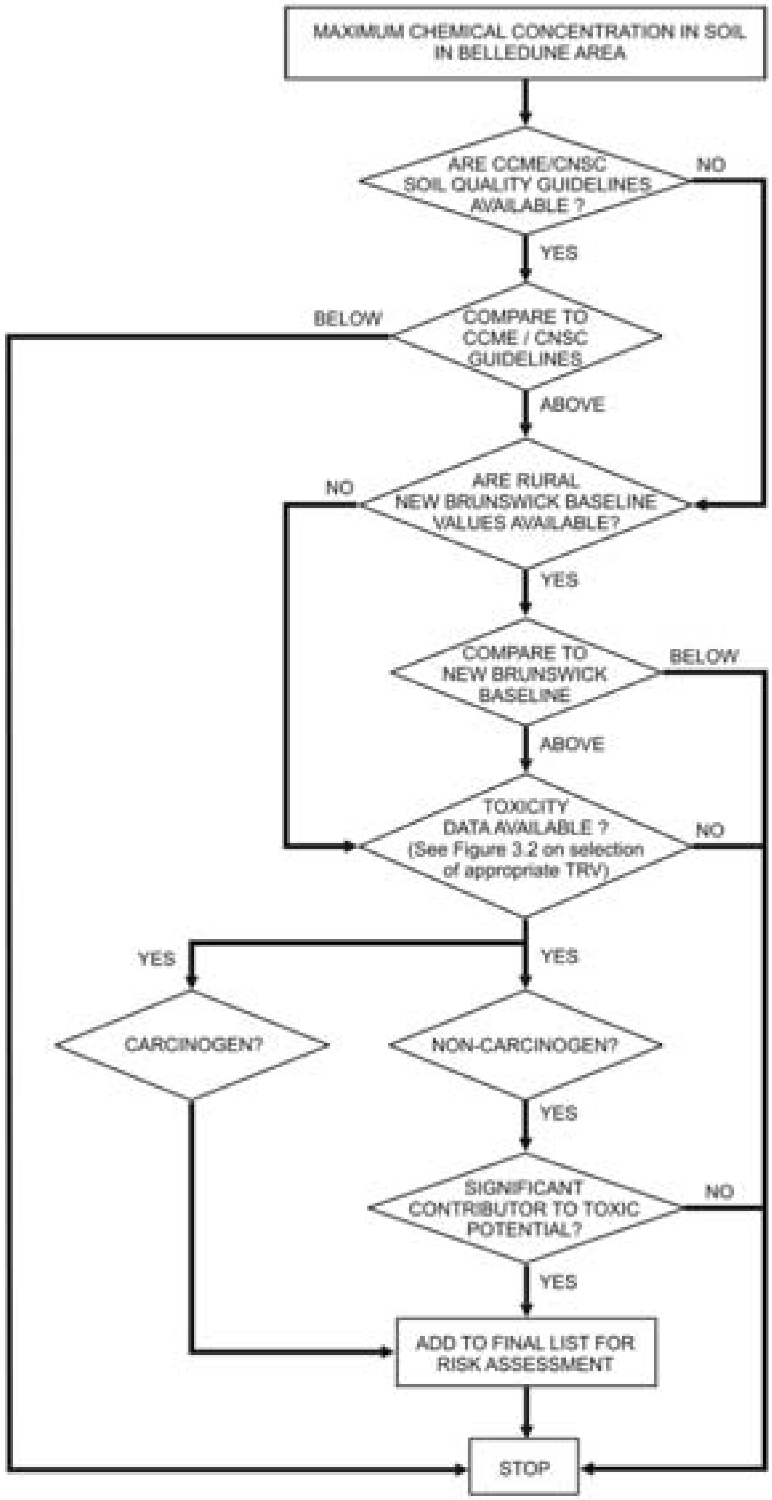
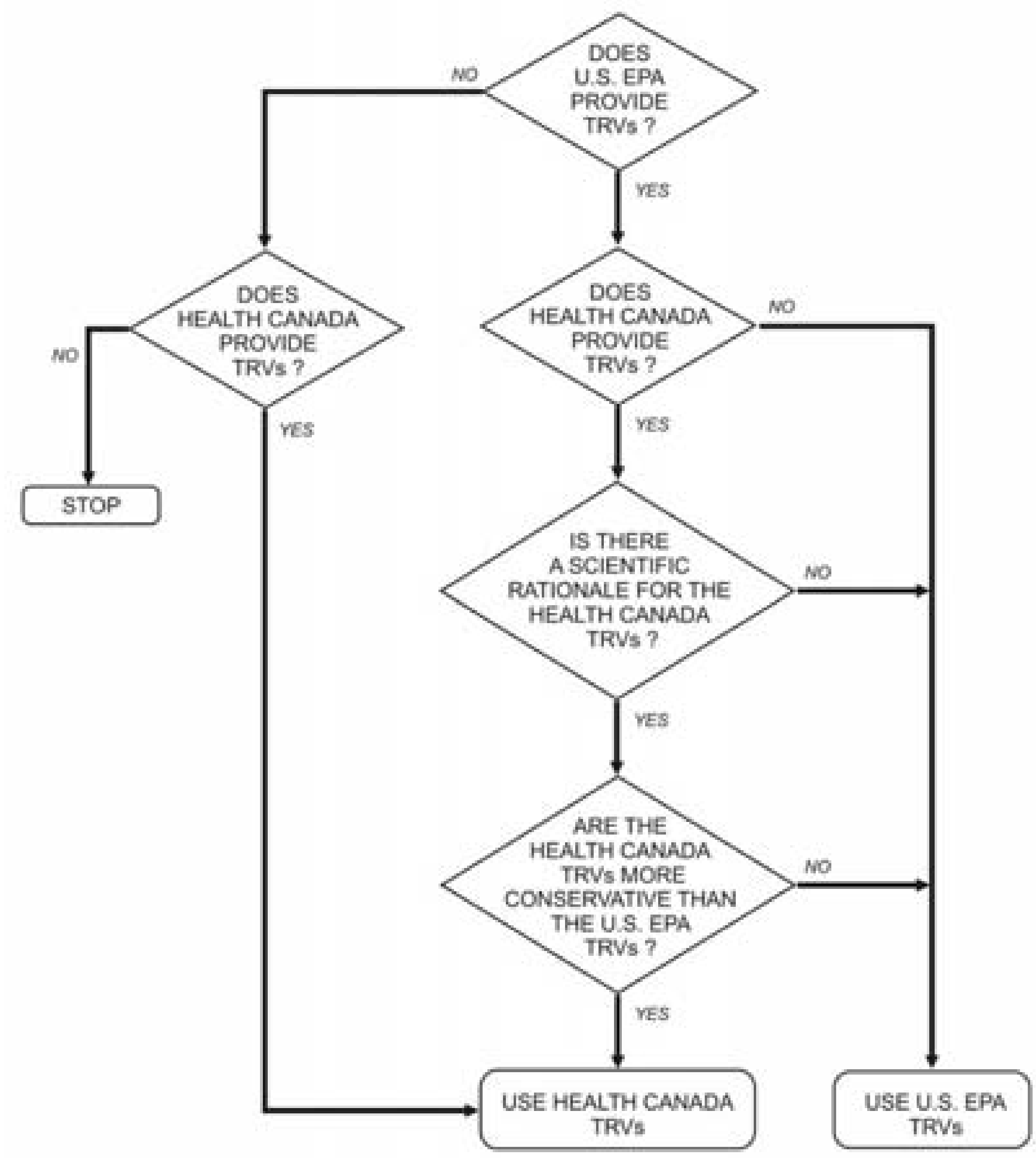


Figure 3.2: Decision-making criteria used for the selection of appropriate toxicity reference values



The methodology used for the selection of COPC was as follows:

- Soil data from the current time period in the community outside the industrial area were used to represent maximum measured soil concentrations as the first step in the screening process. The data considered for the COPC selection were from GEMTEC surveys and Noranda EMP data obtained by the study team prior to June 2004. The industrial area was not considered since the project involves the assessment of the health in the community and there are no residents living in the industrial area. The majority of the maximum data were obtained from the GEMTEC survey and from the Noranda EMP data.

- The maximum measured soil concentrations were then compared to Canadian Council of the Ministers of the Environment (CCME) Soil Quality Guidelines for residential/parkland land use. In the absence of CCME Soil Quality Guidelines for uranium, the Canadian Nuclear Safety Commission (CNSC) soil guideline for uranium as used. The CNSC (2004) guideline is based on ecological effects; human health effects are seen at much higher levels. Chemicals which exceeded these CCME guidelines, or CNSC guidelines, or for which guidelines or standards were not available, continued through the screening process.

- A comparison of the maximum measured soil concentration to the rural New Brunswick 97.5th percentile baseline concentrations calculated from surveys of agricultural and forested soils in New Brunswick was then made. Any chemical with a concentration exceeding this rural New Brunswick baseline value, or with no listed baseline value continued on through the screening procedure. Chemicals that exceeded CCME guidelines or CNSC standards, but were lower than New Brunswick baseline concentrations were eliminated from consideration.

- The above steps resulted in aluminum, antimony, barium, beryllium, cobalt, fluoride, lithium, manganese, molybdenum, nickel, potassium, rubidium, silver, sodium, strontium, tellurium, uranium and vanadium being dropped from further consideration as seen in Table 3.1.

Table 3.1: Selection of Chemicals of Concern based on soil measurements

Chemical	Maximum Measured Concentration in Community (mg/kg)	CCME Guideline for Res/Park (mg/kg)	New Brunswick Baseline Soil Concentration (NB Agr 97th) (mg/kg)	Compare to CCME Guideline	Compare to NB Baseline Soil	Toxicity Data Available?	Oral Toxicity Data - Health Canada (mg/kg-d)	Oral Toxicity Data - U.S.EPA (mg/kg-d)	Toxic Potential	% of Toxic Potential	**COPC?**
Dioxins and furans	0.000001	0.000004	.	pass	.						No COPC
Aluminum	19200	.	31900	.	pass						No COPC
Antimony	12.7	20	0.37	pass	> Baseline						No COPC
Arsenic	111.5	12	29	>CCME	> Baseline	Y	0.002	0.002	55750	7.10	COPC
Barium	106	500	132	pass	> Baseline						No COPC
Beryllium	1.3	4	0.93	pass	> Baseline						No COPC
Bismuth	18	.	1	.	> Baseline	N					No COPC
Boron	11	.	8	.	> Baseline	Y	0.0175	0.2	628.57	0.080	No COPC
Cadmium	15	10	0.36	>CCME	> Baseline	Y	0.0008	0.0005	30000	3.82	COPC
Calcium	18000	.	3350	.	> Baseline	N					No COPC
Chloride	.	.	.	.	.						No COPC
Chromium (Total)	81	64	80	>CCME	> Baseline	Y	0.001	0.003	27000	3.44	COPC
Cobalt	27.4	50	18.2	pass	> Baseline						No COPC
Copper	351	63	34	>CCME	> Baseline	Y	0.25	na	1404	0.18	No COPC
Fluoride	195	400	.	pass	.						No COPC
Iron	51500	.	41200	.	> Baseline	N					No COPC
Lead	2210	140	34.8	>CCME	> Baseline	Y	0.0036	na	613888.89	78.2	COPC
Lithium	30.5	.	41.5	pass	pass						No COPC
Magnesium	12200	.	10900	.	> Baseline	N					No COPC
Manganese	1135	.	1390	.	pass						No COPC
Mercury	0.11	.	0.1	.	> Baseline	Y	0.0003	0.0001	1100	0.14	COPC
Molybdenum	2.3	10	1.71	pass	> Baseline						No COPC
Nickel	54	50	69.2	>CCME	pass						No COPC
Potassium	1740	.	2360	pass	pass						No COPC
Rubidium	23.9	.	34.7	pass	pass						No COPC
Selenium	2	1	1	>CCME	> Baseline	Y	0.0106	0.005	400	0.05	No COPC

Chemical	Maximum Measured Concentration in Community (mg/kg)	CCME Guideline for Res/Park (mg/kg)	New Brunswick Baseline Soil Concentration (NB Agr 97^{th}) (mg/kg)	Compare to CCME Guideline	Compare to NB Baseline Soil	Toxicity Data Available?	Oral Toxicity Data - Health Canada (mg/kg-d)	Oral Toxicity Data - U.S.EPA (mg/kg-d)	Toxic Potential	% of Toxic Potential	**COPC?**
Silver	3.8	20	0.22	pass	> Baseline						No COPC
Sodium	2010	.	130	.	> Baseline	N					No COPC
Strontium	46	.	20.6	.	> Baseline	N					No COPC
Tellurium	0.9	.	0.2	.	> Baseline	N					No COPC
Thallium	3	1	0.28	>CCME	> Baseline	Y	0.00007	0.00008	37500	4.77	COPC
Tin	16.8	.	3.7	.	> Baseline	Y	na	0.6	28	0.0036	No COPC
Uranium	2.8	250 [1]	2.78	pass	> Baseline						No COPC
Vanadium	80	130	78	pass	> Baseline						No COPC
Zinc	5320	200	112	>CCME	> Baseline	Y	7.00	0.3	17733.33	2.26	COPC
Benzo(a)pyrene	0.02	0.7	.	pass	.						No COPC
Benzo(b)fluoranthene	0.01	1	.	pass	.						No COPC
Benzo(g,h,i)perylene	0.03	.	.	pass [2]	.						No COPC
Fluoranthene	0.01	.	.	pass [2]	.						No COPC
Indeno(1;2;3-CD)pyrene	0.01	1	.	pass	.						No COPC
Phenanthrene	0.03	5	.	pass	.						No COPC
Pyrene	0.02	10	.	pass	.						No COPC
Toluene	5.3	0.8	.	>CCME	.	Y	0.22	0.2	26.5	0.00337	No COPC
Xylene	2.04	1	.	>CCME	.	Y	1.50	0.7	2.9	0.00037	No COPC
								Total TP	785462.21		

Note:

1. CNSC(2004) guideline for uranium based on ecological effects
2. Benzo(a)pyrene is more toxic than benzo(g,h,i)perylene or fluoranthene, and using benzo(a)pyrene as a toxicity surrogate, these polycyclic aromatic hydrocarbon compounds were screened out as COPC.

- The next step in the process involved determining whether toxicity data (toxicity reference values) existed so that risks associated with exposure to the various chemicals could be quantified. Figure 3.2 provides a schematic for the selection of the appropriate toxicity reference value (TRV). U.S. EPA toxicity reference values were used as the basis of selection since a rationale exists for all of the values presented in the table. These values were substituted by Health Canada values if Health Canada provided a rationale and if the value was lower (i.e. more restrictive) than the U.S. EPA value. Therefore, the TRVs selected in the assessment were always the lowest values of those provided by Health Canada or the U.S. EPA. Based on this procedure, it was found that toxicity data did not exist for calcium, iron, and magnesium. These chemicals are associated with the parent materials of soils, are considered to be essential nutrients and are typically not toxic at environmental concentrations. Therefore, these chemicals were not considered further. Bismuth (18 mg/kg) is found in relatively lower concentrations than other chemicals in the soil and also is not considered to be very toxic and was not assessed further.

- One of the last steps in the selection of COPC was to identify chemicals that are most likely to contribute significantly to risks. Two important factors for determining potential effects in humans are the concentration of the chemical measured in the soil and its toxicity. Therefore, a toxic potential was calculated which involved a comparison of the maximum measured concentration in soil to the oral toxicity value. The toxic potential is not equivalent to a risk and is only used as a screening tool to identify chemicals that would potentially contribute significantly to the risk. Chemicals with combined toxic potentials that contribute to 99% of the overall toxic potential were considered to be COPC. In this case, cadmium (3.82%), arsenic (7.1%), thallium (4.77%), chromium (3.44%), lead (78.2%) and zinc (2.26%) were considered to be COPC. Boron, copper and selenium were excluded from further consideration.

- To ensure that chemicals emitted to the air from the facility were not overlooked in the procedure, all chemicals reported in NPRI were also added to the list. Thus, combustion products such as nitrogen oxides (NO_x), sulphur oxides (SO_x), carbon monoxide and particulate matter (PM_{10}, $PM_{2.5}$) were added to the list. In the past, ammonia and hydrogen fluoride were emitted from the fertilizer plant, which was closed in 1995. Historical emissions of hydrogen fluoride are most likely captured within the fluoride concentrations measured in the soil. Ammonia, which has been released historically, is not a persistent chemical and was not considered further.

- In addition, chemicals of concern identified by the community (i.e., mercury and dioxins and furans) were included.

Based on the above screening, the COPC for the present study are summarized in Table 3.2.

Table 3.2: Summary of Chemicals of Concern selected for the Belledune Area HHRA

Chemicals Selected by Screening Process	Community Issues
Arsenic	Dioxins and furans
Cadmium	Mercury
Chromium (total and VI)	
Lead	
Thallium	
Zinc	

Data from the Conservation Council of New Brunswick (CCNB) were obtained after the selection process for the COPC. This data was reviewed to ensure that all COPC were identified. A review of the data indicated that the COPC identified in Table 3.2 accounted for approximately 97% of the toxic potential. Antimony concentrations of 40 mg/kg from the schoolyard were identified as a potential issue. The next highest antimony concentration in the community was 12.7 mg/kg which was considered in Table 3.1 of the COPC screen. This value was below CCME criteria and was thus screened out. The schoolyard is treated as a special case and antimony will be considered there (please see Section 7).

3.2 Radioactivity in by-product associated with BMS fertilizer production

A phosphate fertilizer plant was operated in Belledune from 1968 to May 1996 . The plant was located at the current battery recycling facility adjacent to the Noranda smelter. Information suggests that phosphogypsum wastes arising from the production of phosphate fertilizer at this plant were discharged directly to the Baie des Chaleurs via a gypsum outfall.

According to a 1986 report by the New Brunswick Department of Health, Florida phosphate rock was used to produce the phosphate fertilizer. Florida phosphate rock contains about 1Bq/g of radium-226, which is present in the phosphogypsum and hence, discharged to the Baie des Chaleurs. Also according to the 1986 report, the phosphogypsum waste covered about 30 ha of seabed. The same report suggests that a person consuming 1kg per week of combined sea products (fish and shellfish) raised on or near to the phosphogypsum bed would have received a dose of about 1.6 mSv per year. For comparison, the dose from natural background sources of radiation is typically in the order of about 2.4 mSv per year but is quite variable (by a factor of 10) from location to location. (UNSCEAR 2000)

In 1987, CANMET reported on a radiological survey at the Belledune fertilizer plant (Dave and Lim 1987). This study reported a variety of radiation and radioactivity measurements, including, among others, measurements of ambient radon levels, ambient radon decay product levels, and external gamma radiation levels at various locations in and around the plant. These authors concluded that "*external radiation and airborne radioactivity levels outside the plant area were at background levels*." These authors also report four measurements of radium-226 in seawater, ranging from about 0.113 Bq/L adjacent to the outfall to about 0.085 Bq/L 350 m east of the outfall location. Data reported in the MARINA II report (2002) indicate that normal background levels of about 0.05 Bq/L radium-226 might be expected in seawater thus suggesting a small radium-226 increment above background in 1987 close to the outfall. Nonetheless, acknowledging that no one would drink seawater, the radium-226 levels reported near the outfall in 1986 can be compared to the Canadian Drinking Water Standard for radium-226 of 0.6 Bq/L (HC 2002). Thus, while these (limited) data suggest a small gradient in radium-226 concentrations away from the outfall, the total concentration (incremental due to discharge and natural background) of radium-226 in sea water is low and of little concern.

The typical concern with phosphogypsum waste from fertilizer production is potential exposure to radon-222 (and its decay products). In this case, there is no exposure to radon as the phosphogypsum is submerged under the sea. Moreover, in 1987, while the fertilizer plant was in operation and discharging phosphogypsum to the sea, the radioactivity levels in seawater near the outfall were quite small. With the cessation of discharge of phosphogypsum to the sea, the radionuclide levels attributable to plant operations will have decreased even further. Thus, from the present perspective, the potential radiological exposures are thought to be small and not considered further in this assessment.

3.3 Summary

In summary, the risk assessment for the current scenario considered 8 COPC namely: arsenic, cadmium, chromium, lead mercury, thallium, zinc and dioxins and furans as seen in Table 3.3. In addition to assessing the current scenario, the assessment also considered three historical time periods. As seen from the table, arsenic as well as lead and cadmium were considered in these time periods. The rationale for the selection of these chemicals was discussed in Sections 1.4.1 and 1.4.2.

Table 3.3: Summary of COPC and time periods considered in the HHRA

Historical • (1967- 1974) • (1975 – 1984) • (1985 – 1999)	Arsenic Cadmium Lead
Current	Arsenic Cadmium Chromium Lead Mercury Thallium Zinc Dioxins & Furans

4.0 Environmental concentrations

This chapter describes the sources of environmental monitoring data relevant to the HHRA, data limitations and how this data was summarized and supplemented to develop exposure point concentrations (EPC) for the HHRA. As described previously, these EPC involve five study areas, four time periods, nine exposure pathways and up to eight COPC.

A large amount of monitoring data has been collected by numerous programs including Noranda's environmental monitoring program (EMP), the provincial government, the local Belledune government and organizations such as the Conservation Council of New Brunswick (CCNB). Although there is a large amount of monitoring measurements, the environmental data does not provide concentrations for all COPC at all locations and time periods. Since measured concentrations are not available for all locations and all time periods, some infilling of data using models, statistical or physical, has been used to supplement the measured data. Therefore, this study includes air dispersion modeling which was needed to develop spatial patterns of COPC as well as for evaluating historic time periods, in addition to site-specific empirical relationships that combine measured data with information from models.

This chapter provides an overview of methodology, results and discussion specific to EPC. Details of environmental data available and air quality modeling used for this study are provided in Appendices AA and AB respectively.

4.1 Environmental measurement data

This section provides an overview of measurement data used in the HHRA. The sources of data are described and some limited summaries with more detailed information are provided in Appendix AA. These measurement data were the primary basis for estimating exposure point concentrations (EPC) for the HHRA.

A substantial amount of measurement data were available; however, there are some time periods or locations with minimal or no data. Empirical relationships between concentration and distance from the industrial area are present in some of the measurement data. These relationships support the use of site-specific statistical relationships and air dispersion modeling to supplement time periods or locations with minimal or no data, and to reduce the uncertainty in EPC for this HHRA.

4.1.1 Considerations

4.1.1.1 Spatial and temporal scope

Chemicals other than the COPC have been measured in the area; however, based on the COPC screening process described in Section 3, these other chemicals have not been included further in this study.

The industrial area is relatively modern and was developed to contain a buffer zone placed between the industrial area and residential locations. Substantial data have been collected from within the industrial area, and these environmental concentrations tend to be higher than the environmental concentrations outside the industrial area. However, the review and use of environmental measurement data for this study focused on concentrations in the communities where people live and where exposure is long-term. Exposure of Belledune residents to media on or from the industrial area was deemed to be infrequent.

Four time periods were defined to account for variation in environmental concentrations over time. These are: current (2000 and onwards), 1984-1999, 1975-1984, and 1967-1974. These time periods were selected considering both availability of data and major industrial process changes in Belledune that potentially affected environmental concentrations.

4.1.1.2 Data comparability considerations

Environmental data of potential use for the Belledune HHRA have been collected over an extended period of time by several organizations under many different programs. Furthermore, the data have been collected for different purposes, but were considered here for use in the HHRA. Since methodologies for sample collection and laboratory analyses varied between these programs, there may be variations in the measured concentrations even for the same sample.

Some environmental data have been reported as less than (<) a reporting value. This arises when the concentrations are below the laboratory's precision requirements or limit of quantification (LOQ). The LOQ can vary between measurements from different laboratories and sometimes even within the same laboratory. For this study, a value of ½ the reporting value was used in calculations involving those concentrations reported as "<".

The environmental samples for soil have been collected using a variety of methods including grab sampling and a variety of compositing methods. Composite samples were used to reduce the variability between individual samples if there is heterogeneity in the media. Single samples are collected for assessment of small-scale variability or for more efficient data collection if the media can be considered to be locally homogeneous. Sampling variability (i.e., the variation of concentration in samples from the same location) will differ between the various sample collection methods. Rather than combining datasets that were derived using different methodologies, they were considered separately.

4.1.1.3 Concentration metrics

In order to characterize a range of exposures in the GBA, estimates of mean environmental concentration within the three core communities within the GBA (Belledune, Pointe-Verte and Petit-Rocher) were developed, as well as upper bound estimates of the mean concentration. In the likely most exposed areas (Lower Belledune and Town Site #2), mean environmental concentrations and an estimate of the highest environmental concentration were calculated.

The development of an estimate of the mean concentration is appropriate for each study area since this provides average risk estimates at a geographic area level that is comparable to the study of health outcomes in the CHSA. An upper bound on these average concentrations has also been calculated for the three core communities. Estimates of the upper end of concentrations to which individuals may have been exposed are expressed by considering the two sub areas within Belledune where the exposures were likely to be the highest. Mean concentrations within these two areas provide the best estimate for mean exposures to the population. The upper bound estimates of EPC for the two most exposed areas, Townsite #2 and Lower Belledune, reflect the hypothetical residential location within those areas having the highest concentrations. Conservatisim is provided in these concentrations by using an upper bound on concentrations for this particular (hypothetical) location within the study area.

In addition, the precise characterization of small-scale variation such as soil concentrations from one area of a residential yard to another or from one glass of water to another is not required for this HHRA as remedial criteria are not being developed. A person does not remain fixed at one place on the residential property, but instead moves around and is exposed to a variety of different chemical concentrations in different media on the property. Therefore, it is the average (mean) concentration that the person is exposed to that reflects chronic risk and not the highest soil concentration present in a particular location on the property.

In summary, in order to derive both reasonably realistic and conservative estimates of exposure, this risk assessment considered the Upper Confidence Limit (UCL) of the mean (95% two-sided) concentrations within the study areas as well as the mean concentrations for the three core communities. For the likely most exposed sub areas, mean concentrations were calculated for the area and an upper bound estimate of concentrations in the most exposed location within these sub areas were determined.

4.1.1.4 Baseline concentrations

COPC are present at some level in the environment even if no industries had been operating in Belledune. This is because many of the COPC are naturally occurring in the environment. In addition, naturally occurring chemicals are also naturally variable. For example, soil concentrations in an area vary depending on the soil texture (e.g. sandy or clay) or the type of rock producing the soils (e.g., sulphide mineralization or limestone).

Alternative anthropogenic sources (other than the immediate industries) have also added to current environmental COPC levels in the GBA. For example, long-range atmospheric transport of metals (e.g. mercury) originating from industries that are a large distance away can contribute to local environmental concentrations. Further examples of phenomena responsible for adding COPC to the Belledune environment include lead paint chips from the use of lead paint in older houses, or the use of pesticides on gardens, lawns or farmland.

Therefore, the measured COPC concentrations from various media that have been collected in the GBA include both the contributions that are attributable to the Belledune industrial area, as well as the contributions from other sources as well as natural background levels. Contributions from these other sources are termed “baseline contributions”.

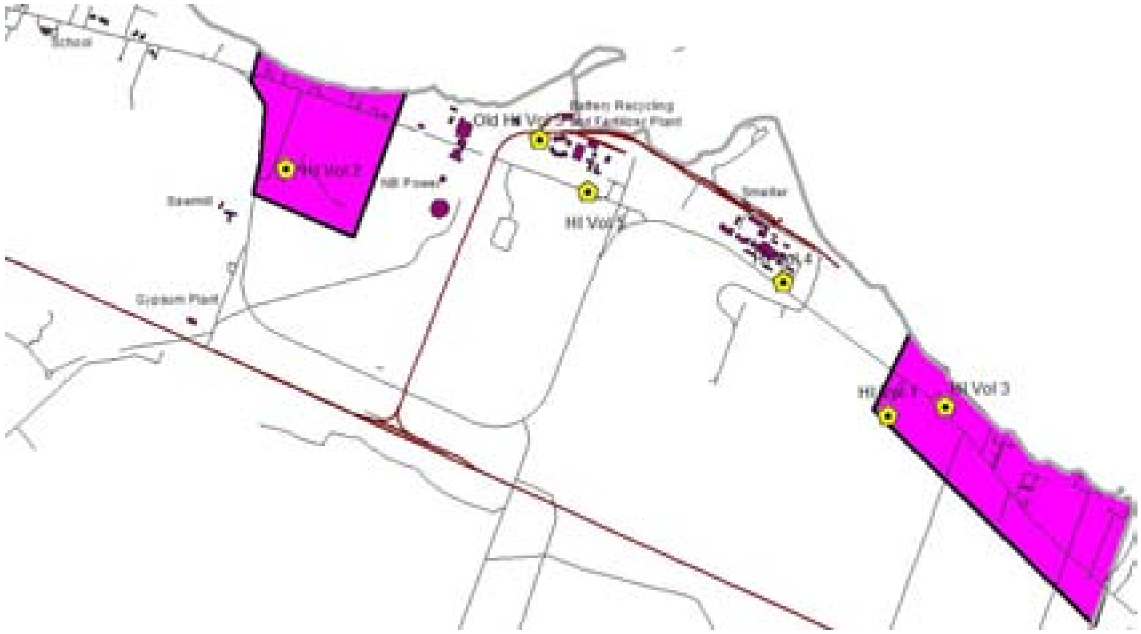
4.1.2 Environmental measurement data

4.1.2.1 Air concentrations

Metal concentrations in air have been measured regularly within the Noranda EMP (Brunswick Mining and Smelting Corporation, 2004a) at five Hi-volume (Hi-vol) sampler locations. The locations of the Noranda Hi-vol monitors are shown in Figure 4.1. Three monitors are located within the community with one in the Townsite study area and two located in the Lower Belledune study area. Two monitors are also located within the industrial area near the Noranda Smelter and the concentrate handling facility. Measurement data from the monitoring locations within the industrial were not considered in this assessment.

The COPC measured in the Noranda EMP included arsenic, cadmium, lead, thallium and zinc. Twenty-four hour average concentrations measured on a six-day cycle were provided for the time period from 1986 through 2002. Appendix AA provides detailed breakdown of the air concentrations. For sulphur dioxide, a combustion product, data were also available at the monitoring locations. Chromium, dioxins, furans and mercury concentrations in air were not measured by the Noranda EMP.

Figure 4.1: Locations of Noranda Hi-Vol air samplers

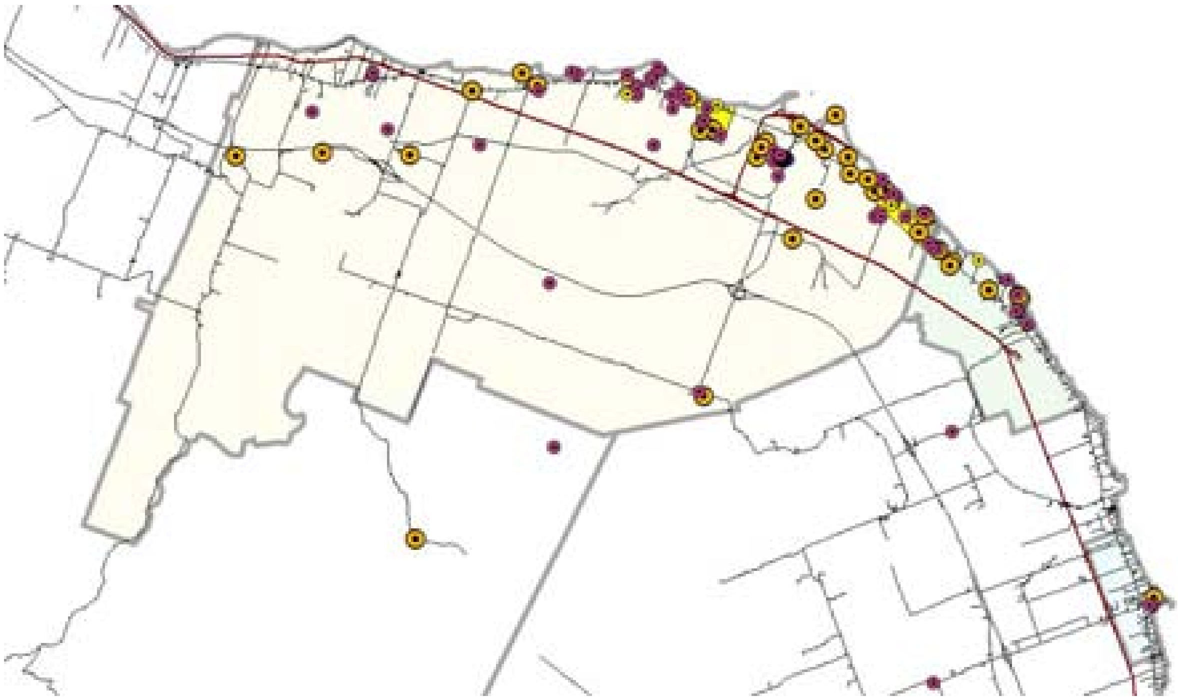


Key uncertainties in the air concentration data related to the estimation of mean concentrations in all study areas since air concentrations were measured only a specific locations in communities close to the industrial areas. Air concentration measurements were also not available for some of the historic time periods, or, for some COPC, at any time. The data gaps and uncertainties in measured air concentrations have been reduced through the use of air dispersion modeling and comparison of predicted and measured values at the Noranda EMP Hi-volume sample locations as discussed in Section 4.2.

4.1.2.2 Soil Concentrations

Soil concentrations have been measured by several organizations. The Noranda EMP (Brunswick Mining and Smelting Corporation, 2004b, c) has measured soil concentrations of arsenic, cadmium, lead, thallium and zinc dating from the 1970s. Recently, soil measurements have been collected by other organizations including CCNB (2004a, b), baseline surveys for the Bennett facility (JWEL, 2003) and from other organizations (e.g., GEMTEC, 2004). Figure 4.2 show locations where soil concentrations have been measured by different organizations in the Belledune area. The orange circles indicate Noranda EMP locations and the red circles indicate measurement locations sampled by other organization. Appendix AA provides a summary of the soil data considered in this assessment.

Figure 4.2: Locations of soil monitoring measurements in the GBA Area



Sources of uncertainty include the fact that although there are many soil monitoring locations covering the GBA for the current period, there is less coverage during earlier periods. In fact there are minimal data available for the 1967 – 1974 time period. In addition, not all COPC have been measured extensively in soil. Some uncertainty is also introduced by differences in sample collection methods (e.g., composite versus grab sampling) or in the laboratory methods used.

4.1.2.3 Well water concentrations

Measured concentration data of COPC in well water were provided by DELG (2004) for communities within or close to the GBA. This data has been collected on an on-going basis. Well water concentration data were also provided by the Belledune Environmental Monitoring Committee. Multiple year measurements for about 30 wells in the Belledune area have been provided. Due to confidentiality considerations specific locations have not been provided for the well water data; only the general areas of the location of wells.

A review of the well water data indicated that there was no apparent contribution of the industrial facilities to the COPC in the well water and that natural variation and geology are likely the major contributors to COPC in well water. Appendix AA provides a summary of the well water data considered in this assessment.

The COPC concentrations in well water varied substantially within the region surrounding the GBA. For example, the mean arsenic concentration in 33 wells from a community in the Bathurst area was 19.8 μg/L while 35 wells in another nearby community averaged 0.91 μg/L. Some information on the distribution across Belledune was available. Two wells east of the industrial area in Belledune averaged 1.6 μg/L while 30 wells in the western portion of Belleune averaged 6.8 μg/L. This example illustrates that the variation in well water is likely dominated by local geochemistry and effects from the industrial area are considered negligible.

Uncertainty in well water concentrations arose because laboratory reporting limits for thallium and chromium were significantly higher in sampling performed in Pointe-Verte and Petit-Rocher compared to the sampling performed for Belledune. For example, the reporting limit for thallium from samples collected from Pointe-Verte and Petit-Rocher was 1 μg/L as compared with 0.1 μg/L in Belledune. These reporting limit differences resulted in well water concentrations being reported as higher for Pointe-Verte and Petit-Rocher than in for Belledune for COPC where many of the measurements were below the reporting limit. For example, consider a true thallium concentration of 0.05 μg/L. The concentration would be estimated as 0.05 μg/L for Belledune and 0.5 μg/L for Pointe-Verte using the substitution with half the reporting limit. The difference in estimated concentration is an artifact of the reporting limit. Thus, some differences in estimated well water concentrations were if fact not real, but rather, artifacts of the different reporting limits.

4.1.2.4 Wild game concentrations

Wild game concentrations of COPC were only measured in 2004 (Brunswick Mining and Smelting Corporation, 2004c). Concentrations of all COPC with the exception of dioxins and furans were measured during the 2004 study in samples of partridge and rabbit captured from within the Belledune industrial area. These were assumed to represent concentrations in wild game. Appendix AA summarizes this data.

The concentrations likely overestimate typical wild game concentrations since the animals were captured in the industrial area where environmental concentrations tend to be the highest. There were no data available for historical concentrations of wild game and this pathway was not assessed historically. This leads to uncertainty in the historical assessment.

A further uncertainty arises due to the small sample size available for wild game (n=3 for both partridge and rabbit).

4.1.2.5 *Seafood concentrations*

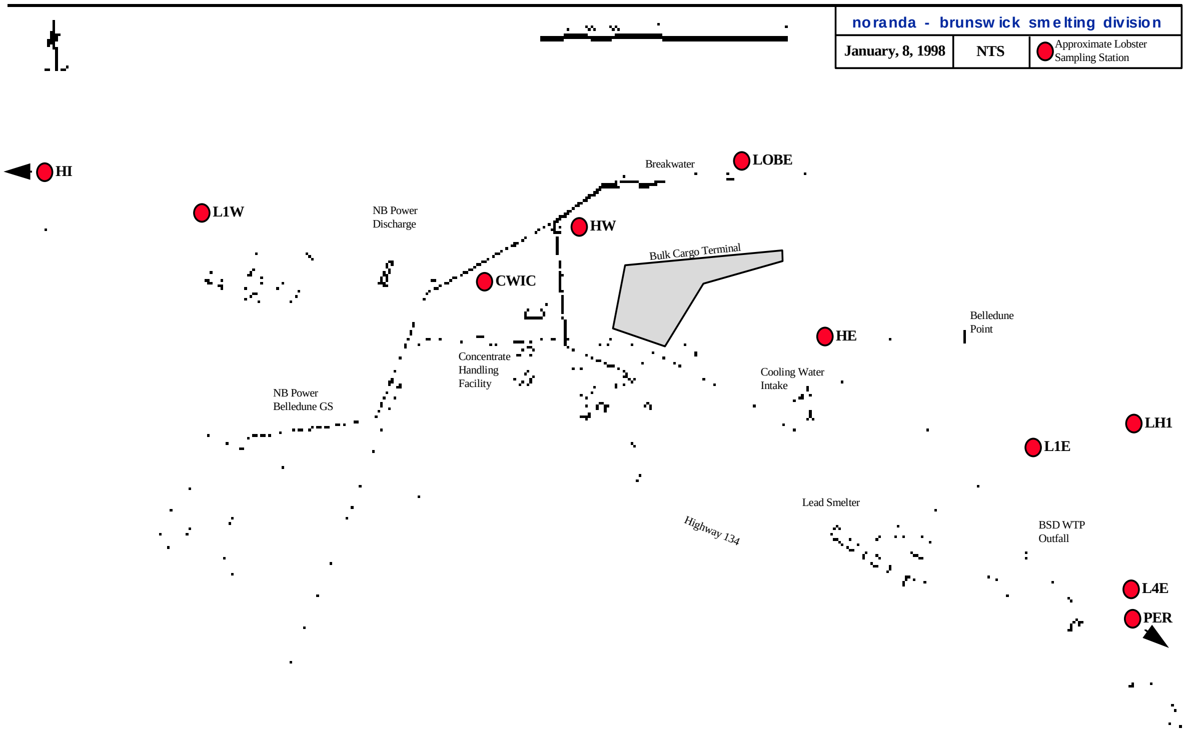
Seafood data from the Baie des Chaleurs were split into three categories based on the key seafood pathways considered in the exposure assessment, namely: fish, lobster and wild mussels.

Available seafood data were summarized from reports from government agencies, industry and consulting firms. The main source of COPC concentrations in mussels and lobsters included the Brunswick Mining and Smelting Corporation Limited (Noranda) data sampled under their Environmental Monitoring Program (EMP) (Brunswick Mining and Smelting Corporation, 2004d, e), which regularly measures concentrations of some COPC in wild mussels and lobster from the GBA area. Additional sources of mussel and lobster data were obtained from the Noranda Research Center (Levaque Charron 1981, Prairie 1981, Wood 1983), and technical reports from the Department of Fisheries and Oceans (Department of Fisheries and Oceans 1980, Uthe *et al*. 1982, 1983, Uthe and Chou 1985, 1986 and Chou and Uthe 1993).

Concentrations of COPC in fish were only available from 1972-1980 and were derived from a handful of studies, which included a MacLaren Marex report (1978) for the Environmental Protection Service , a report from the Department of Fisheries and Oceans (1980) and a report from the Noranda Research Center (Levaque Charron, 1981). These reports measured fish concentrations in a variety of species at different sampling locations across the Baie des Chaleurs and at distant sites, which were considered as baseline sites.

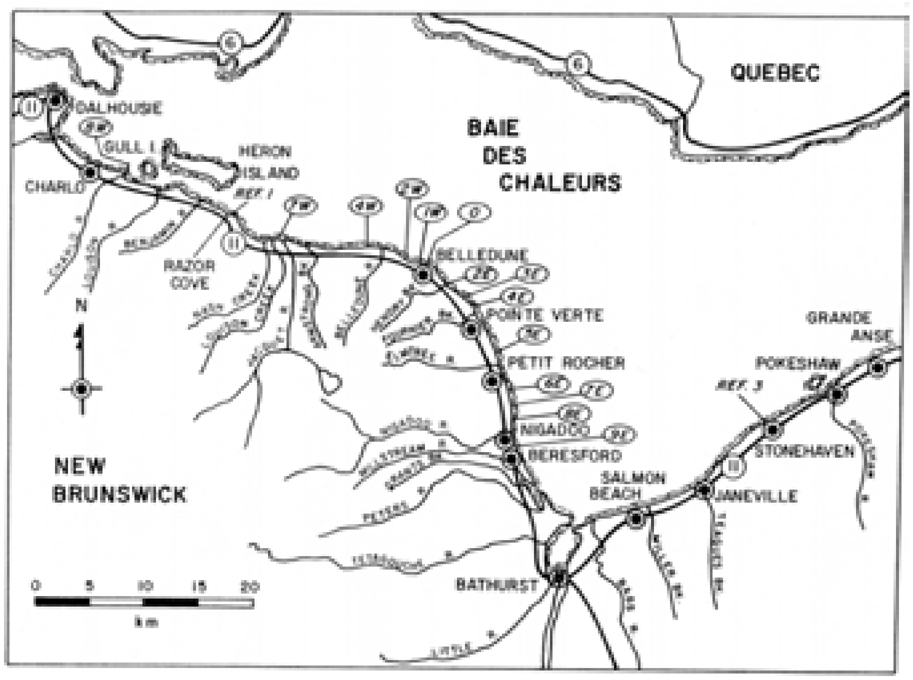
Figure 4.3 shows the Noranda EMP monitoring locations for both lobster and mussels. Figure 4.4 shows the Noranda mussel sampling locations circa 1980.

Figure 4.3: Noranda Lobster Sampling Locations



Note: from Brunswick Mining and Smelting Corporation (2002) *Cadmium and Other Elements in American Lobster from the Belledune, New Brunswick Area: 2001 Results*.

Figure 4.4: Noranda mussel sampling Locations



Note: from Levaque Charron (1981) *Marine Environmental Impact Survey of the Belledune Harbour Area, New Brunswick for the Period May 1979 to April 1980.*

The Noranda EMP uses standard operating procedures (SOPs) for the collection, preparation and measurement of lobster and mussel samples. The SOPs have built-in quality assurance/quality control (QA/QC) procedures and follow protocols that are generally accepted. Because the Noranda EMP was the main source of data for lobsters and mussels, and includes QA/QC procedures, a moderate amount of certainty can be justified around concentrations used for lobsters and mussels.

A larger amount of uncertainty exists around fish concentrations, since they were obtained from several different programs.

Lobsters and mussels were assumed to have limited mobility, while fish were considered to be completely mobile. While mussels spend their lifetime attached in one place, it was recognized that lobsters have some freedom of movement. However, for the purposes of this study, it was assumed that lobsters were confined to one area of the Baie des Chaleurs. Fish, on the other hand, were assumed to swim freely throughout the Baie des Chaleurs. Thus, different mussel and lobster concentrations were used for the five different study areas. Fish concentrations were assumed to be the same for all five study areas with the only distinction made for the baseline scenario.

Table 4.1 shows the sampling sites for lobster and mussels. Lobster and mussel concentrations determined for Belledune west of the industrial area were used to represent concentrations for residents of Townsite #2. Empirical modeling techniques were used to determine concentrations of cadmium, lead, thallium and zinc in wild mussels. Townsite #2 concentrations of these COPC were based on the area directly opposite Townsite #2, after using all sample sites to derive the empirical relationship (see Section 4.2.4). Mussel concentrations of arsenic and mercury in Townsite #2 were based on measured data that included all sample sites in Belledune west of the industrial area.

Table 4.1: Sampling sites for lobster and mussels

Belledune Area Community	Sampling Sites
Belledune west of industrial area (includes Townsite)	1W, 2W, 4W, 7W
Lower Belledune	1E, 2E, 3E, LOBE, LH1
Pointe-Verte	4E, 5E
Petit-Rocher	6E, 7E
Baseline	West of 7W ; East of Janeville

Note: Baseline samples were not obtained from Noranda EMP but from Noranda Research Center, Levaque Charron (1981)

All samples collected from sites along the Southern coast of the Baie des Chaleurs that were West of 7W and East of Janeville were included as baseline samples. The Upper Belledune community contained samples from the Jacquet River area. Examples of baseline sample sites include:, Razor Cove, Janeville, Stonehaven, Pokeshaw and Grande Anse.

Lobster and Wild Mussels

Lobster and mussel samples were excluded when they were sampled inside the closed lobster and shellfish fishery zone in the Belledune Harbour. Despite their proximity to the Noranda industrial lands and to a smaller closed shellfish fishery zone, sample site L1E was included in the lobster and mussel samples. Lower Belledune also included the Noranda “New Lobster Habitat” and “LOBE” sampling sites in order to be conservative. A detailed description of the lobster and wild mussel sampling data is provided in Appendix AA.

Not all COPC were measured in lobsters and mussels for all time periods. When data were not available for a given COPC, time period and study area, lobster data were substituted with those from a nearby study area for the same time period and COPC, or from a different time period for the same study area. For example, arsenic concentrations in lobster in all study areas were not measured until the 1985-1999 time period. For this reason, 1985-1999 arsenic concentrations were used to represent concentrations from 1967-1984 in all study areas in lobster. Empirical modeling methods were used to infill data gaps for mussel concentrations, with the exception of those for arsenic and mercury.

Mussel data sometimes included descriptions of mussel size. The mussel data provided by the Noranda EMP described mussel size as “large” or “small”. Mussel concentrations of only “large” mussels were used for cadmium, lead, thallium and zinc because concentrations were generally higher than those in small mussels. Such a distinction was not made for arsenic and mercury because data did not contain sufficient information to do so.

Limited data on clams in the area indicate that their concentrations were lower than those of the wild mussels. There are no data available for other shellfish such as oysters.

Fish

Only two spatial divisions were made for fish samples – Baie des Chaleurs or baseline. Almost all fish samples considered were fished in the Belledune Harbour or in Grande Anse, New Brunswick. Samples from Belledune Harbour were considered as “Baie des Chaleurs” fish, while fish sampled near Grande Anse were considered baseline. A limited number of fish samples came from waters south of Belledune proper, and were also considered as Baie des Chaleurs fish. Edible fish consisting of 17 different species were considered. Appendix AA provides a detailed breakdown of the fish species.

Uncertainty in the seafood data arose because fish, lobster and mussel data were not available for all contaminants for all time periods. The key uncertainty consisted of the lack of fish data after 1980. Because the release of COPC from industrial activities in Belledune have decreased over the period of facility operations, it was considered reasonable and conservative to assume that some COPC concentrations in fish would have decreased since 1980. However, the use of fish concentrations from 1980 to represent those in all time periods is a major uncertainty in the assessment.

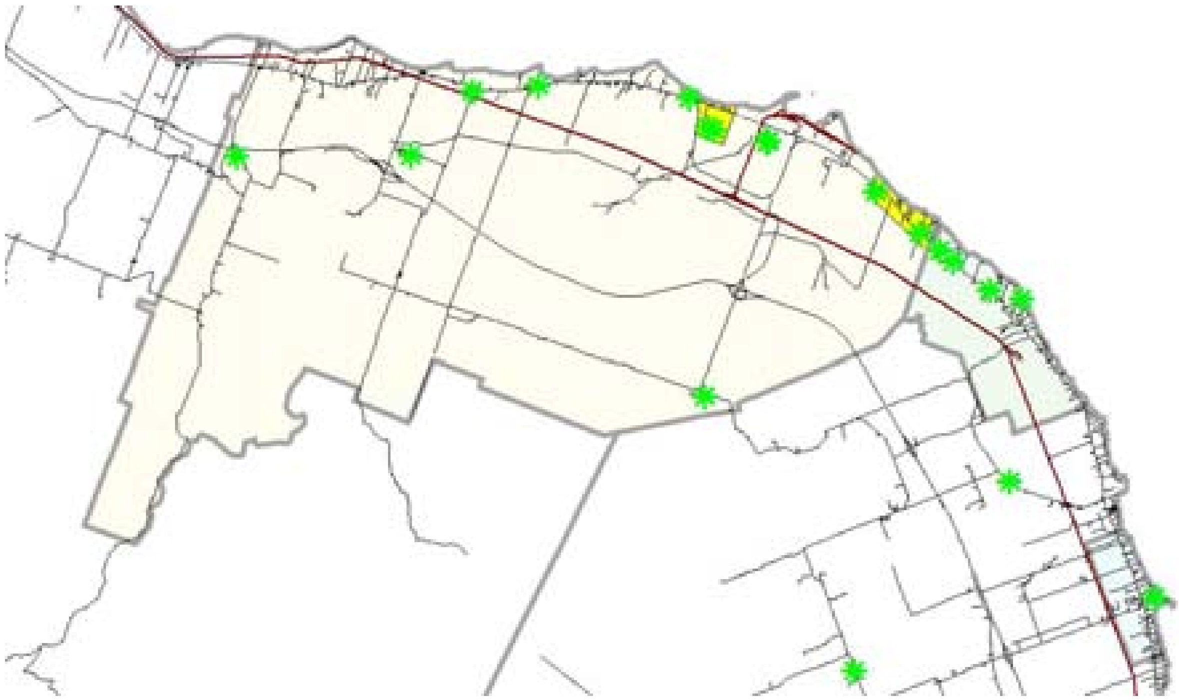
4.1.2.6 Garden vegetable concentrations

Garden vegetable concentrations were obtained the Noranda Environmental Monitoring Program (EMP), which has measured concentrations over an extended period of time (Brunswick Mining and Smelting Corporation, 2004f). These reports provided data from 1975 until present, although data were not available for all years. The Noranda EMP uses standard operating procedures (SOPs) for the collection, preparation and measurement of garden vegetable samples. The procedure involves the washing of samples using distilled water. It should be noted that this is not as comprehensive a cleaning procedure as would be expected under normal household food preparation. The SOPs have built-in quality assurance/quality control (QA/QC) procedures and follow protocols that are generally accepted. Because the Noranda EMP was the only source of data for garden vegetables, and includes QA/QC procedures, an adequate amount of certainty can be justified around concentrations used for garden vegetables. For further information regarding sample characteristics, see Appendix AA.

For the assessment, vegetables were classified into aboveground or “other” vegetables, and belowground or “root” vegetables to conform with the major pathways considered in the exposure assessment. Commonly sampled aboveground vegetables included lettuce, while commonly sampled root vegetables included carrots and potaotes. Many vegetables or specific parts of vegetables were measured. In total, the Noranda EMP sampled COPC concentrations in 6 types of root vegetables and 17 types of other vegetables. For a complete list of all other and root vegetables sampled under the Noranda EMP and included in the HHRA, see Appendix AA.

Most of the garden vegetable monitoring locations were in the Belledune area, with fewer garden locations in Petit-Rocher and surrounding areas. Figure 4.5 shows many of the garden vegetable monitoring locations in the Noranda EMP program. Additional monitoring locations are further away from the Belledune area or have been discontinued over time.

Figure 4.5: Garden vegetable monitoring locations from the Noranda EMP



Appendix AA contains additional specific information on all garden vegetable monitoring locations used in the HHRA.

When data were not available for a given COPC, time period and study area, data were substituted with those from a nearby study area for the same time period and COPC. For example, the only garden vegetable data available for Petit-Rocher were from 1975-1984. Concentrations from 1967-1974 were assumed to be the same as those from 1975-1984, while concentrations from 1985-1999 and current were estimated by using data from monitoring locations in Pointe-Verte for these periods.

Generally there were more monitoring locations and more measurements available during the 1975-1984 and 1985-1999 time periods than in the 1967-1974 or current time periods. Concentrations of lead, cadmium and zinc were consistently measured in vegetables since the 1967-1974 time period. Arsenic was not measured until the 1975-1984 time period, and thallium measurements only began during the 1984-1999 time period. The data gap in arsenic concentrations between 1967-1974 was dealt with by assuming 1975-1984 levels during that time period. Historic data gaps in thallium concentrations were not important for the HHRA because historic exposure to this COPC was not considered.

Concentrations of dioxins and furans, chromium and mercury were not measured as a regular part of the Noranda EMP (Brunswick Mining and Smelting Corporation, 2004f). There were some forage data available for chromium, mercury and dioxins and furans, but there were difficulties involved with extrapolation of forage concentrations to garden vegetable concentrations. For chromium and mercury, all forage concentrations were reported at below the reporting limit. As garden vegetable concentrations are typically even less than forage concentrations, chromium and mercury exposures from garden vegetables were considered negligible and not assessed. Furthermore, there was no significant relationship between chromium concentrations in soil and distance from the Belledune industrial area. Thus, chromium concentrations in garden vegetables were not impacted by industrial activities in Belledune.

Recent data on dioxins and furans concentrations in strawberries and forage were obtained from Noranda for the Belledune area (Brunswick Mining and Smelting Corporation, 2004c). These data were unequivocal in determining the very low levels of dioxins and furans in vegetation, and supported the further exclusion of this exposure pathway for this COPC in the HHRA.

A key uncertainty in the garden vegetable concentrations included the use of Pointe-Verte data for the period 1985 to 1999 to represent concentrations in Petit-Rocher from 1985-1999 and during the current time period. Further uncertainty was introduced by assuming that concentrations in Petit-Rocher from 1967-1974 were the same as those from 1975-1984. For a further discussion of uncertainties in the garden vegetable data, please see Appendix AA.

4.1.3 Empirical relationships

As seen in the above section, while there are wide ranging data for the different media, there are some study locations or time periods for which no measurement data were obtained. Given the data gaps, it was deemed appropriate that empirical relationships between measured and modeled data would be used for infilling data. Two such modeling techniques used for this purpose included air dispersion modeling and empirical modeling based on measured concentrations and air dispersion modeling. Some empirical models were based on measured concentrations and distance from the industrial area as discussed below.

Initial analyses of environmental data indicated empirical relationships in the data that are consistent with a local source for many of the COPC. These relationships include: 1) correlations between concentrations of different COPC measured at the same location; 2) correlations between concentrations measured in different environmental media at the same location; and 3) spatial patterns of soil concentrations that correspond to the pattern of atmospheric deposition predicted for the area.

The weight-of-evidence from these empirical relationships suggests a linkage between emissions from the Belledune Industrial Area and environmental concentrations of COPC in the GBA. The existence of these empirical relationships provided the basis for the use of air dispersion modeling and statistical relationships to supplement the measurement data within the GBA.

4.1.3.1 Conceptual model of industrial area contributions to the surrounding environment

Facilities in the Belledune Industrial Area have released chemicals to the environment and in doing so, have undoubtedly added to environmental levels of COPC in at least some of the media considered in this HHRA. Air concentrations of COPC are related to air emissions from industrial facilities. Based on an examination of the measured data, the pattern of higher soil concentrations nearer the facility than further away, and information on the Belledune industrial area activities, it was evident that the primary mechanism for terrestrial contamination of soils and vegetation in the Belledune area was airborne deposition. Figure 4.7 shows that cadmium concentrations tend to be higher near the facility than further away. This pattern is consistent with air deposition. Direct liquid releases to the Baie des Chaleurs and airborne deposition have potentially contributed to increased COPC concentrations in the marine environment.

Air Releases

Belledune industries have released chemicals to the air both now and in the past as part of their operations. These chemicals have been dispersed through the environment through the actions of wind. As discussed in Section 4.1.2.1 above, the concentrations of COPC in air have been monitored at a few locations close to the industrial area, but concentrations within all of the study areas considered in this HHRA are lacking. Therefore, for the purposes of the HHRA, there was a need to predict air concentrations for both the current and historical time periods in the different study areas. For this reason, the HHRA uses air dispersion modeling to supplement the “patchy” existing measured air data.

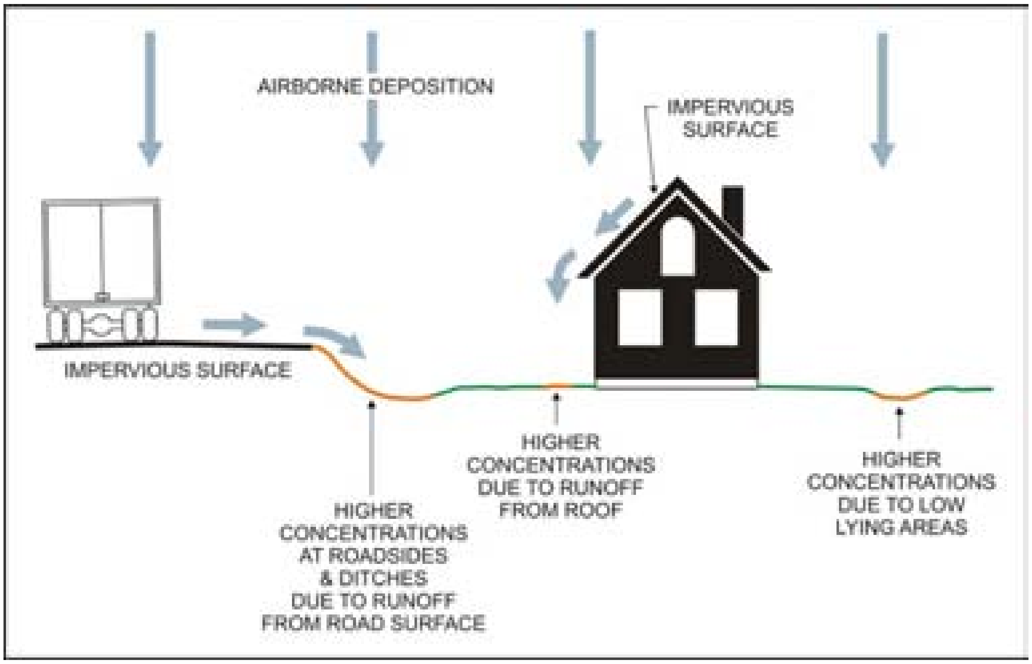
Air dispersion modeling is a tool that allows for the prediction of air concentrations at given locations and at given times, without requiring monitoring measurements. Air dispersion modeling depends on the provision of adequate chemical emissions and release information, and on the assessment of local meteorological conditions. Characterization of emissions and releases provides information on how much chemical is released from a source and the manner in which it was released. Meteorological conditions that include wind direction, speed and atmospheric stability determine how the chemicals are transported from the source.

Chemicals in the air are subject to deposition to the ground through many processes including washing out, or scavenging, by rain and snow, or due to fallout from gravity. Roughly speaking, airborne deposition will be higher in those areas with higher COPC concentrations in air than in areas with lower air concentrations. Over time, airborne deposition will result in spatial patterns of soil concentrations that mimic the spatial pattern of airborne deposition rates and air concentrations. Soil can also potentially contribute indirectly to COPC concentrations in other environmental media (e.g. concentrations in plants) through multimedia transport.

Chemical Build-up in Soil

Chemicals are incorporated into the soil following airborne deposition through physical processes such as tilling, bioturbation (e.g. earthworms), and cracks in the soil, and through chemical processes such as leaching. This results in a chemical concentration profile in the soil that varies depending on the land use, and physical and chemical characteristics of the soil. There are also removal processes from the soil horizon that include surface erosion and leaching. The contribution to soil concentrations, and the pattern within the soil profile, from the same airborne deposition rate will vary from location-to-location due to differences in land use, soil type and physical topography. This can happen at a relatively small scale, for example, on a residential lot as illustrated in Figure 4.6.

Figure 4.6: Conceptual model of airborne deposition



Impervious surfaces such as asphalt roads, building roofs and other hard-packed surfaces do not readily retain deposited chemicals. Rather, they will tend to wash off these surfaces and accumulate where water forms ponds. As a result, surface soils at the side of the road, in ditches, near eaves troughs and in low-lying areas will have higher concentrations than soil in other areas. The variation in soil concentration with depth in the soil will also vary on a property depending on use: areas that are tilled such as gardens will have concentrations relatively uniformly distributed within the top 15 cm while adjacent but undisturbed areas on the yard usually have higher concentrations in the top 5 cm than at greater depths. Soil type will also make a difference; in general, metals are much less mobile in soils with high organic content than in sandier soils.

Vegetation accumulates chemicals through uptake from soil and by direct deposition to the leaves. Uptake of chemicals by vegetation depends on the chemical and the type of vegetation; however, chemical uptake will generally mimic patterns of air concentration, airborne deposition and soil concentrations. Due to these different processes, modeling of vegetation concentrations is complex.

Marine Environment Releases

Effluent has been and continues to be released to the Baie des Chaleurs from the Belledune Industrial Area. The contribution of COPC to the Baie des Chaleur includes direct liquid discharges and airborne deposition attributable to the air releases from industrial facilities.

Physical dispersion modeling in the marine environment is more complex than air dispersion modeling. Sedimentation rates and patterns vary throughout with erosion occurring in some areas and sedimentation in other areas of the Baie des Chaleurs. Water currents tend to flow towards the east in the Belledune area; however, there are likely to be many complexities regarding currents within the Belledune area.

Exposure pathways related to marine environment in this HHRA are consumption of fish, lobsters and wild mussels. Physical dispersion modeling of COPC throughout the Baie des Chaleur and the uptake in to these foods has not been considered necessary since measurement data on concentrations of most COPCs were available.

Physical Placement

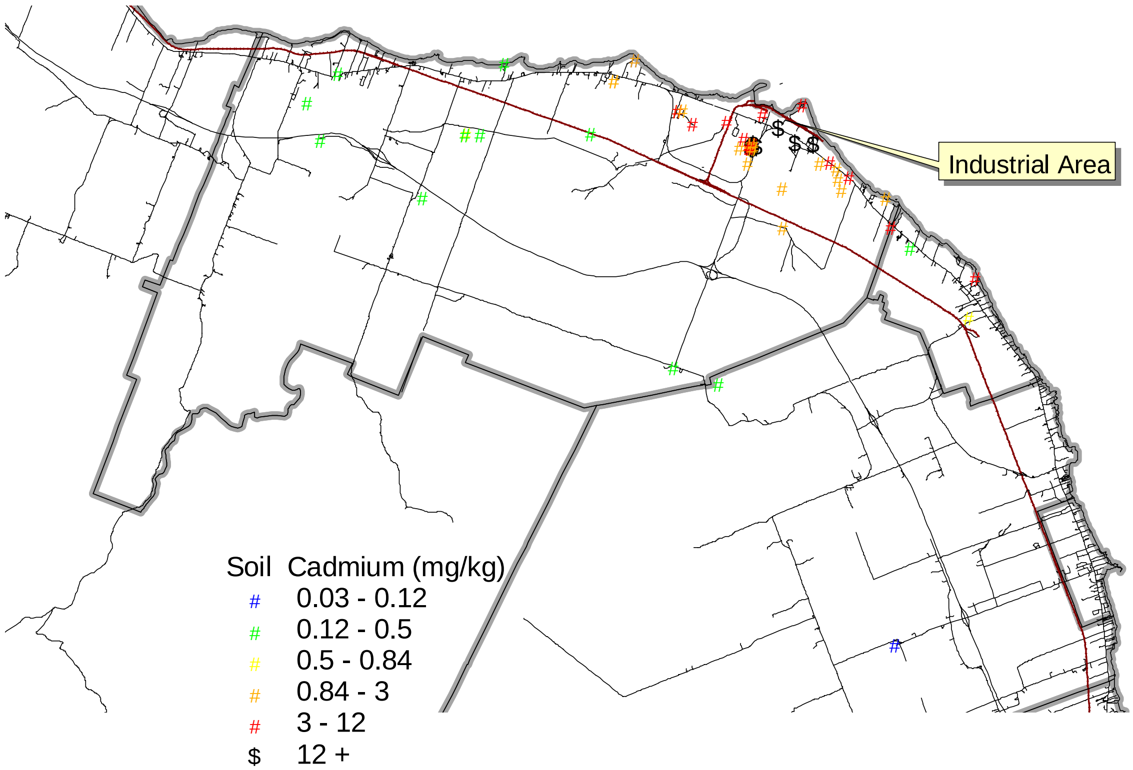
There is potential for transportation of solid materials containing COPC from the industrial area into the community. Anecdotal information includes the use of equipment (e.g. loaders) being used to move snow in the community and inadvertently depositing small amounts of concentrate while doing this work. Lead fragments have been photographed and measured within the community. There may also have been some slag used in the community for fill or construction purposes. As a result, COPC concentrations at some locations are anomalous relative to the general pattern of airborne deposition. Examples include the “Soil 9” location from the Noranda EMP program, the road side near Pointe-Verte bus stop (measured by CCNB and GEMTEC) and the Belledune school.

There is no record of transport of solid materials into the community and “anomalous” COPC concentrations in the measurement data are infrequent. Contamination by solid materials has been considered a special case in this HHRA given the limited number of locations and the limited spatial extent of anomalous concentrations at these locations. Section 7.4.11 provides this analysis.

4.1.3.2 Spatial patterns

Soil concentration data of many COPC show spatial patterns consistent with airborne deposition from the Belledune Industrial Area. Figure 4.7 shows the pattern of cadmium concentrations in soil provided by various sources. Appendix AA provides the detailed concentrations. Orange, red or black symbols indicate areas where cadmium soil concentrations were above the baseline range for New Brunswick. As seen from the figure, cadmium soil concentrations in Belledune are elevated above the upper range of New Brunswick baseline with higher concentrations being measured nearer the industrial area than farther away. This pattern suggests that there is a relationship between cadmium soil concentrations and the dispersion of cadmium in the air from sources in the Belledune Industrial Area. Similar relationships were seen for other COPC. Therefore, it became apparent that the use of an empirical relationship between air dispersion and soil concentrations could be developed.

Figure 4.7: Cadmium soil concentrations in the core study area



4.1.3.3 Temporal patterns

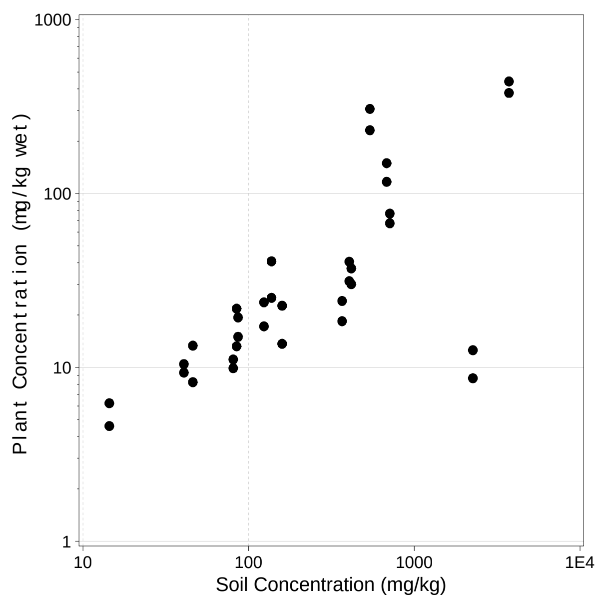
Analyses of soil concentrations show patterns of decreasing soil and vegetation COPC concentrations over time, with the vegetation concentrations decreasing more rapidly with time. This is consistent with the pattern of decreasing air emissions from the smelter.

4.1.3.4 Correlation between environmental media

Figure 4.8 is an illustrative example of the correlation present between various media with the specific example being concentrations of lead in vegetation and concentrations in soil. These data are for forage and soil measured within the Noranda EMP program. Appendix AA provides more detail on the forages sampled. The figure presents the average measured concentrations since 1995. As seen from the figure, there is a general relationship of higher forage concentration with higher soil concentration.

However, the figure also shows a monitoring location, Soil 9 from the Noranda program, where there are relatively low vegetation concentrations with high soil concentrations. Since the vegetation concentrations are low and this area is located at a distance from the Belledune Industrial Area, it is unlikely that the soil concentration arose from airborne deposition alone and thus this point is anomalous and not considered in the relationship. The general relationship between soil and air concentrations is consistent with the approach of most mathematical/physical models that model vegetation chemical concentrations due to uptake from soil and airborne deposition. It should be noted, that the highest forage concentrations are from locations in the Belledune Industrial Area and not from the most exposed residential area. However, the empirical relationship developed for vegetation was based on the data from residential areas and not from the Belledune Industrial Area.

Figure 4.8: Relationship between lead concentrations in forage and lead concentrations in soil



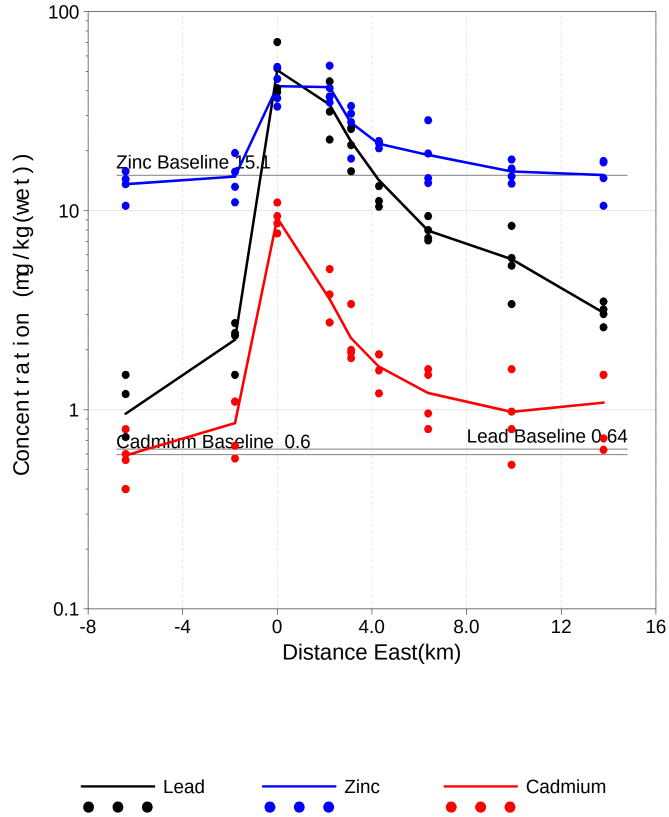
Note: From Noranda EMP since 1995 for forage

4.1.3.5 Seafood

Figure 4.9 provides a relationship between average measured mussel concentrations for the current period obtained from the Noranda EMP. As illustrated in Figure 4.9 below, concentrations of COPC in mussels show a correlation in COPC concentrations at the same location in addition to a relationship of decreasing COPC concentrations with distance from the Belledune Industrial Area. Figure 4.10 shows how the relationship between cadmium concentrations and distance from the Belledune Harbour changes over time. As seen from the figure, cadmium concentrations in mussels have decreased approximately four-fold from the 1981-1984 time period to the 2000-2003 time period.

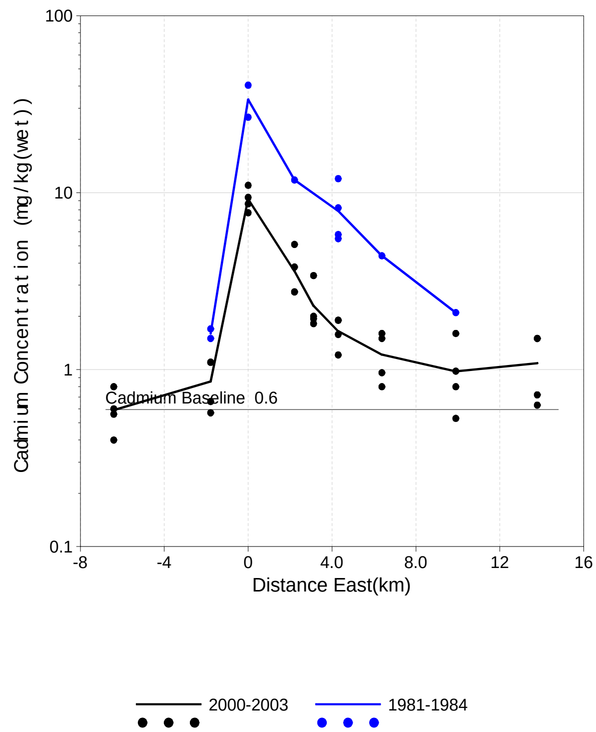
No empirical relationship was developed for fish as the data were unavailable to develop such a relationship.

Figure 4.9: Relationship between concentration of cadmium, lead and zinc in mussels and distance from Belledune Harbour (Chapel Point)



Note: From Noranda EMP data since 1975
Baseline values obtained from Ref. 4 location of Noranda EMP

Figure 4.10: Relationship between concentration of cadmium in mussels over time and distance from Belledune Harbour (Chapel Point)



Note: From Noranda EMP data since 1975
Baseline values obtained from Ref. 4 location of Noranda EMP

4.2 Application of empirical relationships and modeling to supplement environmental measurement data

Multi-media models based on physical/mathematical principles have been used extensively in other studies to predict the environmental concentrations attributable to proposed and existing facilities. These models often utilize air dispersion modeling to estimate the "driving" force for environmental fate. As described above, environmental monitoring data have been collected in the area and empirical relationships are present that are consistent with the emissions from facilities in the Belledune Industrial Area being contributing sources to environmental concentrations. As discussed previously, an integration of air dispersion modeling and empirical (statistical) models of environmental data formed the basis for supplementing existing data in this assessment.

4.2.1 Air dispersion modeling

Air dispersion modeling was conducted to provide estimates of air concentrations throughout the study area since there were a limited number of measurement locations. These predicted air concentrations also provided an explanatory linkage with measured soil concentrations. The following provides a summary of the air dispersion modeling with details provided in Appendix AB.

4.2.1.1 Air dispersion methodology

Air concentrations were predicted in four steps; first, unit air concentration factors were determined at locations throughout the study area for each source considered. Twelve (12) stack (11 located at Noranda smelter and 1 at New Brunswick Power) and five fugitive sources (from Noranda smelter, New Brunswick Power (pet-coke and coal piles), Noranda Battery Recycling Plant, and the Gypsum Plant (raw and finished gypsum piles)) from the industrial area were modeled. Stack emissions from the Gypsum Plant and Chaleur Sawmills were not considered in the assessment because these sources were very small in comparison to the larger sources from Noranda and New Brunswick Power. These unit air concentration factors provided the estimated air concentration, $\mu g/m^3$, at a location for a unit emission rate from a particular source. These factors were calculated using the CALPUFF air dispersion model and processed meteorological data from 2003. Comparison with weather data from previous years indicated that 2003 was a typical year. Appendix AB provides data on the air quality modeling.

Second, COPC air release rates were estimated by time period for each source based on reported data from the facilities or generic factors. Air concentrations were then predicted by multiplying the unit air concentration factor by the release rate for the corresponding stack and time period.

The predicted incremental air concentrations were compared to the total measured values at the air monitoring locations. The measured concentrations reflect the total of incremental due to industrial sources in Belledune plus background levels. Thus, for situations where measurable baseline levels of COPC would be expected, a comparison of predicted incremental and measured total will result in a conservative value (i.e. tending to overestimate the actual contribution of the industrial source).

Validation

Mean predicted air concentrations and mean measured air concentrations were summarized for the three Hi-vol monitoring sites located within the community. Data from the two Hi-vol locations near the facility were not included in the validation since they are located within the industrial area and do not reflect conditions in the community. For each year, concentrations were first averaged for the January to June period and the July to December period and then these values were averaged for the year 2000 through 2002. Measured values from 2003 were not used in the assessment since the data were considered invalid by New Brunswick DELG (D. Grass, Personal Communication, 2004). Sulphur dioxide predictions for the year 2002 were consistent with the National Pollutant Release Inventory (NPRI) reported sulphur dioxide emissions from New Brunswick Power and sulphur dioxide (SO_2) emissions reported by Noranda.

Table 4.2 shows the mean predicted and mean measured concentrations for the five measured COPC and SO_2 at each of the three monitoring locations. Included are combined mean concentrations for the three stations. The ratio between mean measured concentration and mean predicted concentration is provided as an indicator of agreement between predictions and measurements. Ratios less than 1 indicate that the predicted concentrations overestimate the measured concentrations and ratios greater than 1 indicate that the predicted measurements underestimate the measured concentrations.

The initial agreement between predicted and measured values falls with a factor of two(2) for arsenic and cadmium and within a factor of three (3) for thallium. Lead concentrations are under-predicted by a factor of five (5). There will be tendency for the predicted concentrations to under-estimate measured concentrations since they are incremental predictions without consideration of baseline concentrations and baseline contributions of COPC will be present in the measured concentrations. The general agreement between predicted and measured SO_2 and cadmium concentrations is consistent with the industrial contribution being large at these locations compared to the baseline contribution. Zinc is underestimated by a factor of about 10 compared to measured concentrations. It is likely the that the disagreement in zinc concentrations may in part be due to use of glass fibre filters in the Hi-volume samplers. Noranda indicated (J. Cormier, Personal Communication, 2005) that Noranda switched to quartz fibre filters in 2004 due to high variations of zinc ions and possibly other chemicals. The U.S. EPA (1999) recommends the use of quartz fibre filters because of its low metals content; glass fibres should be corrected to account for high metals content. If no correction for zinc content in the glass fibre filters was made, elevated concentrations of zinc would be measured. Fugitive releases from the smelter had been set equal to 10% of the stack releases for all COPC except SO_2 and NO_x, There may have been differences in the proportion of COPC leaving the facility through stacks or through fugitive releases. For example, the proportion of cadmium leaving through fugitive releases may be lower then the proportion of lead leaving through fugitive sources. In that case, predicted lead concentrations would have been underestimated relative to predicted cadmium concentrations.

Table 4.2: Comparison of measured and air dispersion model predictions (µg/m³) for 2000-2002

COPC	Predicted Concentrations (µg/m³)	Measured Concentrations (µg/m³)	Ratio
Arsenic			
Combined	0.0058	0.0094	1.61
HI Vol 1	0.0049	0.0086	1.75
HI Vol 2	0.0058	0.0091	1.56
HI Vol 3	0.0068	0.0106	1.56
Cadmium			
Combined	0.0037	0.0042	1.13
HI Vol 1	0.0032	0.0041	1.25
HI Vol 2	0.0033	0.0031	0.94
HI Vol 3	0.0045	0.0053	1.18
Lead			
Combined	0.0372	0.1721	4.63
HI Vol 1	0.0325	0.1908	5.87
HI Vol 2	0.0336	0.1252	3.73
HI Vol 3	0.0455	0.2001	4.40
SO_2			
Combined	6.8509	11.322	1.65
Bouley	5.3757	11.546	2.15
Townsite	7.3648	7.9031	1.07
Chaleurs	7.8123	14.518	1.86
Thallium			
Combined	0.001	0.0022	2.22
HI Vol 1	0.0009	0.0021	2.46
HI Vol 2	0.0009	0.0019	2.05
HI Vol 3	0.0012	0.0026	2.19
Zinc			
Combined	0.0152	0.1871	12.32
HI Vol 1	0.0105	0.1864	17.68
HI Vol 2	0.0207	0.1691	8.17
HI Vol 3	0.0143	0.2057	14.39

Note : SO_2 validation based on 2002 data.

Adjustment Factors

In order to reduce the uncertainty in predicted air concentrations, the relationship between measured and predicted concentrations at the monitoring locations were used to adjust the initial predicted air concentrations. Ratios at individual monitoring locations were similar for the same COPC suggesting that adjustments by direction would be minimal. The initial predicted air concentrations were multiplied by the ratios in Table 4.2 for the combined measurements. For example, the adjusted air concentrations for cadmium were calculated by multiplying the initial air concentrations by 1.13 to estimate the average air concentrations of cadmium used in the HHRA. The same adjustment was used for all locations regardless of distance or direction from the industrial area.

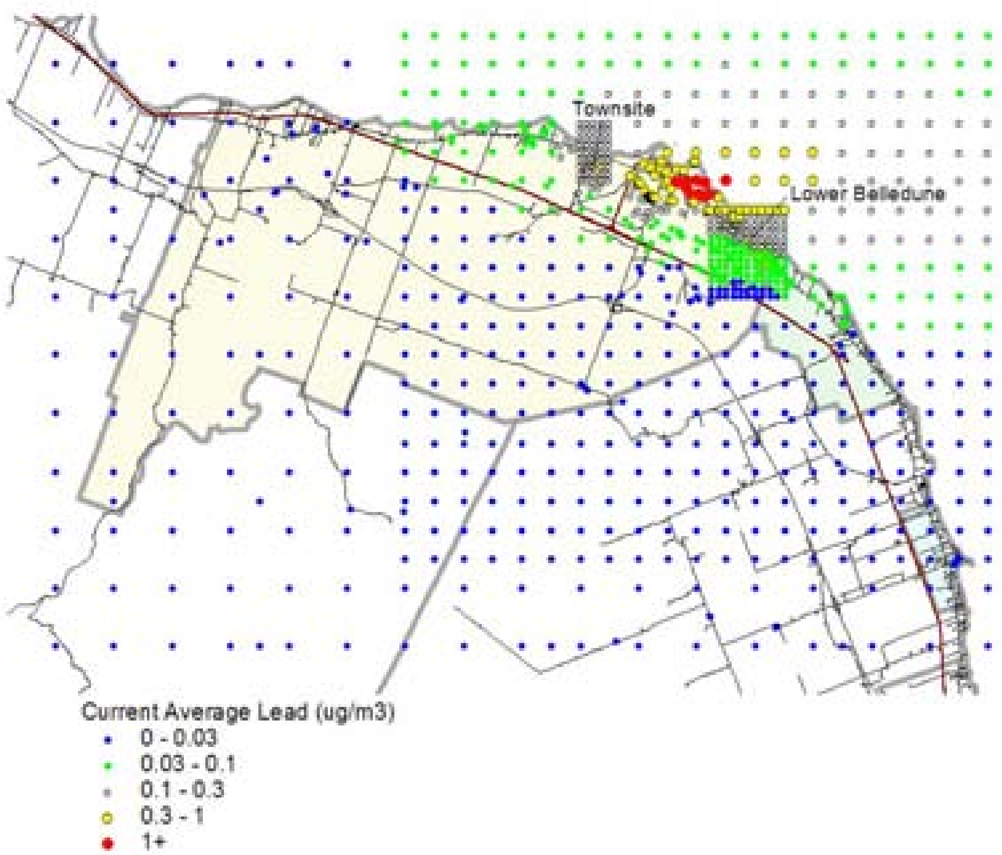
No adjustment was made for zinc because measured zinc concentrations were high due to the use of glass fibre filters, which are known to have a high zinc concentration (U.S. EPA 1999).

Monitoring measurements were not available for nitrogen oxides (NO_x), dioxins and furans, chromium and mercury. Predicted air concentrations for these COPC were estimated by multiplying the initial predictions by a factor of 2.4 which is the average factor for arsenic, cadmium, lead and thallium. The adjustment factor for SO_2 was used for NO_x.

4.2.1.2 Results

Figure 4.11 shows an example of predicted mean air concentrations for lead during the current time period. The map shows the locations where air concentrations were predicted. These points are a combination of where monitoring measurements have been collected and a grid of points covering the GBA communities. A higher density of grids was used closer to the Industrial Area than further away to better delineate the air concentrations attributable to the facility. The figure shows an expected pattern of higher air concentrations towards the east and west from the Belledune Industrial Area that coincides with the pattern of wind directions.

Figure 4.11: Predicted mean air concentrations for lead



Air concentrations for each COPC and relevant time periods were estimated and are discussed further in Appendix AB.

4.2.1.3 Uncertainty in air dispersion modeling

Air dispersion modeling is well-accepted by regulators for predicting air concentrations arising from air releases. This is particularly the case where detailed data on existing emissions and environmental monitoring data for model validation are available.

The CALPUFF/CALMET modeling system used for the air dispersion modeling in this analysis is quite sophisticated and able to account for terrain effects and sea-level interactions. A comparison of meteorology indicated that 2003 was a typical year and, on this basis, prediction of annual mean air concentrations in other years using this data would be similar to predictions using other year's data. Removal of chemicals from the air was not modeled. This results in an expected overestimation of air concentrations as the distance from the Belledune industrial area increases.

The same air dispersion factors were used for the historical period as for the current period; however, higher uncertainty is associated with the historical time periods due to less information on emission rates and release characteristics. Overall, the close agreement, prior to adjustment, between predicted and measured air concentrations of arsenic, cadmium, lead and thallium for the current period is reassuring of the precision of the air dispersion modeling and the reported emissions. The adjustments to predicted concentrations reduced the uncertainty in air dispersion modeling for the current period for these COPC.

4.2.2 Relationship between soil concentration and air concentrations

As discussed previously, estimates of mean and upper bound soil concentrations were needed for each of the exposure areas. Although soil sampling has been conducted in the Belledune area by many groups, the measurements tend to have been collected in the last few years or, in the case of the Noranda EMP, for a limited subset of COPC. In addition, the sampling has generally been more intensive near the industrial area than further away.

Predicted air concentrations have been used as a statistical covariate with soil concentrations to develop an empirical relationship that preserves the central tendency of the monitoring data while explicitly providing statistical characterization of the exposure point concentrations (e.g. confidence intervals). This combined approach removes the uncertainty that would be present in modeling airborne deposition and the behaviour of the COPC in the soil (e.g., leaching or other removal processes) using physical modeling alone. This empirical relationship, “driven” by actual monitoring data, provides a scientific basis for interpolating exposure point concentrations (EPCs) to unmeasured locations, times and COPC since it explicitly provides the expected EPC and the uncertainty in that value.

4.2.2.1 Methodology

The approach used to estimate soil concentrations involved the development of a relationship between measured soil concentrations and the predicted air concentration at those locations. The modeled relationship was an incremental soil concentration related to the incremental concentration attributed to air releases from the Belledune industrial area and an intercept value that reflects the soil concentration when there is no contribution from the air concentrations. The relationship model was:

$$S = mA + b$$

Where:

S = measured soil concentration, in mg/kg, at the monitoring location

m	=	an overall parameter in, mg/kg per µg/m^3, for effects of deposition , build-up in soil as discussed in Section 4.1.3 and air dispersion modeling uncertainty
A	=	predicted air concentration in µg/m^3 at the monitoring location
b	=	soil concentrations, in mg/kg, in the absence of airborne deposition.

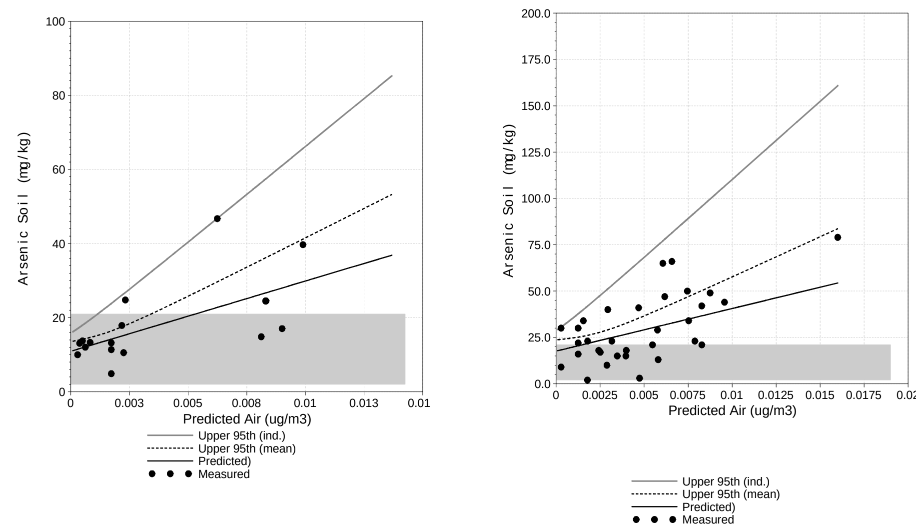
Regression methods were used to fit this relationship and then predict soil concentrations at grid points within the exposure area along with the uncertainty in these predicted concentrations. Details on the data used and the individual regressions are provided in Appendix AA.

As an example, consider arsenic during the current time period shown in Figure 4.12 using Noranda EMP and CCNB soil data from outside the industrial area. The figure shows a pattern of increasing soil concentrations with increasing air concentrations as would be expected if airborne deposition from the industrial source was a contributor to soil concentrations. The gray shading shows a range, from the 5th to 95th percentile, from the N.B. Baseline soil survey. Arsenic soil concentrations at locations where the predicted air concentration from the industrial area are low are consistent with the range of background arsenic concentrations. The plot also shows the predicted soil concentration, the upper 95th confidence level for mean concentrations (UCLM) and the upper 95th percentile level for individual predictions (UCLI). The predicted, UCLM, and UCLI concentrations were retained for each grid point in the corresponding exposure area.

A further example for lead is presented in Figure 4.13. As with the arsenic presentation, soil data using Noranda EMP data as well as CCNB data are shown in the figure. As seen from the figure, there is a similar relationship of increasing soil concentration with increasing air concentration for lead as there was for arsenic.

Figure 4.12: Current period empirical relationship between measured soil concentrations of arsenic and predicted air concentrations

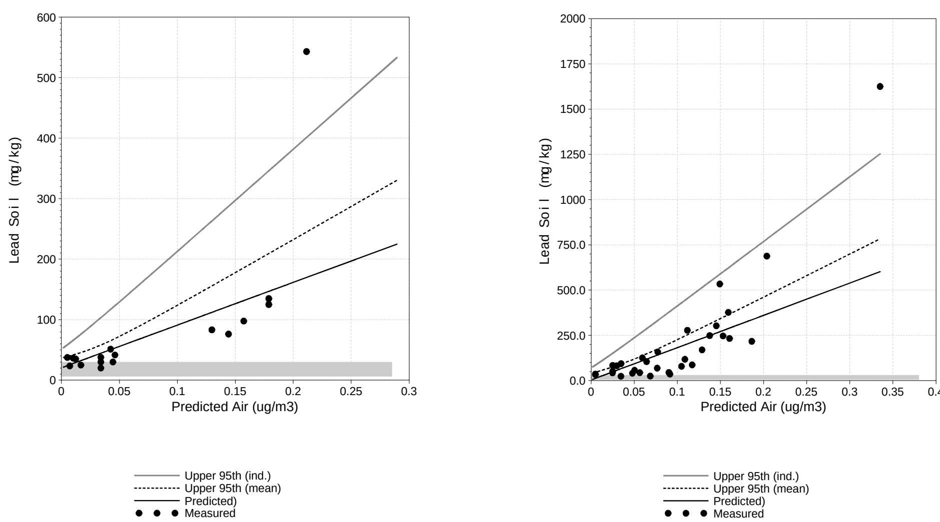
a) Noranda EMP b) CCNB



Note: Concentrations were only measured in 2003 and 2004 by CCNB

Figure 4.13: Current period empirical relationship between measured soil concentrations of lead and predicted air concentrations

a) Noranda EMP b) CCNB



The plot of the relationship between lead concentrations in soil measured by Noranda and the predicted air concentrations indicates an unusually high soil lead concentration as seen in Figure 4.13. This location, Soil 8 or Chalmers, is currently not a residential location and there may be some possibility that processes other than airborne deposition have contributed to the anomalously higher concentrations at this location. However, there were no investigations at this site to warrant removal of it from the empirical relationships. Anecdotal information indicates that snow removal equipment may have contributed to contamination at this site but this has not been confirmed by site investigations.

It should be noted that upper bound EPCs for Lower Belledune and Townsite #2 were sensitive to whether soil data from the Soil 8 location had been included in the empirical model. For example, the upper bound EPC for lead in Lower Belledune during the current period was 330 mg/kg if Soil 8, or Chalmers, location data was included and 198 mg/kg, if the data for Soil 8 is excluded. Cadmium and zinc EPCs were also sensitive to inclusion of this point. This indicates that the upper bound EPCs for lead may be overestimated by a factor of 1.67 and cadmium and zinc by factors of 1.40 and 1.48, respectively for Lower Belledune.

4.2.2.2 Results

Relationships for the current period were fit for all COPC for both the Noranda EMP and the CCNB soil data sets separately. The relationships between soil concentrations from the Noranda EMP and the CCNB are generally similar; however, the estimated soil concentrations based on CCNB data tended to be higher for the same predicted air concentration compared to the soil concentrations based on the Noranda EMP soil concentrations. This may be due to differences in sample collection methodology and laboratory methods (e.g. sample preparation, analytical method and measurement precision).

Table 4.3 shows a summary of the relationships for the Noranda EMP and current period. The p-value indicates the probability of the relationship between predicted air concentration and the measured soil concentration occurring by chance alone. Low p-values indicate that the relationship was unlikely to occur by chance alone; for example, the p-value of <0.0001 for cadmium indicates that there is less than one in 10,000 chance the pattern occurred by chance alone. This p-value indicates statistical significance in the relationship between predicted air concentration and measured soil concentrations. Statistical significance was present for arsenic, cadmium and lead with a non-significant relationship for chromium and thallium although the slope estimates were similar to the other COPC. There was no observable relationship between soil concentrations and air concentrations for dioxins and furans or chromium.

Table 4.3: Relationship between air and soil concentrations for Noranda EMP for current period

COPC	p-value	Intercept (mg/kg)	Slope (mg/kg per µg/m^3)
Arsenic	0.0068	10.92	1897
Cadmium	<0.0001	0.236	627
Chromium	bounded	37.73	0
Dioxins and Furans	bounded	6×10^{-4}	0
Lead	0.0015	20.36	706
Mercury	0.6653	0.06	130
Thallium	0.1478	0.411	367
Zinc	0.6360	135.7	1072

Note: “bounded” indicates that a parameter was constrained and p-value was not calculated.

Noranda EMP data were used to fit relationships for the historic time periods for arsenic, cadmium and lead. The CCNB data were collected during 2003 and 2004; therefore this data could not be used to develop relationships for earlier time periods. Figures and summaries of these relationships are provided in Appendix AA.

4.2.2.3 Uncertainty in soil concentrations

The site-specific relationships have been developed using statistical methods therefore the uncertainty in predicted concentrations has been quantified and has been explicitly incorporated into the upper bound EPC. The UCLs provide a statistical quantification of the uncertainty. We can be confident, to a reasonable degree, that concentrations are lower than the UCL. There is some scatter in measured concentrations about the predicted value; however, this may reflect variations in soil type, low-lying areas on the property, disturbances to the soil profile or sampling variability.

Exact coordinates for the CCNB data were not provided for confidentiality reasons; therefore, some uncertainty has arisen due to the use of approximate coordinates when developing the relationship.

The difference between Noranda EMP and CCNB relationships is not resolvable. To circumvent this, both the Noranda EMP and CCNB relationships have been considered in the HHRA as part of the uncertainty analysis.

4.2.3 Relationship between backyard vegetable concentrations and patterns of air concentrations

A relationship of increasing vegetable concentration with increasing soil concentration is expected given that uptake to vegetables occurs from the soil and from direct airborne deposition to the plants.

4.2.3.1 Methodology

The approach used to develop a relationship for backyard vegetable concentrations was similar to the method used in the relationship between measured soil concentrations and predicted air concentrations. The modeled relationship is an incremental vegetable concentration related to the soil concentration. The relationship was fit using the mean soil and vegetable concentrations collected at the same location and time period. The relationship model was:

$$S = mA + b$$

Where:

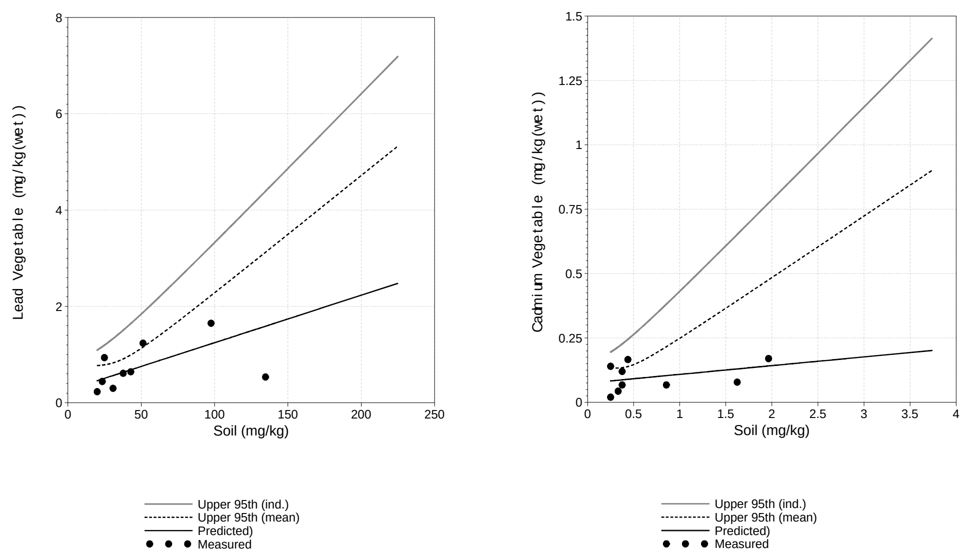
S	=	measured vegetable concentration, in mg/kg(wet), at the monitoring location
m	=	an overall empirical parameter in, mg/kg(wet) per mg/kg(dry) in soil concentration.
A	=	measured soil concentration at locations
b	=	vegetable concentrations, in mg/kg(wet)

Regression methods were used to fit this relationship and then predict vegetable concentrations at grid points within the exposure area along with the uncertainty in these predicted concentrations. The vegetable concentrations at the grid points were based on the predicted soil concentrations using the Noranda EMP relationship. The details on the data used and the individual regressions are provided in Appendix AA.

Figure 4.14 shows examples for lead in other vegetables and cadmium in root vegetables for the current period. There are relatively few measurement points from the current period. Regardless, the data show a pattern of increasing vegetable concentration with increasing soil concentration. The UCL of the mean is substantially higher than the predicted mean concentration in these figures. This is due to a number of factors including the relatively low number of measurements, variation in vegetable concentrations for the same soil concentration and the lack of measurements at higher soil concentrations.

Figure 4.14: Current period empirical relationship between measured concentrations and soil concentrations

a) Lead in Other Vegetables b) Cadmium in Root Vegetables



4.2.3.2 Results

Relationships were fit for arsenic, cadmium, lead, thallium and zinc for the current period and for arsenic, cadmium and lead in the 1985-1999 period. Soil data at garden monitoring locations prior to 1985 were not available.

Table 4.4 shows a summary of the vegetable and soil relationships. The statistical significance of these relationships is lower than the statistical significance observed for the soil relationships. As discussed above this is due, in part, to the low number of monitoring locations during the recent period. For most of the COPC, the p-value is lower (i.e., more statistically significant) for the 1985-1999 time period than in the current time period. The higher statistical significance is likely due, in part, to the larger number of monitoring locations in the early period.

The regression statistics also indicate a tendency of higher contribution to other (aboveground vegetables) than to root crops and a higher contribution during the early time period than in the later time period. These patterns are consistent with aboveground vegetables being more exposed to air deposition than the root vegetables and with decreasing soil and air concentrations over time.

Table 4.4: Relationship between vegetable and soil concentration

Media	Time Period	Spearman Correlation	Number of Data Points	p-value	Intercept (mg/kg(wet)	Slope (mg/kg(wet) per mg/kg)
Arsenic						
Root	Current	0.08	9	bound	0.073	0.0000
Root	1985-1999	-0.16	19	0.895	0.049	0.0002
Other	Current	-0.20	9	bound	0.08	0.0000
Other	1985-1999	0.06	18	0.742	0.069	0.005
Cadmium						
Root	Current	0.49	9	0.709	0.075	0.034
Root	1985-1999	0.41	19	0.19	0.079	0.082
Other	Current	0.45	9	0.337	0.025	0.038
Other	1985-1999	0.32	18	0.086	0.037	0.107
Lead						
Root	Current	0.66	9	0.257	0.24	0.002
Root	1985-1999	0.61	19	0.066	0.13	0.003
Other	Current	0.60	9	0.156	0.26	0.0099
Other	1985-1999	0.45	18	bound	0	0.014
Thallium						
Root	Current	0.41	9	0.158	0.005	0.014
Other	Current	0.63	9	0.044	5.4×10^{-4}	0.0195
Zinc						
Root	Current	0.43	9	0.884	3.96	0.0016
Other	Current	0.42	9	0.271	3.34	0.018

Note: “bounded” indicates p-value not determined because parameter values were constrained

4.2.4 Relationship between wild mussel concentrations and distance from Belledune Harbour

4.2.4.1 Methodology

Liquid effluent has been released from the Belledune industrial area and potential effects in the environment are expected to be related to the distance from the release point. Given the complexity of water dispersion modeling and uptake by mussels, an empirical relationship was developed. Components of this relationship are an intercept term to account for concentrations that would be present without emissions from the industrial facility, the concentration attributable to emissions present near the release point and a term for decreasing concentration with distance from the facility. An exponential decay model was chosen. The relationship modeled was:

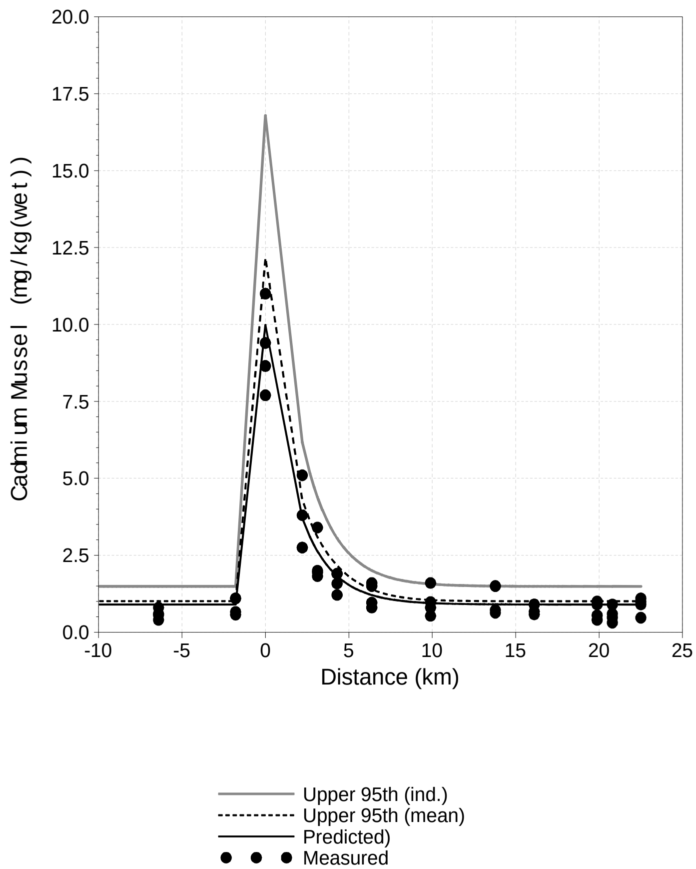
C = m*exp(-lambda d) + b

Where:

C	=	measured concentration in wild mussels with units of mg/kg(wet)
m	=	the concentration in mg/kg(wet) at Belledune Harbour monitoring location attributable to the industrial facilities
lambda	=	exponential decrease with distance
d	=	distance, in m, from release point
b	=	an intercept to account for mussel concentration without contribution from industry.

Figure 4.15 shows the relationship for cadmium concentrations in large wild mussels. Although small mussels were also measured, these concentrations tended to be lower, on average, than concentrations in the large mussels. The relation of large mussels provides a conservative estimate of EPC and reduces the uncertainty of combining large and small mussels in the empirical relationship. Concentrations measured in wild mussels provided by the Noranda EMP for individual years are shown on the plot along with the predicted mean value, the UCL for the predicted mean and the UCL for individual measurements. As seen from the figure, there is a rapid decrease in concentrations as the distance from Belledune Harbour increases. Concentrations level off within a few kilometres to the west and within 5 km or so to the east.

Figure 4.15: Relationship between cadmium concentration in wild mussels and distance from Belledune Harbour



4.2.4.2 Results

Table 4.5 provides the parameter estimates for COPC relationships. The parameter estimate for incremental concentration are higher in earlier time periods than later time periods. This is consistent with decreasing liquid effluent releases from the industrial area. The parameter estimates for exponential decay with distance to the east are relatively stable between time periods and similar between COPC. Parameter estimates for exponential decay to the west are much larger than to the east and are often very large which is consistent with the more rapid drop in concentrations to the west.

Table 4.5: Relationship between wild mussels concentrations and distance

Time Period	Intercept (mg/kg(wet)	Increment (mg/kg(wet)	Lambda(east) per m	Lambda(west) per m
Cadmium				
Current	0.79	8.40	0.00052	0.00269
1984-1999	0.97	20.94	0.00063	0.00236
1975-1984	1.23	39.27	0.00039	$3.89x\ 10^{18}$
Lead				
Current	1.26	50.26	0.00027	5.97×10^{10}
1984-1999	1.84	67.65	0.00033	7.17×10^{9}
1975-1984	1.23	76.26	0.00021	9.12×10^{10}
Thallium				
Current	0.009	0.014	0.00004	36.45
Zinc				
Current	13.56	30.23	0.00022	0.0018

4.2.4.3 Study area concentrations

The empirical relationship was used to estimate the wild mussels concentration for cadmium, lead, thallium and zinc at regularly spaced locations along the shoreline of each study area. At each location, the predicted concentration and the UCLM for the predicted concentration were determined.

4.3 Environmental point concentrations

Estimates of environmental point concentrations (EPCs) were developed by combining historic and ongoing environmental monitoring data and predictions from air dispersion and environmental fate models. The following sections discuss the methodology that was used for developing these estimates.

4.3.1 Air

The EPCs for air were based on the incremental contribution from the industrial area using air dispersion modeling, as discussed in Section 4.2, with adjustments based on comparisons between predictions and monitoring measurements at locations near the industrial area. Table 4.6 shows an example of the average lead concentrations in air for the current period. The best estimate for mean air concentration in a study area was set at the mean concentration after adjustment. Upper bound estimates were set equal to two times the mean predicted concentration for the three core communities. For the two most exposed areas (Townsite #2 and Lower Belledune), the upper bound concentration was set equal to two times the maximum predicted concentration in the area.

Table 4.6: Current period EPC for lead in air (μg/m³)

Location	Best Estimate	Upper Bound
Townsite #2	0.16	0.39
Lower Belledune	0.135	0.58
Belledune	0.04	0.08
Pointe-Verte	0.035	0.07
Petit-Rocher	0.005	0.010

The table of EPCs shows that the mean air concentration in Townsite #2 was predicted to be higher than the mean concentration in Lower Belledune although Lower Belledune is generally downwind from the industrial facilities. Thus, air concentrations in Lower Belledune tend to be higher than the measured concentrations at the Townsite monitoring location and as such should have higher soil concentrations. The fact that the Townsite #2 was predicted to have higher EPCs arises because the average measured concentrations apply to single locations within the study areas as opposed to the best estimate EPC which was developed to estimate the average concentration over the entire study area. The Lower Belledune measured data was from the portion of Lower Belledune closest to the industrial area and where predicted air concentrations were the highest. The Townsite monitor is not in the area with the highest air concentrations present in the Townsite study area and this is why the Townsite #2 EPCs are higher than those of Lower Belledune.

The upper bound EPCs for these two areas were based on air concentrations predicted at the locations with the maximum concentration. The values in Table 4.6 indicate the locations with the highest (upper bound) concentrations were in Lower Belledune and this was consistent with the average measured concentrations and the predominant wind directions. However, there is more variation, or a higher gradient, in air concentrations across Lower Belledune than across Townsite #2. This contributes to a higher average (best estimate) concentration for Townsite #2 than for Lower Belledune. Appendix AB shows the concentration isopleths for lead air concentrations during the current period. Lead concentrations in Townsite #2 range from well above 0.1 μg/m³ to slightly over 2 μg/m³ compared to concentrations in Lower Belledune which range from 0.05 μg/m³ to well over 2 μg/m³.

The EPCs for lead are much lower in Petit-Rocher compared to the Townsite #2 or Lower Belledune.

The EPC for the seventeen combinations of COPC and time periods are summarized in Table 4.7, which gives the best estimate of EPC. Table 4.8 gives the upper bound estimates for EPC. As seen from the tables, air concentrations have decreased substantially from the early time period. For example, the mean lead concentration in Lower Belledune has been estimated to be more the 30 times higher in the 1967-1974 time period than in the current time period.

Table 4.7: Best estimates of EPCs for air (μg/m³)

COPC	Lower Belledune	Townsite	Belledune	Pointe-Verte	Petit-Rocher
Time Period: Current					
Arsenic	0.006	0.009	0.002	0.002	0.0003
Cadmium	0.0025	0.003	0.0008	0.0006	8.90×10^{-5}
Chromium	0.0008	0.009	0.0008	0.0003	3.50×10^{-5}
Dioxins and Furans	1.11×10^{-10}	1.25×10^{-10}	3.18×10^{-11}	3.23×10^{-11}	6.85×10^{-12}
Lead	0.135	0.16	0.04	0.035	0.005
Mercury	0.0002	0.0002	5.90×10^{-5}	5.28×10^{-5}	7.69×10^{-6}
NOx	0.45	0.13	0.19	0.33	0.13
SO_2	4.0	4.5	1.6	1.8	0.38
Thallium	0.0015	0.0019	0.00045	0.0004	5.12×10^{-5}
Zinc	0.008	0.02	0.003	0.002	0.0003
Time Period: 1985-1999					
Arsenic	0.01	0.02	0.004	0.004	0.0006
Cadmium	0.01	0.014	0.004	0.003	0.0004
Lead	0.44	0.50	0.13	0.12	0.02
Time Period: 1975-1984					
Arsenic	0.025	0.03	0.008	0.007	0.001
Cadmium	0.017	0.019	0.005	0.004	0.0006
Lead	0.99	1.12	0.29	0.26	0.037
Time Period: 1967-1974					
Arsenic	0.17	0.20	0.05	0.04	0.008
Cadmium	0.04	0.05	0.01	0.01	0.001
Lead	4.6	5.2	1.4	1.2	0.17

The predicted arsenic EPCs in air range between 0.0003 and 0.009 μg/m³, as indicated in Appendix AB, this range of predicted concentrations are similar to or greater than measurements in major city centers. Similarly, predicted cadmium EPCs are below measurements made in Ontario in 2002 and within the range of the Canadian average baseline concentrations. For lead, the predicted EPCs are higher than the average lead concentrations in Ontario. All other predicted EPCs are well below baseline measured values in Canada.

Table 4.8: Upper bound estimates of EPC for air ($\mu g/m^3$)

COPC	Lower Belledune	Townsite	Belledune	Pointe-Verte	Petit-Rocher
Time Period: Current					
Arsenic	0.027	0.026	0.004	0.0036	0.0006
Cadmium	0.01	0.008	0.0015	0.0013	0.0002
Chromium	0.003	0.044	0.002	0.0005	7.06×10^{-5}
Dioxins and Furans	5.04×10^{-10}	3.21×10^{-10}	6.36×10^{-11}	6.45×10^{-11}	1.37×10^{-11}
Lead	0.58	0.39	0.08	0.07	0.01
Mercury	0.0008	0.0006	0.0001	0.0001	1.54E-05
NOx	1.0	0.45	0.38	0.65	0.26
SO_2	10.9	10.6	3.2	3.6	0.77
Thallium	0.006	0.005	0.0009	0.0007	0.0001
Zinc	0.03	0.09	0.007	0.004	0.0006
Time Period: 1985-1999					
Arsenic	0.06	0.04	0.008	0.008	0.001
Cadmium	0.05	0.03	0.007	0.006	0.0009
Lead	1.9	1.2	0.26	0.23	0.03
Time Period: 1975-1984					
Arsenic	0.11	0.07	0.02	0.01	0.002
Cadmium	0.07	0.05	0.01	0.009	0.001
Lead	4.3	2.6	0.59	0.52	0.07
Time Period: 1967-1974					
Arsenic	0.73	0.48	0.103	0.096	0.015
Cadmium	0.18	0.11	0.02	0.02	0.003
Lead	19.7	12.2	2.7	2.4	0.34

4.3.2 Soil concentrations

The EPCs for soil concentrations were based on combining soil measurement data and the pattern of air dispersion from the Industrial Area. The relationship between measured soil concentration and predicted air concentrations was used to estimate soil concentrations at regularly spaced grids throughout the study areas. An example of this is shown in Appendix AA. The effect of different sources of soil data was explored by developing EPC for soil based on both Noranda and CCNB data. The choice of soil data had no impact on air concentrations, which remained constant and were derived based on the methods explained in Section 4.3.1. The mean of these predictions was considered the best estimate of average soil concentrations at each locations. The upper bound EPC was considered the mean of the UCL at the grid points for the core communities. The maximum UCL of the mean predicted concentrations within the two exposed areas was used as the upper bound EPC for those areas. Table 4.9 shows the EPC for lead in soil for the current period.

Table 4.9: Current period EPC for lead in soil (mg/kg(dry))

Location	Best Estimate	Upper Bound
Townsite	130	230
Lower Belledune	120	330
Belledune	49	67
Pointe-Verte	45	60
Petit-Rocher	24	39

The best estimate EPC for soil in Townsite #2 was higher than the best estimate EPC in Lower Belledune while the upper bound EPC in Townsite #2 was lower than the upper bound EPC in Lower Belledune. This situation arose for the same reason as the pattern for air EPCs; specifically, soil concentrations are more variable across Lower Belledune than across Townsite #2.

EPC were developed using Noranda data for all COPC; however, relationships could not be established for 1967-1974 since measured soil concentrations were not available for that time period. The EPC from 1967-1974 have been set equal to the EPC for 1975-1984.

Table 4.10 shows the best estimate EPC based on the Noranda EMP data. Upper bound EPCs for Noranda EMP are in Table 4.11.

Table 4.10: Best estimate of EPC for soil (mg/kg) using Noranda EMP data

COPC	Lower Belledune	Townsite	Belledune	Pointe-Verte	Petit-Rocher
Time Period: Current					
Arsenic	23	28	15	14	11
Cadmium	1.8	2.2	0.72	0.64	0.29
Chromium	38	38	38	38	38
Dioxins and Furans	$6X10^{-7}$	$6X10^{-7}$	$6X10^{-7}$	$6X10^{-7}$	$6X10^{-7}$
Lead	120	130	49	45	24
Mercury	0.085	0.092	0.068	0.067	0.061
Thallium	0.95	1.1	0.58	0.55	0.43
Zinc	140	160	140	140	140
Time Period: 1985-1999					
Arsenic	33	37	21	20	16
Cadmium	1.6	1.8	0.82	0.77	0.53
Lead	110	120	69	67	52
Time Period: 1975-1984					
Arsenic	30	32	22	21	19
Cadmium	3.5	3.7	2.4	2.3	2
Lead	180	200	120	110	93
Time Period: 1967-1974					
Arsenic	30	32	22	21	19
Cadmium	3.5	3.7	2.4	2.3	2
Lead	180	200	120	110	93

Table 4.1: Upper bound estimates of EPC for soil (mg/kg) using Noranda EMP data

COPC	Lower Belledune	Townsite	Belledune	Pointe-Verte	Petit-Rocher
Time Period: Current					
Arsenic	53	51	18	17	14
Cadmium	5.1	3.5	0.94	0.82	0.48
Chromium	43	43	43	43	43
Dioxins and Furans	$1.2x10^{-6}$	$1.2x10^{-6}$	$1.2x10^{-6}$	$1.2x10^{-6}$	$1.2x10^{-6}$
Lead	330	230	67	60	39
Mercury	0.52	0.43	0.14	0.13	0.11
Thallium	3.1	2.5	0.82	0.74	0.61
Zinc	220	380	160	150	150
Time Period: 1985-1999					
Arsenic	67	50	23	22	18
Cadmium	4.1	2.7	1	0.93	0.69
Lead	270	180	83	78	65
Time Period: 1975-1984					
Arsenic	70	52	27	26	23
Cadmium	6.5	4.7	2.6	2.5	2.2
Lead	510	350	160	150	120
Time Period: 1967-1974					
Arsenic	70	52	27	26	23
Cadmium	6.5	4.7	2.6	2.5	2.2
Lead	510	350	160	150	120

Table 4.12 shows the best estimate and upper bound EPCs for the current period based on the CCNB data. There were no CCNB measurements of dioxins and furans during the current period.

Table 4.12: Best estimate and upper bound EPC estimates for soil (mg/kg) using CCNB data (current period)

COPC	Lower Belledune	Townsite	Belledune	Pointe-Verte	Petit-Rocher
Best Estimates					
Arsenic	32.3	38.7	22.3	21.8	18.3
Cadmium	3.55	4.25	1.09	0.92	0.15
Chromium	40.5	40.5	40.5	40.5	40.5
Lead	244	288	76.3	66.5	12.7
Mercury	0.15	0.19	0.06	0.06	0.03
Thallium	1.68	2.07	0.69	0.61	0.30
Zinc	209	398	147	130	106
Upper Bound					
Arsenic	73.6	71.1	27.8	26.4	23.9
Cadmium	10.2	6.95	1.59	1.35	0.67
Chromium	47.2	47.2	47.2	47.2	47.2
Lead	674	450	109	94.3	46.3
Mercury	0.45	0.36	0.14	0.14	0.13
Thallium	4.81	3.58	1.29	1.19	1.07
Zinc	449	1054	188	163	147

4.3.3 Garden vegetables

The EPC for garden vegetables are based on the summary of monitoring measurements collected from the Noranda EMP program. Table 4.13 shows an example of EPC for cadmium in root vegetables for the current period. The mean of all measured concentrations was used as the best estimate. Upper bound estimates for the core communities were set equal to the UCL of the mean measured value. For the most exposed areas (Townsite #2 and Lower Belledune), the maximum measured concentration for an individual measurement was used.

Table 4.13: Current period EPC for cadmium in root vegetables (mg/kg(wet))

Location	Best Estimate	Upper Bound
Townsite	0.078	0.083
Lower Belledune	0.17	0.18
Belledune	0.10	0.13
Pointe-Verte	0.068	0.088
Petit-Rocher	0.068	0.088

Measured data were available for most time periods and COPC. Arsenic was not measured during the 1967-1974 time period. The EPC for this time period were set equal to the EPC from 1975-1984. Garden measurements were only available in Petit-Rocher for the 1975-1984 time period. The EPC for other time periods were set equal to the Pointe-Verte EPC. There were no measurements of dioxins and furans, chromium and mercury in garden vegetables.

Table 4.14 and Table 4.15 show the best estimates for EPCs in other and root vegetables, respectively. The upper bound estimates for EPCs are in Table 4.16 and Table 4.17.

Table 4.14: Best estimate of EPC for other vegetables (mg/kg(wet))

COPC	Lower Belledune	Townsite	Belledune	Pointe-Verte	Petit-Rocher
Time Period: Current					
Arsenic	0.055	0.077	0.073	0.078	0.078
Cadmium	0.023	0.091	0.058	0.04	0.04
Lead	0.54	1.7	0.82	1.2	1.2
Thallium	0.014	0.026	0.011	0.013	0.013
Zinc	4.8	5.7	6.3	5	5
Time Period: 1985-1999					
Arsenic	0.13	0.076	0.075	0.74	0.74
Cadmium	0.32	0.13	0.13	0.096	0.096
Lead	1.3	0.9	0.73	2.4	2.4
Time Period: 1975-1984					
Arsenic	0.33	0.14	0.23	0.23	0.2
Cadmium	0.8	0.21	0.36	0.26	0.12
Lead	5.1	2.9	3.2	2.5	2.4
Time Period: 1967-1974					
Arsenic	0.33	0.14	0.23	0.23	0.2
Cadmium	0.05	0.11	0.075	0.04	0.04
Lead	0.46	4.3	1.3	0.19	0.19

Table 4.15: Best estimate of EPC for root vegetables (mg/kg(wet))

COPC	Lower Belledune	Townsite	Belledune	Pointe-Verte	Petit-Rocher
Time Period: Current					
Arsenic	0.077	0.058	0.065	0.07	0.07
Cadmium	0.17	0.078	0.1	0.068	0.068
Lead	0.42	0.35	0.34	0.3	0.3
Thallium	0.022	0.02	0.015	0.0088	0.0088
Zinc	5	4.9	4.3	3.6	3.6
Time Period: 1985-1999					
Arsenic	0.043	0.056	0.041	0.092	0.092
Cadmium	0.22	0.12	0.16	0.13	0.13
Lead	0.48	0.29	0.27	0.53	0.53
Time Period: 1975-1984					
Arsenic	0.14	0.12	0.11	0.12	0.044
Cadmium	0.1	0.12	0.12	0.077	0.057
Lead	1.5	1.1	1.4	0.73	2.4
Time Period: 1967-1974					
Arsenic	0.14	0.12	0.11	0.12	0.044
Cadmium	0.047	0.29	0.13	0.05	0.05
Lead	0.29	0.38	0.31	0.17	0.17

Table 4.16: Upper bound estimates of EPC for other vegetables (mg/kg(wet))

COPC	Lower Belledune	Townsite	Belledune	Pointe-Verte	Petit-Rocher
Time Period: Current					
Arsenic	0.06	0.12	0.081	0.12	0.12
Cadmium	0.04	0.34	0.081	0.13	0.13
Lead	0.9	6.3	1.2	2.8	2.8
Thallium	0.02	0.07	0.015	0.031	0.031
Zinc	7.8	16	8.2	7.7	7.7
Time Period: 1985-1999					
Arsenic	0.63	0.27	0.093	2.1	2.1
Cadmium	1.5	0.7	0.16	0.13	0.13
Lead	10	4.8	0.86	5.7	5.7
Time Period: 1975-1984					
Arsenic	3.3	0.61	0.29	0.36	0.31
Cadmium	4.4	0.85	0.47	0.45	0.18
Lead	46	22	4	3.6	4.2
Time Period: 1967-1974					
Arsenic	3.3	0.61	0.29	0.36	0.31
Cadmium	0.2	0.53	0.12	0.29	0.29
Lead	2.4	11	2.4	1.7	1.7

Table 4.17: Upper bound estimates of EPC for root vegetables (mg/kg(wet))

COPC	Lower Belledune	Townsite	Belledune	Pointe-Verte	Petit-Rocher
Time Period: Current					
Arsenic	0.11	0.08	0.077	0.11	0.11
Cadmium	0.18	0.083	0.13	0.088	0.088
Lead	0.5	0.5	0.42	0.56	0.56
Thallium	0.04	0.03	0.019	0.013	0.013
Zinc	8.4	6.1	5.1	5.3	5.3
Time Period: 1985-1999					
Arsenic	0.11	0.15	0.047	0.16	0.16
Cadmium	0.49	0.17	0.18	0.17	0.17
Lead	1.4	0.7	0.31	0.94	0.94
Time Period: 1975-1984					
Arsenic	1.2	0.44	0.14	0.22	0.078
Cadmium	0.38	0.34	0.14	0.13	0.093
Lead	15	3.6	1.8	1.1	6.6
Time Period: 1967-1974					
Arsenic	1.2	0.44	0.14	0.22	0.078
Cadmium	0.12	0.47	0.2	0.05	0.05
Lead	0.37	0.53	0.38	0.17	0.17

4.3.4 Wild game

The EPCs for wild game are based on measurements collected in 2004 from partridge and rabbits captured in the industrial area. The mean of these measurements has been used as the best estimate of EPC for all study areas. The UCL of the mean was used as the upper bound EPC for the three core communities. The maximum measured concentration was used for the upper bound EPC in the most exposed areas. Table 4.18 shows the EPC for lead and the current time period.

Table 4.18: Current period EPC for lead in wild game (mg/kg(wet))

Location	Best Estimate	Upper Bound
Townsite	0.35	1.4
Lower Belledune	0.35	1.4
Belledune	0.35	0.88
Pointe-Verte	0.35	0.88
Petit-Rocher	0.35	0.88

A summary of best estimate EPC in wild game are provided in Table 4.19. The upper bound EPC for wild game in Table 4.20.

Table 4.19: Best estimate of EPC for wild game (mg/kg(wet))

COPC	Lower Belledune	Townsite	Belledune	Pointe-Verte	Petit-Rocher
Time Period: Current					
Arsenic	0.25	0.25	0.25	0.25	0.25
Cadmium	0.034	0.034	0.034	0.034	0.034
Chromium	0.25	0.25	0.25	0.25	0.25
Lead	0.35	0.35	0.35	0.35	0.35
Mercury	0.005	0.005	0.005	0.005	0.005
Thallium	0.025	0.025	0.025	0.025	0.025
Zinc	6.7	6.7	6.7	6.7	6.7

Table 4.20: Upper bound estimate of EPC for wild game (mg/kg(wet))

COPC	Lower Belledune	Townsite	Belledune	Pointe-Verte	Petit-Rocher
Time Period: Current					
Arsenic	0.25	0.25	0.25	0.25	0.25
Cadmium	0.08	0.08	0.058	0.058	0.058
Chromium	0.25	0.25	0.25	0.25	0.25
Lead	1.4	1.4	0.88	0.88	0.88
Mercury	0.005	0.005	0.005	0.005	0.005
Thallium	0.025	0.025	0.025	0.025	0.025
Zinc	9.9	9.9	9.7	9.7	9.7

4.3.5 Well water

The EPC for well water are summaries of measurement data provided from Belledune and DELG. The mean concentration from a study area was used as the best estimate EPC and the UCL of the mean was considered the upper bound estimate. Due to confidentiality considerations separate summaries for Lower Belledune and Townsite areas could not be established. The Belledune EPC was used for Lower Belledune and Townsite areas. As indicated in Section 2.0, this assessment assumed that residents in Townsite #2 were on well water supplies. Table 4.21 shows the best estimate EPC for arsenic in well water during the current period.

Table 4.21: EPC estimates for arsenic in well water (µg/L)

Location	Best Estimate	Upper Bound
Townsite	5.0	7.4
Lower Belledune	5.0	7.4
Belledune	5.0	7.4
Pointe-Verte	3.2	4.9
Petit-Rocher	0.83	1.2

The table shows the EPC for arsenic in Belledune at 5.0 µg/L to be larger than the EPC for either Pointe-Verte or Petit-Rocher; however, this is likely to be due to natural variability as some communities outside the GBA have higher concentrations as shown in Appendix AA.

Table 4.22 gives the best estimate and upper bound EPCs for well water. These EPC were applied to all time periods.

Table 4.22: EPC Estimates for well water (µg/L)

COPC	Lower Belledune	Townsite	Belledune	Pointe-Verte	Petit-Rocher
Best Estimate					
Arsenic	5	5	5	3.2	0.83
Cadmium	0.22	0.22	0.22	0.23	0.21
Chromium	1.3	1.3	1.3	9.5	13
Lead	1.3	1.3	1.3	2.5	1.7
Thallium	0.073	0.073	0.073	0.57	0.5
Zinc	55	55	55	53	22
Upper Bound					
Arsenic	7.4	7.4	7.4	4.9	1.2
Cadmium	0.24	0.24	0.24	0.26	0.32
Chromium	1.5	1.5	1.5	12	22
Lead	1.8	1.8	1.8	3.5	3.2
Thallium	0.094	0.094	0.094	0.71	0.5
Zinc	82	82	82	71	44

4.3.6 Seafood

The EPC for fish are based on measurements made prior to 1985. The best estimate was set equal to the mean concentration and this value was used for all study areas since fish are considered mobile in the Baie des Chaleurs. The upper bound for all areas was set equal to the UCL of the mean of the measured data. Table 4.23 shows the EPC for lead in fish.

Table 4.23: Current period EPC for lead in fish (mg/kg(wet))

Location	Best Estimate	Upper Bound
Townsite	2.8	3.6
Lower Belledune	2.8	3.6
Belledune	2.8	3.6
Pointe-Verte	2.8	3.6
Petit-Rocher	2.8	3.6

The same fish EPCs were used for all time periods. This likely overestimates current EPC since liquid effluents decreased substantially in the early 1980s and decreases have been observed in wild mussels and lobster over time. There were no measured data for dioxins and furans, chromium and thallium and thus these COPC were not assessed for the fish pathway.

A summary of best estimate EPC in fish are provided in Table 4.24. The upper bound EPCs for fish are in Table 4.25.

The EPCs for lobster and wild mussels are based on the data discussed in Section 4.1.2.5. The EPCs in wild mussels for cadmium, lead, thallium and zinc were based on an empirical relationship between measured data and distance from the industrial facilities.

The mean of the predicted concentrations along the shoreline of the study area was used as the best estimate EPC for average concentrations in the study areas. For the most exposed areas (Townsite #2 and Lower Belledune), the upper bound was set equal to the UCLM at the location with the highest concentrations in order to provide a conservative estimate of the highest concentrations present within the study area. The upper bound EPCs for the core communities were set equal to the average of the UCLM at locations along the shore line. The EPCs for Belledune were based on combining data west of the industrial area and the data for Lower Belledune.

Arsenic and mercury EPCs were calculated from measured data collected from multiple sources and did not differentiate by size, large or small, of the wild mussels. For Townsite #2, the best estimate EPC was set equal to the mean concentration measured in Belledune west of the restricted fishery area in the industrial area. Concentrations for other study areas followed the groupings described in Table 4.1. The EPCs for Belledune were based on combining data west of the industrial area and the data for Lower Belledune. Upper bound EPC for arsenic and mercury were calculated as the UCLM of the data for the study area. With the exception of one measurement of arsenic west of the industrial area, the data was from the 1975-1984 period.

Lobster EPCs were based on measured data and calculated in the manner described above for arsenic and mercury in wild mussels.

A summary of the best estimate EPCs in lobster and wild mussels are provided in Tables 4.26 and 4.28 respectively. The upper bound EPCs for lobster and wild mussels are provided in Tables 4.27 and 4.29 respectively. There were no measured data for dioxins and furans and chromium and thus these COPC were not assessed for the lobster and wild mussel pathways.

Table 4.24: Best estimate of EPC for fish (mg/kg(wet))

COPC	Lower Belledune	Townsite	Belledune	Pointe-Verte	Petit-Rocher
Time Period: Current					
Arsenic	0.44	0.44	0.44	0.44	0.44
Cadmium	0.069	0.069	0.069	0.069	0.069
Lead	2.8	2.8	2.8	2.8	2.8
Mercury	0.081	0.081	0.081	0.081	0.081
Zinc	16	16	16	16	16
Time Period: 1985-1999					
Arsenic	0.44	0.44	0.44	0.44	0.44
Cadmium	0.069	0.069	0.069	0.069	0.069
Lead	2.8	2.8	2.8	2.8	2.8
Time Period: 1975-1984					
Arsenic	0.44	0.44	0.44	0.44	0.44
Cadmium	0.069	0.069	0.069	0.069	0.069
Lead	2.8	2.8	2.8	2.8	2.8
Time Period: 1967-1974					
Arsenic	0.44	0.44	0.44	0.44	0.44
Cadmium	0.069	0.069	0.069	0.069	0.069
Lead	2.8	2.8	2.8	2.8	2.8

Table 4.25: Upper bound estimate of EPC for fish (mg/kg(wet))

COPC	Lower Belledune	Townsite	Belledune	Pointe-Verte	Petit-Rocher
Time Period: Current					
Arsenic	0.56	0.56	0.56	0.56	0.56
Cadmium	0.079	0.079	0.079	0.079	0.079
Lead	3.4	3.4	3.4	3.4	3.4
Mercury	0.11	0.11	0.11	0.11	0.11
Zinc	18	18	18	18	18
Time Period: 1985-1999					
Arsenic	0.44	0.44	0.44	0.44	0.44
Cadmium	0.069	0.069	0.069	0.069	0.069
Lead	2.8	2.8	2.8	2.8	2.8
Time Period: 1975-1984					
Arsenic	0.44	0.44	0.44	0.44	0.44
Cadmium	0.069	0.069	0.069	0.069	0.069
Lead	2.8	2.8	2.8	2.8	2.8
Time Period: 1967-1974					
Arsenic	0.44	0.44	0.44	0.44	0.44
Cadmium	0.069	0.069	0.069	0.069	0.069
Lead	2.8	2.8	2.8	2.8	2.8

Table 4.26: Best estimate of EPC for lobster (mg/kg(wet))

COPC	Lower Belledune	Townsite	Belledune	Pointe-Verte	Petit-Rocher
Time Period: Current					
Arsenic	2.25	1.91	2.17	2.07	1.87
Cadmium	0.025	0.02	0.02	0.02	0.02
Lead	0.32	0.18	0.28	0.20	0.19
Mercury	0.14	0.125	0.13	0.12	0.1
Zinc	22.7	22.8	22.8	25.0	25.8
Time Period: 1985-1999					
Arsenic	3.19	3.07	3.15	3.23	3.79
Cadmium	0.05	0.03	0.04	0.04	0.04
Lead	0.39	0.33	0.38	0.33	0.15
Time Period: 1975-1984					
Arsenic	3.19	3.07	3.15	3.23	3.79
Cadmium	0.19	0.07	0.14	0.13	0.06
Lead	1.31	0.33	1.31	0.33	0.15
Time Period: 1967-1974					
Arsenic	3.19	3.07	3.15	3.23	3.79
Cadmium	0.19	0.19	0.19	0.115	0.115
Lead	3.4	3.4	3.4	0.25	0.25

Table 4.27: Upper bound estimate of EPC for lobster (mg/kg(wet))

COPC	Lower Belledune	Townsite	Belledune	Pointe-Verte	Petit-Rocher
Time Period: Current					
Arsenic	3.16	4.52	2.87	4.70	5.02
Cadmium	0.03	0.03	0.03	0.03	0.04
Lead	0.41	0.37	0.36	0.32	0.35
Mercury	0.16	0.14	0.15	0.17	0.11
Zinc	24.7	45.6	23.8	49.9	51.5
Time Period: 1985-1999					
Arsenic	3.44	3.44	3.36	3.70	4.27
Cadmium	0.053	0.036	0.05	0.04	0.04
Lead	0.50	0.80	0.48	0.59	0.27
Time Period: 1975-1984					
Arsenic	3.44	3.44	3.36	3.70	4.27
Cadmium	0.24	0.13	0.19	0.24	0.13
Lead	2.62	0.80	2.62	0.59	0.27
Time Period: 1967-1974					
Arsenic	3.44	3.44	3.36	3.70	4.27
Cadmium	0.47	0.47	0.47	1.07	1.07
Lead	15.1	15.1	15.1	0.89	0.89

Table 4.28: Best estimate of EPC for wild mussels (mg/kg(wet))

COPC	Lower Belledune	Townsite	Belledune	Pointe-Verte	Petit-Rocher
Time Period: Current					
Arsenic	2.11	1.58	2.11	1.63	1.55
Cadmium	2.13	0.81	1.00	1.01	0.79
Lead	20.3	1.26	4.23	8.02	1.87
Mercury	0.05	0.05	0.05	0.05	0.04
Thallium	0.02	0.01	0.01	0.02	0.02
Zinc	27.4	14.1	15.8	19.5	14.4
Time Period: 1985-1999					
Arsenic	1.83	1.58	1.7	1.63	1.55
Cadmium	3.28	1.07	1.34	1.26	0.97
Lead	22.6	1.84	5.09	7.91	2.16
Time Period: 1975-1984					
Arsenic	1.83	1.58	1.7	1.63	1.55
Cadmium	10.9	1.23	2.75	3.57	1.30
Lead	36.7	1.23	6.77	16.7	3.6
Time Period: 1967-1974					
Arsenic	1.83	1.58	1.7	1.63	1.55
Cadmium	10.9	1.23	2.75	3.57	1.30
Lead	36.7	1.23	6.77	16.7	3.6

Table 4.29: Upper bound estimate of EPC for wild mussels (mg/kg(wet))

COPC	Lower Belledune	Townsite	Belledune	Pointe-Verte	Petit-Rocher
Time Period: Current					
Arsenic	4.22	2.39	4.22	2.01	3.46
Cadmium	3.30	1.31	1.26	1.23	1.03
Lead	28.7	3.58	6.66	10.3	3.91
Thallium	0.04	0.03	0.03	0.04	0.04
Mercury	0.08	0.08	0.08	0.10	0.13
Zinc	33.2	19.4	18.5	21.9	16.5
Time Period: 1985-1999					
Arsenic	2.44	2.39	2.07	2.01	3.46
Cadmium	5.81	2.26	1.92	1.75	1.51
Lead	33.8	4.66	8.03	10.5	4.80
Time Period: 1975-1984					
Arsenic	2.44	2.39	2.07	2.01	3.46
Cadmium	18.0	3.16	4.78	5.31	3.16
Lead	53.1	10.3	15.8	24.9	10.96
Time Period: 1967-1974					
Arsenic	2.44	2.34	2.07	2.01	3.46
Cadmium	18.0	3.15	4.78	5.31	3.16
Lead	53.1	10.3	15.8	24.9	10.96

4.3.7 Summary EPC statistical values and data gaps

4.3.7.1 Statistical values used for EPCs

Table 4.30 summarizes the statistical values used to estimate EPCs. The best estimate for the study areas was set equal to the mean of measurement data or the mean predicted concentration based from air dispersion modeling or empirical models. This applied to EPCs for core communities and the two most exposed areas. This approach provides an estimate of EPCs averaged over the study area that does not intentionally over- or under-estimate concentrations.

Upper bound EPCs for the core communities were used to address uncertainty in the best estimate EPCs. The upper confidence limit of the mean (UCLM) was used to provide an upper bound estimate of the mean EPC in the study area that is unlikely to be exceeded. Since 95% two-sided confidence intervals were used, there is less than a 2.5% chance that the mean concentration exceeds the upper bound EPCs. This approach was used for all pathways with the exception of air for which a factor was applied to the best estimate. There were insufficient monitoring data to establish statistically-based UCLMs for the air pathway.

The upper bound EPCs for the most exposed study areas, Townsite #2 and Lower Belledune, were calculated differently than the upper bound EPC for the core communities. These EPCs provide an upper bound estimate for those locations where the environmental concentrations were highest within the most exposed study area. These EPCs provide a conservative upper bound of concentrations for the most exposed people. The UCLM at the location with the highest modelled concentration was used for pathways where air dispersion or empirical modelling values were used to estimate EPCs. The exception was the air pathway where multiplying by a factor of two was used to estimate the upper bound EPC. For backyard vegetable and wild game pathways the maximum concentrations in the study area were used as the upper bound EPCs due to the small amount of data in those areas. For wellwater, fish, lobster and wild mussel concentrations of the arsenic and mercury, the upper bound was set equal to the UCLM of the measured data.

Table 4.30: Statistical values used for EPCs

Pathway	Best Estimate (all study areas)	Upper Bound for Most Exposed Areas (Townsite #2, Lower Belledune)	Upper Bound for Core Communities (Belledune, Pointe-Verte, Petit-Rocher)
Air	mean from air dispersion model estimate	2 * model estimate at location with highest concentration	2 * mean model estimate
Soil	mean from empirical model	UCLM from empirical model at location with highest predicted concentration	UCLM from empirical model
Well water	mean from measurements	UCLM from measured	UCLM from measured
Vegetables	mean from measurements	maximum measured	UCLM from measured
Wild Game	mean from measurement	maximum measured	UCLM from measured
Fish	mean from measurements	UCLM from measured	UCLM from measured
Lobster	mean from measurements	UCLM from measured	UCLM from measured
Wild Mussels	mean from empirical model (cadmium, lead, thallium, zinc) mean from measured (arsenic, mercury)	UCLM from empirical model at location with highest predicted concentration (cadmium, lead, thallium, zinc) UCLM from measured (arsenic, mercury)	UCLM from empirical model (cadmium, lead, thallium, zinc) UCLM from measured (arsenic, mercury)

4.3.7.2 Summary of infilling and data gaps for current time period

Table 4.30 summarizes the EPCs calculated for the current time period. Those EPCs that were based on infilling with EPCs from other study areas and those COPC without and EPC estimated for a pathway are shown. Infilling occurred when no measured data or modeling values from the study area during the time period were available. In some cases, EPCs from another study area or time period were used to infill this data gap. The major infilling was use of data from 1972-1980 to calculate fish EPCs for the current period and the use of wild game concentrations measured from the industrial area as the EPC for all study areas. EPCs for dioxins and furans were only available for air and soil. EPCs for chromium, mercury and thallium were not available for some pathways.

Table 4.31: Summary of EPC developed for current period risk assessment

	COPC	Townsite #2	Lower Belledune	Belledune	Pointe-Verte	Petite Rocher
Air	complete	✓	✓	✓	✓	✓
Soil	complete	✓	✓	✓	✓	✓
Well water	no dioxins and furans or mercury	same as Belledune, includes data prior to 2000	same as Belledune, includes data prior to 2000	includes data prior to 2000	includes data prior to 2000	includes data prior to 2000
Root and Other Vegetables	no dioxins and furans, mercury or chromium	✓	✓	✓	✓	used Pointe-Verte values
Wild Game	no dioxins and furans	data from industrial area	data from industrial area	data from industrial area	data from industrial area	data from industrial area
Fish	no dioxins and furans, chromium or thallium	data from local Baie des Chaleurs during 1972-1980	data from local Baie des Chaleurs during 1972-1980	data from local Baie des Chaleurs during 1972-1980	data from local Baie des Chaleurs during 1972-1980	data from local Baie des Chaleurs during 1972-1980
Lobster	no dioxin and furans or chromium	✓	✓	✓	✓	✓
Mussels	no dioxins and furans or chromium	mercury from earlier time period	arsenic and mercury from earlier time period	mercury from earlier time period	arsenic and mercury from earlier time period	arsenic and mercury from earlier time period

Note: ✓ indicates that EPC based on concentrations measured within the study area during the time period

4.4 Uncertainty and data gaps in environmental concentrations

Environmental monitoring of lead, arsenic, zinc and cadmium has been extensive in the Belledune area. Integration of monitoring data with physical and empirical models provided sufficient characterization for HHRA purposes for these COPC with the possible exception of wild game.

Existing environmental data are not available for some combinations of COPC, media, location and time period. Some of these concentrations have been estimated using empirical models based on site-specific data; however, mathematical and physical models are required to estimate some of the other concentrations.

4.4.1 COPC with limited or no environmental measurements

There were no measurements in some media for dioxins and furans, mercury and chromium. For other environmental media, there were a limited number of monitoring data . There was no information available for concentrations of dioxins and furans in backyard vegetables, well water or seafood. The limited 2004 concentrations in forage and strawberries suggested that dioxins and furans were of negligible significance in the garden vegetable exposure pathway, while concentrations in other ingestion exposure pathways (excluding soil) were simply not available. Therefore, the assessment of dioxins and furans was only related to soil and air. This adds to the uncertainty in the assessment and will be discussed in more detail in Section 7.

There were limited mercury data for most environmental media. The majority of the available information for mercury was for seafood, while additional information was available on mercury levels in wild game. Air and soil concentrations were predicted based on air dispersion modeling methods with a small number of soil measurements available for establishing the relationship between air concentration and soil concentration. Only a limited number of exposure pathways were considered for mercury in the HHRA. Section 7 will discuss this data gap in more detail.

Chromium concentrations were not provided in backyard vegetables. Data presented above suggest that chromium is a minor COPC with little relationship with proximity to the industrial area. Chromium was not considered in the earlier time periods and therefore this information gap was not important. The lack of chromium data in backyard vegetables will be discussed in Section 7.

4.4.2 Air

Air concentrations of some COPC were measured at only three locations within the community. To supplement this data, air dispersion modeling was used to predict air concentrations of all COPC throughout the study areas for current and historical time periods. Uncertainty in the air dispersion modeling was reduced by applying adjustment factors in order to match the predicted concentrations with the measured air concentrations at the three monitoring locations.

There is likely to be some overestimation of air concentrations as distance from the industrial area increases since deposition from the air was not included in the air dispersion model. There is substantial uncertainty in the predicted air concentrations in the past due to uncertainty in the total emissions, possible variation in the relative contribution of fugitive emissions in the past and the lack of air measurements for developing specific adjustments for those time periods.

The empirical relationship between measured soil concentrations and predicted air concentrations from the industrial area suggests that the air dispersion modeling is consistent with the deposition pattern of soil concentrations.

4.4.3 Soil

There appear to be systematic differences in soil concentrations measured by the Noranda EMP and by the CCNB, with higher concentration values measured by CCNB. The reason for this is currently unknown, but could be resolved by a comparison study including an inter-laboratory comparison of split samples and a comparison of sample collection and preparation methods. For this study, exposures were calculated using both sources of soil monitoring data.

Empirical relationships were used to estimate EPCs for the study area. The statistical significance present in these relationships combined with the anticipated pattern of soil concentrations due to air deposition suggests that the approach provides a useful estimate of mean soil concentrations within the study areas. It is unlikely that the soil relationships have underestimated soil concentrations attributable to airborne deposition. The UCL from the regression provide a quantitative measure of the uncertainty in using these relationships.

A small number of locations exhibited soil concentrations that were substantially above the concentrations arising from deposition alone. These locations were not residential and the intakes or risks from these locations have been handled as a special case in Section 7.4.11.

4.4.4 Backyard vegetables

There are relatively few measurements during the current period for all study areas and this results in the EPC best estimates and upper bounds being more uncertain than EPCs for earlier time periods. Additional monitoring would reduce the uncertainty in these concentrations.

For example, uncertainty exists in the cadmium concentrations in root garden vegetables collected in Townsite #2, because of only 3 measurements made, one appeared to be abnormally high. This anomalously high data point was used in the estimation of both average and upper bound cadmium concentrations for Townsite #2. This data point could not be excluded due to the very small sample size, and was thus identified as contributing large uncertainty to cadmium concentrations in garden vegetables in Townsite #2.

Uncertainty is introduced into backyard vegetable concentrations for Petit-Rocher, because most of its concentrations were extrapolated from other areas or time periods. Concentrations in Petit-Rocher garden vegetables were only available for 1975-1984, and these concentrations were assumed to also represent concentrations during 1967-1974. It is uncertain whether this assumption would under- or over-estimate concentrations in Petit-Rocher during this period. Garden vegetable concentrations in Pointe-Verte were used to estimate concentrations in Petit-Rocher during the 1985-1999 and current time periods, and this is expected to conservatively over-estimate concentrations during these periods.

4.4.5 Well water

Uncertainty is present in the well water characterization due to the lack of precise locations for the wells and large variation in concentrations likely attributable to natural geochemistry. It has been assumed that industrial area contribution to well water concentrations within the community is small compared to the baseline variability.

The reporting limits for well water concentration varied between the two sources of information. This introduces some uncertainty in comparisons of well water concentrations and intakes between different study areas. For example, the estimated mean of 0.5 µg/L for thallium in the DELG where values were reported as <1 µg/L data is large compared to a mean measured value of 0.07 µg/L in the measurements provided by Belledune where the reporting limit was <0.1 µg/L. A similar situation occurs for chromium.

4.4.6 Seafood

Uncertainty in the seafood data arose because fish, lobster and mussel data were not available for all contaminants for all time periods. These data gaps were filled using concentrations from preceding or subsequent time periods and/or from nearby study areas.

There is large uncertainty in the current period COPC concentrations in fish since they are based on measurement data that precede 1980. Current COPC concentrations are likely to be lower due to the early 1980's reduction in liquid effluent releases from the Belledune industrial facilities. However, new data are needed to confirm this hypothesis.

4.4.7 Wild game

No wild game COPC concentrations were available prior to 2004. As a result, 2004 COPC concentrations were assumed in order to estimate historical exposures. This assumption is associated with a large amount of uncertainty, and is thought to possibly underestimate historical exposures. This is because wild game concentrations are anticipated to have been higher in the past due to higher environmental concentrations at that time. However, the 2004 wild game concentrations are thought to overestimate current wild game concentrations because the animals were captured inside the industrial area, where environmental concentrations tend to be higher. Further uncertainty arises due to the small sample size available for wild game (n=3 for both partridge and rabbit).

4.5 Summary of data considered in the assessment

As described above, there are a number of uncertainties in the soil data, vegetation data and fish data. In order to address some of these uncertainties different assessments of the data were done. Table 4.32 provides a summary of the different analyses considered in the HHRA. As seen from the table, the main analyses involved the use of the Noranda EMP data. This data was considered because it was collected historically as well as currently and involved a variety of different media. For the historical assessment, a separate analysis was conducted considering the use of modeled data for backyard vegetables as opposed to measured data to determine whether the exposures would likely be different. Another separate analysis was done removing the wild game pathway to determine whether there would be a significant different in exposures. Section 7 provides the results of these different analyses. For the current assessment, measurement data served as the main basis of assessment using the Noranda EMP. Separate analyses were carried out considering the following:

- CCNB soil data
- Modeled backyard vegetable concentrations

The results of these analyses are presented in Section 7.0.

Table 4.32: Summary of the different analyses considered in the HHRA

Pathways	Historical Time Periods	Current Time Period
Air	Modeled	Modeled
Soil	Empirical Relationship with Air (Noranda)	Empirical Relationship with Air (Noranda) *Empirical Relationship with Air (CCNB)*
Well Water	Measured	Measured
Back yard Vegetables	Measured and *Empirical Relationship with Soil*	Measured and *Empirical Relationship with Soil*
Local Fish	Measured	**Application of historical data set**
Local Lobster	Measured	Measured
Wild Mussels	Measured	Measured and empirical relationship with distance for Cd, Pb, Ti and Zn
Wild Game	Not considered	Measured

Note: Regular type indicates the main assessment
Italics indicates secondary assessments that were carried out
Bold type indicates that these were considered in the assessment but were highly uncertain

5.0 Exposure assessment

People come into contact with COPC in a variety of ways: breathing contaminated air, touching contaminated soil, consuming contaminated water, soil or food. For all of these pathways of exposure, the exposure assessment estimates the quantity of a given quantity that can reach the person's lungs, digestive system or skin. Thus, the exposure assessment comprises three elements:

- determination of potential exposure pathways;
- frequency and duration of actual and/or potential exposure;
- estimation of the magnitude of exposure.

5.1 Exposure pathways considered

Residents in Belledune and its vicinity can be exposed to COPC via different exposure routes including inhalation, ingestion and dermal (skin) contact. There are several components of the ingestion route such as ingestion of soil, consumption of backyard produce, wildlife and fish and ingestion of water. These components are known as pathways of exposure and contribute to the total daily exposures. Figure 2.1 (in Section 2.1) provides a conceptual model of the site. From this model it was determined that the pathways considered in the assessment were:

- inhalation of COPC from air;
- ingestion of COPC in well water;
- ingestion of COPC in backyard produce;
- ingestion of COPC in fish and local shellfish from the Baie des Chaleurs;
- ingestion of COPC in wildlife;
- ingestion of COPC in soil/dust;
- dermal contact with COPC in soils.

Ingestion of supermarket foods was also considered for the Belledune Area HHRA, but this pathway was not included in the conceptual model because concentrations of COPC are not derived from the local environment. COPC concentrations in supermarket foods are extremely variable, as foods are imported from different national and international sources. It is recognized that residents in Townsite #2 may be municipally supplied from a surface water source at Jacquet River; however, this source is not influenced by the industrial facilities and thus, it is assumed that these residents obtain their drinking water from wells that could be potentially impacted by the industrial facilities.

5.2 Frequency, magnitude and duration of exposure

In risk assessment, there are generic exposure factors available to describe typical patterns of behaviour of the receptors such as how much water they drink and how much backyard produce they consume. These factors are assumed to govern the exposures experienced by residents in the Belledune area and vicinity. There are several sources that present this information such as the *U.S. EPA Exposure Factors Handbook* (U.S. EPA 1997) and the *Compendium of Canadian Exposure Factors* (Richardson 1997). Health Canada in a recent document entitled *Guidance on Human Health Screening Level Risk Assessment* (Health Canada 2003) has summarized the data from a number of these sources and this summary is used in this assessment. Table 5.1 summarizes the receptor characteristics that were used in this assessment. Dietary characteristics are presented separately.

The receptor characteristics from Health Canada (2003) are widely used in risk assessment. This source has been peer reviewed and the primary data on which it is based are considered to be scientifically sound.

Table 5.1: Summary of receptor characteristics considered for this assessment

Receptor Characteristic	Infant	Toddler	Child	Teen	Adult	Source
Age	0 - 6 mo	7 mo - 4 yr	5 - 11 yr	12 - 19 yr	20+ yr	HC 1994
Body Weight (kg)	8.2	16.5	32.9	59.7	70.7	Richardson 1997
Soil Ingestion Rate (g/d)	0.02	0.08	0.02	0.02	0.02	CCME 1996, MADEP 2002
Inhalation Rate (m^3/d)	2.1	9.3	14.5	15.8	15.8	Richardson 1997, Allan and Richardson 1998
Water Ingestion Rate (L/d)	0.3	0.6	0.8	1.0	1.5	Richardson 1997
Skin Surface Area (cm^2)						
Hands	320	430	590	800	890	Richardson 1997
Arms	550	890	1480	2230	2500	Richardson 1997
Legs	910	1690	3070	4970	5720	Richardson 1997
TOTAL	1780	3010	5140	8000	9110	Richardson 1997
Soil Loading to exposed skin (kg/cm^2/event)	2.62×10^{-8}	2.29×10^{-8}	2.03×10^{-8}	1.90×10^{-8}	1.88×10^{-8}	Kissel *et al.* 1996; 1998

Source: Adapted from Health Canada 2003.

5.2.1 Dietary characteristics

The New Brunswick Health and Wellness Department and the Universities of Moncton and New Brunswick recently published a study entitled *New Brunswick Nutrition Survey* (May 2004). This document presents the findings of the 1996 to 1997 New Brunswick Nutrition Survey, which was the first major survey in New Brunswick since 1972 and considered both eaters and non-eaters of all food groups surveyed. The report focused on weight status, intake of nutrients and selected foods, the contribution of food groups to nutrient intakes, health and nutrition-related attitudes and behaviour, and food security. The information provided in the document is not sufficient for risk assessment purposes on its own but was combined with information from *Guidance on Human Health Screening Level Risk Assessment* (Health Canada 2003) to determine the dietary characteristics of the people in the Belledune area.

5.2.1.1 New Brunswick Nutrition Survey

The New Brunswick Nutrition Survey (2004) was conducted from 1996-97 on men and women between the ages of 18-74 years who were considered eligible for provincial Medicare health insurance coverage. The study made use of several different survey techniques, and those relating to the food consumption rates of interest in HHRA included both 24-hour recall and food frequency methods. Individuals were selected using a stratified single-stage random sampling design, and were sampled over the course of two seasons; fall 1996 (September 1996 to January 1997) and spring 1997 (April to July). In order to achieve a probability sample, samples from more than 2,000 people were needed, and thus 2,423 and 2,076 people were sampled in spring and fall, respectively. An attempt was made to interview different individuals in person on each day of the week, and one-third of all samples were randomly selected as repeats.

The 24-hour recall study component was conducted in a way in which food weight was either documented or estimated. Food frequency questionnaires were then used to estimate food intake patterns in the longer term, as they questioned respondents about how frequently they consumed certain food during the past month. These questionnaires were dispensed following the 24-hour recall.

Data from the New Brunswick Nutrition survey that were considered in the development of the dietary characteristics were the adult intake rates (as portions/day) specific for consumption of fish, lobster and shellfish. As described above, the New Brunswick Nutrition survey employed 24-hour dietary recall methods and a food frequency questionnaire. The survey presented adult fish, shellfish and lobster yearly-averaged intake rates (portions/day) collected for different communities across New Brunswick, and also provided province-wide rates that were broken down by age and gender. Communities of relevance to the Belledune area included Campbellton and Bathurst, New Brunswick because it was assumed they would have similar fish and seafood consumptions habits. Province-wide age and gender-specific fish and seafood intake rates were compared to rates derived by geographic region in order to select the most appropriate rates that were conservative representations of intakes in the Belledune area. Table 5.2 provides a summary of the data considered in the assessment.

As seen from Table 5.2, mean yearly-averaged intake rates for fish (as portions/day) for Campbellton and Bathurst were 0.22 and 0.25, respectively, while maximum fish intakes rates were 2.10 and 3.00, respectively. Fish intake rates for these communities were deemed to be significantly higher than province-wide rates, and thus, fish intake rates for Bathurst were adopted for use in the Belledune area HHRA. Lobster and shellfish intake rates for Campbellton and Bathurst were captured in the province-wide rates, and thus the use of the province-wide values was considered appropriate. In order to ensure that exposures were not underestimated in the GBA, it was assumed that the seafood eater consumed average amounts of fish, lobster and shellfish. However, separate analyses were carried out for the maximum fish, lobster and shellfish consumers separately to capture individuals who consume large amounts of seafood. It should be noted that individuals who consume large amounts of seafood only represent a very small portion of the New Brunswick population.

Table 5.2: Summary of fish and seafood intake rates considered for this assessment

	Fish Intake Rate (portions/d)		Shellfish Intake Rate (portions/d)		Lobster Intake Rate (portions/d)	
	Average	Max	Average	Max	Average	Max
Breakdown of New Brunswick Survey by Age Range						
18-34 yrs	0.16	2.06	0.04	1.00[1]	0.01	0.35
35-49 yrs	0.17	2.35	0.04[2]	0.81	0.01	0.32
50-64 yrs	0.19	2.18	0.03	0.70	0.01	0.86
65-74 yrs	0.18	2.69	0.02	0.97	0.005	0.16
Mean – All ages	0.17	2.32	0.03	0.87	0.01	0.42
Breakdown by Geographic Community						
Campbellton, NB	0.22	2.10	0.05	0.71	0.01	0.86
Bathurst, NB	0.25	3.00	0.05	1.43	0.01	0.48
Selected for Belledune HHRA	0.25	3.00	0.03	0.87	0.01	0.42

Notes: 1 – The value of 1.00 is an average intake rate for males and females, and the maximum intake rate of 1.43 for males 18-34 years old is captured in this rate.

2 – The value of 0.04 is an average intake rate for males and females, and the rate of 0.05 for males 35-49 years old is captured in this rate.

For use in the HHRA, the selected yearly-averaged fish and seafood rates were converted into rates in grams/day. This conversion was performed by estimating an average portion weight of 74 g per serving of fish and 200 g per serving of shellfish and lobster, respectively (New Brunswick Department of Health and Wellness, 2004). This is equivalent to eating a 3 oz fish slice, a 1lb lobster with the shell on or 1lb of mussels. From the selected intake rates, it was indicated that for an average adult, approximately 0.25 daily portions of 74 g of fish (0.25 x 74 = 18.5 g/day) are consumed, while for a maximally exposed adult, 3.00 daily portions (3.00 x 74 = 222 g/day) are consumed (i.e., 1/2lb fish meal a day). For an average adult consuming shellfish, about 0.031 portions of 200g of shellfish (0.031 x 200 g = 6.3 g/day) are consumed (i.e. an equivalent of approximately 5 lbs of mussels over a year), while for a maximally exposed adult, 0.869 daily portions (0.869 x 200 = 173.8 g/day) are consumed (i.e., approximately 1lb of mussels every day over a year). For an average adult consuming lobster, about 0.009 daily portions of 200 g of lobster (0.009 x 200 = 1.8 g/day) are consumed (i.e. equivalent to 3 one pound lobsters over the year), while for a maximally exposed adult, 0.42 daily portions (0.42 x 200 = 84 g/day) are consumed (i.e., 1 lb of lobster every other day for a year).

The New Brunswick Nutrition Survey (2004) does not breakdown shellfish into mussels, oysters, clams etc. For the purposes of this assessment, it has been assumed that all the shellfish intakes were equivalent to the intake of wild mussels from the Baie des Chaleurs. This would tend to overestimate exposure due to wild mussel consumption as well as other shellfish since wild mussels had higher concentrations than clams.

The New Brunswick Nutrition Survey (2004) does not provide any dietary information for children. Therefore, in an attempt to obtain fish and shellfish intake rates for children and teens, a factor of 74% was applied to the adult rates. This factor is based on the ratio between adult intakes and child intakes provided in Richardson (1997). Fish and seafood intake rates for infants and toddlers were derived from Health Canada (1994) rates that include both eaters of seafood and non-eaters of seafood. For the infant, a fish intake rate of 0.5 g/day was provided. For the toddler, a marine and freshwater fish intake rate of 2.64g/day was provided, as well as a shellfish intake rate of 0.28 g/day. Due to the uncertainty in this methodology, maximum intakes of seafood for children were not calculated.

All other intake rates were obtained from Health Canada (2003).

The Ontario Ministry of the Environment in their document entitled *Soil Investigation and Human Health Risk Assessment for the Rodney Street Community, Port Colborne* (October 2001), derived the percentage of the vegetable intake that an individual would obtain from a backyard garden. From their calculations they determined that 7.3% of total annual consumption of vegetables comes from backyard gardens. This value was adopted in this assessment.

There is no information provided on the consumption of wildlife in New Brunswick. As well, Health Canada (2003) and the *Compendium of Canadian Exposure Factors* (Richardson 1997) only provide wildlife consumption data for First Nations people. Due to the absence of any other data, this data was considered in the assessment. There is also no breakdown of the wildlife into big game (caribou and moose) and small game (rabbits, ptarmigan, grouse etc.) categories. First Nations people generally have a diet that is mainly large game with very small amounts of small game. In the Belledune area, it is our understanding that rabbits are caught in the Industrial park area and consumed. The amount consumed has not been determined via the survey instruments. In the absence of this data it was decided to use the proportion of small game obtained from surveys in Saskatchewan and the Northwest Territories which indicated that small game intakes make up about 5% of the total wild game ingested. The use of these values are uncertain and the effect on exposure will be discussed in a subsequent section. Table 5.3 provides a summary of the dietary characteristics used in this assessment. All of the dietary components were assumed to be obtained from the GBA area. Supermarket exposures were considered as part of baseline exposures.

Table 5.3: Summary of dietary characteristics considered for this assessment

Receptor Characteristic	Infant	Toddler	Child	Teen	Adult	Source/Rationale
Age	0 – 6 mo	7 mo. – 4yr	5 – 11 yr	12 – 19 yr	20+ yr	HC 2003*
Total Daily Consumption of Root Vegetables (g/d)	83.0	105.0	161.0	227.0	188.0	Richardson 1997*
Daily Consumption of Backyard Root Vegetables (g/d)	6.06	7.67	11.8	16.6	13.7	Applied MOE factor of 7.3% for backyard produce
Total Daily Consumption of Other Vegetables (g/d)	72.0	67.0	98.0	120	137	Richardson 1997*
Daily Consumption of Other Backyard Vegetables (g/d)	5.26	4.89	7.15	8.76	10.0	Applied MOE factor of 7.3% for backyard produce
Daily Consumption of Fish (g/d) – mean	0.5	2.64	13.7	13.7	18.5	Based on NB Nutrition Survey
Daily Consumption of Fish (g/d) – max	-	-	-	-	222.0	Based on NB Nutrition Survey
Daily Consumption of Shellfish (g/d) – mean	-	-	4.63	4.63	6.25	Based on NB Nutrition Survey
Daily Consumption of Shellfish (g/d) – max	-	-	-	-	173.8	Based on NB Nutrition Survey
Daily Consumption of Lobster (g/d) – mean	-	0.28	1.30	1.30	1.75	Based on NB Nutrition Survey
Daily Consumption of Lobster (g/d) – max	-	-	-	-	84.0	Based on NB Nutrition Survey
Daily Consumption of wild game (g/d)	-	4.25	6.25	8.75	13.5	Richardson 1997 based on First Nations populations eaters only and applied a factor of 5%

*Source: Health Canada 2003

5.2.2 Receptors considered in the assessment

The different types of receptors considered in the assessment were selected to ensure that a range of exposures were captured in the GBA. Both a local seafood and non-local seafood eater were selected for the GBA. The various age stages were considered for these two types of receptors. In addition, as described above, an assessment of adults who consume large amounts of fish, wild mussels and local lobster were also evaluated. Specifically, receptors were divided according to whether they were “maximum local seafood eaters” (5-7 large meals per week or either local lobster, wild mussels or fish) or “average local seafood eaters” (1-2 medium meals per week). As indicated previously, “maximum local seafood eaters” are considered to be only a very small fraction of the Northern New Brunswick population.

In summary, the following receptors were considered in the assessment:

- Local seafood eater (all life stages);
- Non-local seafood eater (all life stages);
- Maximum fish eater (adult);
- Maximum local lobster eater (adult);
- Maximum wild mussel eater (adult).

5.2.3 Estimation of exposure magnitude

The magnitudes of the exposures were quantified for each pathway and the total exposure to the receptor was evaluated. Exposure is a function of the concentration of the COPC and of the parameters that describe the exposed population.

The exposure assessment for contaminants performed on the Belledune area considered the inhalation, dermal and ingestion exposure routes. A deterministic (single) point estimate was developed. The equations that were employed in the pathways model are presented below. These equations are generally used in risk assessments and are used by agencies such as Health Canada and the U.S. EPA.

<u>Inhalation Route</u>

Intake of contaminants via inhalation by human receptors was calculated using the equation (5-1) for the inhalation route:

$$I_{air} = \frac{C_{air} \times R_{air}}{BW} \qquad (5\text{-}1)$$

where:

I_{air} = exposure to contaminant through inhalation [mg/kg-d]
C_{air} = air concentration [mg/m^3] - obtained from air dispersion modeling see Section 4
R_{air} = air inhalation rate [m^3/d] - see Table 5.1
BW= body weight [kg] - see Table 5.1

There were no available data therefore it was assumed that under all exposure scenarios receptors were assumed to be breathing contaminated outdoor air 24 hours per day. This is a conservative assumption because outdoor air concentrations for the selected COPC are typically always higher outdoors than indoors. For this reason, the fraction of time spent indoors versus outdoors was not relevant for the calculation of inhalation exposure.

Dermal Route

Dermal exposure for human receptors was calculated using equation (5-2) for the dermal route:

$$I_{dermal} = \frac{C_{soil} \times SA \times SL \times RAF \times EF}{BW} \qquad (5\text{-}2)$$

where:

I_{dermal} = exposure to contaminant in soil through the dermal route [mg/kg-d]
C_{soil} = soil concentration [mg/kg (dw)] – see Section 4 for soil concentrations considered
SA = skin surface area – total [cm^2] – see Table 5.1
SL = loading to exposed skin [kg (dw)/cm^2-event] - see Table 5.1
RAF = dermal absorption factor [-], COPC specific see Section 5.2.4
EF = exposure frequency [events/d], assumed to be 1
BW = body weight [kg] - see Table 5.1

Under all exposure scenarios, receptors were assumed to be exposed to contaminated outdoor soil. This is a conservative assumption because outdoor soil concentrations for the selected COPC are typically always higher outdoors than indoors. For this reason, the fraction of time spent indoors versus outdoors was not relevant for the calculation of dermal exposure.

Ingestion Route

Ingestion intake for the water exposure pathway was calculated using equation (5-3) for the water exposure pathway, equation (5-4) for the soil pathway and equation (5-5) for the food pathway:

$$I_{water} = \frac{C_{water} \times R_{water}}{BW} \quad (5\text{-}3)$$

where:

- I_{water} = exposure to contaminant through the water pathway [mg/kg-d]
- C_{water} = measured well-water concentration [mg/L] – See Section 4 for well water concentrations used
- R_{water} = water ingestion rate [L/d] - see Table 5.1
- BW = body weight [kg] - see Table 5.1

$$I_{soil} = \frac{C_{soil} \times R_{soil}}{BW} \times \frac{1}{1000} \quad (5\text{-}4)$$

where:

- I_{soil} = exposure to contaminant through the soil pathway [mg/kg-d]
- C_{soil} = soil concentration [mg/kg (dw)] – See Section 4 for soil concentrations used in the assessment
- R_{soil} = soil ingestion rate [g (dw)/d] - see Table 5.1
- BW = body weight [kg] - see Table 5.1
- 1/1000 = unit conversion factor [kg/g]

$$I_{food\ x} = \frac{C_x \times R_x}{BW} \times \frac{1}{1000} \quad (5\text{-}5)$$

where:

- $I_{food\ x}$ = exposure to contaminant through the food pathway [mg/kg-d], where x is supermarket food, backyard produce (root vegetables, other vegetables), fish, hare, as applicable
- C_x = concentration of contaminant [mg/kg (ww)] for each x
- R_x = food ingestion rate of x [g (ww)/d], where x is backyard produce (root vegetables, other vegetables), fish, lobster, wild mussels, hare, as applicable -see Table 5.3
- BW = body weight [kg] – see Table 5.1
- 1/1000 = unit conversion factor [kg/g]

As discussed in Section 4, measured data were used as much as possible. Air concentrations were obtained using air dispersion modeling. Soil concentrations were obtained using a combination of measured data and data derived from empirical relationships with modeled air concentrations.

5.2.4 Other considerations

Some other considerations in estimating exposure are presented below.

Ingestion and Inhalation exposure

For purposes of this assessment, gastrointestinal and respiratory absorption for the COPC were assumed to be 100%.

Dermal exposure

Regulatory literature (Health Canada and U.S.EPA) recommends assumptions concerning dermal absorption rates (as the proportion of the dermally applied dose) for environmental contaminants. Table 5.4 summarizes the dermal absorption factors used in this assessment.

Table 5.4: Summary of the dermal absorption factors used in the assessment

COPC	Relative Absorption Factors	References
Arsenic	0.03	Health Canada 2003
Cadmium	0.14	Health Canada 2003
Chromium	0.09	Health Canada 2003
Lead	0.006	Health Canada 2003
Mercury	0.05	Health Canada 2003
Thallium	0.01	Health Canada 2003
Zinc	0.02	Health Canada 2003
Dioxins and Furans	0.03	U.S. EPA 2001

Note: Value for chromium VI used, the RAF for chromium III is 0.04.

Supermarket Foods

There are some data available for determining exposures to COPC resulting from ingestion of supermarket foods across Canada, and these are provided in Table 5.5 for adults and Table 5.6 for children. These intakes are assumed to be the same as COPC intakes from supermarket food for Belledune area residents. Although exposures resulting from supermarket foods do not result from exposure to environmental concentrations caused by industrial activities in Belledune, they represent part of baseline exposure and as such are important in the estimation of risk in the Belledune area. Most of these intakes were calculated for average Canadians, while some were specific to communities on the East coast.

Tables 5.7 and 5.8 present the total intakes for COPC exposures in the general Canadian population for adults and children respectively. These data were used to compare total exposure estimates for the Belledune area and to determine whether they were higher than exposures in the general Canadian population. General exposure data were not available for all COPC, and this table was in-filled to the extent possible.

Table 5.5: Summary of COPC exposures from supermarket foods for Canadian adults

COPC	Supermarket Food Intake for Adults (µg/kg-d)	Reference	City	Year
Arsenic	0.549	(1)	Halifax	1985-1988
Cadmium	0.307	(2)	Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Toronto, Whitehorse, Calgary	1993-1999
Chromium	< 0.3	(3)	-	1992
Dioxins and furans	0.627[a]	(2)	Halifax	1994
Lead	0.183	(2)	Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Toronto, Whitehorse, Calgary	1993-1999
Mercury	0.019-0.022	(4)	Whitehorse, Ottawa	1998, 2000
Thallium	0.025	(2)	Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Toronto, Whitehorse, Calgary	1993-1999
Zinc	184.4	(2)	Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Toronto, Whitehorse, Calgary	1993-1999

Notes:

a - in pg of toxic equivalents/kg-day

1 - from Dabeka *et al*. (1993), which provides city-specific intakes that are more recent than Health Canada (1993) rates. Health Canada (1993) "Priority Substances List (PSL) Assessment Report - Arsenic and its Compounds" presents intakes of 0.02-0.6 µg/kg-d based on Dabeka *et al.* (1987) assuming that 37% of arsenic in food is assumed to be present as inorganic arsenic.

2 - calculated from Health Canada (2004) Food Program Canadian Total Diet Studies; average for male and female adults

3 - Health Canada (1994c) PSL for Chromium and its Compounds. Food analysis performed in 1992 for Health and Welfare Canada by Mann Testing Laboratories (unpublished)

4 - From Dabeka *et al*. (2003). (Alternative of 0.186 µg/kg-d calculated from Canadian Drinking Water Guidelines for Mercury (1979). The average daily intake of mercury from food in (µg/kg-d) was derived from an intake of 0.013 mg/day assuming a body weight of 70 kg.)

Table 5.6: Summary of COPC exposures from supermarket foods for Canadian children

COPC	Total COPC Intake for Infants (µg/kg-d)	Total COPC Intake for Toddlers (µg/kg-d)	Total COPC Intake for Children (µg/kg-d)	Total COPC Intake for Teenagers (µg/kg-d)	Reference	City	Year
Arsenic	<0.04-2.4	1.02	1.01	0.598	(1)	Halifax	1985-1988
Cadmium	0.612	0.726	0.738	0.453	(2)	Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Toronto, Whitehorse, Calgary	1993-1999
Chromium	<0.9[a]	<1.0	<0.7	<0.4	(3)	-	1992
PCDD/Fs[b]	2.25	2.16	1.58	0.985	(2)	Halifax	1994
Lead	0.469	0.481	0.368	0.224	(2)	Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Toronto, Whitehorse, Calgary	1993-1999
Mercury	0.031-0.038	0.023-0.031	0.032-0.038	0.023-0.026	(4)	Whitehorse, Ottawa	1998-2000
Thallium	0.026	0.064	0.067	0.039	(2)	Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Toronto, Whitehorse, Calgary	1993-1999
Zinc	734.7	554.7	398.2	259.4	(2)	Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Toronto, Whitehorse, Calgary	1993-1999

Notes:

a - This the highest chromium intake reported for infants; it is for a non-breast fed infant.

b - in pg of toxic equivalents/kg-d

1 - All except infant from Dabeka *et al*. (1993), which provides city-specific intakes that are more recent than Health Canada (1993) rates. Health Canada (1993) "Priority Substances List Assessment Report - Arsenic and its Compounds" presents intakes of <0.04-2.4, <0.05-2.0, <0.03-1.9 and <0.02-1.2 µg/kg-d for infants, toddlers, children and teens, based on Dabeka *et al.* (1987) assuming that 37% of arsenic in food is assumed to be present as inorganic arsenic. Infant intake taken from Health Canada (1993) Arsenic PSL Report, and is not based on data from Halifax.

2 - calculated from Health Canada (2004) Food Program Canadian Total Diet Studies; average for male and female and different ages comprising age group classification

3 - Health Canada (1994c) PSL for Chromium and its Compounds. Food analysis performed in 1992 for Health and Welfare Canada by Mann Testing Laboratories (unpublished)

4 - From Dabeka *et al.* (2003). (Alternative of 0.186 µg/kg-d calculated from Canadian Drinking Water Guidelines for Mercury (1979). The average daily intake of mercury from food in (µg/kg-d) was derived from an intake of 0.013 mg/day assuming a body weight of 70 kg.)

Table 5.7: Summary of total COPC exposures for Canadian adults

COPC	Total COPC Intake for Adults (µg/kg-d)	Reference	Additional Specifications
Arsenic	0.1 – 0.7	(1)	General Canadians
	<0.1 – 12	(1)	Canadians living in the vicinity of point sources
Cadmium	0.308 – 0.309	(2)	General Canadians
	0.335 – 0.345	(2)	Canadians living in the vicinity of point sources
Chromium	< 0.4	(3)	-
Dioxins and furans	0.56 – 2.1[a]	(4)	Averaged over an exposure period of 53 years
Lead	0.75	(5)	-
Mercury	< 0.214	(6)	-
Thallium	-	-	-
Zinc	228.57	(7)	-

Notes:

a – in pg of toxic equivalents/kg-d
1 - from Health Canada (1993) Priority Substances List (PSL) Assessment Report – Arsenic and its Compounds.
2 - from Health Canada (1994b) PSL Assessment Report – Cadmium and its Compounds.
3 - from Health Canada (1994c) PSL Assessment Report – Chromium and its Compounds.
4 - from Health Canada (1990) PSL Assessment Report No.1 – Polychlorinated Dibenzodioxins and Polychlorinated Dibenzofurans.
5 - from Health Canada (1992) Guidelines for Canadian Drinking Water Quality – Lead.
6 - from Health Canada (1979) Guidelines for Canadian Drinking Water Quality – Mercury.
7 - from Health Canada (1979b) Guidelines for Canadian Drinking Water Quality – Zinc.

Table 5.8: Summary of total COPC exposures for Canadian children

COPC	Total COPC Intake for Infants (µg/kg-d)	Total COPC Intake for Toddlers (µg/kg-d)	Total COPC Intake for Children (µg/kg-d)	Total COPC Intake for Teenagers (µg/kg-d)	Reference	Additional Specifications
Arsenic	0.1-2.6	0.3-2.4	0.2-2.1	0.1-1.3	(1)	General Canadians
	<0.1-14	<0.4-3.5	<0.2-23	<0.1-11	(1)	Canadians living in the vicinity of point sources
Cadmium*	0.617-0.621	0.729-0.733	0.739-0.742	0.52-0.522	(2)	General Canadians
	0.651-0.761	0.795-0.826	0.782-0.798	0.549-0.561	(2)	Canadians living in the vicinity of point sources
Chromium	<1.6[a]	<1.5	<0.9	<0.05	(3)	-
PCDD/Fs[b]	165[c]	3.1-11.0	1.3-5.0	1.3-5.0	(4)	Averaged over an exposure period of 0.5, 2.5, and 14 years for the infant, toddler, child and teen, respectively
Lead	-	2.17[d]	-	-	(5)	-
Mercury	-	-	-	-	(6)	-
Thallium	-	-	-	-	-	-
Zinc	-	-	-	-	(7)	-

Notes:

a - This the highest chromium intake reported for infants; it is for a non-breast fed infant.
b - Age classes reported were different from our classification, and children were grouped according to their age. "Neonate" lasting 0.5 years was classified as "infant," "infant" lasting 2.5 years was classified as "toddler," and "child" lasting 14 years was considered both "child" and "teen."
c - in pg of toxic equivalents/kg-d
d - Health Canada (1992) reports this as a "child" but it was re-classified as a "toddler" due to its age of 2 years.
1 - from Health Canada (1993) Priority Substances List (PSL) Assessment Report – Arsenic and its Compounds.
2 - from Health Canada (1994b) PSL Assessment Report – Cadmium and its Compounds. * The total intakes for cadmium were adjusted to reflect the updated supermarket intakes for children provided in Table 5.6.
3 - from Health Canada (1994c) PSL Assessment Report – Chromium and its Compounds.
4 - from Health Canada (1990) PSL Assessment Report No.1 – Polychlorinated Dibenzodioxins and Polychlorinated Dibenzofurans.
5 - from Health Canada (1992) Guidelines for Canadian Drinking Water Quality – Lead.
6 - from Health Canada (1979) Guidelines for Canadian Drinking Water Quality – Mercury.
7 - from Health Canada (1979b) Guidelines for Canadian Drinking Water Quality – Zinc.

5.3 Exposure estimates

Table 5.9 provides a summary of the calculated total intakes for all COPC for the average local seafood eater during the current time period using the Noranda EMP data. Supermarket food intakes are included in these intakes. Appendix D provides a sample calculation and Appendix E provides all the results of the assessment for the other receptors and provides a breakdown of the intakes by separate pathways. As seen from Table 5.9, children in Lower Belledune have the highest intakes for cadmium, lead and mercury. It should be noted that supermarket food intakes account for between 54% and 90% of cadmium intakes, 6% and 29% of lead intakes and 40% to 87% of mercury intakes. Infants in all study areas have the highest arsenic and zinc exposure with supermarket foods accounting for 78% to 88% of the arsenic intakes and approximately 98% of the intakes for zinc. Toddlers in Petit-Rocher have the highest exposure to chromium. Supermarket food accounts for 56% of the exposure. Toddlers in Pointe-Verte have the highest exposure to thallium with supermarket food accounting for 62% of the total intakes. The breakdown by various pathways are seen in Table 5.12 and it appears that supermarket foods account for a large portion of the total intakes of COPC with the exception of lead. Table 5.10 provides the total intakes for arsenic, cadmium and lead for the three historical time periods using the Noranda EMP data. As seen from this table, exposures in the 1967-1974 time period were highest for arsenic, cadmium and lead.

Table 5.11 provides a summary of the total intakes using the CCNB soil data. As discussed in Section 4, the CCNB soil measurements are generally higher than the soil measurements obtained from the Noranda EMP program. The results shown in Table 5.10 reflect this trend; however, the total intakes are only slightly higher than those presented in Table 5.9. For example, for lead exposure for a child in Lower Belledune, the intake is 4.91×10^{-3} mg/kg-d using the Noranda EMP soil data and 4.99×10^{-3} mg/kg-d using the CCNB soil data. The cadmium intake for a child in Lower Belledune is 1.15×10^{-3} mg/kg-d and is the same using both the Noranda EMP and CCNB soil data.

Table 5.9: Summary of total intakes for current time period for average seafood eaters using Noranda soil data

Receptor Locations	Total Intakes (mg/kg d)															
	Arsenic		Cadmium		Chromium		Lead		Mercury		Thallium		Zinc		Dioxins and Furans	
	Best Estimate	Upper Bound	Best Estimate	Upper Bound	Best Estimate	Upper Bound	Best Estimate	Upper Bound	Best Estimate	Upper Bound	Best Estimate	Upper Bound	Best Estimate	Upper Bound	Best Estimate	Upper Bound
Townsite – Infant	$1.57x10^{-3}$	$1.77x10^{-3}$	$7.48x10^{-4}$	$9.18x10^{-4}$	$1.06x10^{-3}$	$1.09x10^{-3}$	$2.38x10^{-3}$	$5.82x10^{-3}$	$3.97x10^{-5}$	$4.27x10^{-5}$	$6.35x10^{-5}$	$1.04x10^{-4}$	$7.45x10^{-1}$	$7.54x10^{-1}$	$2.25x10^{-9}$	$2.25x10^{-9}$
Townsite – Toddler	$1.46x10^{-3}$	$1.70x10^{-3}$	$8.31x10^{-4}$	$9.32x10^{-4}$	$1.31x10^{-3}$	$1.37x10^{-3}$	$2.47x10^{-3}$	$4.90x10^{-3}$	$4.39x10^{-5}$	$5.12x10^{-5}$	$9.67x10^{-5}$	$1.24x10^{-4}$	$5.66x10^{-1}$	$5.73x10^{-1}$	$2.16x10^{-9}$	$2.17x10^{-9}$
Townsite – Child	$1.25x10^{-3}$	$1.36x10^{-3}$	$9.44x10^{-4}$	$1.09x10^{-3}$	$8.17x10^{-4}$	$8.41x10^{-4}$	$2.47x10^{-3}$	$4.54x10^{-3}$	$8.17x10^{-5}$	$1.01x10^{-4}$	$8.94x10^{-5}$	$1.09x10^{-4}$	$4.14x10^{-1}$	$4.20x10^{-1}$	$1.58x10^{-9}$	$1.58x10^{-9}$
Townsite – Teen	$7.67x10^{-4}$	$8.39x10^{-4}$	$5.78x10^{-4}$	$6.67x10^{-4}$	$4.82x10^{-4}$	$4.97x10^{-4}$	$1.48x10^{-3}$	$2.80x10^{-3}$	$5.05x10^{-5}$	$6.10x10^{-5}$	$5.50x10^{-5}$	$6.78x10^{-5}$	$2.69x10^{-1}$	$2.73x10^{-1}$	$9.85x10^{-10}$	$9.86x10^{-10}$
Townsite – Adult	$7.45x10^{-4}$	$8.25x10^{-4}$	$4.38x10^{-4}$	$5.33x10^{-4}$	$3.96x10^{-4}$	$4.10x10^{-4}$	$1.51x10^{-3}$	$2.88x10^{-3}$	$5.02x10^{-5}$	$6.21x10^{-5}$	$4.06x10^{-5}$	$5.26x10^{-5}$	$1.95x10^{-1}$	$1.99x10^{-1}$	$6.27x10^{-10}$	$6.28x10^{-10}$
Lower Belledune – Infant	$1.56x10^{-3}$	$1.76x10^{-3}$	$7.71x10^{-4}$	$8.04x10^{-4}$	$1.06x10^{-3}$	$1.08x10^{-3}$	$1.67x10^{-3}$	$2.66x10^{-3}$	$3.97x10^{-5}$	$4.30x10^{-5}$	$5.63x10^{-5}$	$8.13x10^{-5}$	$7.45x10^{-1}$	$7.51x10^{-1}$	$2.25x10^{-9}$	$2.25x10^{-9}$
Lower Belledune – Toddler	$1.44x10^{-3}$	$1.71x10^{-3}$	$8.51x10^{-4}$	$8.98x10^{-4}$	$1.31x10^{-3}$	$1.34x10^{-3}$	$2.07x10^{-3}$	$3.91x10^{-3}$	$4.40x10^{-5}$	$5.21x10^{-5}$	$9.28x10^{-5}$	$1.18x10^{-4}$	$5.66x10^{-1}$	$5.71x10^{-1}$	$2.16x10^{-9}$	$2.17x10^{-9}$
Lower Belledune – Child	$1.25x10^{-3}$	$1.37x10^{-3}$	$1.15x10^{-3}$	$1.34x10^{-3}$	$8.13x10^{-4}$	$8.23x10^{-4}$	$4.91x10^{-3}$	$7.04x10^{-3}$	$8.22x10^{-5}$	$1.02x10^{-4}$	$8.87x10^{-5}$	$1.03x10^{-4}$	$4.15x10^{-1}$	$4.20x10^{-1}$	$1.58x10^{-9}$	$1.58x10^{-9}$
Lower Belledune – Teen	$7.68x10^{-4}$	$8.43x10^{-4}$	$6.96x10^{-4}$	$8.06x10^{-4}$	$4.80x10^{-4}$	$4.86x10^{-4}$	$2.80x10^{-3}$	$4.05x10^{-3}$	$5.07x10^{-5}$	$6.15x10^{-5}$	$5.44x10^{-5}$	$6.42x10^{-5}$	$2.70x10^{-1}$	$2.73x10^{-1}$	$9.85x10^{-10}$	$9.86x10^{-10}$
Lower Belledune – Adult	$7.45x10^{-4}$	$8.27x10^{-4}$	$5.63x10^{-4}$	$6.87x10^{-4}$	$3.95x10^{-4}$	$4.01x10^{-4}$	$3.04x10^{-3}$	$4.42x10^{-3}$	$5.05x10^{-5}$	$6.27x10^{-5}$	$4.01x10^{-5}$	$4.83x10^{-5}$	$1.96x10^{-1}$	$1.99x10^{-1}$	$6.27x10^{-10}$	$6.28x10^{-10}$
Belledune – Infant	$1.54x10^{-3}$	$1.65x10^{-3}$	$7.40x10^{-4}$	$7.78x10^{-4}$	$1.06x10^{-3}$	$1.08x10^{-3}$	$1.60x10^{-3}$	$1.99x10^{-3}$	$3.96x10^{-5}$	$4.18x10^{-5}$	$4.83x10^{-5}$	$5.52x10^{-5}$	$7.45x10^{-1}$	$7.48x10^{-1}$	$2.25x10^{-9}$	$2.25x10^{-9}$
Belledune – Toddler	$1.39x10^{-3}$	$1.51x10^{-3}$	$8.24x10^{-4}$	$8.54x10^{-4}$	$1.31x10^{-3}$	$1.34x10^{-3}$	$1.74x10^{-3}$	$2.26x10^{-3}$	$4.38x10^{-5}$	$4.96x10^{-5}$	$8.64x10^{-5}$	$9.16x10^{-5}$	$5.66x10^{-1}$	$5.69x10^{-1}$	$2.16x10^{-9}$	$2.17x10^{-9}$
Belledune – Child	$1.25x10^{-3}$	$1.33x10^{-3}$	$9.71x10^{-4}$	$1.03x10^{-3}$	$8.13x10^{-4}$	$8.22x10^{-4}$	$2.60x10^{-3}$	$3.49x10^{-3}$	$8.20x10^{-5}$	$1.01x10^{-4}$	$8.36x10^{-5}$	$8.99x10^{-5}$	$4.14x10^{-1}$	$4.17x10^{-1}$	$1.58x10^{-9}$	$1.58x10^{-9}$
Belledune – Teen	$7.63x10^{-4}$	$8.16x10^{-4}$	$5.93x10^{-4}$	$6.31x10^{-4}$	$4.80x10^{-4}$	$4.86x10^{-4}$	$1.52x10^{-3}$	$2.06x10^{-3}$	$5.06x10^{-5}$	$6.09x10^{-5}$	$5.09x10^{-5}$	$5.49x10^{-5}$	$2.69x10^{-1}$	$2.71x10^{-1}$	$9.85x10^{-10}$	$9.86x10^{-10}$
Belledune – Adult	$7.41x10^{-4}$	$8.06x10^{-4}$	$4.54x10^{-4}$	$4.94x10^{-4}$	$3.95x10^{-4}$	$4.01x10^{-4}$	$1.61x10^{-3}$	$2.20x10^{-3}$	$5.04x10^{-5}$	$6.22x10^{-5}$	$3.72x10^{-5}$	$4.11x10^{-5}$	$1.95x10^{-1}$	$1.97x10^{-1}$	$6.27x10^{-10}$	$6.27x10^{-10}$
Pointe-Verte – Infant	$1.48x10^{-3}$	$1.61x10^{-3}$	$7.02x10^{-4}$	$7.74x10^{-4}$	$1.36x10^{-3}$	$1.45x10^{-3}$	$1.87x10^{-3}$	$3.20x10^{-3}$	$3.96x10^{-5}$	$4.17x10^{-5}$	$6.29x10^{-5}$	$8.35x10^{-5}$	$7.44x10^{-1}$	$7.48x10^{-1}$	$2.25x10^{-9}$	$2.25x10^{-9}$
Pointe-Verte – Toddler	$1.33x10^{-3}$	$1.44x10^{-3}$	$8.01x10^{-4}$	$8.47x10^{-4}$	$1.61x10^{-3}$	$1.71x10^{-3}$	$1.86x10^{-3}$	$2.84x10^{-3}$	$4.36x10^{-5}$	$4.98x10^{-5}$	$1.02x10^{-4}$	$1.16x10^{-4}$	$5.65x10^{-1}$	$5.69x10^{-1}$	$2.16x10^{-9}$	$2.17x10^{-9}$
Pointe-Verte – Child	$1.20x10^{-3}$	$1.28x10^{-3}$	$9.55x10^{-4}$	$1.02x10^{-3}$	$1.01x10^{-3}$	$1.07x10^{-3}$	$3.23x10^{-3}$	$4.45x10^{-3}$	$8.08x10^{-5}$	$1.04x10^{-4}$	$9.50x10^{-5}$	$1.07x10^{-4}$	$4.14x10^{-1}$	$4.18x10^{-1}$	$1.58x10^{-9}$	$1.58x10^{-9}$
Pointe-Verte – Teen	$7.34x10^{-4}$	$7.86x10^{-4}$	$5.82x10^{-4}$	$6.24x10^{-4}$	$6.18x10^{-4}$	$6.54x10^{-4}$	$1.88x10^{-3}$	$2.64x10^{-3}$	$5.00x10^{-5}$	$6.27x10^{-5}$	$5.85x10^{-5}$	$6.64x10^{-5}$	$2.69x10^{-1}$	$2.72x10^{-1}$	$9.85x10^{-10}$	$9.86x10^{-10}$
Pointe-Verte – Adult	$7.04x10^{-4}$	$7.60x10^{-4}$	$4.46x10^{-4}$	$4.90x10^{-4}$	$5.69x10^{-4}$	$6.14x10^{-4}$	$2.01x10^{-3}$	$2.82x10^{-3}$	$4.97x10^{-5}$	$6.42x10^{-5}$	$4.75x10^{-5}$	$5.59x10^{-5}$	$1.95x10^{-1}$	$1.98x10^{-1}$	$6.27x10^{-10}$	$6.27x10^{-10}$
Petit-Rocher – Infant	$1.38x10^{-3}$	$1.47x10^{-3}$	$7.00x10^{-4}$	$7.75x10^{-4}$	$1.50x10^{-3}$	$1.82x10^{-3}$	$1.78x10^{-3}$	$3.12x10^{-3}$	$3.96x10^{-5}$	$4.17x10^{-5}$	$5.99x10^{-5}$	$7.54x10^{-5}$	$7.43x10^{-1}$	$7.47x10^{-1}$	$2.25x10^{-9}$	$2.25x10^{-9}$
Petit-Rocher – Toddler	$1.23x10^{-3}$	$1.29x10^{-3}$	$7.99x10^{-4}$	$8.47x10^{-4}$	$1.75x10^{-3}$	$2.07x10^{-3}$	$1.71x10^{-3}$	$2.69x10^{-3}$	$4.32x10^{-5}$	$4.88x10^{-5}$	$9.86x10^{-5}$	$1.07x10^{-4}$	$5.64x10^{-1}$	$5.68x10^{-1}$	$2.16x10^{-9}$	$2.17x10^{-9}$
Petit-Rocher – Child	$1.14x10^{-3}$	$1.19x10^{-3}$	$9.23x10^{-4}$	$9.95x10^{-4}$	$1.11x10^{-3}$	$1.31x10^{-3}$	$2.32x10^{-3}$	$3.50x10^{-3}$	$7.91x10^{-5}$	$1.05x10^{-4}$	$9.25x10^{-5}$	$1.03x10^{-4}$	$4.12x10^{-1}$	$4.17x10^{-1}$	$1.58x10^{-9}$	$1.58x10^{-9}$
Petit-Rocher – Teen	$6.92x10^{-4}$	$7.26x10^{-4}$	$5.64x10^{-4}$	$6.09x10^{-4}$	$6.82x10^{-4}$	$8.24x10^{-4}$	$1.38x10^{-3}$	$2.12x10^{-3}$	$4.90x10^{-5}$	$6.33x10^{-5}$	$5.68x10^{-5}$	$6.32x10^{-5}$	$2.68x10^{-1}$	$2.71x10^{-1}$	$9.85x10^{-10}$	$9.86x10^{-10}$
Petit-Rocher – Adult	$6.52x10^{-4}$	$6.85x10^{-4}$	$4.25x10^{-4}$	$4.73x10^{-4}$	$6.51x10^{-4}$	$8.29x10^{-4}$	$1.44x10^{-3}$	$2.23x10^{-3}$	$4.86x10^{-5}$	$6.49x10^{-5}$	$4.56x10^{-5}$	$5.19x10^{-5}$	$1.94x10^{-1}$	$1.97x10^{-1}$	$6.27x10^{-10}$	$6.27x10^{-10}$

Table 5.10: Summary of total intakes for average seafood eaters for historical time periods using Noranda EMP data

Receptor Locations	Total Intakes (mg/kg d)																	
	1967-1974						1975-1984						1985-1999					
	Arsenic		Cadmium		Lead		Arsenic		Cadmium		Lead		Arsenic		Cadmium		Lead	
	Best Estimate	Upper Bound	Best Estimate	Upper Bound	Best Estimate	Upper Bound	Best Estimate	Upper Bound	Best Estimate	Upper Bound	Best Estimate	Upper Bound	Best Estimate	Upper Bound	Best Estimate	Upper Bound	Best Estimate	Upper Bound
Townsite – Infant	4.96×10^{-4}	1.25×10^{-3}	3.17×10^{-4}	7.42×10^{-4}	5.01×10^{-3}	1.17×10^{-2}	4.53×10^{-4}	1.14×10^{-3}	2.55×10^{-4}	8.38×10^{-4}	3.77×10^{-3}	1.89×10^{-2}	3.73×10^{-4}	6.95×10^{-4}	1.95×10^{-4}	6.05×10^{-4}	1.44×10^{-3}	4.64×10^{-3}
Townsite – Toddler	5.54×10^{-4}	1.19×10^{-3}	2.30×10^{-4}	4.87×10^{-4}	5.70×10^{-3}	1.28×10^{-2}	4.58×10^{-4}	9.60×10^{-4}	1.72×10^{-4}	4.88×10^{-4}	3.64×10^{-3}	1.23×10^{-2}	4.25×10^{-4}	6.96×10^{-4}	1.32×10^{-4}	3.42×10^{-4}	1.79×10^{-3}	3.96×10^{-3}
Townsite – Child	3.21×10^{-4}	7.41×10^{-4}	3.54×10^{-4}	8.24×10^{-4}	4.46×10^{-3}	1.11×10^{-2}	2.46×10^{-4}	5.61×10^{-4}	3.18×10^{-4}	8.27×10^{-4}	3.41×10^{-3}	1.10×10^{-2}	2.06×10^{-4}	3.66×10^{-4}	2.65×10^{-4}	5.89×10^{-4}	2.08×10^{-3}	4.14×10^{-3}
Townsite – Teen	2.12×10^{-4}	4.97×10^{-4}	2.24×10^{-4}	5.10×10^{-4}	2.72×10^{-3}	6.74×10^{-3}	1.67×10^{-4}	3.89×10^{-4}	1.92×10^{-4}	5.08×10^{-4}	2.08×10^{-3}	7.04×10^{-3}	1.38×10^{-4}	2.48×10^{-4}	1.61×10^{-4}	3.59×10^{-4}	1.21×10^{-3}	2.50×10^{-3}
Townsite – Adult	2.15×10^{-4}	4.69×10^{-4}	2.13×10^{-4}	5.02×10^{-4}	2.52×10^{-3}	6.34×10^{-3}	1.77×10^{-4}	3.77×10^{-4}	1.97×10^{-4}	5.12×10^{-4}	2.05×10^{-3}	6.77×10^{-3}	1.54×10^{-4}	2.64×10^{-4}	1.64×10^{-4}	3.68×10^{-4}	1.27×10^{-3}	2.54×10^{-3}
Lower Belledune – Infant	6.24×10^{-4}	3.59×10^{-3}	9.91×10^{-5}	2.95×10^{-4}	2.28×10^{-3}	8.28×10^{-3}	5.87×10^{-4}	3.43×10^{-3}	6.14×10^{-4}	3.18×10^{-3}	5.39×10^{-3}	4.29×10^{-2}	3.88×10^{-4}	9.48×10^{-4}	3.90×10^{-4}	1.36×10^{-3}	1.83×10^{-3}	8.82×10^{-3}
Lower Belledune – Toddler	5.94×10^{-4}	2.54×10^{-3}	9.63×10^{-5}	2.76×10^{-4}	4.10×10^{-3}	1.51×10^{-2}	5.13×10^{-4}	2.19×10^{-3}	3.36×10^{-4}	1.60×10^{-3}	4.35×10^{-3}	2.61×10^{-2}	4.15×10^{-4}	8.80×10^{-4}	2.34×10^{-4}	7.47×10^{-4}	1.93×10^{-3}	6.61×10^{-3}
Lower Belledune – Child	3.57×10^{-4}	1.69×10^{-3}	1.62×10^{-3}	2.75×10^{-3}	8.29×10^{-3}	1.86×10^{-2}	2.94×10^{-4}	1.42×10^{-3}	1.81×10^{-3}	3.73×10^{-3}	8.99×10^{-3}	2.70×10^{-2}	2.11×10^{-4}	4.51×10^{-4}	6.53×10^{-4}	1.39×10^{-3}	5.14×10^{-3}	9.95×10^{-3}
Lower Belledune - Teen	2.39×10^{-4}	1.16×10^{-3}	8.99×10^{-4}	1.54×10^{-3}	4.71×10^{-3}	1.08×10^{-2}	2.00×10^{-4}	9.93×10^{-4}	1.03×10^{-3}	2.21×10^{-3}	5.24×10^{-3}	1.74×10^{-2}	1.41×10^{-4}	3.02×10^{-4}	3.88×10^{-4}	8.47×10^{-4}	2.92×10^{-3}	5.91×10^{-3}
Lower Belledune - Adult	2.40×10^{-4}	1.04×10^{-3}	1.02×10^{-3}	1.72×10^{-3}	4.95×10^{-3}	1.06×10^{-2}	2.07×10^{-4}	9.06×10^{-4}	1.14×10^{-3}	2.35×10^{-3}	5.56×10^{-3}	1.65×10^{-2}	1.58×10^{-4}	3.18×10^{-4}	4.06×10^{-4}	8.63×10^{-4}	3.19×10^{-3}	6.15×10^{-3}
Belledune - Infant	4.75×10^{-4}	6.58×10^{-4}	1.63×10^{-4}	2.56×10^{-4}	1.85×10^{-3}	3.09×10^{-3}	4.64×10^{-4}	6.35×10^{-4}	3.37×10^{-4}	4.31×10^{-4}	3.72×10^{-3}	4.81×10^{-3}	3.16×10^{-4}	4.30×10^{-4}	2.17×10^{-4}	2.55×10^{-4}	1.09×10^{-3}	1.33×10^{-3}
Belledune - Toddler	4.37×10^{-4}	6.15×10^{-4}	1.18×10^{-4}	1.84×10^{-4}	2.22×10^{-3}	3.82×10^{-3}	4.13×10^{-4}	5.66×10^{-4}	1.99×10^{-4}	2.53×10^{-4}	2.99×10^{-3}	4.01×10^{-3}	3.31×10^{-4}	4.44×10^{-4}	1.39×10^{-4}	1.63×10^{-4}	1.26×10^{-3}	1.59×10^{-3}
Belledune - Child	2.62×10^{-4}	3.77×10^{-4}	4.86×10^{-4}	8.31×10^{-4}	2.81×10^{-3}	5.63×10^{-3}	2.43×10^{-4}	3.39×10^{-4}	5.56×10^{-4}	8.88×10^{-4}	3.96×10^{-3}	6.25×10^{-3}	1.85×10^{-4}	2.57×10^{-4}	3.12×10^{-4}	4.14×10^{-4}	2.30×10^{-3}	3.14×10^{-3}
Belledune - Teen	1.77×10^{-4}	2.55×10^{-4}	2.81×10^{-4}	4.79×10^{-4}	1.65×10^{-3}	3.26×10^{-3}	1.66×10^{-4}	2.32×10^{-4}	3.26×10^{-4}	5.15×10^{-4}	2.39×10^{-3}	3.72×10^{-3}	1.24×10^{-4}	1.74×10^{-4}	1.89×10^{-4}	2.48×10^{-4}	1.32×10^{-3}	1.79×10^{-3}
Belledune - Adult	1.87×10^{-4}	2.71×10^{-4}	3.03×10^{-4}	5.17×10^{-4}	1.69×10^{-3}	3.39×10^{-3}	1.78×10^{-4}	2.51×10^{-4}	3.49×10^{-4}	5.57×10^{-4}	2.44×10^{-3}	3.85×10^{-3}	1.43×10^{-4}	2.02×10^{-4}	1.93×10^{-4}	2.57×10^{-4}	1.44×10^{-3}	1.96×10^{-3}
Pointe-Verte - Infant	4.27×10^{-4}	6.63×10^{-4}	8.35×10^{-5}	2.51×10^{-4}	1.02×10^{-3}	2.45×10^{-3}	4.17×10^{-4}	6.42×10^{-4}	2.47×10^{-4}	4.11×10^{-4}	2.80×10^{-3}	4.05×10^{-3}	7.15×10^{-4}	1.72×10^{-3}	1.77×10^{-4}	2.30×10^{-4}	2.37×10^{-3}	4.94×10^{-3}
Pointe-Verte - Toddler	3.81×10^{-4}	5.72×10^{-4}	7.03×10^{-5}	1.71×10^{-4}	1.70×10^{-3}	3.12×10^{-3}	3.58×10^{-4}	5.26×10^{-4}	1.52×10^{-4}	2.41×10^{-4}	2.47×10^{-3}	3.50×10^{-3}	4.87×10^{-4}	1.01×10^{-3}	1.17×10^{-4}	1.50×10^{-4}	1.89×10^{-3}	3.34×10^{-3}
Pointe-Verte - Child	2.26×10^{-4}	3.55×10^{-4}	5.63×10^{-4}	9.10×10^{-4}	3.75×10^{-3}	6.02×10^{-3}	2.08×10^{-4}	3.19×10^{-4}	6.36×10^{-4}	9.54×10^{-4}	4.94×10^{-3}	7.10×10^{-3}	3.04×10^{-4}	6.79×10^{-4}	2.84×10^{-4}	3.81×10^{-4}	3.16×10^{-3}	4.80×10^{-3}
Pointe-Verte - Teen	1.53×10^{-4}	2.42×10^{-4}	3.17×10^{-4}	5.15×10^{-4}	2.12×10^{-3}	3.44×10^{-3}	1.42×10^{-4}	2.21×10^{-4}	3.65×10^{-4}	5.50×10^{-4}	2.86×10^{-3}	4.12×10^{-3}	2.06×10^{-4}	4.62×10^{-4}	1.71×10^{-4}	2.28×10^{-4}	1.86×10^{-3}	2.89×10^{-3}
Pointe-Verte - Adult	1.54×10^{-4}	2.40×10^{-4}	3.53×10^{-4}	5.72×10^{-4}	2.29×10^{-3}	3.66×10^{-3}	1.45×10^{-4}	2.22×10^{-4}	4.00×10^{-4}	5.99×10^{-4}	3.08×10^{-3}	4.43×10^{-3}	2.09×10^{-4}	4.59×10^{-4}	1.76×10^{-4}	2.36×10^{-4}	1.99×10^{-3}	3.02×10^{-3}
Petit-Rocher - Infant	2.42×10^{-4}	3.64×10^{-4}	7.96×10^{-5}	2.48×10^{-4}	6.74×10^{-4}	1.86×10^{-3}	2.40×10^{-4}	3.61×10^{-4}	1.41×10^{-4}	2.12×10^{-4}	3.85×10^{-3}	8.32×10^{-3}	6.16×10^{-4}	1.58×10^{-3}	1.75×10^{-4}	2.30×10^{-4}	2.27×10^{-3}	4.84×10^{-3}
Petit-Rocher - Toddler	2.11×10^{-4}	2.99×10^{-4}	6.29×10^{-5}	1.62×10^{-4}	9.92×10^{-4}	1.83×10^{-3}	2.07×10^{-4}	2.91×10^{-4}	9.62×10^{-5}	1.40×10^{-4}	2.96×10^{-3}	5.85×10^{-3}	3.77×10^{-4}	8.49×10^{-4}	1.14×10^{-4}	1.48×10^{-4}	1.73×10^{-3}	3.15×10^{-3}
Petit-Rocher - Child	1.12×10^{-4}	1.75×10^{-4}	2.39×10^{-4}	6.01×10^{-4}	1.42×10^{-3}	3.12×10^{-3}	1.09×10^{-4}	1.69×10^{-4}	2.74×10^{-4}	5.75×10^{-4}	3.55×10^{-3}	7.01×10^{-3}	2.42×10^{-4}	5.92×10^{-4}	2.42×10^{-4}	3.46×10^{-4}	2.28×10^{-3}	3.87×10^{-3}
Petit-Rocher - Teen	7.41×10^{-5}	1.16×10^{-4}	1.38×10^{-4}	3.44×10^{-4}	8.12×10^{-4}	1.80×10^{-3}	7.24×10^{-5}	1.12×10^{-4}	1.60×10^{-4}	3.31×10^{-4}	2.22×10^{-3}	4.52×10^{-3}	1.64×10^{-4}	4.01×10^{-4}	1.47×10^{-4}	2.09×10^{-4}	1.37×10^{-3}	2.38×10^{-3}
Petit-Rocher - Adult	7.30×10^{-5}	1.14×10^{-4}	1.50×10^{-4}	3.79×10^{-4}	8.81×10^{-4}	1.96×10^{-3}	7.16×10^{-5}	1.11×10^{-4}	1.72×10^{-4}	3.61×10^{-4}	2.17×10^{-3}	4.23×10^{-3}	1.57×10^{-4}	3.83×10^{-4}	1.50×10^{-4}	2.15×10^{-4}	1.43×10^{-3}	2.45×10^{-3}

Table 5.11: Summary of total intakes for current time periods for average seafood eaters using CCNB soil data

Receptor Locations	Total Intakes (mg/kg d)															
	Arsenic		Cadmium		Chromium		Lead		Mercury		Thallium		Zinc		Dioxins and Furans	
	Best Estimate	Upper Bound	Best Estimate	Upper Bound	Best Estimate	Upper Bound	Best Estimate	Upper Bound	Best Estimate	Upper Bound	Best Estimate	Upper Bound	Best Estimate	Upper Bound	Best Estimate	Upper Bound
Townsite – Infant	1.60×10^{-3}	1.82×10^{-3}	7.55×10^{-4}	9.29×10^{-4}	1.07×10^{-3}	1.10×10^{-3}	2.76×10^{-3}	6.37×10^{-3}	4.00×10^{-5}	4.25×10^{-5}	6.59×10^{-5}	1.07×10^{-4}	7.46×10^{-1}	7.56×10^{-1}	2.25×10^{-9}	2.25×10^{-9}
Townsite – Toddler	1.52×10^{-3}	1.80×10^{-3}	8.42×10^{-4}	9.50×10^{-4}	1.33×10^{-3}	1.39×10^{-3}	3.22×10^{-3}	5.99×10^{-3}	4.44×10^{-5}	5.08×10^{-5}	1.01×10^{-4}	1.29×10^{-4}	5.67×10^{-1}	5.77×10^{-1}	2.16×10^{-9}	2.16×10^{-9}
Townsite – Child	1.26×10^{-3}	1.38×10^{-3}	9.47×10^{-4}	1.09×10^{-3}	8.19×10^{-4}	8.45×10^{-4}	2.57×10^{-3}	4.68×10^{-3}	8.18×10^{-5}	1.01×10^{-4}	9.01×10^{-5}	1.10×10^{-4}	4.14×10^{-1}	4.20×10^{-1}	1.58×10^{-9}	1.58×10^{-9}
Townsite – Teen	7.72×10^{-4}	8.48×10^{-4}	5.79×10^{-4}	6.69×10^{-4}	4.84×10^{-4}	5.00×10^{-4}	1.53×10^{-3}	2.88×10^{-3}	5.05×10^{-5}	6.09×10^{-5}	5.54×10^{-5}	6.82×10^{-5}	2.69×10^{-1}	2.73×10^{-1}	9.85×10^{-10}	9.85×10^{-10}
Townsite – Adult	7.49×10^{-4}	8.32×10^{-4}	4.40×10^{-4}	5.35×10^{-4}	3.98×10^{-4}	4.12×10^{-4}	1.56×10^{-3}	2.95×10^{-3}	5.03×10^{-5}	6.21×10^{-5}	4.09×10^{-5}	5.29×10^{-5}	1.95×10^{-1}	1.99×10^{-1}	6.27×10^{-10}	6.27×10^{-10}
Lower Belledune – Infant	1.58×10^{-3}	1.81×10^{-3}	7.76×10^{-4}	8.20×10^{-4}	1.07×10^{-3}	1.09×10^{-3}	1.98×10^{-3}	3.51×10^{-3}	3.99×10^{-5}	4.28×10^{-5}	5.81×10^{-5}	8.55×10^{-5}	7.45×10^{-1}	7.51×10^{-1}	2.25×10^{-9}	2.25×10^{-9}
Lower Belledune - Toddler	1.48×10^{-3}	1.81×10^{-3}	8.61×10^{-4}	9.26×10^{-4}	1.32×10^{-3}	1.37×10^{-3}	2.70×10^{-3}	5.59×10^{-3}	4.44×10^{-5}	5.17×10^{-5}	9.64×10^{-5}	1.26×10^{-4}	5.66×10^{-1}	5.72×10^{-1}	2.16×10^{-9}	2.16×10^{-9}
Lower Belledune – Child	1.26×10^{-3}	1.38×10^{-3}	1.15×10^{-3}	1.35×10^{-3}	8.16×10^{-4}	8.27×10^{-4}	4.99×10^{-3}	7.26×10^{-3}	8.22×10^{-5}	1.02×10^{-4}	8.92×10^{-5}	1.04×10^{-4}	4.15×10^{-1}	4.20×10^{-1}	1.58×10^{-9}	1.58×10^{-9}
Lower Belledune – Teen	7.72×10^{-4}	8.52×10^{-4}	6.97×10^{-4}	8.10×10^{-4}	4.82×10^{-4}	4.89×10^{-4}	2.84×10^{-3}	4.17×10^{-3}	5.07×10^{-5}	6.14×10^{-5}	5.47×10^{-5}	6.48×10^{-5}	2.70×10^{-1}	2.73×10^{-1}	9.85×10^{-10}	9.85×10^{-10}
Lower Belledune – Adult	7.48×10^{-4}	8.35×10^{-4}	5.64×10^{-4}	6.91×10^{-4}	3.96×10^{-4}	4.03×10^{-4}	3.08×10^{-3}	4.52×10^{-3}	5.05×10^{-5}	6.27×10^{-5}	4.03×10^{-5}	4.88×10^{-5}	1.96×10^{-1}	1.99×10^{-1}	6.27×10^{-10}	6.27×10^{-10}
Belledune – Infant	1.56×10^{-3}	1.68×10^{-3}	7.42×10^{-4}	7.80×10^{-4}	1.07×10^{-3}	1.09×10^{-3}	1.66×10^{-3}	2.10×10^{-3}	3.96×10^{-5}	4.18×10^{-5}	4.86×10^{-5}	5.63×10^{-5}	7.45×10^{-1}	7.48×10^{-1}	2.25×10^{-9}	2.25×10^{-9}
Belledune – Toddler	1.43×10^{-3}	1.56×10^{-3}	8.26×10^{-4}	8.57×10^{-4}	1.32×10^{-3}	1.37×10^{-3}	1.87×10^{-3}	2.46×10^{-3}	4.38×10^{-5}	4.96×10^{-5}	8.70×10^{-5}	9.39×10^{-5}	5.66×10^{-1}	5.69×10^{-1}	2.16×10^{-9}	2.16×10^{-9}
Belledune – Child	1.25×10^{-3}	1.33×10^{-3}	9.71×10^{-4}	1.03×10^{-3}	8.16×10^{-4}	8.26×10^{-4}	2.62×10^{-3}	3.52×10^{-3}	8.20×10^{-5}	1.01×10^{-4}	8.36×10^{-5}	9.02×10^{-5}	4.14×10^{-1}	4.17×10^{-1}	1.58×10^{-9}	1.58×10^{-9}
Belledune – Teen	7.66×10^{-4}	8.20×10^{-4}	5.94×10^{-4}	6.32×10^{-4}	4.82×10^{-4}	4.88×10^{-4}	1.53×10^{-3}	2.07×10^{-3}	5.06×10^{-5}	6.09×10^{-5}	5.10×10^{-5}	5.51×10^{-5}	2.69×10^{-1}	2.71×10^{-1}	9.85×10^{-10}	9.85×10^{-10}
Belledune – Adult	7.44×10^{-4}	8.09×10^{-4}	4.54×10^{-4}	4.94×10^{-4}	3.96×10^{-4}	4.03×10^{-4}	1.62×10^{-3}	2.22×10^{-3}	5.04×10^{-5}	6.22×10^{-5}	3.72×10^{-5}	4.13×10^{-5}	1.95×10^{-1}	1.97×10^{-1}	6.27×10^{-10}	6.27×10^{-10}
Pointe-Verte – Infant	1.50×10^{-3}	1.63×10^{-3}	7.03×10^{-4}	7.76×10^{-4}	1.37×10^{-3}	1.46×10^{-3}	1.92×10^{-3}	3.29×10^{-3}	3.96×10^{-5}	4.18×10^{-5}	6.31×10^{-5}	8.46×10^{-5}	7.44×10^{-1}	7.48×10^{-1}	2.25×10^{-9}	2.25×10^{-9}
Pointe-Verte – Toddler	1.37×10^{-3}	1.49×10^{-3}	8.03×10^{-4}	8.50×10^{-4}	1.62×10^{-3}	1.73×10^{-3}	1.97×10^{-3}	3.01×10^{-3}	4.35×10^{-5}	4.98×10^{-5}	1.02×10^{-4}	1.18×10^{-4}	5.65×10^{-1}	5.69×10^{-1}	2.16×10^{-9}	2.16×10^{-9}
Pointe-Verte – Child	1.21×10^{-3}	1.29×10^{-3}	9.56×10^{-4}	1.02×10^{-3}	1.02×10^{-3}	1.07×10^{-3}	3.25×10^{-3}	4.47×10^{-3}	8.08×10^{-5}	1.04×10^{-4}	9.50×10^{-5}	1.07×10^{-4}	4.14×10^{-1}	4.18×10^{-1}	1.58×10^{-9}	1.58×10^{-9}
Pointe-Verte – Teen	7.37×10^{-4}	7.90×10^{-4}	5.82×10^{-4}	6.24×10^{-4}	6.19×10^{-4}	6.57×10^{-4}	1.89×10^{-3}	2.66×10^{-3}	4.99×10^{-5}	6.27×10^{-5}	5.85×10^{-5}	6.66×10^{-5}	2.69×10^{-1}	2.72×10^{-1}	9.85×10^{-10}	9.85×10^{-10}
Pointe-Verte – Adult	7.07×10^{-4}	7.64×10^{-4}	4.46×10^{-4}	4.90×10^{-4}	5.70×10^{-4}	6.16×10^{-4}	2.02×10^{-3}	2.83×10^{-3}	4.96×10^{-5}	6.42×10^{-5}	4.75×10^{-5}	5.60×10^{-5}	1.95×10^{-1}	1.98×10^{-1}	6.27×10^{-10}	6.27×10^{-10}
Petit-Rocher – Infant	1.40×10^{-3}	1.49×10^{-3}	7.00×10^{-4}	7.76×10^{-4}	1.51×10^{-3}	1.83×10^{-3}	1.75×10^{-3}	3.14×10^{-3}	3.95×10^{-5}	4.17×10^{-5}	5.95×10^{-5}	7.65×10^{-5}	7.43×10^{-1}	7.47×10^{-1}	2.25×10^{-9}	2.25×10^{-9}
Petit-Rocher – Toddler	1.26×10^{-3}	1.34×10^{-3}	7.98×10^{-4}	8.48×10^{-4}	1.76×10^{-3}	2.10×10^{-3}	1.66×10^{-3}	2.73×10^{-3}	4.30×10^{-5}	4.89×10^{-5}	9.80×10^{-5}	1.09×10^{-4}	5.64×10^{-1}	5.68×10^{-1}	2.16×10^{-9}	2.16×10^{-9}
Petit-Rocher – Child	1.15×10^{-3}	1.20×10^{-3}	9.23×10^{-4}	9.96×10^{-4}	1.11×10^{-3}	1.32×10^{-3}	2.31×10^{-3}	3.51×10^{-3}	7.91×10^{-5}	1.05×10^{-4}	9.25×10^{-5}	1.03×10^{-4}	4.12×10^{-1}	4.17×10^{-1}	1.58×10^{-9}	1.58×10^{-9}
Petit-Rocher – Teen	6.95×10^{-4}	7.31×10^{-4}	5.64×10^{-4}	6.09×10^{-4}	6.84×10^{-4}	8.26×10^{-4}	1.37×10^{-3}	2.12×10^{-3}	4.90×10^{-5}	6.33×10^{-5}	5.68×10^{-5}	6.34×10^{-5}	2.68×10^{-1}	2.71×10^{-1}	9.85×10^{-10}	9.85×10^{-10}
Petit-Rocher – Adult	6.54×10^{-4}	6.89×10^{-4}	4.25×10^{-4}	4.73×10^{-4}	6.52×10^{-4}	8.31×10^{-4}	1.44×10^{-3}	2.23×10^{-3}	4.86×10^{-5}	6.49×10^{-5}	4.55×10^{-5}	5.20×10^{-5}	1.94×10^{-1}	1.97×10^{-1}	6.27×10^{-10}	6.27×10^{-10}

Table 5.12 breaks down the total intakes for the current time period provided in Table 5.9 into the respective pathways. In this way, it can be determined which pathways contribute significantly to the intakes. Table 5.12 shows that with the exception of lead, supermarket food intakes are a significant pathway. It must be noted that the results presented here are intakes, and do not represent risks. Intakes presented in the absence of toxicity reference values (TRVs) cannot give indication of the presence or absence of risk, or measure of risk against any risk acceptability benchmarks. Section 7 provides this comparison. Additionally, different pathways are significant for the same COPC depending on the location or receptor. For arsenic, the table shows that consumption of well water is the next most significant pathway followed by soil ingestion and wild game consumption. Soil ingestion represents about 8% to 10% of the intake for a toddler in Townsite #2 and Lower Belledune.

For cadmium, the intake of wild mussels and then consumption of backyard produce are the next most significant pathways of exposure after supermarket foods. The soil pathway represents approximately 1.3% of the intake for a toddler.

For chromium, exposure in Townsite #2, Lower Belledune and Belledune, the soil pathways and wild game pathways are the next most significant pathways after supermarket food. It should be noted that no data were available for backyard produce and local seafood and thus these pathways were not assessed.

For lead exposure, the consumption of aboveground backyard vegetable (44.5%) is the most significant pathway for an infant in Townsite #2, followed by supermarket food (19.7%), soil (13.7%) and backyard root vegetables (10.9%). For toddlers, soil is the major pathway (26.2%), followed by aboveground backyard vegetables (19.9%), supermarket food (19.5%) and fish (18.4%). For children, teens and adults in Townsite #2, fish consumption is the major pathway (44% to 49%), followed by aboveground backyard vegetables (15% to 16%) and supermarket food (12% to 15%). For the infant in Lower Belledune, the pathways in order of significance are supermarket food (28%), aboveground backyard vegetables (20.6%), backyard root vegetables (18.8%) and soil (16.9%). For the toddler, the pathways in order of significance are soil (27%), supermarket food (23.2%) and fish (22%). For the child, teen and adult, the pathways in order of significance are wild mussels (56% to 58%) and local fish (23% to 24%). Similar trends are also seen in Pointe-Verte and Petit-Rocher.

For mercury, the pathways in order of significance are supermarket food, local fish, wild mussels and lobsters. It should be noted that data were not available for drinking water and backyard produce and thus these pathways were not evaluated.

Thallium exposures in Townsite #2 and Lower Belledune are dominated by supermarket food, followed by aboveground and belowground backyard vegetables. There were no available fish data and as such this pathway was not evaluated.

For zinc, the supermarket food was the dominant pathway followed by fish.

For dioxins and furans, supermarket food was also the dominant pathway. No data were available for water, backyard vegetables, wild game and local seafood; therefore, these pathways were not considered. Table 5.13 provides a similar breakdown for CCNB soil data.

Table 5.13 provides a summary for the total intakes for the maximum adult seafood eaters in an attempt to capture the intakes that a very small sector of the population may experience. As seen from the table the intakes of these individuals are larger than those of the average seafood eater depending on the COPC and the type of seafood being consumed.

All intakes discussed in Section 5.0 will be interpreted in a risk framework in Section 7.0, following the toxicity assessment for all COPC in Section 6.0.

Table 5.12: Percent intake (best estimate) by pathway for current time period for average local seafood eaters using Noranda EMP data

	Percent of Total Intake										
Arsenic	Inhalation	Dermal	Water	Soil	Root Veg	Other Veg	Wild Game	Fish	Local Lobster	Wild Mussels	Supermarket Food
Townsite - Infant	0.15%	0.33%	11.56%	4.40%	2.70%	3.15%	-	0.05%	-	-	77.66%
Townsite - Toddler	0.35%	0.26%	12.33%	9.38%	1.82%	1.56%	4.40%	0.14%	0.07%		69.68%
Townsite - Child	0.32%	0.23%	9.63%	1.37%	1.64%	1.34%	3.79%	0.43%	0.18%	0.53%	80.54%
Townsite - Teen	0.32%	0.30%	10.84%	1.24%	2.08%	1.48%	4.78%	0.39%	0.16%	0.48%	77.94%
Townsite - Adult	0.28%	0.29%	14.13%	1.08%	1.50%	1.46%	6.40%	0.46%	0.19%	0.56%	73.65%
Lower Belledune - Infant	0.11%	0.27%	11.67%	3.61%	3.64%	2.27%	-	0.05%	-	-	78.39%
Lower Belledune - Toddler	0.25%	0.21%	12.55%	7.77%	2.48%	1.13%	4.48%	0.15%	0.08%	-	70.91%
Lower Belledune - Child	0.22%	0.19%	9.63%	1.12%	2.18%	0.95%	3.79%	0.43%	0.21%	0.71%	80.56%
Lower Belledune - Teen	0.22%	0.24%	10.83%	1.01%	2.77%	1.05%	4.77%	0.39%	0.19%	0.64%	77.88%
Lower Belledune - Adult	0.19%	0.24%	14.14%	0.87%	2.00%	1.04%	6.41%	0.46%	0.22%	0.75%	73.68%
Belledune - Infant	0.03%	0.18%	11.82%	2.35%	3.13%	3.03%	-	0.05%	-	-	79.40%
Belledune - Toddler	0.08%	0.14%	12.94%	5.14%	2.17%	1.55%	4.62%	0.15%	0.08%	-	73.13%
Belledune - Child	0.07%	0.12%	9.69%	0.72%	1.87%	1.27%	3.81%	0.44%	0.21%	0.71%	81.09%
Belledune - Teen	0.07%	0.16%	10.90%	0.65%	2.37%	1.40%	4.81%	0.39%	0.18%	0.64%	78.42%
Belledune - Adult	0.06%	0.15%	14.21%	0.56%	1.70%	1.39%	6.44%	0.46%	0.22%	0.75%	74.05%
Pointe-Verte - Infant	0.03%	0.18%	7.97%	2.37%	3.50%	3.36%	-	0.05%	-	-	82.54%
Pointe-Verte - Toddler	0.08%	0.14%	8.78%	5.23%	2.44%	1.72%	4.83%	0.16%	0.08%	-	76.54%
Pointe-Verte - Child	0.07%	0.12%	6.50%	0.73%	2.08%	1.40%	3.95%	0.45%	0.20%	0.57%	83.93%
Pointe-Verte - Teen	0.07%	0.16%	7.35%	0.66%	2.65%	1.55%	4.99%	0.41%	0.18%	0.52%	81.47%
Pointe-Verte - Adult	0.06%	0.16%	9.69%	0.58%	1.93%	1.56%	6.78%	0.49%	0.22%	0.61%	77.93%
Petit-Rocher - Infant	0.01%	0.15%	2.20%	2.02%	3.74%	3.59%	-	0.06%	-	-	88.23%
Petit-Rocher - Toddler	0.01%	0.12%	2.45%	4.52%	2.64%	1.87%	5.23%	0.17%	0.08%	-	82.90%
Petit-Rocher - Child	0.01%	0.10%	1.77%	0.61%	2.19%	1.48%	4.16%	0.48%	0.19%	0.57%	88.44%
Petit-Rocher - Teen	0.01%	0.14%	2.01%	0.56%	2.81%	1.64%	5.29%	0.43%	0.18%	0.52%	86.41%
Petit-Rocher - Adult	0.01%	0.14%	2.70%	0.50%	2.08%	1.68%	7.32%	0.52%	0.21%	0.63%	84.20%

Note: receptor is not exposed via this pathway.

	Percent of Total Intake										
Cadmium	Inhalation	Dermal	Water	Soil	Root Veg	Other Veg	Wild Game	Fish	Local Lobster	Wild Mussels	Supermarket Food
Townsite - Infant	0.10%	0.23%	1.07%	0.70%	7.73%	7.77%	-	0.56%	-	-	81.83%
Townsite - Toddler	0.21%	0.15%	0.96%	1.26%	4.38%	3.24%	1.06%	1.32%	0.05%	-	87.39%
Townsite - Child	0.14%	0.10%	0.56%	0.14%	2.96%	2.09%	0.69%	3.02%	0.09%	12.05%	78.15%
Townsite - Teen	0.14%	0.13%	0.63%	0.12%	3.76%	2.30%	0.87%	2.72%	0.08%	10.85%	78.38%
Townsite - Adult	0.16%	0.17%	1.06%	0.14%	3.47%	2.93%	1.49%	4.09%	0.13%	16.33%	70.05%
Lower Belledune - Infant	0.08%	0.19%	1.04%	0.58%	16.30%	1.87%	-	0.54%	-	-	79.40%
Lower Belledune - Toddler	0.17%	0.13%	0.93%	1.05%	9.28%	0.78%	1.03%	1.29%	0.05%	-	85.29%
Lower Belledune - Child	0.10%	0.07%	0.46%	0.10%	5.29%	0.43%	0.57%	2.49%	0.09%	26.12%	64.30%
Lower Belledune - Teen	0.10%	0.09%	0.53%	0.09%	6.78%	0.47%	0.72%	2.26%	0.08%	23.75%	65.13%
Lower Belledune - Adult	0.10%	0.11%	0.82%	0.09%	5.86%	0.57%	1.16%	3.19%	0.11%	33.48%	54.52%
Belledune - Infant	0.03%	0.08%	1.08%	0.24%	10.36%	4.99%	-	0.56%	-	-	82.66%
Belledune - Toddler	0.05%	0.05%	0.96%	0.42%	5.85%	2.08%	1.07%	1.33%	0.05%	-	88.13%
Belledune - Child	0.03%	0.03%	0.55%	0.04%	3.82%	1.29%	0.67%	2.94%	0.10%	14.50%	76.03%
Belledune - Teen	0.03%	0.04%	0.62%	0.04%	4.85%	1.43%	0.84%	2.65%	0.09%	13.07%	76.34%
Belledune - Adult	0.04%	0.05%	1.02%	0.04%	4.44%	1.80%	1.44%	3.95%	0.13%	19.49%	67.61%
Pointe-Verte - Infant	0.02%	0.07%	1.18%	0.22%	7.10%	3.65%	-	0.60%	-	-	87.15%
Pointe-Verte - Toddler	0.05%	0.05%	1.03%	0.39%	3.91%	1.48%	1.10%	1.37%	0.04%	-	90.59%
Pointe-Verte - Child	0.03%	0.03%	0.58%	0.04%	2.52%	0.91%	0.68%	2.99%	0.08%	14.90%	77.25%
Pointe-Verte - Teen	0.03%	0.04%	0.65%	0.04%	3.22%	1.01%	0.86%	2.70%	0.07%	13.49%	77.89%
Pointe-Verte - Adult	0.03%	0.05%	1.08%	0.04%	2.94%	1.27%	1.46%	4.03%	0.11%	20.09%	68.90%
Petit-Rocher - Infant	0.00%	0.03%	1.10%	0.10%	7.12%	3.66%	-	0.60%	-	-	87.39%
Petit-Rocher - Toddler	0.01%	0.02%	0.96%	0.18%	3.93%	1.48%	1.10%	1.37%	0.05%	-	90.91%
Petit-Rocher - Child	0.00%	0.01%	0.55%	0.02%	2.61%	0.94%	0.70%	3.09%	0.09%	12.04%	79.93%
Petit-Rocher - Teen	0.00%	0.02%	0.62%	0.02%	3.32%	1.04%	0.89%	2.79%	0.09%	10.87%	80.34%
Petit-Rocher - Adult	0.00%	0.02%	1.05%	0.02%	3.08%	1.33%	1.53%	4.22%	0.13%	16.44%	72.18%

Note: receptor is not exposed via this pathway.

Table 5.12: Percent intake (best estimate) by pathway for current time period for average local seafood eaters using Noranda EMP data (cont'd)

	Percent of Total Intake										
Chromium	Inhalation	Dermal	Water	Soil	Root Veg	Other Veg	Wild Game	Fish	Local Lobster	Wild Mussels	Supermarket Food
Townsite - Infant	0.21%	1.82%	4.52%	8.67%	na	na	-	na	na	na	84.78%
Townsite - Toddler	0.37%	1.08%	3.63%	13.92%	na	na	4.90%	na	na	na	76.10%
Townsite - Child	0.47%	1.32%	3.90%	2.81%	na	na	5.81%	na	na	na	85.69%
Townsite - Teen	0.48%	1.79%	4.55%	2.62%	na	na	7.60%	na	na	na	82.96%
Townsite - Adult	0.49%	2.07%	7.02%	2.69%	na	na	12.04%	na	na	na	75.68%
Lower Belledune - Infant	0.02%	1.82%	4.53%	8.68%	na	na	-	na	na	na	84.95%
Lower Belledune - Toddler	0.04%	1.08%	3.64%	13.97%	na	na	4.92%	na	na	na	76.36%
Lower Belledune - Child	0.05%	1.32%	3.92%	2.82%	na	na	5.84%	na	na	na	86.05%
Lower Belledune - Teen	0.05%	1.80%	4.57%	2.63%	na	na	7.63%	na	na	na	83.31%
Lower Belledune - Adult	0.05%	2.08%	7.05%	2.70%	na	na	12.10%	na	na	na	76.02%
Belledune - Infant	0.02%	1.82%	4.53%	8.68%	na	na	-	na	na	na	84.95%
Belledune - Toddler	0.04%	1.08%	3.64%	13.97%	na	na	4.92%	na	na	na	76.36%
Belledune - Child	0.04%	1.32%	3.92%	2.82%	na	na	5.84%	na	na	na	86.05%
Belledune - Teen	0.05%	1.80%	4.57%	2.63%	na	na	7.63%	na	na	na	83.32%
Belledune - Adult	0.05%	2.08%	7.05%	2.70%	na	na	12.10%	na	na	na	76.02%
Pointe-Verte - Infant	0.00%	1.42%	25.64%	6.77%	na	na	-	na	na	na	66.17%
Pointe-Verte - Toddler	0.01%	0.88%	21.55%	11.37%	na	na	4.00%	na	na	na	62.18%
Pointe-Verte - Child	0.01%	1.06%	22.88%	2.26%	na	na	4.69%	na	na	na	69.10%
Pointe-Verte - Teen	0.01%	1.40%	25.85%	2.05%	na	na	5.93%	na	na	na	64.76%
Pointe-Verte - Adult	0.01%	1.45%	35.54%	1.88%	na	na	8.39%	na	na	na	52.73%
Petit-Rocher - Infant	0.00%	1.29%	32.65%	6.13%	na	na	-	na	na	na	59.94%
Petit-Rocher - Toddler	0.00%	0.81%	27.86%	10.46%	na	na	3.68%	na	na	na	57.18%
Petit-Rocher - Child	0.00%	0.97%	29.43%	2.07%	na	na	4.29%	na	na	na	63.23%
Petit-Rocher - Teen	0.00%	1.27%	32.89%	1.85%	na	na	5.37%	na	na	na	58.62%
Petit-Rocher - Adult	0.00%	1.26%	43.68%	1.64%	na	na	7.33%	na	na	na	46.09%

Note: na - pathway not assessed for this COPC.
- receptor is not exposed via this pathway

	Percent of Total Intake										
Lead	Inhalation	Dermal	Water	Soil	Root Veg	Other Veg	Wild Game	Fish	Local Lobster	Wild Mussels	Supermarket Food
Townsite - Infant	1.72%	0.19%	2.00%	13.65%	10.88%	44.54%	-	7.29%	-	-	19.73%
Townsite - Toddler	3.64%	0.14%	1.91%	26.14%	6.59%	19.85%	3.67%	18.44%	0.12%	-	19.50%
Townsite - Child	2.84%	0.10%	1.28%	3.27%	5.06%	14.53%	2.70%	47.87%	0.29%	7.16%	14.89%
Townsite - Teen	2.85%	0.14%	1.47%	3.01%	6.57%	16.39%	3.49%	44.08%	0.26%	6.59%	15.15%
Townsite - Adult	2.35%	0.13%	1.82%	2.48%	4.49%	15.43%	4.44%	49.13%	0.29%	7.35%	12.09%
Lower Belledune - Infant	2.07%	0.24%	2.85%	16.91%	18.78%	20.59%	-	10.40%	-	-	28.16%
Lower Belledune - Toddler	3.66%	0.14%	2.28%	27.02%	9.49%	7.65%	4.37%	21.94%	0.26%	-	23.20%
Lower Belledune - Child	1.21%	0.04%	0.64%	1.43%	3.08%	2.37%	1.36%	24.09%	0.26%	58.02%	7.50%
Lower Belledune - Teen	1.27%	0.06%	0.78%	1.38%	4.20%	2.81%	1.84%	23.30%	0.25%	56.10%	8.01%
Lower Belledune - Adult	0.99%	0.06%	0.90%	1.07%	2.70%	2.49%	2.21%	24.44%	0.26%	58.86%	6.01%
Belledune - Infant	0.65%	0.10%	2.97%	7.49%	15.68%	32.87%	-	10.85%	-	-	29.37%
Belledune - Toddler	1.32%	0.07%	2.71%	13.67%	9.04%	13.94%	5.20%	26.13%	0.28%	-	27.64%
Belledune - Child	0.69%	0.04%	1.21%	1.15%	4.65%	6.84%	2.57%	45.45%	0.43%	22.83%	14.14%
Belledune - Teen	0.71%	0.05%	1.43%	1.08%	6.17%	7.88%	3.38%	42.74%	0.40%	21.47%	14.69%
Belledune - Adult	0.56%	0.04%	1.71%	0.86%	4.09%	7.21%	4.18%	46.27%	0.44%	23.25%	11.39%
Pointe-Verte - Infant	0.48%	0.08%	4.88%	5.91%	11.75%	42.49%	-	9.28%	-	-	25.13%
Pointe-Verte - Toddler	1.06%	0.06%	4.85%	11.75%	7.39%	19.67%	4.86%	24.38%	0.18%	-	25.79%
Pointe-Verte - Child	0.48%	0.03%	1.87%	0.85%	3.28%	8.33%	2.07%	36.60%	0.24%	34.87%	11.39%
Pointe-Verte - Teen	0.49%	0.04%	2.21%	0.80%	4.37%	9.64%	2.74%	34.60%	0.23%	32.98%	11.89%
Pointe-Verte - Adult	0.39%	0.03%	2.62%	0.63%	2.86%	8.69%	3.33%	36.92%	0.24%	35.19%	9.09%
Petit-Rocher - Infant	0.07%	0.05%	3.42%	3.28%	12.35%	44.67%	-	9.76%	-	-	26.41%
Petit-Rocher - Toddler	0.16%	0.03%	3.52%	6.76%	8.04%	21.40%	5.29%	26.53%	0.19%	-	28.07%
Petit-Rocher - Child	0.09%	0.02%	1.74%	0.63%	4.57%	11.60%	2.88%	50.98%	0.32%	11.31%	15.86%
Petit-Rocher - Teen	0.10%	0.03%	2.02%	0.58%	5.98%	13.18%	3.74%	47.32%	0.30%	10.49%	16.26%
Petit-Rocher - Adult	0.08%	0.02%	2.45%	0.47%	4.00%	12.16%	4.66%	51.66%	0.32%	11.46%	12.71%

Note: receptor is not exposed via this pathway.

Table 5.12: Percent intake (best estimate) by pathway for current time period for average local seafood eaters using Noranda EMP data (cont'd)

	Percent of Total Intake										
Mercury	Inhalation	Dermal	Water	Soil	Root Veg	Other Veg	Wild Game	Fish	Local Lobster	Wild Mussels	Supermarket Food
Townsite - Infant	0.16%	0.07%	na	0.57%	na	na	-	12.38%	-	-	86.84%
Townsite - Toddler	0.31%	0.04%	na	1.02%	na	na	2.93%	29.38%	4.83%	-	61.48%
Townsite - Child	0.13%	0.02%	na	0.07%	na	na	1.16%	41.04%	6.02%	8.74%	42.82%
Townsite - Teen	0.13%	0.02%	na	0.06%	na	na	1.45%	36.63%	5.37%	7.80%	48.53%
Townsite - Adult	0.11%	0.02%	na	0.05%	na	na	1.90%	42.00%	6.16%	8.95%	40.81%
Lower Belledune - Infant	0.12%	0.06%	na	0.52%	na	na	-	12.39%	-	-	86.91%
Lower Belledune - Toddler	0.24%	0.04%	na	0.93%	na	na	2.92%	29.29%	5.27%	-	61.31%
Lower Belledune - Child	0.10%	0.02%	na	0.06%	na	na	1.16%	40.83%	6.55%	8.70%	42.59%
Lower Belledune - Teen	0.10%	0.02%	na	0.06%	na	na	1.45%	36.46%	5.85%	7.77%	48.31%
Lower Belledune - Adult	0.08%	0.02%	na	0.05%	na	na	1.89%	41.77%	6.70%	8.90%	40.59%
Belledune - Infant	0.04%	0.05%	na	0.42%	na	na	-	12.41%	-	-	87.08%
Belledune - Toddler	0.08%	0.03%	na	0.75%	na	na	2.94%	29.43%	5.18%	-	61.59%
Belledune - Child	0.03%	0.01%	na	0.05%	na	na	1.16%	40.92%	6.42%	8.72%	42.69%
Belledune - Teen	0.03%	0.02%	na	0.04%	na	na	1.45%	36.53%	5.73%	7.78%	48.41%
Belledune - Adult	0.03%	0.02%	na	0.04%	na	na	1.89%	41.86%	6.57%	8.92%	40.68%
Pointe-Verte - Infant	0.03%	0.05%	na	0.41%	na	na	-	12.41%	-	-	87.09%
Pointe-Verte - Toddler	0.07%	0.03%	na	0.75%	na	na	2.95%	29.59%	4.67%	-	61.93%
Pointe-Verte - Child	0.03%	0.01%	na	0.05%	na	na	1.18%	41.52%	5.85%	8.05%	43.32%
Pointe-Verte - Teen	0.03%	0.02%	na	0.04%	na	na	1.47%	37.01%	5.21%	7.17%	49.05%
Pointe-Verte - Adult	0.02%	0.02%	na	0.04%	na	na	1.92%	42.49%	5.98%	8.23%	41.29%
Petit-Rocher - Infant	0.00%	0.04%	na	0.38%	na	na	-	12.42%	-	-	87.15%
Petit-Rocher - Toddler	0.01%	0.03%	na	0.69%	na	na	2.98%	29.86%	3.93%	-	62.50%
Petit-Rocher - Child	0.00%	0.01%	na	0.05%	na	na	1.20%	42.41%	4.98%	7.11%	44.24%
Petit-Rocher - Teen	0.00%	0.02%	na	0.04%	na	na	1.49%	37.72%	4.42%	6.32%	49.98%
Petit-Rocher - Adult	0.00%	0.02%	na	0.04%	na	na	1.96%	43.42%	5.09%	7.28%	42.19%

Note: na - pathway not assessed for this COPC.
- receptor is not exposed via this pathway

	Percent of Total Intake										
Thallium	Inhalation	Dermal	Water	Soil	Root Veg	Other Veg	Wild Game	Fish	Local Lobster	Wild Mussels	Supermarket Food
Townsite - Infant	0.75%	0.10%	4.23%	4.20%	23.27%	26.50%	-	na	-	-	40.94%
Townsite - Toddler	1.09%	0.05%	2.76%	5.49%	9.61%	8.05%	6.66%	na	0.09%	-	66.20%
Townsite - Child	0.92%	0.04%	2.00%	0.74%	7.99%	6.38%	5.31%	na	0.22%	1.48%	74.92%
Townsite - Teen	0.90%	0.05%	2.24%	0.67%	10.09%	7.00%	6.66%	na	0.20%	1.33%	70.88%
Townsite - Adult	1.02%	0.07%	3.84%	0.76%	9.55%	9.14%	11.75%	na	0.30%	2.05%	61.52%
Lower Belledune - Infant	0.67%	0.10%	4.78%	4.11%	28.46%	15.67%		na	-	-	46.22%
Lower Belledune - Toddler	0.89%	0.04%	2.88%	4.95%	10.85%	4.39%	6.94%	na	0.09%	-	68.97%
Lower Belledune - Child	0.73%	0.03%	2.01%	0.65%	8.72%	3.37%	5.35%	na	0.22%	3.38%	75.52%
Lower Belledune - Teen	0.71%	0.04%	2.26%	0.58%	11.05%	3.71%	6.73%	na	0.20%	3.04%	71.67%
Lower Belledune - Adult	0.81%	0.06%	3.89%	0.67%	10.49%	4.85%	11.90%	na	0.31%	4.70%	62.32%
Belledune - Infant	0.24%	0.07%	5.57%	2.92%	22.45%	14.89%		na	-	-	53.86%
Belledune - Toddler	0.30%	0.03%	3.09%	3.24%	7.88%	3.85%	7.45%	na	0.10%	-	74.06%
Belledune - Child	0.24%	0.02%	2.14%	0.42%	6.27%	2.92%	5.68%	na	0.24%	1.90%	80.17%
Belledune - Teen	0.24%	0.03%	2.42%	0.38%	7.99%	3.23%	7.20%	na	0.21%	1.72%	76.59%
Belledune - Adult	0.27%	0.04%	4.20%	0.44%	7.66%	4.27%	12.84%	na	0.33%	2.69%	67.26%
Pointe-Verte - Infant	0.15%	0.05%	33.38%	2.12%	10.27%	12.73%		na	-	-	41.30%
Pointe-Verte - Toddler	0.20%	0.02%	20.47%	2.59%	3.98%	3.63%	6.31%	na	0.08%	-	62.71%
Pointe-Verte - Child	0.17%	0.02%	14.70%	0.35%	3.29%	2.86%	5.00%	na	0.21%	2.87%	70.53%
Pointe-Verte - Teen	0.17%	0.02%	16.46%	0.31%	4.15%	3.14%	6.27%	na	0.19%	2.57%	66.72%
Pointe-Verte - Adult	0.17%	0.03%	25.65%	0.33%	3.57%	3.72%	10.05%	na	0.26%	3.61%	52.61%
Petit-Rocher - Infant	0.02%	0.04%	30.56%	1.75%	10.80%	13.39%		na	-	-	43.44%
Petit-Rocher - Toddler	0.03%	0.02%	18.44%	2.11%	4.12%	3.76%	6.53%	na	0.09%	-	64.90%
Petit-Rocher - Child	0.02%	0.01%	13.14%	0.28%	3.38%	2.94%	5.13%	na	0.21%	2.48%	72.40%
Petit-Rocher - Teen	0.02%	0.02%	14.73%	0.25%	4.27%	3.23%	6.45%	na	0.19%	2.23%	68.61%
Petit-Rocher - Adult	0.03%	0.02%	23.28%	0.27%	3.73%	3.88%	10.48%	na	0.27%	3.17%	54.87%

Note: na - pathway not assessed for this COPC.
- receptor is not exposed via this pathway

Table 5.12: Percent intake (best estimate) by pathway for current time period for average local seafood eaters using Noranda EMP data (cont'd)

Zinc	**Percent of Total Intake**										
	Inhalation	Dermal	Water	Soil	Root Veg	Other Veg	Wild Game	Fish	Local Lobster	Wild Mussels	Supermarket Food
Townsite - Infant	0.00%	0.00%	0.27%	0.05%	0.49%	0.49%	-	0.13%	-	-	98.56%
Townsite - Toddler	0.00%	0.00%	0.35%	0.14%	0.40%	0.30%	0.30%	0.46%	0.07%	-	97.97%
Townsite - Child	0.00%	0.00%	0.32%	0.02%	0.42%	0.30%	0.31%	1.63%	0.22%	0.48%	96.29%
Townsite - Teen	0.00%	0.00%	0.34%	0.02%	0.51%	0.31%	0.36%	1.38%	0.18%	0.41%	96.48%
Townsite - Adult	0.00%	0.00%	0.60%	0.02%	0.49%	0.42%	0.66%	2.17%	0.29%	0.64%	94.71%
Lower Belledune - Infant	0.00%	0.00%	0.27%	0.05%	0.49%	0.41%	-	0.13%	-	-	98.64%
Lower Belledune - Toddler	0.00%	0.00%	0.35%	0.12%	0.41%	0.25%	0.30%	0.46%	0.07%	-	98.03%
Lower Belledune - Child	0.00%	0.00%	0.32%	0.02%	0.43%	0.25%	0.31%	1.62%	0.22%	0.93%	95.91%
Lower Belledune - Teen	0.00%	0.00%	0.34%	0.02%	0.51%	0.26%	0.36%	1.37%	0.18%	0.79%	96.16%
Lower Belledune - Adult	0.00%	0.00%	0.60%	0.02%	0.49%	0.35%	0.65%	2.16%	0.29%	1.24%	94.20%
Belledune - Infant	0.00%	0.00%	0.27%	0.05%	0.43%	0.55%	-	0.13%	-	-	98.58%
Belledune - Toddler	0.00%	0.00%	0.35%	0.12%	0.35%	0.33%	0.30%	0.46%	0.07%	-	98.01%
Belledune - Child	0.00%	0.00%	0.32%	0.02%	0.37%	0.33%	0.31%	1.63%	0.22%	0.54%	96.26%
Belledune - Teen	0.00%	0.00%	0.34%	0.02%	0.44%	0.35%	0.36%	1.38%	0.18%	0.45%	96.47%
Belledune - Adult	0.00%	0.00%	0.60%	0.02%	0.43%	0.46%	0.66%	2.17%	0.29%	0.72%	94.66%
Pointe-Verte - Infant	0.00%	0.00%	0.26%	0.05%	0.36%	0.43%	-	0.13%	-	-	98.77%
Pointe-Verte - Toddler	0.00%	0.00%	0.34%	0.12%	0.30%	0.26%	0.30%	0.46%	0.07%	-	98.15%
Pointe-Verte - Child	0.00%	0.00%	0.31%	0.02%	0.31%	0.26%	0.31%	1.63%	0.24%	0.66%	96.26%
Pointe-Verte - Teen	0.00%	0.00%	0.33%	0.02%	0.37%	0.27%	0.36%	1.38%	0.20%	0.56%	96.50%
Pointe-Verte - Adult	0.00%	0.00%	0.57%	0.02%	0.36%	0.36%	0.66%	2.17%	0.32%	0.88%	94.65%
Petit-Rocher - Infant	0.00%	0.00%	0.11%	0.04%	0.36%	0.43%	-	0.13%	-	-	98.92%
Petit-Rocher - Toddler	0.00%	0.00%	0.14%	0.12%	0.30%	0.26%	0.31%	0.46%	0.08%	-	98.34%
Petit-Rocher - Child	0.00%	0.00%	0.13%	0.02%	0.31%	0.26%	0.31%	1.63%	0.25%	0.49%	96.60%
Petit-Rocher - Teen	0.00%	0.00%	0.14%	0.02%	0.37%	0.27%	0.37%	1.38%	0.21%	0.42%	96.82%
Petit-Rocher - Adult	0.00%	0.00%	0.24%	0.02%	0.36%	0.36%	0.66%	2.18%	0.33%	0.66%	95.18%

Note: receptor is not exposed via this pathway.

Dioxins and Furans	**Percent of Total Intake**										
	Inhalation	Dermal	Water	Soil	Root Veg	Other Veg	Wild Game	Fish	Local Lobster	Wild Mussels	Supermarket Food
Townsite - Infant	0.00%	0.00%	na	0.06%	na	na	na	na	na	na	99.93%
Townsite - Toddler	0.00%	0.00%	na	0.13%	na	na	na	na	na	na	99.86%
Townsite - Child	0.00%	0.00%	na	0.02%	na	na	na	na	na	na	99.97%
Townsite - Teen	0.00%	0.00%	na	0.02%	na	na	na	na	na	na	99.97%
Townsite - Adult	0.00%	0.01%	na	0.03%	na	na	na	na	na	na	99.96%
Lower Belledune - Infant	0.00%	0.00%	na	0.06%	na	na	na	na	na	na	99.93%
Lower Belledune - Toddler	0.00%	0.00%	na	0.13%	na	na	na	na	na	na	99.86%
Lower Belledune - Child	0.00%	0.00%	na	0.02%	na	na	na	na	na	na	99.97%
Lower Belledune - Teen	0.00%	0.00%	na	0.02%	na	na	na	na	na	na	99.97%
Lower Belledune - Adult	0.00%	0.01%	na	0.03%	na	na	na	na	na	na	99.96%
Belledune - Infant	0.00%	0.00%	na	0.06%	na	na	na	na	na	na	99.93%
Belledune - Toddler	0.00%	0.00%	na	0.13%	na	na	na	na	na	na	99.86%
Belledune - Child	0.00%	0.00%	na	0.02%	na	na	na	na	na	na	99.97%
Belledune - Teen	0.00%	0.00%	na	0.02%	na	na	na	na	na	na	99.97%
Belledune - Adult	0.00%	0.01%	na	0.03%	na	na	na	na	na	na	99.97%
Pointe-Verte - Infant	0.00%	0.00%	na	0.06%	na	na	na	na	na	na	99.93%
Pointe-Verte - Toddler	0.00%	0.00%	na	0.13%	na	na	na	na	na	na	99.86%
Pointe-Verte - Child	0.00%	0.00%	na	0.02%	na	na	na	na	na	na	99.97%
Pointe-Verte - Teen	0.00%	0.00%	na	0.02%	na	na	na	na	na	na	99.97%
Pointe-Verte - Adult	0.00%	0.01%	na	0.03%	na	na	na	na	na	na	99.97%
Petit-Rocher - Infant	0.00%	0.00%	na	0.06%	na	na	na	na	na	na	99.93%
Petit-Rocher - Toddler	0.00%	0.00%	na	0.13%	na	na	na	na	na	na	99.86%
Petit-Rocher - Child	0.00%	0.00%	na	0.02%	na	na	na	na	na	na	99.97%
Petit-Rocher - Teen	0.00%	0.00%	na	0.02%	na	na	na	na	na	na	99.97%
Petit-Rocher - Adult	0.00%	0.01%	na	0.03%	na	na	na	na	na	na	99.97%

Note: na - pathway not assessed for this COPC.

Table 5.13: Percent intake (best estimate) by pathway for current time period for average local seafood eaters using CCNB soil data

	Percent of Total Intake										
Arsenic	Inhalation	Dermal	Water	Soil	Root Veg	Other Veg	Wild Game	Fish	Local Lobster	Wild Mussels	Supermarket Food
Townsite - Infant	0.15%	0.44%	11.36%	5.91%	2.66%	3.09%	-	0.05%	-	-	76.34%
Townsite - Toddler	0.34%	0.34%	11.91%	12.38%	1.76%	1.51%	4.25%	0.14%	0.06%	-	67.30%
Townsite - Child	0.32%	0.31%	9.57%	1.87%	1.63%	1.33%	3.77%	0.43%	0.18%	0.53%	80.07%
Townsite - Teen	0.31%	0.41%	10.78%	1.68%	2.07%	1.47%	4.75%	0.39%	0.16%	0.47%	77.51%
Townsite - Adult	0.27%	0.40%	14.06%	1.46%	1.49%	1.46%	6.37%	0.46%	0.19%	0.56%	73.28%
Lower Belledune - Infant	0.10%	0.37%	11.49%	4.98%	3.58%	2.23%	-	0.05%	-	-	77.18%
Lower Belledune - Toddler	0.24%	0.29%	12.16%	10.55%	2.40%	1.10%	4.34%	0.14%	0.08%	-	68.71%
Lower Belledune - Child	0.22%	0.26%	9.58%	1.56%	2.17%	0.95%	3.77%	0.43%	0.21%	0.71%	80.14%
Lower Belledune - Teen	0.22%	0.34%	10.78%	1.40%	2.76%	1.05%	4.75%	0.39%	0.19%	0.64%	77.50%
Lower Belledune - Adult	0.19%	0.33%	14.07%	1.22%	1.99%	1.04%	6.38%	0.46%	0.22%	0.75%	73.35%
Belledune - Infant	0.03%	0.26%	11.67%	3.50%	3.09%	3.00%	-	0.05%	-	-	78.40%
Belledune - Toddler	0.08%	0.21%	12.60%	7.55%	2.11%	1.51%	4.50%	0.15%	0.08%	-	71.22%
Belledune - Child	0.07%	0.18%	9.65%	1.08%	1.86%	1.26%	3.80%	0.44%	0.20%	0.71%	80.74%
Belledune - Teen	0.07%	0.24%	10.86%	0.98%	2.36%	1.39%	4.79%	0.39%	0.18%	0.64%	78.10%
Belledune - Adult	0.06%	0.23%	14.15%	0.85%	1.70%	1.38%	6.42%	0.46%	0.22%	0.75%	73.78%
Pointe-Verte - Infant	0.03%	0.26%	7.86%	3.55%	3.45%	3.32%	-	0.05%	-	-	81.47%
Pointe-Verte - Toddler	0.07%	0.21%	8.55%	7.71%	2.37%	1.68%	4.70%	0.15%	0.08%	-	74.47%
Pointe-Verte - Child	0.07%	0.18%	6.48%	1.10%	2.07%	1.39%	3.93%	0.45%	0.20%	0.57%	83.56%
Pointe-Verte - Teen	0.07%	0.24%	7.32%	0.99%	2.64%	1.54%	4.97%	0.41%	0.18%	0.52%	81.13%
Pointe-Verte - Adult	0.06%	0.24%	9.66%	0.87%	1.92%	1.55%	6.75%	0.48%	0.22%	0.61%	77.64%
Petit-Rocher - Infant	0.01%	0.24%	2.17%	3.18%	3.69%	3.55%	-	0.06%	-	-	87.11%
Petit-Rocher - Toddler	0.01%	0.19%	2.39%	7.01%	2.57%	1.82%	5.09%	0.17%	0.08%	-	80.67%
Petit-Rocher - Child	0.01%	0.16%	1.76%	0.97%	2.18%	1.47%	4.14%	0.47%	0.19%	0.57%	88.07%
Petit-Rocher - Teen	0.01%	0.21%	2.00%	0.88%	2.80%	1.64%	5.27%	0.43%	0.18%	0.52%	86.06%
Petit-Rocher - Adult	0.01%	0.22%	2.69%	0.79%	2.08%	1.68%	7.29%	0.52%	0.21%	0.63%	83.88%

Note: receptor is not exposed via this pathway.

	Percent of Total Intake										
Cadmium	Inhalation	Dermal	Water	Soil	Root Veg	Other Veg	Wild Game	Fish	Local Lobster	Wild Mussels	Supermarket Food
Townsite - Infant	0.10%	0.45%	1.06%	1.37%	7.66%	7.70%	-	0.55%	-	-	81.09%
Townsite - Toddler	0.20%	0.30%	0.94%	2.45%	4.32%	3.19%	1.04%	1.30%	0.04%	-	86.21%
Townsite - Child	0.14%	0.20%	0.56%	0.27%	2.95%	2.08%	0.69%	3.01%	0.09%	12.02%	77.97%
Townsite - Teen	0.14%	0.26%	0.63%	0.25%	3.75%	2.30%	0.86%	2.71%	0.08%	10.83%	78.19%
Townsite - Adult	0.16%	0.33%	1.06%	0.27%	3.46%	2.92%	1.48%	4.08%	0.13%	16.28%	69.84%
Lower Belledune - Infant	0.08%	0.36%	1.03%	1.12%	16.18%	1.86%	-	0.54%	-	-	78.83%
Lower Belledune - Toddler	0.17%	0.24%	0.92%	2.00%	9.18%	0.78%	1.02%	1.27%	0.05%	-	84.37%
Lower Belledune - Child	0.10%	0.14%	0.46%	0.19%	5.28%	0.43%	0.56%	2.48%	0.09%	26.08%	64.20%
Lower Belledune - Teen	0.10%	0.18%	0.53%	0.17%	6.77%	0.47%	0.72%	2.26%	0.08%	23.71%	65.02%
Lower Belledune - Adult	0.10%	0.21%	0.82%	0.18%	5.85%	0.56%	1.16%	3.18%	0.11%	33.41%	54.41%
Belledune - Infant	0.03%	0.12%	1.08%	0.36%	10.34%	4.99%	-	0.56%	-	-	82.53%
Belledune - Toddler	0.05%	0.08%	0.96%	0.64%	5.84%	2.07%	1.07%	1.33%	0.05%	-	87.92%
Belledune - Child	0.03%	0.05%	0.55%	0.07%	3.82%	1.29%	0.67%	2.94%	0.10%	14.49%	76.00%
Belledune - Teen	0.03%	0.07%	0.62%	0.06%	4.85%	1.43%	0.84%	2.65%	0.09%	13.06%	76.30%
Belledune - Adult	0.04%	0.08%	1.02%	0.07%	4.43%	1.80%	1.44%	3.95%	0.13%	19.48%	67.57%
Pointe-Verte - Infant	0.02%	0.10%	1.18%	0.32%	7.09%	3.65%	-	0.59%	-	-	87.04%
Pointe-Verte - Toddler	0.05%	0.07%	1.02%	0.55%	3.91%	1.48%	1.10%	1.37%	0.04%	-	90.42%
Pointe-Verte - Child	0.03%	0.04%	0.58%	0.06%	2.52%	0.91%	0.68%	2.99%	0.08%	14.89%	77.22%
Pointe-Verte - Teen	0.03%	0.06%	0.65%	0.05%	3.22%	1.01%	0.86%	2.70%	0.07%	13.48%	77.86%
Pointe-Verte - Adult	0.03%	0.07%	1.08%	0.06%	2.94%	1.27%	1.46%	4.02%	0.11%	20.08%	68.88%
Petit-Rocher - Infant	0.00%	0.02%	1.10%	0.05%	7.13%	3.66%	-	0.60%	-	-	87.44%
Petit-Rocher - Toddler	0.01%	0.01%	0.96%	0.09%	3.93%	1.49%	1.10%	1.37%	0.05%	-	90.99%
Petit-Rocher - Child	0.00%	0.01%	0.55%	0.01%	2.61%	0.94%	0.70%	3.09%	0.09%	12.04%	79.94%
Petit-Rocher - Teen	0.00%	0.01%	0.62%	0.01%	3.32%	1.04%	0.89%	2.79%	0.09%	10.87%	80.36%
Petit-Rocher - Adult	0.00%	0.01%	1.05%	0.01%	3.08%	1.33%	1.53%	4.22%	0.13%	16.44%	72.19%

Note: receptor is not exposed via this pathway.

Table 5.13: Percent intake (best estimate) by pathway for current time period for average local seafood eaters using CCNB soil data (Cont'd)

	Percent of Total Intake										
Chromium	Inhalation	Dermal	Water	Soil	Root Veg	Other Veg	Wild Game	Fish	Local Lobster	Wild Mussels	Supermarket Food
Townsite - Infant	0.21%	1.94%	4.48%	9.23%	na	na	-	na	na	na	84.14%
Townsite - Toddler	0.37%	1.15%	3.59%	14.77%	na	na	4.85%	na	na	na	75.28%
Townsite - Child	0.47%	1.41%	3.89%	3.00%	na	na	5.80%	na	na	na	85.43%
Townsite - Teen	0.47%	1.92%	4.54%	2.80%	na	na	7.57%	na	na	na	82.69%
Townsite - Adult	0.49%	2.22%	6.99%	2.88%	na	na	12.00%	na	na	na	75.42%
Lower Belledune - Infant	0.02%	1.94%	4.49%	9.25%	na	na	-	na	na	na	84.30%
Lower Belledune - Toddler	0.04%	1.15%	3.60%	14.82%	na	na	4.86%	na	na	na	75.53%
Lower Belledune - Child	0.05%	1.42%	3.91%	3.02%	na	na	5.82%	na	na	na	85.80%
Lower Belledune - Teen	0.05%	1.93%	4.56%	2.81%	na	na	7.61%	na	na	na	83.05%
Lower Belledune - Adult	0.05%	2.23%	7.02%	2.89%	na	na	12.05%	na	na	na	75.76%
Belledune - Infant	0.02%	1.94%	4.49%	9.25%	na	na	-	na	na	na	84.30%
Belledune - Toddler	0.03%	1.15%	3.60%	14.82%	na	na	4.86%	na	na	na	75.53%
Belledune - Child	0.04%	1.42%	3.91%	3.02%	na	na	5.82%	na	na	na	85.80%
Belledune - Teen	0.05%	1.93%	4.56%	2.81%	na	na	7.61%	na	na	na	83.05%
Belledune - Adult	0.05%	2.23%	7.02%	2.89%	na	na	12.05%	na	na	na	75.76%
Pointe-Verte - Infant	0.00%	1.51%	25.48%	7.21%	na	na	-	na	na	na	65.78%
Pointe-Verte - Toddler	0.01%	0.94%	21.36%	12.09%	na	na	3.97%	na	na	na	61.63%
Pointe-Verte - Child	0.01%	1.14%	22.82%	2.42%	na	na	4.68%	na	na	na	68.93%
Pointe-Verte - Teen	0.01%	1.50%	25.78%	2.19%	na	na	5.92%	na	na	na	64.60%
Pointe-Verte - Adult	0.01%	1.55%	35.46%	2.01%	na	na	8.37%	na	na	na	52.61%
Petit-Rocher - Infant	0.00%	1.37%	32.47%	6.54%	na	na	-	na	na	na	59.62%
Petit-Rocher - Toddler	0.00%	0.86%	27.64%	11.13%	na	na	3.65%	na	na	na	56.72%
Petit-Rocher - Child	0.00%	1.04%	29.37%	2.22%	na	na	4.28%	na	na	na	63.09%
Petit-Rocher - Teen	0.00%	1.36%	32.82%	1.98%	na	na	5.36%	na	na	na	58.48%
Petit-Rocher - Adult	0.00%	1.35%	43.58%	1.75%	na	na	7.32%	na	na	na	45.99%

Note: na - pathway not assessed for this COPC.
- receptor is not exposed via this pathway

	Percent of Total Intake										
Lead	Inhalation	Dermal	Water	Soil	Root Veg	Other Veg	Wild Game	Fish	Local Lobster	Wild Mussels	Supermarket Food
Townsite - Infant	1.48%	0.36%	1.72%	25.46%	9.37%	38.34%	-	6.28%	-	-	16.99%
Townsite - Toddler	2.79%	0.22%	1.46%	43.36%	5.04%	15.19%	2.81%	14.11%	0.09%	-	14.92%
Townsite - Child	2.74%	0.21%	1.23%	6.82%	4.87%	13.98%	2.60%	46.05%	0.28%	6.89%	14.33%
Townsite - Teen	2.75%	0.29%	1.42%	6.30%	6.34%	15.81%	3.36%	42.51%	0.25%	6.36%	14.61%
Townsite - Adult	2.28%	0.27%	1.76%	5.23%	4.36%	14.98%	4.30%	47.68%	0.29%	7.13%	11.73%
Lower Belledune - Infant	1.74%	0.42%	2.39%	30.01%	15.77%	17.29%	-	8.74%	-	-	23.64%
Lower Belledune - Toddler	2.81%	0.23%	1.75%	43.84%	7.28%	5.87%	3.36%	16.84%	0.20%	-	17.82%
Lower Belledune - Child	1.19%	0.09%	0.63%	2.97%	3.03%	2.33%	1.34%	23.70%	0.25%	57.08%	7.38%
Lower Belledune - Teen	1.25%	0.13%	0.76%	2.88%	4.13%	2.76%	1.81%	22.93%	0.24%	55.21%	7.88%
Lower Belledune - Adult	0.98%	0.12%	0.89%	2.24%	2.67%	2.46%	2.18%	24.14%	0.26%	58.13%	5.94%
Belledune - Infant	0.63%	0.16%	2.85%	11.18%	15.05%	31.54%	-	10.42%	-	-	28.19%
Belledune - Toddler	1.22%	0.10%	2.52%	19.74%	8.40%	12.96%	4.84%	24.28%	0.26%	-	25.68%
Belledune - Child	0.68%	0.06%	1.20%	1.77%	4.62%	6.80%	2.55%	45.15%	0.43%	22.69%	14.05%
Belledune - Teen	0.70%	0.08%	1.42%	1.67%	6.13%	7.83%	3.36%	42.48%	0.40%	21.34%	14.60%
Belledune - Adult	0.56%	0.07%	1.70%	1.34%	4.07%	7.17%	4.16%	46.04%	0.44%	23.13%	11.33%
Pointe-Verte - Infant	0.47%	0.12%	4.74%	8.45%	11.42%	41.33%	-	9.03%	-	-	24.44%
Pointe-Verte - Toddler	1.01%	0.08%	4.60%	16.38%	7.00%	18.63%	4.60%	23.10%	0.17%	-	24.43%
Pointe-Verte - Child	0.48%	0.04%	1.87%	1.25%	3.27%	8.29%	2.06%	36.44%	0.24%	34.73%	11.34%
Pointe-Verte - Teen	0.49%	0.05%	2.20%	1.18%	4.36%	9.60%	2.73%	34.47%	0.23%	32.85%	11.85%
Pointe-Verte - Adult	0.39%	0.05%	2.61%	0.93%	2.85%	8.66%	3.32%	36.81%	0.24%	35.07%	9.06%
Petit-Rocher - Infant	0.07%	0.02%	3.47%	1.77%	12.54%	45.37%	-	9.91%	-	-	26.83%
Petit-Rocher - Toddler	0.17%	0.02%	3.64%	3.71%	8.31%	22.11%	5.46%	27.41%	0.19%	-	28.99%
Petit-Rocher - Child	0.10%	0.01%	1.75%	0.33%	4.58%	11.64%	2.89%	51.14%	0.32%	11.34%	15.91%
Petit-Rocher - Teen	0.10%	0.01%	2.02%	0.31%	6.00%	13.22%	3.75%	47.45%	0.30%	10.52%	16.31%
Petit-Rocher - Adult	0.08%	0.01%	2.45%	0.25%	4.01%	12.19%	4.68%	51.78%	0.32%	11.48%	12.74%

Note: receptor is not exposed via this pathway.

Table 5.13: Percent intake (best estimate) by pathway for current time period for average local seafood eaters using CCNB soil data (cont'd)

	Percent of Total Intake										
Mercury	Inhalation	Dermal	Water	Soil	Root Veg	Other Veg	Wild Game	Fish	Local Lobster	Wild Mussels	Supermarket Food
Townsite - Infant	0.16%	0.13%	na	1.14%	na	na	-	12.29%	-	-	86.27%
Townsite - Toddler	0.31%	0.09%	na	2.04%	na	na	2.90%	29.06%	4.78%	-	60.82%
Townsite - Child	0.13%	0.04%	na	0.14%	na	na	1.16%	41.01%	6.01%	8.73%	42.78%
Townsite - Teen	0.13%	0.05%	na	0.12%	na	na	1.45%	36.60%	5.37%	7.79%	48.49%
Townsite - Adult	0.11%	0.05%	na	0.11%	na	na	1.90%	41.97%	6.15%	8.94%	40.78%
Lower Belledune - Infant	0.12%	0.11%	na	0.91%	na	na	-	12.33%	-	-	86.54%
Lower Belledune - Toddler	0.24%	0.07%	na	1.62%	na	na	2.90%	29.08%	5.23%	-	60.86%
Lower Belledune - Child	0.10%	0.03%	na	0.11%	na	na	1.16%	40.81%	6.54%	8.69%	42.57%
Lower Belledune - Teen	0.10%	0.04%	na	0.10%	na	na	1.44%	36.44%	5.84%	7.76%	48.28%
Lower Belledune - Adult	0.08%	0.04%	na	0.08%	na	na	1.89%	41.75%	6.69%	8.89%	40.57%
Belledune - Infant	0.04%	0.04%	na	0.38%	na	na	-	12.42%	-	-	87.12%
Belledune - Toddler	0.08%	0.03%	na	0.68%	na	na	2.94%	29.45%	5.18%	-	61.64%
Belledune - Child	0.03%	0.01%	na	0.05%	na	na	1.16%	40.92%	6.42%	8.72%	42.69%
Belledune - Teen	0.03%	0.02%	na	0.04%	na	na	1.45%	36.54%	5.73%	7.78%	48.41%
Belledune - Adult	0.03%	0.01%	na	0.03%	na	na	1.89%	41.87%	6.57%	8.92%	40.68%
Pointe-Verte - Infant	0.03%	0.04%	na	0.35%	na	na	-	12.42%	-	-	87.15%
Pointe-Verte - Toddler	0.07%	0.03%	na	0.64%	na	na	2.96%	29.63%	4.68%	-	62.00%
Pointe-Verte - Child	0.03%	0.01%	na	0.04%	na	na	1.18%	41.53%	5.85%	8.05%	43.32%
Pointe-Verte - Teen	0.03%	0.01%	na	0.04%	na	na	1.47%	37.02%	5.21%	7.17%	49.05%
Pointe-Verte - Adult	0.02%	0.01%	na	0.03%	na	na	1.92%	42.50%	5.98%	8.24%	41.29%
Petit-Rocher - Infant	0.00%	0.02%	na	0.17%	na	na	-	12.45%	-	-	87.36%
Petit-Rocher - Toddler	0.01%	0.01%	na	0.30%	na	na	2.99%	29.99%	3.94%	-	62.75%
Petit-Rocher - Child	0.00%	0.01%	na	0.02%	na	na	1.20%	42.43%	4.98%	7.11%	44.26%
Petit-Rocher - Teen	0.00%	0.01%	na	0.02%	na	na	1.50%	37.73%	4.43%	6.32%	49.99%
Petit-Rocher - Adult	0.00%	0.01%	na	0.02%	na	na	1.97%	43.43%	5.10%	7.28%	42.20%

Note: na - pathway not assessed for this COPC.
- receptor is not exposed via this pathway

	Percent of Total Intake										
Thallium	Inhalation	Dermal	Water	Soil	Root Veg	Other Veg	Wild Game	Fish	Local Lobster	Wild Mussels	Supermarket Food
Townsite - Infant	0.72%	0.18%	4.08%	7.65%	22.42%	25.52%		na	-	-	39.44%
Townsite - Toddler	1.04%	0.09%	2.63%	9.88%	9.16%	7.67%	6.35%	na	0.08%	-	63.10%
Townsite - Child	0.91%	0.07%	1.98%	1.40%	7.93%	6.34%	5.27%	na	0.22%	1.47%	74.40%
Townsite - Teen	0.89%	0.10%	2.22%	1.25%	10.02%	6.96%	6.62%	na	0.20%	1.32%	70.43%
Townsite - Adult	1.02%	0.12%	3.81%	1.43%	9.48%	9.07%	11.66%	na	0.30%	2.04%	61.07%
Lower Belledune - Infant	0.64%	0.16%	4.63%	7.04%	27.57%	15.18%		na	-	-	44.77%
Lower Belledune - Toddler	0.86%	0.07%	2.77%	8.43%	10.45%	4.23%	6.68%	na	0.09%	-	66.42%
Lower Belledune - Child	0.72%	0.06%	2.00%	1.14%	8.68%	3.35%	5.33%	na	0.22%	3.36%	75.13%
Lower Belledune - Teen	0.71%	0.08%	2.25%	1.03%	11.00%	3.69%	6.70%	na	0.20%	3.02%	71.32%
Lower Belledune - Adult	0.81%	0.10%	3.87%	1.18%	10.43%	4.82%	11.83%	na	0.31%	4.68%	61.98%
Belledune - Infant	0.24%	0.08%	5.54%	3.46%	22.32%	14.81%		na	-	-	53.55%
Belledune - Toddler	0.29%	0.03%	3.07%	3.85%	7.83%	3.82%	7.40%	na	0.10%	-	73.59%
Belledune - Child	0.24%	0.03%	2.14%	0.50%	6.26%	2.92%	5.68%	na	0.24%	1.90%	80.10%
Belledune - Teen	0.24%	0.03%	2.42%	0.45%	7.99%	3.23%	7.19%	na	0.21%	1.72%	76.52%
Belledune - Adult	0.27%	0.04%	4.19%	0.52%	7.65%	4.26%	12.83%	na	0.33%	2.68%	67.20%
Pointe-Verte - Infant	0.15%	0.05%	33.30%	2.35%	10.25%	12.70%		na	-	-	41.20%
Pointe-Verte - Toddler	0.20%	0.02%	20.41%	2.88%	3.97%	3.62%	6.29%	na	0.08%	-	62.52%
Pointe-Verte - Child	0.17%	0.02%	14.70%	0.39%	3.29%	2.86%	5.00%	na	0.21%	2.87%	70.50%
Pointe-Verte - Teen	0.17%	0.03%	16.45%	0.35%	4.15%	3.14%	6.27%	na	0.19%	2.57%	66.69%
Pointe-Verte - Adult	0.17%	0.03%	25.64%	0.36%	3.57%	3.72%	10.04%	na	0.26%	3.61%	52.59%
Petit-Rocher - Infant	0.02%	0.03%	30.73%	1.22%	10.86%	13.46%		na	-	-	43.68%
Petit-Rocher - Toddler	0.03%	0.01%	18.56%	1.47%	4.15%	3.78%	6.57%	na	0.09%	-	65.33%
Petit-Rocher - Child	0.02%	0.01%	13.15%	0.20%	3.38%	2.94%	5.14%	na	0.21%	2.49%	72.46%
Petit-Rocher - Teen	0.02%	0.01%	14.75%	0.18%	4.28%	3.23%	6.45%	na	0.19%	2.23%	68.66%
Petit-Rocher - Adult	0.03%	0.02%	23.30%	0.18%	3.73%	3.88%	10.49%	na	0.27%	3.18%	54.92%

Note: na - pathway not assessed for this COPC.
- receptor is not exposed via this pathway

Table 5.13: Percent intake (best estimate) by pathway for current time period for average local seafood eaters using CCNB soil data (cont'd)

Zinc	Percent of Total Intake										
	Inhalation	Dermal	Water	Soil	Root Veg	Other Veg	Wild Game	Fish	Local Lobster	Wild Mussels	Supermarket Food
Townsite - Infant	0.00%	0.01%	0.27%	0.13%	0.49%	0.49%	-	0.13%	-	-	98.48%
Townsite - Toddler	0.00%	0.01%	0.35%	0.34%	0.40%	0.30%	0.30%	0.46%	0.07%	-	97.77%
Townsite - Child	0.00%	0.01%	0.32%	0.06%	0.42%	0.30%	0.31%	1.63%	0.22%	0.48%	96.26%
Townsite - Teen	0.00%	0.01%	0.34%	0.05%	0.51%	0.31%	0.36%	1.38%	0.18%	0.41%	96.45%
Townsite - Adult	0.00%	0.01%	0.60%	0.06%	0.49%	0.42%	0.66%	2.17%	0.29%	0.64%	94.67%
Lower Belledune - Infant	0.00%	0.00%	0.27%	0.07%	0.49%	0.41%	-	0.13%	-	-	98.62%
Lower Belledune - Toddler	0.00%	0.00%	0.35%	0.18%	0.41%	0.25%	0.30%	0.46%	0.07%	-	97.97%
Lower Belledune - Child	0.00%	0.00%	0.32%	0.03%	0.43%	0.25%	0.31%	1.62%	0.22%	0.93%	95.90%
Lower Belledune - Teen	0.00%	0.00%	0.34%	0.03%	0.51%	0.26%	0.36%	1.37%	0.18%	0.79%	96.15%
Lower Belledune - Adult	0.00%	0.01%	0.60%	0.03%	0.49%	0.35%	0.65%	2.16%	0.29%	1.24%	94.19%
Belledune - Infant	0.00%	0.00%	0.27%	0.05%	0.43%	0.55%	-	0.13%	-	-	98.57%
Belledune - Toddler	0.00%	0.00%	0.35%	0.13%	0.35%	0.33%	0.30%	0.46%	0.07%	-	98.00%
Belledune - Child	0.00%	0.00%	0.32%	0.02%	0.37%	0.33%	0.31%	1.63%	0.22%	0.54%	96.26%
Belledune - Teen	0.00%	0.00%	0.34%	0.02%	0.44%	0.35%	0.36%	1.38%	0.18%	0.45%	96.46%
Belledune - Adult	0.00%	0.00%	0.60%	0.02%	0.43%	0.46%	0.66%	2.17%	0.29%	0.72%	94.65%
Pointe-Verte - Infant	0.00%	0.00%	0.26%	0.04%	0.36%	0.43%	-	0.13%	-	-	98.78%
Pointe-Verte - Toddler	0.00%	0.00%	0.34%	0.11%	0.30%	0.26%	0.30%	0.46%	0.07%	-	98.15%
Pointe-Verte - Child	0.00%	0.00%	0.31%	0.02%	0.31%	0.26%	0.31%	1.63%	0.24%	0.66%	96.26%
Pointe-Verte - Teen	0.00%	0.00%	0.33%	0.02%	0.37%	0.27%	0.36%	1.38%	0.20%	0.56%	96.50%
Pointe-Verte - Adult	0.00%	0.00%	0.57%	0.02%	0.36%	0.36%	0.66%	2.17%	0.32%	0.88%	94.65%
Petit-Rocher - Infant	0.00%	0.00%	0.11%	0.03%	0.36%	0.43%	-	0.13%	-	-	98.93%
Petit-Rocher - Toddler	0.00%	0.00%	0.14%	0.09%	0.30%	0.26%	0.31%	0.46%	0.08%	-	98.37%
Petit-Rocher - Child	0.00%	0.00%	0.13%	0.02%	0.31%	0.26%	0.31%	1.63%	0.25%	0.49%	96.60%
Petit-Rocher - Teen	0.00%	0.00%	0.14%	0.01%	0.37%	0.27%	0.37%	1.38%	0.21%	0.42%	96.83%
Petit-Rocher - Adult	0.00%	0.00%	0.24%	0.02%	0.36%	0.36%	0.66%	2.18%	0.33%	0.66%	95.19%

Note: receptor is not exposed via this pathway.

Table 5.14 a to c provides a breakdown by pathway for the three different historical pathways for arsenic, cadmium and lead. Supermarket foods are not presented as no data were available. In the earliest time period, the water pathway was most significant in Townsite #2 for arsenic, followed by soil, inhalation and backyard produce. For cadmium in Townsite #2, wild mussels was the most significant pathway followed by backyard root vegetables and aboveground backyard vegetables. For lead in Townsite #2, the inhalation pathway was most significant followed by aboveground backyard vegetables and fish. For Lower Belledune, a similar trend was seen.

As time passes, the inhalation pathway becomes less significant and the backyard produce and soil pathways become more significant.

Table 5.14a: Percent intake (best estimate) by pathway for 1967-1974 for average seafood eaters using Noranda EMP data

	Percent of Total Intake									
Arsenic	Inhalation	Dermal	Water	Soil	Root Veg	Other Veg	Wild Game	Fish	Local Lobster	Wild Mussels
Townsite - Infant	10.36%	1.18%	36.59%	15.79%	17.59%	18.33%	na	0.16%	-	-
Townsite - Toddler	20.42%	0.77%	32.56%	28.09%	9.90%	7.59%	na	0.38%	0.28%	-
Townsite - Child	27.59%	1.02%	37.62%	6.09%	13.16%	9.62%	na	1.70%	1.13%	2.07%
Townsite - Teen	25.08%	1.23%	39.22%	5.08%	15.47%	9.83%	na	1.41%	0.94%	1.73%
Townsite - Adult	20.91%	1.16%	49.06%	4.23%	10.68%	9.36%	na	1.59%	1.06%	1.95%
Lower Belledune - Infant	6.97%	0.87%	29.12%	11.70%	17.15%	34.06%	na	0.13%	-	-
Lower Belledune - Toddler	16.09%	0.67%	30.37%	24.40%	11.31%	16.53%	na	0.35%	0.27%	-
Lower Belledune - Child	20.93%	0.85%	33.78%	5.09%	14.47%	20.16%	na	1.52%	1.05%	2.15%
Lower Belledune - Teen	18.82%	1.02%	34.84%	4.20%	16.83%	20.38%	na	1.26%	0.87%	1.78%
Lower Belledune - Adult	15.83%	0.97%	43.95%	3.53%	11.72%	19.56%	na	1.43%	0.99%	2.02%
Belledune - Infant	2.77%	0.83%	38.20%	11.12%	16.42%	30.48%	na	0.17%	-	-
Belledune - Toddler	6.63%	0.66%	41.28%	24.04%	11.22%	15.33%	na	0.48%	0.37%	-
Belledune - Child	8.65%	0.84%	46.08%	5.03%	14.40%	18.77%	na	2.08%	1.42%	2.74%
Belledune - Teen	7.68%	1.00%	46.90%	4.10%	16.54%	18.71%	na	1.69%	1.16%	2.23%
Belledune - Adult	6.13%	0.90%	56.21%	3.27%	10.94%	17.07%	na	1.83%	1.25%	2.41%
Pointe-Verte - Infant	2.88%	0.91%	27.56%	12.24%	21.49%	34.73%	na	0.19%	-	-
Pointe-Verte - Toddler	7.11%	0.75%	30.72%	27.28%	15.15%	18.01%	na	0.55%	0.43%	-
Pointe-Verte - Child	9.39%	0.96%	34.70%	5.78%	19.68%	22.32%	na	2.41%	1.69%	3.05%
Pointe-Verte - Teen	8.31%	1.14%	35.26%	4.70%	22.56%	22.22%	na	1.96%	1.37%	2.48%
Pointe-Verte - Adult	6.98%	1.08%	44.41%	3.94%	15.69%	21.30%	na	2.23%	1.56%	2.82%
Petit-Rocher - Infant	0.81%	1.40%	12.55%	18.79%	13.44%	52.67%	na	0.33%	-	-
Petit-Rocher - Toddler	2.04%	1.18%	14.32%	42.88%	9.70%	27.96%	na	0.99%	0.92%	-
Petit-Rocher - Child	3.00%	1.69%	17.99%	10.10%	14.01%	38.53%	na	4.85%	3.99%	5.83%
Petit-Rocher - Teen	2.73%	2.05%	18.75%	8.42%	16.47%	39.34%	na	4.05%	3.33%	4.86%
Petit-Rocher - Adult	2.34%	1.98%	24.11%	7.22%	11.69%	38.49%	na	4.69%	3.86%	5.63%

Note: na - pathway not assessed for this COPC.
- receptor is not exposed via this pathway

	Percent of Total Intake									
Cadmium	Inhalation	Dermal	Water	Soil	Root Veg	Other Veg	Wild Game	Fish	Local Lobster	Wild Mussels
Townsite - Infant	3.71%	0.92%	2.52%	2.81%	67.57%	21.66%	na	0.81%	-	-
Townsite - Toddler	11.26%	0.93%	3.45%	7.71%	58.55%	13.80%	na	2.92%	1.38%	-
Townsite - Child	5.72%	0.46%	1.50%	0.63%	29.25%	6.58%	na	4.93%	2.07%	48.86%
Townsite - Teen	5.44%	0.58%	1.64%	0.55%	36.00%	7.03%	na	4.30%	1.81%	42.65%
Townsite - Adult	4.82%	0.58%	2.18%	0.49%	26.42%	7.11%	na	5.15%	2.17%	51.08%
Lower Belledune - Infant	10.54%	2.78%	8.07%	8.52%	35.16%	32.35%	na	2.58%	-	-
Lower Belledune - Toddler	23.85%	2.10%	8.25%	17.43%	22.73%	15.38%	na	6.97%	3.29%	-
Lower Belledune - Child	1.11%	0.09%	0.33%	0.13%	1.04%	0.67%	na	1.08%	0.45%	95.09%
Lower Belledune - Teen	1.20%	0.14%	0.41%	0.13%	1.46%	0.82%	na	1.07%	0.45%	94.33%
Lower Belledune - Adult	0.90%	0.12%	0.46%	0.10%	0.90%	0.70%	na	1.08%	0.45%	95.30%
Belledune - Infant	1.88%	1.16%	4.91%	3.56%	57.47%	29.45%	na	1.57%	-	-
Belledune - Toddler	5.69%	1.17%	6.71%	9.72%	49.66%	18.72%	na	5.67%	2.67%	-
Belledune - Child	1.08%	0.22%	1.09%	0.30%	9.31%	3.35%	na	3.59%	1.51%	79.54%
Belledune - Teen	1.13%	0.30%	1.30%	0.28%	12.50%	3.90%	na	3.42%	1.44%	75.72%
Belledune - Adult	0.88%	0.27%	1.53%	0.22%	8.13%	3.50%	na	3.63%	1.53%	80.32%
Pointe-Verte - Infant	3.14%	2.20%	9.91%	6.74%	44.24%	30.70%	na	3.06%	-	-
Pointe-Verte - Toddler	8.21%	1.92%	11.70%	15.93%	33.04%	16.87%	na	9.55%	2.78%	-
Pointe-Verte - Child	0.80%	0.18%	0.98%	0.25%	3.17%	1.54%	na	3.10%	0.80%	89.17%
Pointe-Verte - Teen	0.86%	0.26%	1.20%	0.24%	4.38%	1.85%	na	3.04%	0.79%	87.38%
Pointe-Verte - Adult	0.65%	0.22%	1.36%	0.18%	2.75%	1.60%	na	3.11%	0.81%	89.33%
Petit-Rocher - Infant	0.46%	1.98%	9.65%	6.06%	46.42%	32.22%	na	3.21%	-	-
Petit-Rocher - Toddler	1.27%	1.84%	12.14%	15.23%	36.91%	18.84%	na	10.67%	3.10%	-
Petit-Rocher - Child	0.26%	0.37%	2.14%	0.50%	7.48%	3.64%	na	7.31%	1.89%	76.41%
Petit-Rocher - Teen	0.27%	0.51%	2.55%	0.48%	10.08%	4.26%	na	6.99%	1.81%	73.05%
Petit-Rocher - Adult	0.21%	0.45%	2.97%	0.37%	6.47%	3.77%	na	7.32%	1.90%	76.54%

Note: na - pathway not assessed for this COPC.
- receptor is not exposed via this pathway

Table 5.14a: Percent intake (best estimate) by pathway for 1967-1974 for average

seafood eaters using Noranda EMP data (cont'd)

Lead	Inhalation	Dermal	Water	Soil	Root Veg	Other Veg	Wild Game	Fish	Local Lobster	Wild Mussels
	Percent of Total Intake									
Townsite - Infant	26.50%	0.13%	0.95%	9.61%	5.60%	55.37%	na	1.84%	-	-
Townsite - Toddler	51.36%	0.09%	0.83%	16.82%	3.10%	22.55%	na	4.25%	1.01%	-
Townsite - Child	51.32%	0.08%	0.71%	2.69%	3.05%	21.14%	na	14.12%	3.00%	3.88%
Townsite - Teen	50.47%	0.11%	0.80%	2.43%	3.88%	23.36%	na	12.74%	2.71%	3.50%
Townsite - Adult	46.00%	0.11%	1.09%	2.22%	2.93%	24.31%	na	15.69%	3.34%	4.31%
Lower Belledune - Infant	51.56%	0.28%	2.08%	19.81%	9.33%	12.89%	na	4.05%	-	-
Lower Belledune - Toddler	63.01%	0.11%	1.15%	21.86%	3.26%	3.31%	na	5.90%	1.41%	-
Lower Belledune - Child	24.37%	0.04%	0.38%	1.36%	1.24%	1.20%	na	7.59%	1.61%	62.21%
Lower Belledune - Teen	25.76%	0.06%	0.46%	1.32%	1.69%	1.43%	na	7.36%	1.57%	60.36%
Lower Belledune - Adult	20.69%	0.05%	0.56%	1.06%	1.13%	1.31%	na	7.99%	1.70%	65.52%
Belledune - Infant	18.82%	0.22%	2.57%	15.56%	12.31%	45.53%	na	4.99%	-	-
Belledune - Toddler	34.50%	0.13%	2.13%	25.76%	6.45%	17.54%	na	10.90%	2.60%	-
Belledune - Child	21.27%	0.08%	1.12%	2.55%	3.91%	10.14%	na	22.35%	4.75%	33.82%
Belledune - Teen	21.85%	0.11%	1.32%	2.40%	5.19%	11.71%	na	21.06%	4.48%	31.88%
Belledune - Adult	17.97%	0.10%	1.63%	1.97%	3.54%	10.99%	na	23.41%	4.98%	35.42%
Pointe-Verte - Infant	30.02%	0.38%	8.93%	27.38%	12.31%	11.94%	na	9.04%	-	-
Pointe-Verte - Toddler	39.55%	0.17%	5.31%	32.59%	4.63%	3.30%	na	14.19%	0.25%	-
Pointe-Verte - Child	14.07%	0.06%	1.62%	1.86%	1.62%	1.10%	na	16.79%	0.26%	62.62%
Pointe-Verte - Teen	14.94%	0.08%	1.97%	1.81%	2.23%	1.32%	na	16.37%	0.26%	61.03%
Pointe-Verte - Adult	11.67%	0.07%	2.30%	1.41%	1.44%	1.17%	na	17.27%	0.27%	64.39%
Petit-Rocher - Infant	6.45%	0.47%	9.00%	33.72%	18.63%	18.06%	na	13.67%	-	-
Petit-Rocher - Toddler	9.66%	0.24%	6.09%	45.57%	7.96%	5.68%	na	24.39%	0.43%	-
Petit-Rocher - Child	5.27%	0.12%	2.84%	3.99%	4.27%	2.91%	na	44.25%	0.69%	35.66%
Petit-Rocher - Teen	5.54%	0.18%	3.42%	3.85%	5.81%	3.43%	na	42.70%	0.67%	34.40%
Petit-Rocher - Adult	4.31%	0.15%	4.00%	2.99%	3.74%	3.05%	na	44.89%	0.70%	36.17%

Note: na - pathway not assessed for this COPC.
- receptor is not exposed via this pathway

Table 5.14b: Percent intake (best estimate) by pathway for 1975-1984 for average seafood eaters using Noranda soil data

	Percent of Total Intake									
Arsenic	Inhalation	Dermal	Water	Soil	Root Veg	Other Veg	Wild Game	Fish	Local Lobster	Wild Mussels
Townsite - Infant	1.71%	1.29%	40.12%	17.31%	19.29%	20.10%	na	0.18%	-	-
Townsite - Toddler	3.73%	0.94%	39.39%	33.99%	11.98%	9.18%	na	0.46%	0.34%	-
Townsite - Child	5.43%	1.33%	49.14%	7.95%	17.19%	12.57%	na	2.22%	1.47%	2.70%
Townsite - Teen	4.80%	1.57%	49.84%	6.45%	19.66%	12.49%	na	1.80%	1.20%	2.19%
Townsite - Adult	3.83%	1.41%	59.65%	5.15%	12.99%	11.38%	na	1.94%	1.29%	2.37%
Lower Belledune - Infant	1.11%	0.93%	30.96%	12.43%	18.23%	36.21%	na	0.14%	-	-
Lower Belledune - Toddler	2.80%	0.78%	35.18%	28.26%	13.10%	19.15%	na	0.41%	0.32%	-
Lower Belledune - Child	3.82%	1.03%	41.08%	6.19%	17.60%	24.53%	na	1.85%	1.28%	2.62%
Lower Belledune - Teen	3.37%	1.22%	41.48%	5.00%	20.04%	24.26%	na	1.50%	1.03%	2.12%
Lower Belledune - Adult	2.75%	1.12%	50.78%	4.08%	13.55%	22.60%	na	1.65%	1.14%	2.33%
Belledune - Infant	0.43%	0.85%	39.13%	11.39%	16.81%	31.22%	na	0.17%	-	-
Belledune - Toddler	1.06%	0.70%	43.74%	25.47%	11.89%	16.24%	na	0.51%	0.39%	-
Belledune - Child	1.40%	0.91%	49.73%	5.43%	15.55%	20.25%	na	2.24%	1.53%	2.95%
Belledune - Teen	1.23%	1.07%	50.18%	4.38%	17.69%	20.02%	na	1.81%	1.24%	2.38%
Belledune - Adult	0.97%	0.95%	59.30%	3.45%	11.54%	18.01%	na	1.93%	1.32%	2.54%
Pointe-Verte - Infant	0.44%	0.94%	28.25%	12.55%	22.03%	35.60%	na	0.19%	-	-
Pointe-Verte - Toddler	1.14%	0.80%	32.69%	29.04%	16.12%	19.17%	na	0.58%	0.46%	-
Pointe-Verte - Child	1.53%	1.05%	37.71%	6.28%	21.39%	24.26%	na	2.62%	1.84%	3.32%
Pointe-Verte - Teen	1.34%	1.23%	37.94%	5.05%	24.27%	23.91%	na	2.11%	1.48%	2.67%
Pointe-Verte - Adult	1.11%	1.15%	47.21%	4.19%	16.68%	22.64%	na	2.37%	1.66%	2.99%
Petit-Rocher - Infant	0.12%	1.41%	12.64%	18.92%	13.53%	53.04%	na	0.33%	-	-
Petit-Rocher - Toddler	0.31%	1.20%	14.58%	43.64%	9.87%	28.45%	na	1.01%	0.93%	-
Petit-Rocher - Child	0.46%	1.73%	18.46%	10.36%	14.38%	39.54%	na	4.98%	4.10%	5.98%
Petit-Rocher - Teen	0.42%	2.10%	19.20%	8.62%	16.87%	40.27%	na	4.14%	3.41%	4.97%
Petit-Rocher - Adult	0.36%	2.02%	24.60%	7.36%	11.93%	39.27%	na	4.78%	3.93%	5.74%

Note: na - pathway not assessed for this COPC.
- receptor is not exposed via this pathway

	Percent of Total Intake									
Cadmium	Inhalation	Dermal	Water	Soil	Root Veg	Other Veg	Wild Game	Fish	Local Lobster	Wild Mussels
Townsite - Infant	1.92%	1.14%	3.13%	3.50%	35.22%	53.10%	na	1.99%	-	-
Townsite - Toddler	6.25%	1.24%	4.61%	10.30%	32.79%	36.38%	na	7.73%	0.69%	-
Townsite - Child	2.65%	0.51%	1.67%	0.70%	13.69%	14.48%	na	10.92%	0.87%	54.50%
Townsite - Teen	2.64%	0.68%	1.91%	0.64%	17.58%	16.16%	na	9.95%	0.79%	49.66%
Townsite - Adult	2.17%	0.63%	2.35%	0.53%	11.98%	15.18%	na	11.06%	0.88%	55.22%
Lower Belledune - Infant	0.71%	0.45%	1.30%	1.38%	12.29%	83.04%	na	0.83%	-	-
Lower Belledune - Toddler	2.84%	0.60%	2.37%	5.00%	14.12%	70.16%	na	3.97%	0.94%	-
Lower Belledune - Child	0.41%	0.09%	0.29%	0.12%	2.02%	9.57%	na	1.92%	0.41%	85.18%
Lower Belledune - Teen	0.44%	0.12%	0.36%	0.11%	2.76%	11.36%	na	1.86%	0.39%	82.60%
Lower Belledune - Adult	0.33%	0.10%	0.41%	0.09%	1.74%	9.89%	na	1.92%	0.41%	85.11%
Belledune - Infant	0.38%	0.56%	2.38%	1.72%	25.58%	67.87%	na	1.51%	-	-
Belledune - Toddler	1.41%	0.70%	3.99%	5.78%	27.18%	53.03%	na	6.69%	1.23%	-
Belledune - Child	0.39%	0.19%	0.96%	0.26%	7.49%	13.94%	na	6.23%	1.02%	69.51%
Belledune - Teen	0.40%	0.26%	1.12%	0.24%	9.91%	16.02%	na	5.85%	0.96%	65.23%
Belledune - Adult	0.32%	0.23%	1.33%	0.19%	6.49%	14.46%	na	6.25%	1.02%	69.70%
Pointe-Verte - Infant	0.44%	0.75%	3.36%	2.28%	22.97%	68.14%	na	2.06%	-	-
Pointe-Verte - Toddler	1.58%	0.89%	5.41%	7.37%	23.43%	51.13%	na	8.77%	1.42%	-
Pointe-Verte - Child	0.30%	0.16%	0.87%	0.22%	4.31%	8.96%	na	5.45%	0.79%	78.95%
Pointe-Verte - Teen	0.31%	0.23%	1.04%	0.21%	5.83%	10.54%	na	5.24%	0.76%	75.84%
Pointe-Verte - Adult	0.24%	0.20%	1.20%	0.16%	3.72%	9.27%	na	5.45%	0.79%	78.97%
Petit-Rocher - Infant	0.11%	1.12%	5.46%	3.43%	29.77%	56.51%	na	3.61%	-	-
Petit-Rocher - Toddler	0.35%	1.20%	7.94%	9.96%	27.37%	38.22%	na	13.86%	1.09%	-
Petit-Rocher - Child	0.09%	0.32%	1.86%	0.44%	7.38%	9.83%	na	12.64%	0.89%	66.56%
Petit-Rocher - Teen	0.10%	0.44%	2.20%	0.41%	9.83%	11.37%	na	11.94%	0.84%	62.88%
Petit-Rocher - Adult	0.08%	0.39%	2.58%	0.32%	6.38%	10.17%	na	12.64%	0.89%	66.56%

Note: na - pathway not assessed for this COPC.
- receptor is not exposed via this pathway

Table 5.14b: Percent intake (best estimate) by pathway for 1975-1984 for average seafood eaters using Noranda soil data (cont'd)

	Percent of Total Intake									
Lead	Inhalation	Dermal	Water	Soil	Root Veg	Other Veg	Wild Game	Fish	Local Lobster	Wild Mussels
Townsite - Infant	7.64%	0.18%	1.26%	12.79%	22.40%	49.78%	na	5.96%	-	-
Townsite - Toddler	17.41%	0.14%	1.30%	26.35%	14.59%	23.86%	na	16.20%	0.16%	-
Townsite - Child	14.51%	0.11%	0.92%	3.52%	11.95%	18.65%	na	44.88%	0.38%	5.07%
Townsite - Teen	14.28%	0.15%	1.04%	3.18%	15.23%	20.63%	na	40.56%	0.35%	4.58%
Townsite - Adult	12.23%	0.14%	1.34%	2.72%	10.80%	20.16%	na	46.91%	0.40%	5.30%
Lower Belledune - Infant	4.71%	0.12%	0.88%	8.37%	21.21%	60.55%	na	4.16%	-	-
Lower Belledune - Toddler	12.86%	0.11%	1.09%	20.63%	16.53%	34.72%	na	13.55%	0.51%	-
Lower Belledune - Child	4.87%	0.04%	0.35%	1.25%	6.15%	12.32%	na	17.04%	0.57%	57.41%
Lower Belledune - Teen	5.01%	0.05%	0.41%	1.18%	8.19%	14.26%	na	16.10%	0.54%	54.25%
Lower Belledune - Adult	3.98%	0.05%	0.49%	0.94%	5.40%	12.94%	na	17.31%	0.58%	58.30%
Belledune - Infant	2.03%	0.11%	1.28%	7.74%	27.47%	55.35%	na	6.04%	-	-
Belledune - Toddler	5.54%	0.10%	1.58%	19.11%	21.46%	31.80%	na	19.68%	0.74%	-
Belledune - Child	3.27%	0.06%	0.80%	1.81%	12.46%	17.62%	na	38.66%	1.30%	24.03%
Belledune - Teen	3.25%	0.08%	0.91%	1.65%	16.03%	19.69%	na	35.28%	1.19%	21.93%
Belledune - Adult	2.69%	0.07%	1.13%	1.36%	10.97%	18.57%	na	39.39%	1.33%	24.49%
Pointe-Verte - Infant	2.37%	0.14%	3.26%	9.99%	19.31%	56.92%	na	8.02%	-	-
Pointe-Verte - Toddler	5.92%	0.12%	3.67%	22.53%	13.78%	29.87%	na	23.89%	0.23%	-
Pointe-Verte - Child	2.31%	0.04%	1.23%	1.41%	5.29%	10.94%	na	31.01%	0.26%	47.51%
Pointe-Verte - Teen	2.39%	0.06%	1.46%	1.34%	7.09%	12.74%	na	29.49%	0.25%	45.18%
Pointe-Verte - Adult	1.87%	0.05%	1.71%	1.05%	4.60%	11.39%	na	31.22%	0.27%	47.83%
Petit-Rocher - Infant	0.24%	0.08%	1.58%	5.91%	46.57%	39.79%	na	5.83%	-	-
Petit-Rocher - Toddler	0.70%	0.08%	2.04%	15.26%	38.05%	23.91%	na	19.88%	0.08%	-
Petit-Rocher - Child	0.46%	0.05%	1.14%	1.60%	24.45%	14.66%	na	43.19%	0.16%	14.30%
Petit-Rocher - Teen	0.44%	0.06%	1.25%	1.41%	30.33%	15.79%	na	38.00%	0.14%	12.58%
Petit-Rocher - Adult	0.38%	0.06%	1.63%	1.22%	21.75%	15.61%	na	44.47%	0.17%	14.72%

Note: na - pathway not assessed for this COPC.
- receptor is not exposed via this pathway

Table 5.14c: Percent intake (best estimate) by pathway for 1985-1999 for average seafood eaters using Noranda EMP data

	Percent of Total Intake									
Arsenic	Inhalation	Dermal	Water	Soil	Root Veg	Other Veg	Wild Game	Fish	Local Lobster	Wild Mussels
Townsite - Infant	1.13%	1.79%	48.67%	24.01%	11.15%	13.03%	na	0.21%	-	-
Townsite - Toddler	2.19%	1.16%	42.46%	41.90%	6.15%	5.29%	na	0.49%	0.37%	-
Townsite - Child	3.52%	1.81%	58.50%	10.82%	9.75%	7.99%	na	2.64%	1.75%	3.22%
Townsite - Teen	3.16%	2.17%	60.15%	8.90%	11.31%	8.05%	na	2.17%	1.44%	2.65%
Townsite - Adult	2.40%	1.85%	68.49%	6.76%	7.11%	6.98%	na	2.23%	1.48%	2.72%
Lower Belledune - Infant	0.89%	1.54%	46.81%	20.66%	8.26%	21.63%	na	0.21%	-	-
Lower Belledune - Toddler	1.83%	1.06%	43.55%	38.44%	4.86%	9.36%	na	0.50%	0.39%	-
Lower Belledune - Child	2.82%	1.58%	57.25%	9.48%	7.35%	13.50%	na	2.58%	1.78%	3.65%
Lower Belledune - Teen	2.53%	1.90%	58.98%	7.81%	8.54%	13.63%	na	2.13%	1.47%	3.01%
Lower Belledune - Adult	1.91%	1.61%	66.77%	5.89%	5.34%	11.74%	na	2.17%	1.50%	3.07%
Belledune - Infant	0.33%	1.19%	57.42%	16.00%	9.64%	15.15%	na	0.25%	-	-
Belledune - Toddler	0.70%	0.84%	54.50%	30.36%	5.79%	6.69%	na	0.63%	0.48%	-
Belledune - Child	0.98%	1.14%	65.40%	6.83%	7.99%	8.81%	na	2.95%	2.02%	3.88%
Belledune - Teen	0.88%	1.36%	66.89%	5.59%	9.22%	8.83%	na	2.41%	1.65%	3.18%
Belledune - Adult	0.65%	1.13%	73.87%	4.12%	5.62%	7.42%	na	2.40%	1.64%	3.16%
Pointe-Verte - Infant	0.14%	0.52%	16.46%	6.94%	9.50%	66.33%	na	0.11%	-	-
Pointe-Verte - Toddler	0.44%	0.56%	24.06%	20.29%	8.78%	45.10%	na	0.43%	0.34%	-
Pointe-Verte - Child	0.55%	0.68%	25.72%	4.07%	10.80%	52.88%	na	1.79%	1.25%	2.26%
Pointe-Verte - Teen	0.49%	0.80%	26.12%	3.30%	12.37%	52.61%	na	1.45%	1.02%	1.84%
Pointe-Verte - Adult	0.41%	0.75%	32.65%	2.75%	8.54%	50.05%	na	1.64%	1.15%	2.07%
Petit-Rocher - Infant	0.03%	0.48%	4.93%	6.41%	11.03%	76.99%	na	0.13%	-	-
Petit-Rocher - Toddler	0.09%	0.57%	8.00%	20.81%	11.32%	58.14%	na	0.55%	0.51%	-
Petit-Rocher - Child	0.11%	0.68%	8.33%	4.07%	13.57%	66.45%	na	2.25%	1.85%	2.70%
Petit-Rocher - Teen	0.10%	0.80%	8.48%	3.31%	15.57%	66.22%	na	1.83%	1.50%	2.20%
Petit-Rocher - Adult	0.09%	0.80%	11.25%	2.93%	11.41%	66.91%	na	2.19%	1.80%	2.63%

Note: na - pathway not assessed for this COPC.
- receptor is not exposed via this pathway

	Percent of Total Intake									
Cadmium	Inhalation	Dermal	Water	Soil	Root Veg	Other Veg	Wild Game	Fish	Local Lobster	Wild Mussels
Townsite - Infant	1.81%	0.73%	4.11%	2.24%	45.85%	43.12%	na	2.15%	-	-
Townsite - Toddler	5.87%	0.79%	6.03%	6.56%	42.58%	29.45%	na	8.32%	0.39%	-
Townsite - Child	2.28%	0.30%	2.00%	0.41%	16.25%	10.72%	na	10.75%	0.45%	56.84%
Townsite - Teen	2.26%	0.40%	2.28%	0.37%	20.85%	11.95%	na	9.78%	0.41%	51.71%
Townsite - Adult	1.87%	0.37%	2.82%	0.31%	14.26%	11.27%	na	10.92%	0.46%	57.73%
Lower Belledune - Infant	0.80%	0.33%	2.05%	1.02%	42.42%	52.30%	na	1.07%	-	-
Lower Belledune - Toddler	2.93%	0.41%	3.40%	3.39%	44.48%	40.34%	na	4.70%	0.35%	-
Lower Belledune - Child	0.82%	0.11%	0.81%	0.15%	12.23%	10.58%	na	4.37%	0.29%	70.64%
Lower Belledune - Teen	0.83%	0.15%	0.94%	0.14%	16.01%	12.03%	na	4.05%	0.27%	65.57%
Lower Belledune - Adult	0.67%	0.14%	1.14%	0.11%	10.69%	11.08%	na	4.42%	0.29%	71.46%
Belledune - Infant	0.42%	0.30%	3.68%	0.92%	53.32%	39.44%	na	1.92%	-	-
Belledune - Toddler	1.45%	0.35%	5.73%	2.88%	52.57%	28.60%	na	7.91%	0.52%	-
Belledune - Child	0.50%	0.12%	1.70%	0.16%	17.98%	9.33%	na	9.15%	0.54%	60.52%
Belledune - Teen	0.50%	0.16%	1.94%	0.15%	23.05%	10.39%	na	8.32%	0.49%	55.03%
Belledune - Adult	0.41%	0.14%	2.40%	0.12%	15.78%	9.81%	na	9.29%	0.55%	61.49%
Pointe-Verte - Infant	0.44%	0.35%	4.67%	1.07%	56.20%	34.91%	na	2.36%	-	-
Pointe-Verte - Toddler	1.47%	0.39%	7.03%	3.21%	53.51%	24.45%	na	9.38%	0.56%	-
Pointe-Verte - Child	0.47%	0.12%	1.94%	0.17%	16.97%	7.40%	na	10.06%	0.54%	62.34%
Pointe-Verte - Teen	0.47%	0.16%	2.22%	0.15%	21.91%	8.29%	na	9.21%	0.49%	57.09%
Pointe-Verte - Adult	0.39%	0.15%	2.73%	0.12%	14.87%	7.76%	na	10.20%	0.54%	63.23%
Petit-Rocher - Infant	0.06%	0.24%	4.39%	0.73%	56.87%	35.32%	na	2.39%	-	-
Petit-Rocher - Toddler	0.21%	0.27%	6.73%	2.25%	55.13%	25.19%	na	9.66%	0.56%	-
Petit-Rocher - Child	0.08%	0.10%	2.11%	0.13%	19.91%	8.68%	na	11.80%	0.61%	56.58%
Petit-Rocher - Teen	0.08%	0.13%	2.39%	0.12%	25.37%	9.60%	na	10.66%	0.55%	51.11%
Petit-Rocher - Adult	0.06%	0.12%	2.98%	0.10%	17.49%	9.13%	na	12.00%	0.62%	57.51%

Note: na - pathway not assessed for this COPC.
- receptor is not exposed via this pathway

Table 5.14c: Percent intake (best estimate) by pathway for 1985-1999 for average seafood eaters using Noranda EMP data (cont'd)

Lead	Percent of Total Intake									
	Inhalation	Dermal	Water	Soil	Root Veg	Other Veg	Wild Game	Fish	Local Lobster	Wild Mussels
Townsite - Infant	8.91%	0.29%	3.29%	20.62%	14.75%	40.14%	na	12.01%	-	-
Townsite - Toddler	15.84%	0.17%	2.64%	33.10%	7.49%	14.99%	na	25.45%	0.32%	-
Townsite - Child	10.62%	0.11%	1.51%	3.56%	4.94%	9.43%	na	56.76%	0.63%	12.43%
Townsite - Teen	10.97%	0.15%	1.79%	3.37%	6.60%	10.95%	na	53.79%	0.60%	11.78%
Townsite - Adult	8.81%	0.14%	2.16%	2.71%	4.39%	10.03%	na	58.34%	0.65%	12.78%
Lower Belledune - Infant	6.17%	0.21%	2.59%	15.08%	19.36%	47.13%	na	9.45%	-	-
Lower Belledune - Toddler	12.88%	0.15%	2.44%	28.43%	11.54%	20.67%	na	23.53%	0.35%	-
Lower Belledune - Child	3.79%	0.04%	0.61%	1.34%	3.34%	5.71%	na	23.03%	0.30%	61.84%
Lower Belledune - Teen	4.00%	0.06%	0.74%	1.30%	4.57%	6.77%	na	22.32%	0.29%	59.94%
Lower Belledune - Adult	3.09%	0.05%	0.86%	1.00%	2.92%	5.97%	na	23.28%	0.30%	62.52%
Belledune - Infant	3.08%	0.22%	4.35%	15.37%	18.39%	42.72%	na	15.87%	-	-
Belledune - Toddler	5.87%	0.14%	3.75%	26.49%	10.02%	17.13%	na	36.10%	0.51%	-
Belledune - Child	2.51%	0.06%	1.37%	1.82%	4.22%	6.88%	na	51.41%	0.65%	31.08%
Belledune - Teen	2.64%	0.08%	1.65%	1.75%	5.73%	8.11%	na	49.50%	0.63%	29.92%
Belledune - Adult	2.04%	0.07%	1.92%	1.36%	3.67%	7.17%	na	51.80%	0.66%	31.31%
Pointe-Verte - Infant	1.25%	0.10%	3.85%	6.86%	16.71%	63.91%	na	7.33%	-	-
Pointe-Verte - Toddler	3.44%	0.09%	4.80%	17.09%	13.16%	37.03%	na	24.09%	0.30%	-
Pointe-Verte - Child	1.61%	0.04%	1.91%	1.28%	6.04%	16.21%	na	37.37%	0.41%	35.14%
Pointe-Verte - Teen	1.64%	0.05%	2.24%	1.20%	7.97%	18.59%	na	35.01%	0.39%	32.91%
Pointe-Verte - Adult	1.30%	0.05%	2.66%	0.95%	5.22%	16.79%	na	37.43%	0.41%	35.19%
Petit-Rocher - Infant	0.18%	0.08%	2.67%	5.62%	17.37%	66.46%	na	7.62%	-	-
Petit-Rocher - Toddler	0.53%	0.08%	3.49%	14.68%	14.36%	40.42%	na	26.29%	0.14%	-
Petit-Rocher - Child	0.32%	0.04%	1.77%	1.40%	8.39%	22.53%	na	51.96%	0.26%	13.32%
Petit-Rocher - Teen	0.32%	0.06%	2.03%	1.28%	10.86%	25.31%	na	47.68%	0.23%	12.22%
Petit-Rocher - Adult	0.26%	0.05%	2.46%	1.04%	7.26%	23.33%	na	52.01%	0.26%	13.33%

Note: na - pathway not assessed for this COPC.
- receptor is not exposed via this pathway

Table 5.15: Total intakes for maximum fish, lobster and mussels eaters (best estimate)

Receptor Locations (Adults)	Total Intakes (mg/kg d)											
	Arsenic			Cadmium			Chromium			Lead		
	Max. Fish	Max. Lobster	Max. Mussels	Max. Fish	Max. Lobster	Max. Mussels	Max. Fish	Max. Lobster	Max. Mussels	Max. Fish	Max. Lobster	Max. Mussels
Townsite	$7.77x10^{-4}$	$8.05x10^{-4}$	$8.53x10^{-4}$	$5.63x10^{-4}$	$3.75x10^{-4}$	$2.34x10^{-3}$	$3.96x10^{-4}$	$3.96x10^{-4}$	$3.96x10^{-4}$	$9.58x10^{-3}$	$8.68x10^{-4}$	$3.75x10^{-3}$
Lower Belledune	$7.76x10^{-4}$	$8.15x10^{-4}$	$8.90x10^{-4}$	$5.71x10^{-4}$	$3.86x10^{-4}$	$5.60x10^{-3}$	$3.95x10^{-4}$	$3.95x10^{-4}$	$3.95x10^{-4}$	$9.42x10^{-3}$	$8.79x10^{-4}$	$5.03x10^{-2}$
Belledune	$7.72x10^{-4}$	$8.08x10^{-4}$	$8.86x10^{-4}$	$5.62x10^{-4}$	$3.76x10^{-4}$	$2.81x10^{-3}$	$3.95x10^{-4}$	$3.95x10^{-4}$	$3.95x10^{-4}$	$9.41x10^{-3}$	$8.21x10^{-4}$	$1.09x10^{-2}$
Pointe-Verte	$7.36x10^{-4}$	$7.69x10^{-4}$	$8.16x10^{-4}$	$5.53x10^{-4}$	$3.60x10^{-4}$	$2.83x10^{-3}$	$5.69x10^{-4}$	$5.69x10^{-4}$	$5.69x10^{-4}$	$9.48x10^{-3}$	$7.92x10^{-4}$	$2.03x10^{-2}$
Petit-Rocher	$6.84x10^{-4}$	$7.10x10^{-4}$	$7.57x10^{-4}$	$5.52x10^{-4}$	$3.63x10^{-4}$	$2.28x10^{-3}$	$6.51x10^{-4}$	$6.51x10^{-4}$	$6.51x10^{-4}$	$9.45x10^{-3}$	$7.49x10^{-4}$	$5.11x10^{-3}$

Receptor Locations (Adults)	Total Intakes (mg/kg d)											
	Mercury			Thallium			Zinc			Dioxins and Furans		
	Max. Fish	Max. Lobster	Max. Mussels	Max. Fish	Max. Lobster	Max. Mussels	Max. Fish	Max. Lobster	Max. Mussels	Max. Fish	Max. Lobster	Max. Mussels
Townsite	$2.75x10^{-4}$	$1.70x10^{-4}$	$1.46x10^{-4}$	$3.97x10^{-5}$	$4.56x10^{-5}$	$6.29x10^{-5}$	$2.39x10^{-1}$	$2.16x10^{-1}$	$2.23x10^{-1}$	$6.27x10^{-10}$	$6.27x10^{-10}$	$6.27x10^{-10}$
Lower Belledune	$2.75x10^{-4}$	$1.84x10^{-4}$	$1.46x10^{-4}$	$3.81x10^{-5}$	$4.40x10^{-5}$	$9.06x10^{-5}$	$2.39x10^{-1}$	$2.16x10^{-1}$	$2.56x10^{-1}$	$6.27x10^{-10}$	$6.27x10^{-10}$	$6.27x10^{-10}$
Belledune	$2.75x10^{-4}$	$1.80x10^{-4}$	$1.46x10^{-4}$	$3.60x10^{-5}$	$4.20x10^{-5}$	$6.38x10^{-5}$	$2.39x10^{-1}$	$2.16x10^{-1}$	$2.27x10^{-1}$	$6.27x10^{-10}$	$6.27x10^{-10}$	$6.27x10^{-10}$
Pointe-Verte	$2.75x10^{-4}$	$1.64x10^{-4}$	$1.35x10^{-4}$	$4.57x10^{-5}$	$5.16x10^{-5}$	$9.34x10^{-5}$	$2.39x10^{-1}$	$2.18x10^{-1}$	$2.36x10^{-1}$	$6.27x10^{-10}$	$6.27x10^{-10}$	$6.27x10^{-10}$
Petit-Rocher	$2.75x10^{-4}$	$1.40x10^{-4}$	$1.20x10^{-4}$	$4.40x10^{-5}$	$4.99x10^{-5}$	$8.42x10^{-5}$	$2.38x10^{-1}$	$2.18x10^{-1}$	$2.23x10^{-1}$	$6.27x10^{-10}$	$6.27x10^{-10}$	$6.27x10^{-10}$

5.4 Uncertainty

As discussed in this section, a number of assumptions were used to present an exposure estimate that is a reasonable upper bound value for residents in the Belledune area and vicinity. The assumptions used for the human receptor characteristics were obtained from extensive surveys of Canadian populations and are generally thought to be protective of most segments of the society. Some of the assumptions used in the exposure assessment and the likely effect on the assessment are provided in Table 5.16 .

Table 5.16: Summary of assumptions and for exposure and impact on assessment

Receptor Characteristic	Assumption	How assessment affected?
Residency Time	It was assumed that a person was present in their residence 24 hrs a day, 365 days per year for a 70-year lifetime.	This assumption would likely overestimate exposures for some residents as it does not account for time they may not be present at their residence. For example, going on holiday. For other residents this would likely underestimate exposures, as they may spend time during the day (at work, school) closer to the industrial area than their residence. Overall, given the conservative residency assumption, it is unlikely that exposures to nearby residences will be underestimated.
Soil Ingestion	It was assumed that soil ingestion occurs at the same rate every day of the year for a lifetime of 70 years. It was assumed that individuals were ingesting soil at a range of concentrations between the mean and the UCL (95^{th} two-sided) of the mean concentration. Soil concentrations from both the Noranda EMP and CCNB were assessed separately to determine the range of soil exposures that Belledune residents encounter, and to quantify the uncertainty associated with the use of one data source over another.	This assumption would likely overestimate exposure since for about 4-5 months of the year the soil would be covered with snow and therefore would not be accessible. The assumption about the range of soil concentrations will account for exposures to soil concentrations that are higher than average, and would likely overestimate chronic exposure. The use of both Noranda EMP and CCNB soil concentrations in producing a range of soil exposures proved useful in quantifying uncertainty in this exposure pathway. It was determined that the source of soil data had only a small impact on the exposure results, as the soil pathway was a relatively minor pathway of exposure for most COPC with the exception of infants and toddlers in Lower Belledune and Townsite #2 exposed to lead.

Table 5.16: Summary of assumptions and for exposure and impact on assessment (cont'd)

Receptor Characteristic	Assumption	How assessment affected?
Soil Ingestion (Contd)	It was assumed that the COPC in the soil were 100% bioavailable via ingestion. It was assumed that soil ingestion occurs from the top 5 to 10 cm of the soil. It was assumed that soil ingestion rates included intakes of housedust and that concentrations of the COPC associated with incremental risk from Belledune industries were greater in outdoor soil than in indoor dust.	It is well known that not all of the COPC in the soil is available for uptake by the gut, but in the absence of site-specific data, 100% bioavailability was assumed. This would tend to overestimate exposure. The assumption that exposure to soil occurs from the top 5 to 10 cm of the soil is realistic since receptors are generally exposed to this layer of soil. The assumption that outdoor exposure to soil encompasses housedust would likely overestimate exposure since residents spend more time during the day exposed to indoor housedust than to outdoor soil. The uncertainty introduced by the assumptions made regarding soil ingestion does not impact on the total exposure since the soil ingestion exposure pathway is relatively minor , with the exception of arsenic and lead exposures in infants and toddlers in Townsite #2 and Lower Belledune.
Inhalation of Air	It was assumed that individuals were exposed to COPC concentrations in outdoor air for 24 hours a day, ranging from the mean concentration to the UCL (95th two-sided) of the mean concentration, over a 70-year period. It was assumed that concentrations of the COPC in outdoor air were those associated with incremental exposures from Belledune industries, and that these COPC were higher in outdoor than indoor air. Air concentrations were modeled using air dispersion modeling techniques. Modeling was validated using measured air concentrations, and adjustment factors were applied based on the difference between modeled and measured concentrations	This assumption would most likely overestimate exposure since it does not account for decreases in COPC concentration in air over time as well as for time away from the residence. Furthermore, the assumption about the range of air concentrations will account for exposures to air that are higher than average, and would likely overestimate exposure, since the mean concentrations were benchmarked to the measured values. Since the UCL has arbitrarily been assigned to be a factor of 2 higher, this greatly overestimates exposure. Exposure is likely further overestimated as residents spend a large portion of the day indoors where COPC levels from Belledune industries will be lower. The air dispersion modeling used to estimate air concentrations likely introduced uncertainty into the HHRA, but this uncertainty was reduced during the application of adjustment factors to mimic measured data.

Table 5.16: Summary of assumptions and for exposure and impact on assessment (cont'd)

Receptor Characteristic	Assumption	How assessment affected?
Inhalation of Air (Cont'd)		The addition of uncertainty caused by assumptions relating to inhalation had only a small impact on the results of the HHRA because inhalation of air was shown to contribute insignificantly to overall exposure and risk for most COPC.
Drinking Water Intakes	It was assumed that individuals living in the Belledune area obtained his or her drinking water from domestic wells located in their study area over a 70-year lifetime.	This assumption would most likely result in an overestimation of exposure since approximately half of the residents are on a municipal supply, where water undergoes treatment processes that should reduce concentrations of some COPC.
	It was assumed that individuals were ingesting COPC in drinking water at levels ranging from the mean concentration to the UCL (95th two-sided) of the mean concentration in each area.	The assumption of exposure to a range of drinking water concentrations in the domestic well over a 70-year period will account for exposures that are higher than average, and would likely overestimate exposure.
	Privacy issues dictated that only area-specific well water concentrations could be obtained.	The use of area-specific well water concentrations added uncertainty to the HHRA, but its effect on exposure is not known.
	Well water data from Petit-Rocher and Pointe-Verte had a higher detection limit than those from other study areas. Many samples were below the detection limit, and half the detection limit was used.	The effect of the higher detection limits in well water data for Petit-Rocher and Pointe-Verte likely overestimated exposure from drinking water, because an assumption that concentration was equal to half the detection limit was used. Further, the fact that many samples were below the detection limit likely resulted in an overestimate of drinking water concentrations and exposures.
		The addition of uncertainty caused by assumptions relating to drinking water had only a small impact on the results of the HHRA because drinking water was shown to contribute only a small fraction to overall exposure and risk for most COPC, with the exception of arsenic. In addition, the drinking water pathway is not influenced by the industries and is considered to be baseline exposure.

Table 5.16: Summary of assumptions and for exposure and impact on assessment (cont'd)

Receptor Characteristic	Assumption	How assessment affected?
Skin Contact with Soil	It was assumed that skin contact with soil occurs in an area with soil concentrations ranging from the mean concentration to the UCL (95th two-sided) of the mean soil COPC concentration. Skin contact was assumed to occur 365 days of the year for a 70-year lifespan. It was also assumed that the COPC in the soil was in contact with the skin for 24 hours before any washing occurs. Soil concentrations from both the Noranda EMP and CCNB were assessed separately to determine the range of soil exposures that Belledune residents encounter, and to quantify the uncertainty associated with the use of one data source over another. Relative absorption factors were used from the MOE in order to represent COPC uptake via dermal contact with soil.	The assumption of exposure to a range of soil concentrations over a 70-year period will account for exposures that are higher than average, and would likely overestimate exposure This assumption would tend to overestimate exposure since it includes periods when the soil is covered with snow. The 24 hours before washing assumption will tend to overestimate exposure since it is unlikely that the soil will remain on the skin for that period of time. The use of both Noranda EMP and CCNB soil concentrations in producing a range of soil exposures proved useful in quantifying uncertainty in this exposure pathway. It was determined that the source of soil data had only a small impact on the HHRA results, as Noranda and CCNB soil concentrations did not produce significantly different exposure estimates from dermal contact with soil. The use of relative absorption factors from the MOE is likely to add uncertainty to exposure estimates from this exposure pathway. However, the added uncertainty involved with using these factors should be less than would be added if it was assumed that 100%of the COPC in soil passed through the skin barrier. The uncertainty resulting from assumptions made regarding dermal contact with soil had a negligible impact on the total intakes , because dermal contact with soil was shown to contribute insignificantly to overall exposure.
Consumption of local seafood	It was assumed that the consumption of fish and shellfish from the local area at the same rate and concentration occurs every day of the year for a 70-year lifetime. Seafood intake rates were derived using 24-hour dietary recall methods in the New Brunswick Nutrition Survey (2004). It was assumed that the consumption of fish occurs at the mean and maximum rates consumed by residents of Bathurst, NB, and that consumption of lobster and shellfish occurs at the mean and maximum rates consumed by residents of New Brunswick.	The use of both average and maximum seafood intake rates to produce a range of seafood exposure estimates will likely tend to overestimate exposure for average eaters since they are unlikely to consume local seafood everyday for 70 years. Some seafood would be obtained from the supermarket and not from local sources. The use of maximum seafood intake rates in the sensitivity analysis showed that seafood intake rates are an important determinant of COPC exposure in residents of Belledune, and the use of these (maximum) rates will highly overestimate lifetime exposure. The use of 24-hour dietary recall survey results likely introduces uncertainty into exposure estimates. The use of both Bathurst and province-wide data to estimate local seafood intake rates in Belledune should neither under- nor overestimate exposure because they were the most appropriate rates found for Belledune.

Table 5.16: Summary of Assumptions and for Exposure and Impact on Assessment (Cont'd)

Receptor Characteristic	Assumption	How assessment affected?
Consumption of local seafood (Cont'd)	It was assumed that shellfish consumed consisted entirely of wild mussels.	The assumption about all shellfish being present as wild mussels should tend to overestimate exposure, as immobile mussels are typically more contaminated by COPC than semi-mobile shellfish. Also, wild mussel concentrations were higher than clams for the Baie des Chaleurs.
	It was assumed that residents consumed lobster muscle and did not consume the hepatopancreas (digestive gland).	The assumption that lobster hepatopancreas is not consumed may tend to underestimate exposure in individuals who do consume this gland. However, given that lobster was not shown to be a major exposure pathway for most COPC in either best estimate or upper bound exposures, that hepatopancreas consumption is likely uncommon, and that maximum exposures were captured in the sensitivity analysis, this assumption likely does not lead to a significant underestimate of the exposure.
	It was assumed that concentrations in seafood ranging from the mean concentration to the UCL (95th two-sided) of the mean concentration were consumed.	The assumption of exposure to a range of seafood concentrations over a 70-year period will account for exposures that are higher than average, and would likely overestimate exposure.
	Because fish concentrations in the GBA were only available from 1972-1980, these concentrations were used to represent concentrations in the remaining time periods. Further, fish data came from three different sources and likely from three different laboratories.	The assumption about fish concentrations being present at 1972-1980 levels likely overestimates COPC exposure from fish for the remaining time periods, because it is likely that fish concentrations have decreased since 1980. The use of fish data from different laboratories is likely to have further introduced uncertainty into these estimates. Because of the importance of the fish exposure pathway, the assumptions made are critical to the results of the HHRA and it is recommended that further studies be conducted to determine current COPC concentrations in fish in the Baie des Chaleurs.
	An empirical relationship between wild mussel concentrations and distance from Belledune Harbour was used for infilling purposes, as data were not available for all time periods, study areas and COPC. Lobster concentrations from preceding or subsequent time periods and/or nearby study areas were used to infill lobster data. Although most lobster and mussel data came from the same laboratory, additional data were derived from different laboratories.	The data infilling that occurred for local lobster and wild mussel data likely introduced some uncertainty into the exposure, but this assumption probably did not have as great an impact on the assessment as the assumption about fish, because lobster and wild mussel data were more abundant than fish for most COPC and study areas. The use of lobster and mussel data from different laboratories is likely to have further introduced uncertainty into these estimates.
		Because wild mussels were determined to be a very important exposure pathway for several COPC, further studies are recommended to reduce uncertainty in wild mussel concentrations and exposures.

Table 5.16: Summary of assumptions and for exposure and impact on assessment (cont'd)

Receptor Characteristic	Assumption	How assessment affected?
Consumption of wild game	It was assumed that rabbits and partridge were consumed at the rate that First Nations people consume wildlife, and that they were consumed every day at this rate for a 70-year time period. Intake rates for First Nations people were developed using 24-hour dietary recall methods.	This assumption will tend to overestimate exposure since it is unlikely that wildlife would be consumed at the rate of a First Nations person who subsists mainly on a traditional diet. It is further unlikely that wildlife will be consumed every day, as it may only be seasonally available in the area. Furthermore, the Belledune Industrial Area is not large enough to allow an adequate supply of wild game for the entire GBA. The use of 24-hour dietary recall methods is likely to add uncertainty to exposure estimates for consumption of wild game.
	It was assumed that mean concentrations of COPC measured in rabbits and partridge obtained from the Belledune Industrial Area in 2004 were consumed.	The assumption that concentrations in wild game caught in the Belledune Industrial Area are representative of all concentrations in the GBA may tend to overestimate exposure, as wild game caught there are likely to be more exposed to COPC than other wild game.
	The empirical relationship between wild game and forage concentrations in the current time period were coupled with historical forage concentrations to estimate historical concentrations in wild game.	The use of the empirical relationship between current wild game and forage concentrations to estimate historical concentrations in wild game introduces uncertainty into exposure estimates. It is not known whether this uncertainty would lead to an under- or overestimate of exposure.
	A very small number of samples were used to represent concentrations in wild game (n=3 for both partridge and rabbit).	Further uncertainty arises due to the small sample size available for wild game.
		The uncertainty resulting from assumptions made regarding consumption of wild game had a negligible impact on the HHRA results, because this exposure pathway was shown to contribute a small fraction of the total exposure (1-20%). For chromium, the wild game pathway is 8-50% of the total exposure; however, all intakes related to chromium do not result in the toxicity reference value being exceeded (see Section 7.0).

Table 5.16: Summary of assumptions and for exposure and impact on assessment (cont'd)

Receptor Characteristic	Assumption	How assessment affected?
Consumption of backyard garden vegetables	It was assumed that backyard vegetables would be consumed every day of the year for 70 years at a rate estimated by the Ontario MOE for communities in Ontario.	This assumption will tend to overestimate exposure for people in the area who do not have a backyard garden and do not produce as many vegetables in their garden as has been assumed in the assessment. Furthermore, exposure will likely be further overestimated, as backyard gardens are seasonally limited. The use of MOE methods from Ontario to estimate an intake rate for backyard garden vegetables in New Brunswick is likely to introduce uncertainty, but its effect on exposure estimates is unknown.
	It was assumed that COPC concentrations in garden vegetables ranging from the mean to the UCL (95th two-sided) of the mean were consumed every day for a lifetime of 70 years.	The assumption of exposure to a range of garden vegetable concentrations over a 70-year period will account for exposures that are higher than average, and would likely overestimate exposure.
	Despite a smaller sample size for COPC concentrations in garden vegetables in the current period, these were the only measurements available and were thus used in the calculation of exposure to garden vegetables in the current period.	The small sample size in garden vegetable concentrations in the current period introduces uncertainty into exposure estimates. It is not known whether exposures would likely be under- or overestimated as a result.
	A very small number of samples were used to represent cadmium concentrations in Townsite #2 during the current period. One sample appeared abnormally high but was used due to the lack of alternate data.	The very small sample size used to estimate cadmium concentrations in Townsite #2 in the current period introduces further uncertainty into exposure estimates. It is not known whether exposure would likely be under- or overestimated as a result.
	Because COPC concentrations in Petit-Rocher garden vegetables were only available for 1975-1984, these concentrations were also used for 1967-1974. Concentrations from neighbouring Pointe-Verte were used to represent concentrations in Petit-Rocher garden vegetables during the 1985-1999 and current time periods.	The use of 1975-1984 data to represent concentrations in 1967-1974 would likely underestimate exposures during this earliest time period because the general trend in environmental concentrations of COPC in Belledune is a decreasing one. The use of Pointe-Verte concentrations for 1985-1999 and current time periods likely overestimates exposure in Petit-Rocher because Pointe-Verte is closer to the Belledune Industrial Area, and a general trend of decreasing vegetable concentrations with increasing distance from the industrial area was noted. The uncertainty introduced by the assumptions made to estimate exposure from consumption of garden vegetables is significant when it is considered that consumption of garden vegetables is an important exposure pathway for certain COPC in certain areas. It is recommended that further studies be performed measuring levels of COPC in garden vegetables across the GBA in order to reduce the uncertainty associated with this exposure pathway.

6.0 Toxicity assessment

The toxicity assessment (determination of the harmfulness of a given contaminant) identifies what potential adverse effects are associated with the identified contaminants, and what is the relationship between the magnitude of exposure and the probability of occurrence of adverse effects. The type and intensity of the adverse effect or health problem depends on the contaminant and the amount of exposure. In general, the toxicity assessment uses results from animal (and when available human) studies to determine the likely adverse health effect associated with a given exposure. Based on the results of the exposure assessment and the toxicity assessment, the likelihood of both cancer and non-cancer adverse health effects occurring as a result of exposure was evaluated. Non-cancer health effects can range from rashes and breathing difficulties to organ failure, birth defects and death, while cancers may occur in a variety of organ systems.

6.1 Toxicity reference values

There are many agencies that derive and publish toxicity reference values (TRVs). For some chemicals, the TRVs produced by different agencies can differ substantially. While there are many sources of TRVs, there are two main agencies that were used in this assessment:

- United States Environmental Protection Agency (U.S. EPA) - Toxicity values from the on-line database IRIS (Integrated Risk Information System).

- Health Canada – Health Canada's *Guidelines for Federal Contaminated Site Risk Assessment in Canada* (Health Canada, 2003) is Canada's most concise and current source for toxicity values.

Figure 3.2 in Section 3.1 provided the rationale for the selection of the TRVs used in this assessment. Tolerable Daily Intakes (TDIs) and Reference Doses (RfDs) are used to assess non-carcinogenic or threshold effects, and slope factors are used to assess carcinogenic effects. Table 6.1 provides a summary of the TRVs that were used in this assessment. The table also provides a biological endpoint or health effect for which each of these numbers is based and also provides whether it is based on a human or rat study. As one of the objectives of the study was to link the results of the risk assessment to the community health status assessment (CHSA), it was important to state the endpoints for which the TRVs were derived. Therefore, for this study TRVs from Health Canada and U.S. EPA that included a toxicological endpoint were used so that linkages could occur. Toxicity profiles are provided for each of the COPC in Appendix C.

Acute effects relating to these COPC were not provided as the effects in the Belledune community evaluated related to chronic exposure.

For the combustion gases and particulate matter, both acute and chronic effects were discussed as well as the other points provided above. The reference concentration for NO_x is 40 µg/m^3 and for SO_2 is 500 µg/m^3.

COPC with similar toxicological endpoints can be summed together so that the appropriate linkages can be made. It can be seen that from an oral pathway standpoint that there were no similar endpoints and thus all non-carcinogenic COPC were assessed separately. Arsenic was the only carcinogen that was assessed for the oral pathway. Arsenic, cadmium and chromium were assessed for carcinogenicity through the inhalation pathway.

6.2 Uncertainty and data gaps

In terms of toxicity, the TRVs were selected to be very protective. For example, the slope factors used in assessment represent risks from upper bound (95th percentile) dose-response estimates. The TRVs for non-carcinogenic effects are set to protect the most sensitive individuals within the population. The most restrictive of the TRVs from Health Canada or the U.S. EPA were used to ensure that the appropriate health effects were evaluated in this study. As the most restrictive TRVs were used in the assessment, it may be possible that some risks would be overestimated.

Table 6.1: Toxicity reference values for COPC

COPC	Non-Carcinogenic TRV (mg/kg-d)	Non-Carcinogenic Health Effect	Reference	Carcinogenic TRV $(mg/kg\text{-}d)^{-1}$	Carcinogenic Health Effect	Reference
Dioxins and furans	2×10^{-9} (oral)	Provisional TDI for reproductive effects. Based on the mid-point of values from a range of studies.	WHO JECFA (2002)	-	-	-
Arsenic	0.002 (oral)	Not known	Health Canada Food Directorate (2002)	1.2 (oral) 28 (inhalation)	Internal cancers (liver, lung, bladder, kidney (oral, human)) Lung Cancer (inhalation, human, occupational exposure)	Health Canada (2003)
Cadmium	0.001 (oral)	Significant proteinurea (Human, occupational exposure)	U.S. EPA (2004)	42.9 (inhalation)	Lung tumours (inhalation, rat)	Health Canada (2003)
Chromium (Total)	0.003 (oral)	No effect (oral, rat study, IRIS)	U.S. EPA (2004)	47.6 (inhalation)	Lung cancer (inhalation, human, occupational exposure)	Health Canada (2003)
Lead	0.0036 (oral)	Increases in blood lead levels or in lead retention[(1)]	Health Canada (2003)	-	-	-
Methyl mercury	0.0001 (oral)	Neurological Effects (epidemiological study)	U.S. EPA (2004)	-	-	-
Thallium	8×10^{-5} (oral)	Increased SGOT and LDH levels (rat study)	U.S. EPA (2004)	-	-	-
Zinc	0.3 (oral)	Decrease in erythrocyte superoxide dismutase (ESOD) concentration in adult females (human study)	U.S. EPA (2004)	-	-	-

Notes: 1 - Health Canada's oral lead TRV is most likely based on increases in blood lead levels or in lead retention because although not explicitly stated, the TRV is very similar to JECFA's 1993 value of 0.0035 mg/kg-d in WHO (1996). The lead value is based on an acceptable blood lead level in children of 10 µg/dL.

7.0 Risk characterization

In the final step of the HHRA, the information from the exposure assessment and the toxicity assessment is integrated to complete risk characterization.

7.1 Carcinogens

For carcinogenic contaminants, a risk is calculated by multiplying the estimated dose (in mg/kg-d) by the appropriate slope factor (in per mg/kg-d). This is shown in Equation 7.1. The estimate corresponds to an incremental risk of an individual developing cancer over a lifetime as a result of exposure.

Risk is defined as follows:

$$Risk = (D_i \times SF_i) + (D_o \times SF_o) + (D_d \times SF_d) \qquad (7.1)$$

Where:

- D_i = Dose due to inhalation exposure (mg/kg-d)
- D_o = Dose due to oral (ingestion) exposure (mg/kg-d)
- D_d = Dose due to dermal exposure (mg/kg-d)
- SF_i = Slope Factor for inhalation exposure $(mg/kg\text{-}d)^{-1}$
- SF_o = Slope Factor for oral exposure $(mg/kg\text{-}d)^{-1}$
- SF_d = Slope Factor for dermal exposure $(mg/kg\text{-}d)^{-1}$ (assumed equal to SF_o)

Cancer risk levels for child receptors are generally not calculated since there is a latency period before the potential effect is realized. In this case a composite receptor was assessed. This composite receptor encompasses the exposure of an individual for a lifetime of exposure, otherwise known as "lifetime average daily dose (LADD)". In this assessment, an adult and a composite risk estimate were calculated.

For carcinogenic contaminants (e.g. arsenic), it is assumed that there is no such thing as "zero" risk except when there is "zero" exposure. As discussed above, the total risk from individual carcinogenic COPC was calculated based on the above equation. Since any level of exposure to a carcinogen is associated with a risk, regulatory agencies such as, Health Canada, the U.S. EPA, and New Brunswick, generally specify a level of risk that is considered acceptable, tolerable, or essentially negligible.

In 1989, Health Canada (HWC 1989) established that a cancer risk in the range of one in one hundred thousand (1×10^{-5}) to one in a million (1×10^{-6}) was an "essentially negligible" risk for carcinogens in drinking water. Since that time a 1 x 10^{-5} risk level has been widely accepted by federal agencies and others involved in contaminated site risk assessment (HC 2003).

The Atlantic provinces have all implemented a common approach to contaminated site risk assessment (Atlantic PIRI 1999). Within this framework, an acceptable or essentially negligible cancer risk level of 1 x 10^{-5} has been used. This level of risk was deemed to be essentially negligible for soil carcinogens associated with the Sydney Tar Ponds in Nova Scotia (JDAC 2002).

It should be noted that the background incidence of cancer in Canada is approximately 0.4 (NCIC 2001; NCI 1999) which is significantly higher than the risk level discussed above. This means that an incremental cancer risk of 1 x 10^{-5} will increase the lifetime risk of a person from 0.4 (4 in 10) to 0.40001. This level will not be detectable compared to background with any epidemiological method especially on smaller populations that may reside near contaminated sites (HC 2003).

For this assessment, incremental risks due to arsenic exposure from the industrial facilities in Belledune were calculated. These risk levels were compared to the regulatory risk level of 1 x 10^{-5}. As indicated in earlier sections, arsenic is considered to be a carcinogen via the oral and inhalation exposure routes. Cadmium and chromium are considered to be carcinogenic via the inhalation route. As discussed in Section 4.3.1, predicted concentrations of cadmium and chromium in the current time period are within the limits of baseline concentrations and thus the carcinogenic effects of cadmium and chromium are not evaluated in this assessment. In addition, as discussed in Section 2.0, there are no sufficient toxicological data to assess lead as a carcinogen.

7.2 Non-carcinogens

For many non-carcinogenic effects, protective biological mechanisms must be overcome before an adverse effect from exposure to the chemical is manifested. This is known as a "threshold" concept.

For non-carcinogenic contaminants, the hazard quotient (HQ) is defined as follows:

$$HQ = \frac{D_i}{TRV_i} + \frac{D_o}{TRV_o} + \frac{D_d}{TRV_d} \qquad (7\text{-}2)$$

Where:

D_i = Dose due to inhalation exposure (mg/kg-d)
D_o = Dose due to oral (ingestion) exposure (mg/kg-d)
D_d = Dose due to dermal exposure (mg/kg-d)
TRV_i = Non-cancer toxicity reference value for inhalation exposure (mg/kg-d)

TRV_o = Non-cancer toxicity reference value for oral exposure (mg/kg-d)
TRV_d = Non-cancer toxicity reference value for dermal exposure (mg/kg-d) (assumed equal to TRV_o)

In general, the exposure above of a toxicity reference value does not mean that an effect will occur; what it means is that there is an increased risk of an adverse effect occurring. In risk assessments, 20% of the dose or a hazard quotient of 0.2 is generally used to assess acceptable exposure from each individual exposure pathway by Health Canada. Since baseline exposures are being considered in this assessment as well as exposures from multiple exposure pathways, a hazard quotient value of 1 was used.

Another presentation method involves the comparison of total intakes to the TRV graphically. For the current exposure scenarios, the contribution from the inhalation exposure pathway was insignificant and thus the total exposure was compared to the oral TRV. This is an acceptable method of comparing intakes.

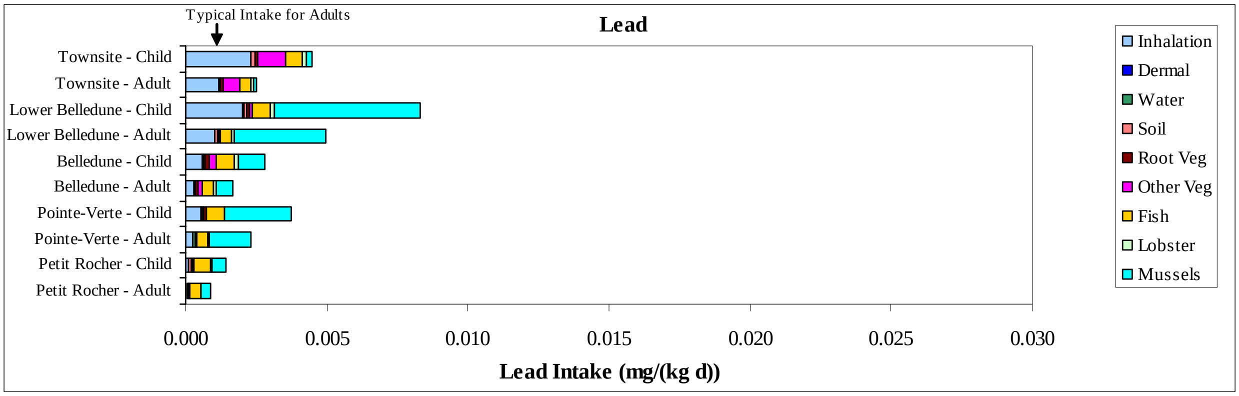
7.3 Risk results for historical exposure

This section provides the findings of risk assessment based on the historical data. As discussed previously, the historical analysis focused on exposure to arsenic, cadmium and lead. In general, the best estimate results are discussed in this section. The results relating to the upper bound estimates are provided in Appendix AE. For all historical risk results presented in this section, Noranda EMP data are the basis because CCNB soil data were not available for historical time periods. The results for all life stages are discussed to illustrate the range of exposure experienced for different life stages. Figures are presented for the adult and child. In the historic time period, the exposures for a child were higher than for an infant or toddler.

7.3.1 Historical exposure to lead

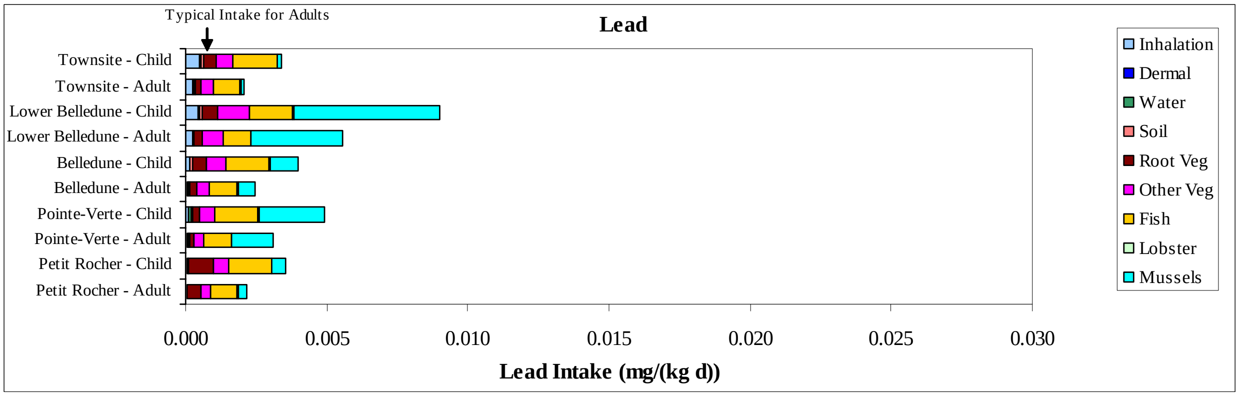
During the earliest time period studied (1967-1974), using best estimates or average concentrations in the environmental media, infants in Townsite #2 and children and adults in Lower Belledune would have had oral exposure levels at or beyond the current toxic reference value (TRV) associated with a blood lead level of 10µg/dL, which itself is associated with adverse neurocognitive developmental outcomes. For children living just west of the smelter along the shoreline, and in Lower Belledune, inhalation was estimated to be the main exposure pathway for lead followed by ingestion of local wild mussels and fish. The soil pathway was relatively minor. Soil concentrations of lead in Townsite #2 and Lower Belledune in this time frame were 197.5 mg/kg and 184.9 mg/kg respectively. For children living further west or east of the smelter (greater Belledune, Pointe-Verte, Petit-Rocher) during this period, inhalationwas an important pathway, but their diet of local wild mussels and fish also contributed to their exposure in similar proportions (refer to Figure 7.1 below).

Figure 7.1: Predicted Intakes of Lead (Best Estimate) – 1967 to 1974



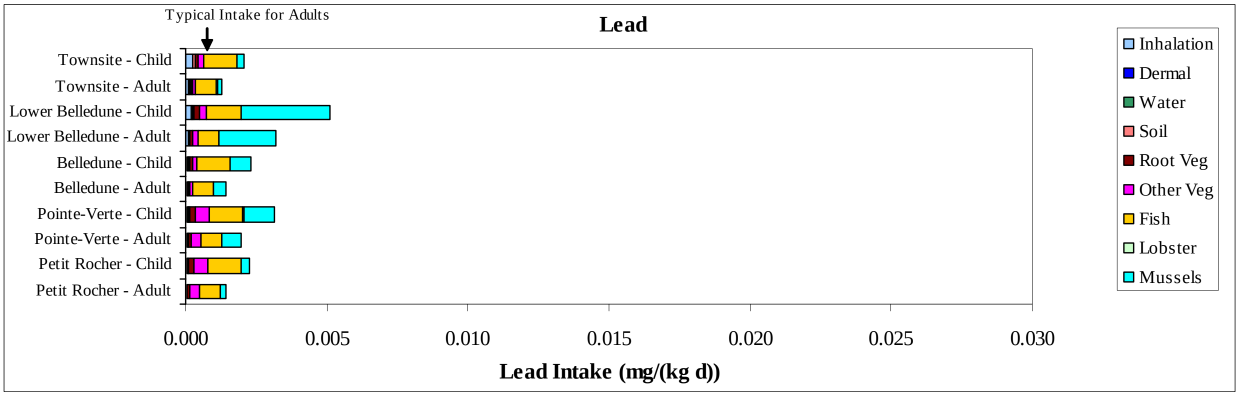
As illustrated in Figure 7.2, by the 1975-1984 period, again using best estimates or average concentrations, exposures in Townsite#2 have decreased. In Lower Belledune exposures have increased and all age groups were predicted to have had oral exposure to lead beyond the current oral toxic reference value (TRV). The interesting change in this period is that the inhalation pathway was estimated to be significantly lower than in the earlier time period. Most of the estimated exposure commitment to lead was predicted to occur from local wild mussels, fish and backyard garden vegetables. The intake of soil was still a relatively minor pathway. In greater Belledune, infants and children were predicted to have exposures above the oral TRV. Lead exposures in Pointe-Verte and Petit-Rocher also increased during this time period, mainly due to consumption of fish and backyard vegetables. In Pointe-Verte, children were predicted to have exposures above the oral TRV. In Petit-Rocher, the infant and child were predicted to have oral exposures above the TRV.

Figure 7.2: Predicted Intakes of Lead (Best Estimate) – 1975 to 1984



By the 1985-1999 period, the intakes predicted from the best estimates of environmental media indicate that the intakes had decreased substantially from the previous time period. During this period, the inhalation pathway is minimal, with the main pathways remaining ingestion of local wild mussels, and fish (refer to Figure 7.3 below). The backyard vegetable pathway has also decreased. In this time period, only children in Lower Belledune were predicted to have oral exposures to lead above the TRV.

Figure 7.3: Predicted Intakes of Lead (Best Estimate) – 1985 to 1999



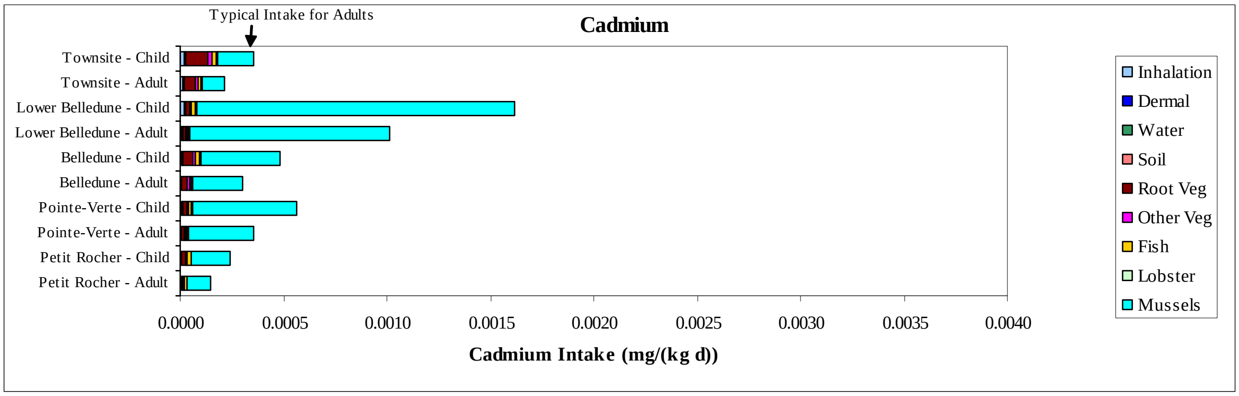
As will be discussed in the next section, current estimated exposure to lead are lower than the historical exposures. Most of the estimated exposure in the current time period relates to ingestion of local fish and wild mussels.

7.3.2 Historical exposure to cadmium

Unlike the historical pattern of lead where the study team saw a prominent pathway of inhalation in the earliest period, the historical pattern of cadmium exposure is estimated to be primarily due to ingestion rather than inhalation in all periods. Similar to the lead exposure pattern, the cadmium exposure pattern illustrates a decreasing estimated exposure over time periods with the highest exposure being experienced in 1975-1984.

During the early period (1967-1974), no exposures above the oral TRV were predicted for infants and toddlers; however, exposure estimates indicate that the oral TRV was exceeded by children and adults in Lower Belledune. Cadmium is not considered carcinogenic through the oral pathway. The kidney is the target tissue of non-cancer cadmium toxicity. The health effect associated with oral ingestion as shown in Table 6.1 is significant proteinurea, a reflection of abnormal kidney function.[1] The most significant pathway during this period for all receptors was the ingestion of local wild mussels, as illustrated in Figure 7.4 below.

Figure 7.4: Predicted Intakes of Cadmium (Best Estimate) – 1967 to 1974



Cadmium is also considered to be carcinogenic via the inhalation pathway. The incremental inhalation risks for an adult in the 1967-1974 time period at the different receptor locations are presented in Table 7.1. As seen from Table 7.1, predicted incremental risks for cadmium exposure are above the acceptable limit of 1 x 10^{-5} in Townsite #2 and Lower Belledune. The risks decrease the farther away the study areas are from the industrial activities. The incremental risk in Petit-Rocher is not presented since the air concentrations are at baseline levels.

Table 7.1: Summary of incremental inhalation risks for adult for cadmium exposures in 1967-1974 Time Period

Location	Incremental Risk
Townsite #2	4.8 x 10^{-5}
Lower Belledune	4.2 x 10^{-5}
Belledune	1.0 x 10^{-5}
Pointe-Verte	8.5 x 10^{-5}
Petit-Rocher	-

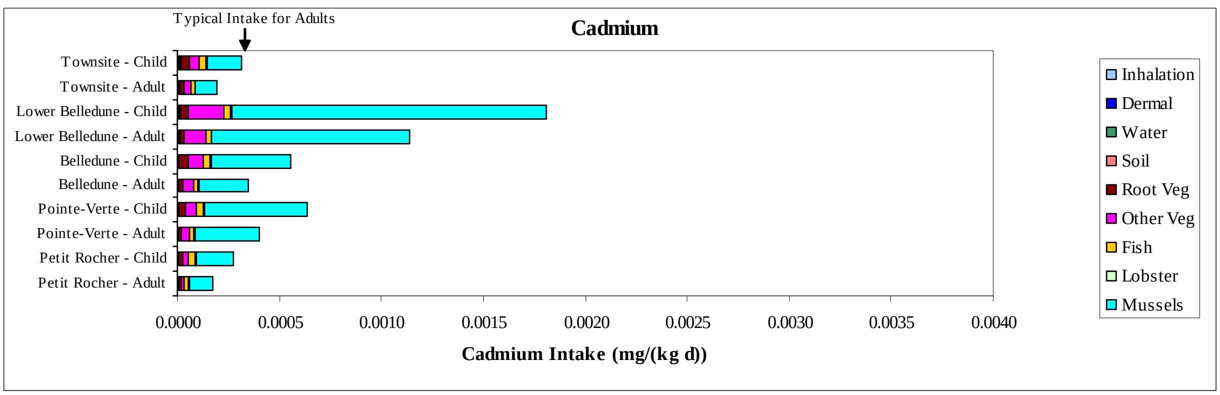
[1] US EPA (2004) – United States Environmental Protection Agency. *Integrated Risk Information System.* On-line database.

The second time period studied (1975-1984) showed an increase in exposure estimates for cadmium compared to the first period (see Figure 7.5). This is due to the fact that exposure to backyard vegetables had increased. In this time period, the oral TRV was predicted to be exceeded by children, teens and adults in Lower Belledune. The incremental risks due to cadmium inhalation exposure for the 1975-1984 time period are presented in Table 7.2. As seen from the table, the incremental risks in this time period are lower than the previous time period; however, the incremental risks predicted in Townsite #2 and Lower Belledune are still above the acceptable limit of 1×10^{-5}.

Table 7.2: Summary of incremental inhalation risks for adult for cadmium exposures in 1975-1984 time period

Location	Incremental Risk
Townsite #2	2.3×10^{-5}
Lower Belledune	2.0×10^{-5}
Belledune	3.4×10^{-6}
Pointe-Verte	2.0×10^{-6}
Petit-Rocher	-

Figure 7.5: Predicted Intakes of Cadmium (Best Estimate) – 1975 to 1984



By the 1985-1999 time period, exposure levels to cadmium had decreased substantially. At the best estimate environmental concentrations, there are no exposures that were predicted to exceed the oral TRV. As illustrated in Figure 7.6 below, the predominant pathway remained ingestion of local wild mussels. While being an important pathway, ingestion of vegetables is lower than in the previous time period. The incremental risks from the inhalation of cadmium are presented in Table 7.3. As seen from the table, the incremental risks are similar to the previous time period.

Figure 7.6: Predicted Intakes of Cadmium (Best Estimate) – 1985 to 1999

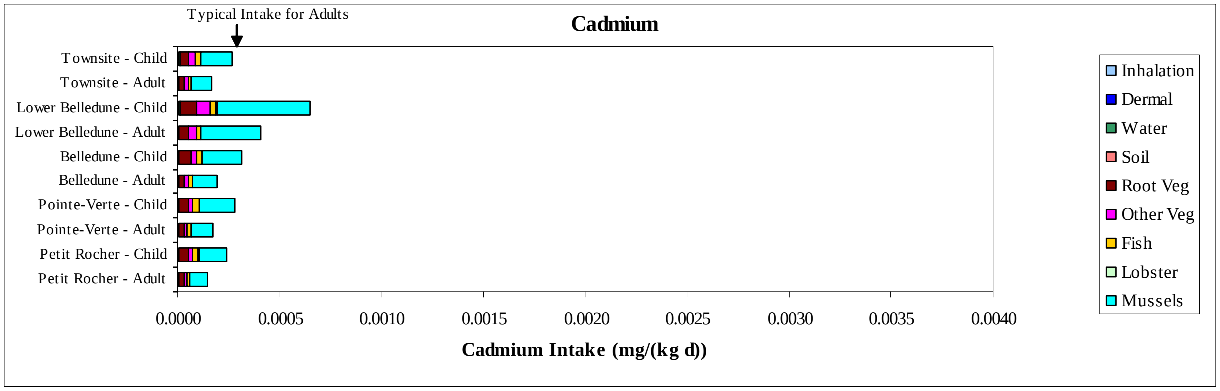


Table 7.3: Summary of incremental inhalation risks for adult for cadmium exposures in 1985-1999 time period

Location	Incremental Risk
Townsite #2	2.3×10^{-5}
Lower Belledune	2.0×10^{-5}
Belledune	2.2×10^{-6}
Pointe-Verte	1.1×10^{-6}
Petit-Rocher	-

As will be discussed in the next section, the current estimated exposure to cadmium are lower than historical exposures .

7.3.3 Historical exposure to arsenic

Arsenic is an unusual COPC in that it has both cancer causing and non-cancer causing properties. The cancer causing properties are related to internal cancers (liver, lung, bladder and kidney). Evidence from many studies shows that long-term intake of arsenic at sufficiently high doses results in a pattern of skin changes. The changes can include the appearance of small "corns" or "warts" on the torso and on the palms of hands and the soles of feet as well as darkening of the skin. A small proportion of corns may develop into skin cancer. The skin cancers generally develop after prolonged exposure, predominantly occur as squamous cell and basal cell carcinomas, and are highly treatable if detected in time. However, the basis for the non-carcinogenic TRV that Health Canada uses in federal jurisdictions is not provided.

Figure 7.7 shows the predicted arsenic intakes in the early period (1967 – 1974). Oral exposures at the best estimate environmental concentrations were predicted to be below the non-carcinogenic arsenic oral TRV. As seen in Figure 7.7, backyard vegetables and well water were the major contributors to exposure. The figure also shows the typical intake for adult Canadians. The predicted intakes for adults are below this range as seen in the figure.

The incremental risks due to inhalation and oral exposure to arsenic are presented in Table 7.4 for this time period. As seen from the table, the incremental inhalation risks are all above an acceptable risk of 1 x 10^{-5} except in Petit-Rocher. The incremental ingestion risk in Lower Belledune is marginally above the acceptable risk level (1.2 x 10^{-5}), while in the rest of the study area, the incremental ingestion risks are below the acceptable risk level. Since the endpoints of inhalation (lung cancer) and ingestion (lung cancer and internal cancers) are similar, the incremental risks can be added together. Thus, the total incremental risks due to arsenic exposure for an adult are all above an acceptable risk level of 1 x 10^{-5} with the exception of the Petit-Rocher location.

Figure 7.7: Predicted Intakes of Arsenic (Best Estimate) – 1967 to 1974

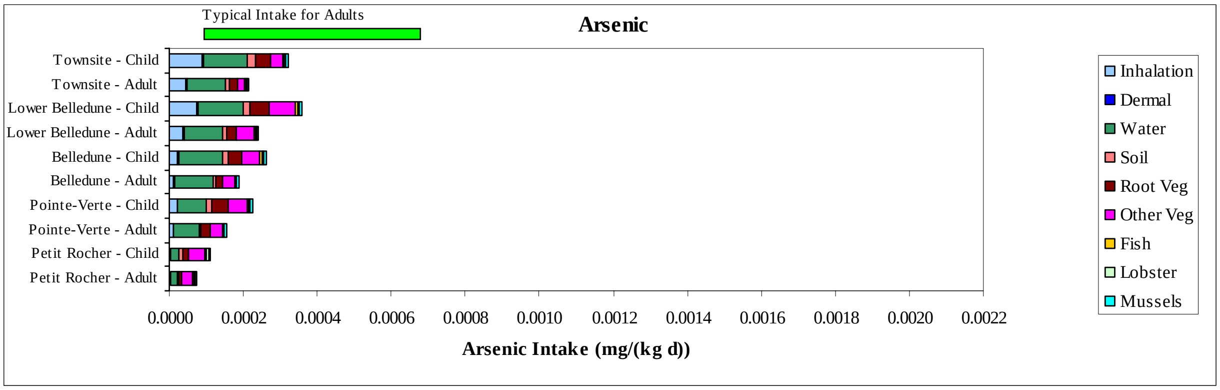


Table 7.4: Summary of incremental risks for adult for arsenic exposures in 1967-1974

Location	Incremental Inhalation Risk	Incremental Ingestion Risk
Townsite #2	1.4 x 10^{-4}	7.2 x 10^{-6}
Lower Belledune	1.2 x 10^{-4}	1.2 x 10^{-5}
Belledune	3.6 x 10^{-5}	7.9 x 10^{-6}
Pointe-Verte	3.4 x 10^{-5}	8.5 x 10^{-6}
Petit-Rocher	4.8 x 10^{-6}	5.7 x 10^{-6}

The second time period studied (1975-1984) showed very similar exposure estimates for arsenic compared to the first period. Similarly, the oral TRV was not predicted to be exceeded at any location. Figure 7.8 indicates that well water and backyard vegetables are the major pathways of exposure. Incremental risks for this time period are presented in Table 7.5. As seen from the table, incremental arsenic inhalation risks are above the acceptable risk level in Townsite #2 and Lower Belledune in this time period. Similarly, incremental ingestion risks are above the acceptable level in Lower Belledune and Pointe-Verte. This is mainly due to a lack of baseline data for backyard vegetables and as such incremental ingestion risks are overestimated. Summing the incremental risks results in the acceptable risk level being exceeded at all study areas with the exception of Petit-Rocher.

Figure 7.8: Predicted Intakes of Arsenic (Best Estimate) – 1975 to 1984

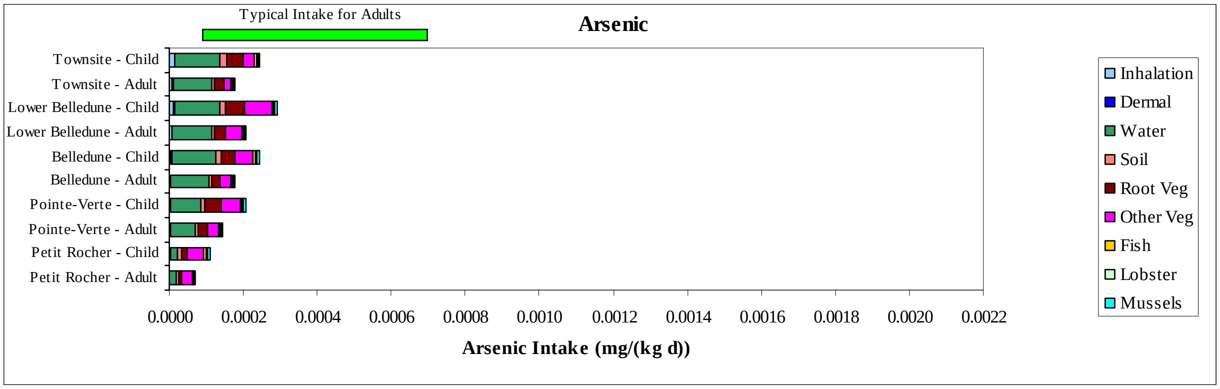


Table 7.5: Summary of incremental risks for adult for arsenic exposures in 1975-1984

Location	Incremental Inhalation Risk	Incremental Ingestion Risk
Townsite #2	2.6 x 10^{-5}	8.9 x 10^{-6}
Lower Belledune	2.2 x 10^{-5}	1.4 x 10^{-5}
Belledune	6.0 x 10^{-6}	9.9 x 10^{-6}
Pointe-Verte	5.6 x 10^{-6}	1.1 x 10^{-5}
Petit-Rocher	1.3 x 10^{-7}	7.1 x 10^{-6}

By the 1985-1999 time period, exposure levels to arsenic had increased slightly, with the backyard vegetable pathway (mainly aboveground vegetables) increasing above other time periods (see Figure 7.9). All best estimate exposures were not predicted to exceed the oral TRV for any location. Table 7.6 provides the predicted incremental risks. As seen from the table, the incremental inhalation risks are slightly lower than the previous time period; however, the incremental ingestion risks have increased over the acceptable risk level of 1 x 10-5 in Pointe-Verte and Petit-Rocher. This is due to the lack of baseline data for backyard vegetables and thus the incremental risks have been over estimated.

Figure 7.9: Predicted Intakes of Arsenic (Best Estimate) – 1985 to 1999

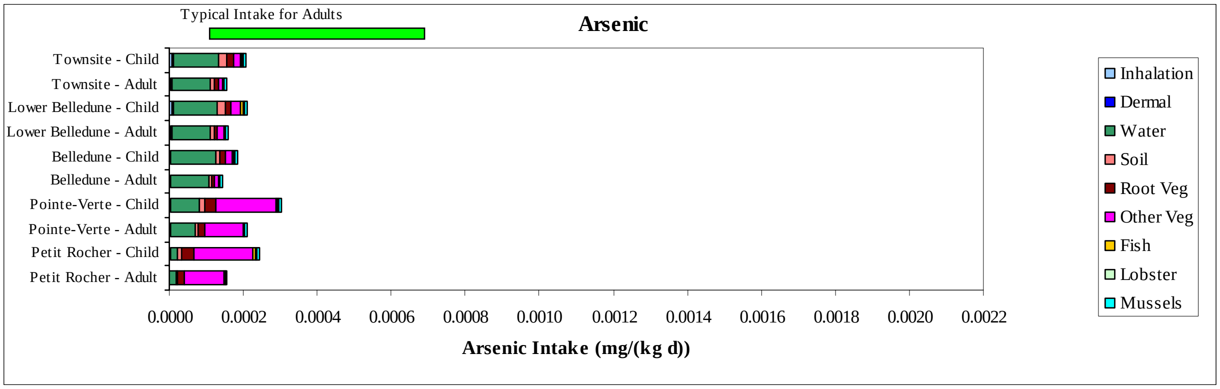


Table 7.6: Summary of incremental risks for adult for arsenic exposures in 1985-1999

Location	Incremental Inhalation Risk	Incremental Ingestion Risk
Townsite #2	2.1×10^{-5}	8.3×10^{-6}
Lower Belledune	1.7×10^{-5}	9.5×10^{-6}
Belledune	6.0×10^{-6}	6.2×10^{-6}
Pointe-Verte	3.8×10^{-6}	3.2×10^{-5}
Petit-Rocher	-	3.3×10^{-6}

As will be discussed in the next section, the current estimated exposure to arsenic decreases to below historical levels.

7.4 Summary of current exposure findings

This section contains the summary of findings for current exposure levels to each COPC. In order to describe the potential range of exposures and the associated potential health risks, the findings are presented according to COPC with a description of the both the “best estimate” and “upper-bound” exposures according to the various receptor age groups (e.g. infant, toddler, child, teen, adult), local seafood consumption, and various sites (e.g., Townsite #2, Pointe-Verte). The results that are presented are based on the Noranda EMP data. As discussed in Section 5, the use of the CCNB soil data does not provide substantially different results; therefore, for consistency with historical exposures, the Noranda EMP data have been used in the risk characterization. The adult and child exposures are provided in figures as an example, the other life stages are tabulated. All results are presented in Appendix AE.

7.4.1 Current exposure to arsenic

As illustrated in Figure 7.10, the predicted arsenic exposures for the best estimates for an average seafood eater (adult and child) are below the oral arsenic TRV. Intakes for infants, toddlers and teens are also below the oral TRV (see Appendix AE). As seen in the figure, the inhalation pathway is insignificant and thus a comparison to the oral TRV is appropriate. The figure also shows that supermarket food is the most significant pathway for arsenic exposure. The total intakes due to arsenic exposure for adults are within the typical intakes for the general Canadian population. . The upper bound estimates for average seafood eating adults (Figure 7.11) are slightly higher than typical background exposures but are still below the oral TRV. Exposures for other life stages are not predicted to exceed the oral TRV. As well, these figures demonstrate that the primary pathway for exposure is consumption of well water. Soil ingestion and backyard vegetables are minor pathways and dermal contact is insignificant. The incremental risks due to arsenic exposure are presented in Table 7.7. As seen in the table, the incremental inhalation risks in Townsite #2 and Lower Belledune are above an acceptable risk of 1 x 10^{-5}; however, it should be pointed out that Appendix AB indicates that the predicted air concentrations are not different from those experienced in other areas in Canada. Incremental inhalation risks have not been calculated for Petit-Rocher since the arsenic air concentrations are within baseline levels. Incremental ingestion risks are the same in all study areas and are above an acceptable risk level of 1 x 10^{-5}. This is due to the fact that background exposures to garden vegetables have not been accounted for in the assessment. Therefore, the incremental ingestion risks are over estimated. A similar pattern is observed for the composite receptor, where the inhalation risks are above an acceptable limit of 1 x 10^{-5} for Townsite #2 and Lower Belledune and the ingestion risks are the same. The risks for the composite receptor are higher than the adult because an adult is only exposed during the adult life stage, whereas the composite receptor is exposed over all life stages for a lifetime.

Figure 7.10: Predicted Intakes of Arsenic (Best Estimate) – Current

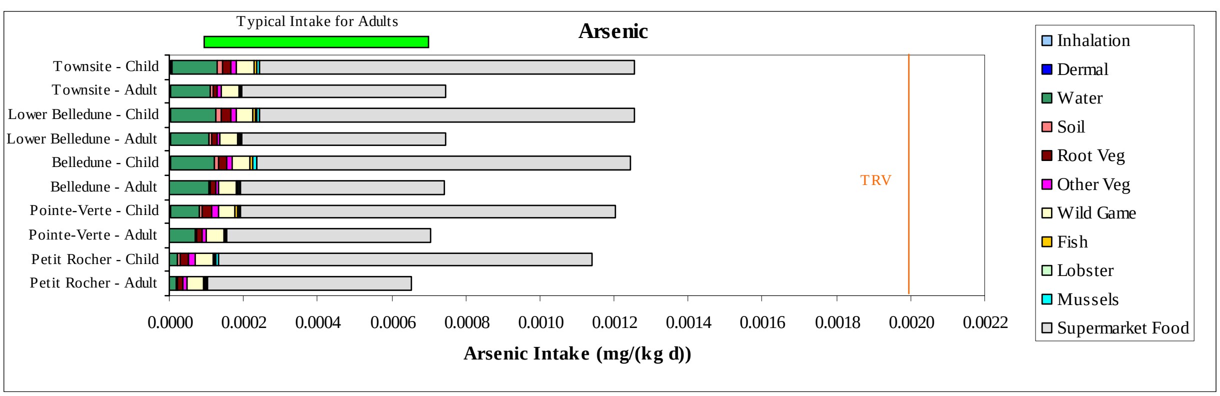


Figure 7.11: Predicted Intakes of Arsenic (Upper Bound) – Current

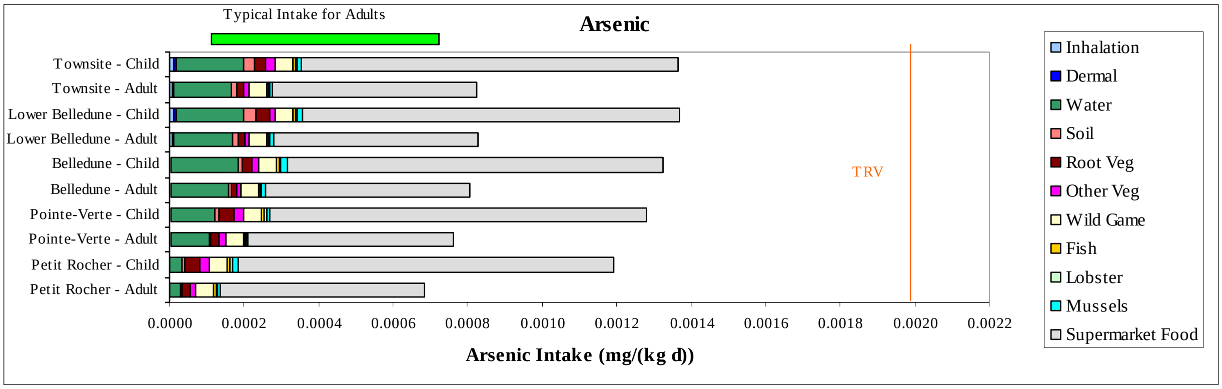


Table 7.7: Summary of incremental risks for exposures to arsenic in current time period

Location	Adult Receptor		Composite Receptor	
	Incremental Inhalation Risk	Incremental Ingestion Risk	Incremental Inhalation Risk	Incremental Ingestion Risk
Townsite #2	2.7×10^{-5}	4.9×10^{-5}	6.1×10^{-5}	1.0×10^{-4}
Lower Belledune	1.8×10^{-5}	4.9×10^{-5}	4.0×10^{-5}	1.0×10^{-4}
Belledune	3.4×10^{-6}	4.7×10^{-5}	7.8×10^{-6}	9.5×10^{-5}
Pointe-Verte	2.7×10^{-6}	4.7×10^{-5}	6.1×10^{-6}	9.5×10^{-5}
Petit-Rocher	-	4.6×10^{-5}	-	9.3×10^{-5}

7.4.2 Current exposure to cadmium

As seen from Figure 7.12, best estimate or average environmental concentrations result in exposures for all locations that are below the oral TRV for cadmium, with the exception of the child in Lower Belledune; supermarket foods account for the majority of the exposure. The inhalation pathway is insignificant and as such a comparison of the intakes of the oral TRV is appropriate. At the upper bound estimates (Figure 7.13), exposures for children in Townsite #2 and Lower Belledune exceed the TRV. The primary pathway of exposure is supermarket food. Consumption of wild mussels is also a major pathway. At the upper bound estimates, infants, toddlers and teens do not exceed the oral TRV. As mentioned in Section 7.3, cadmium is a carcinogen via the inhalation pathway. The predicted air concentrations of cadmium are within baseline and thus there are no incremental inhalation risks associated with cadmium in the air.

Figure 7.12: Predicted Intakes of Cadmium (Best Estimate) – Current

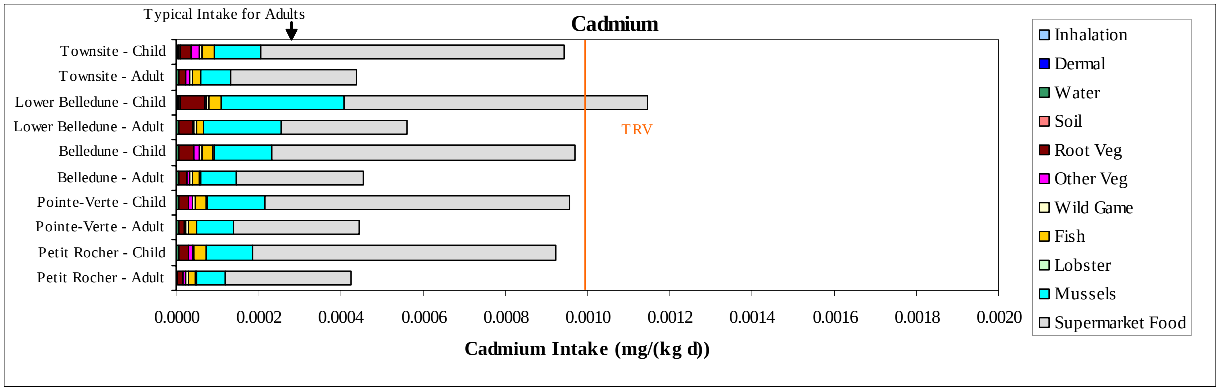
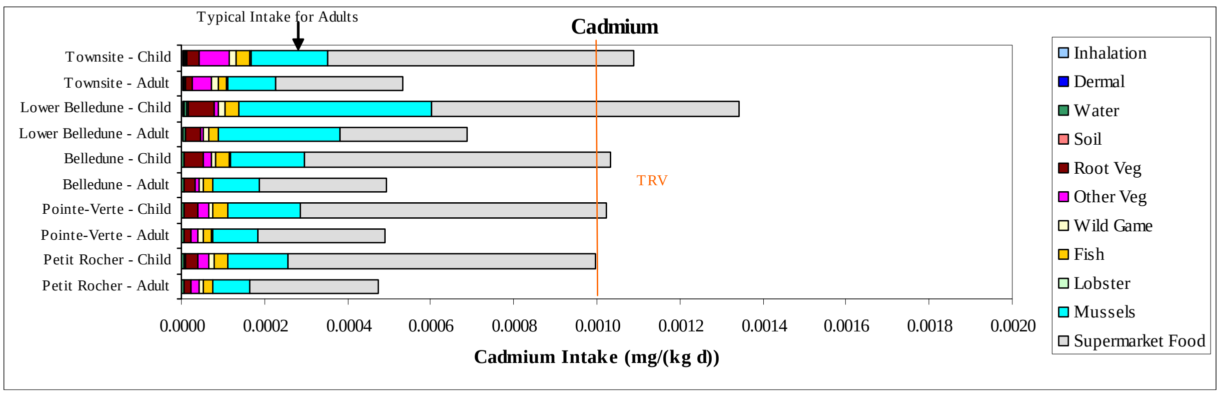


Figure 7.13: Predicted Intakes of Cadmium (Upper Bound) – Current



7.4.3 Current exposure to chromium

Current exposure estimates for chromium were all well below the TRV as seen in Figures 7.14 and 7.15. Well water is a significant pathway of exposure in Pointe-Verte and Petit-Rocher; however, this is misleading since chromium concentrations were measured below the detection limit in all of the study areas. The differences between Pointe-Verte and Petit-Rocher and the other study areas is that the detection limit is 10 times higher in these two areas as compared to the other study areas.

Data were not available to assess all pathways for chromium exposure (i.e. vegetation and seafood). This adds to the uncertainty regarding the exposure to chromium. However, as the exposures are well below the oral TRV, the inclusion of these pathways is unlikely to change the chromium assessment.

Figure 7.14: Predicted Intakes of Chromium (Best Estimate) – Current

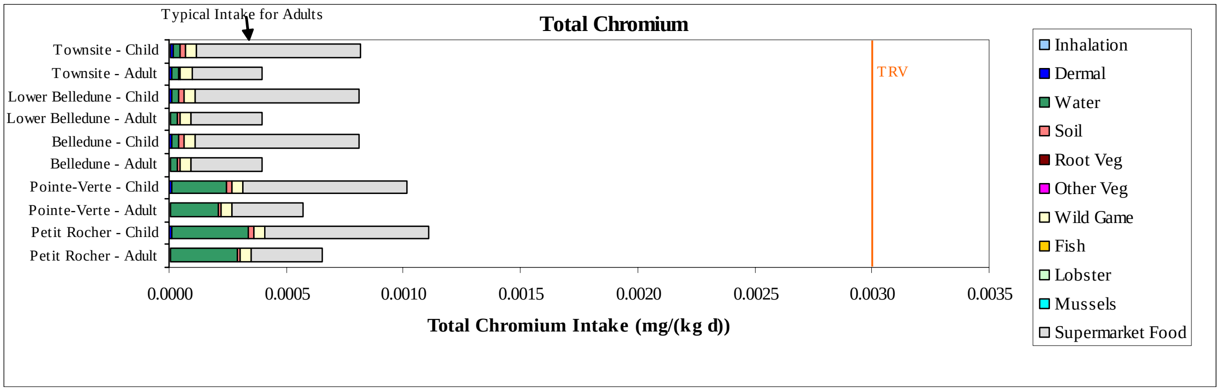
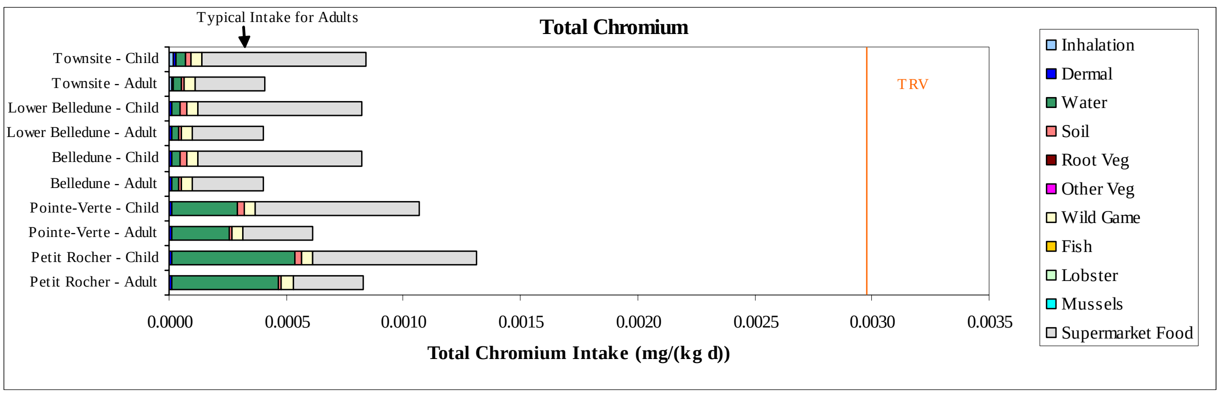


Figure 7.15: Predicted Intakes of Chromium (Upper Bound) – Current



7.4.4 Current exposure to lead

Figure 7.16 demonstrates that the best estimates or average environmental concentrations result in exposures for child and adult receptors that are below the oral TRV with the exception of children in Lower Belledune. The major pathways of exposure for children in Lower Belledune are consumption of local wild mussels and fish. The TRV is not exceeded for infants and toddlers. As described in Section 4.0, there is large uncertainty surrounding the COPC concentrations in fish due to the use of data that were collected prior to 1985. The uncertainties in the fish data need to be addressed by conducting a fish sampling program in the Baie des Chaleurs. At the upper bound estimate, there are several more receptors that have exposures that exceed the oral TRV, namely child receptors in Townsite #2. Again, the consumption of local wild mussels and fish dominate the exposures. The supermarket food intakes are not a predominant pathway in the exposure of lead. It is interesting to note that for all receptors with the exception of the toddler in Lower Belledune, the soil ingestion and dermal exposure contribute little to overall exposure.

Although not illustrated here (see Appendix AE), upper bound exposures for several receptors exceed the lead TRV. These upper bound receptors include the Townsite #2 infant and toddler, the Lower Belledune toddler, teen and adult. The major pathways of exposure for the infant and toddler include garden vegetables and soil. Garden vegetables contribute most to exposure and soil ingestion contributes secondarily. In Lower Belledune, the exposure in the toddlers is mainly due to soil ingestion. Therefore, the soil ingestion pathway is only an important pathway for the toddler in Lower Belledune at the upper bound soil concentration.

Figure 7.16: Predicted Intakes of Lead (Best Estimate) – Current

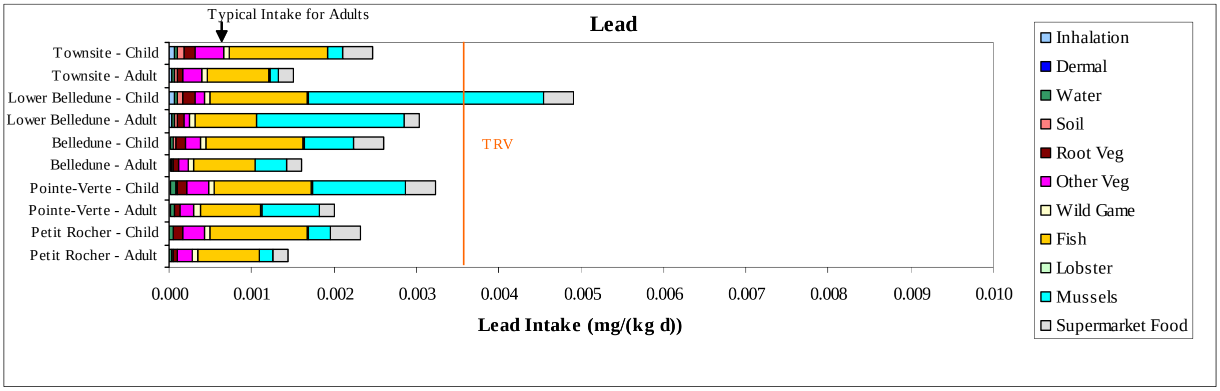
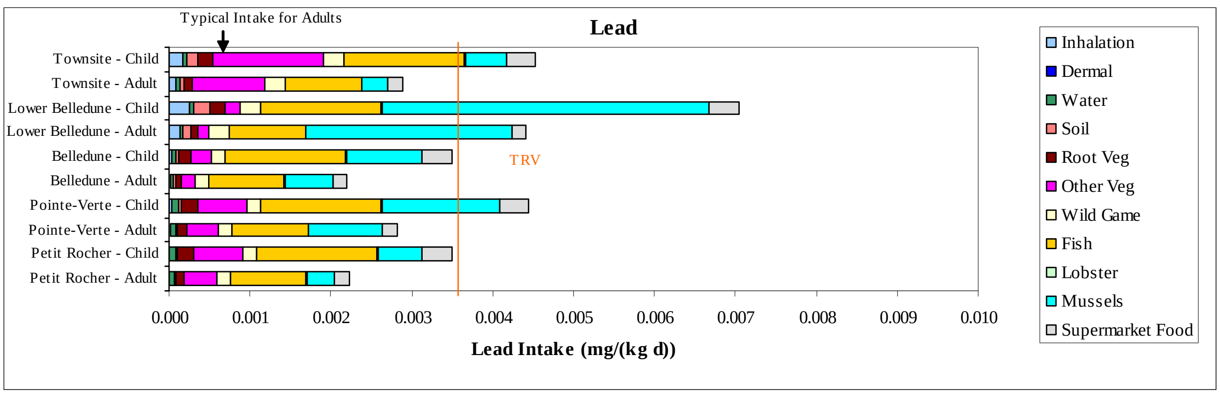


Figure 7.17: Predicted Intakes of Lead (Upper Bound) – Current



7.4.5 Current exposure to mercury

Current exposure estimates based on the best estimate environmental concentrations for mercury were all below the TRV for methyl mercury as seen in Figures 7.18 and 7.19. Methyl mercury which has a high toxicity is the form of mercury that is found in seafood tissue. The predominant pathway is supermarket foods followed by ingestion of fish. At the upper bound estimate, children in Pointe-Verte and Petit-Rocher meet or exceed the TRV. This is due mainly to supermarket food and fish exposure. As discussed in Section 4.0, the concentrations in fish are highly uncertain since they are based on data that is 20 years old. Supermarket food intakes are uncertain since they are based on the entire Canadian population and not just northern New Brunswick.

Figure 7.18: Predicted Intakes of Mercury (Best Estimate) – Current

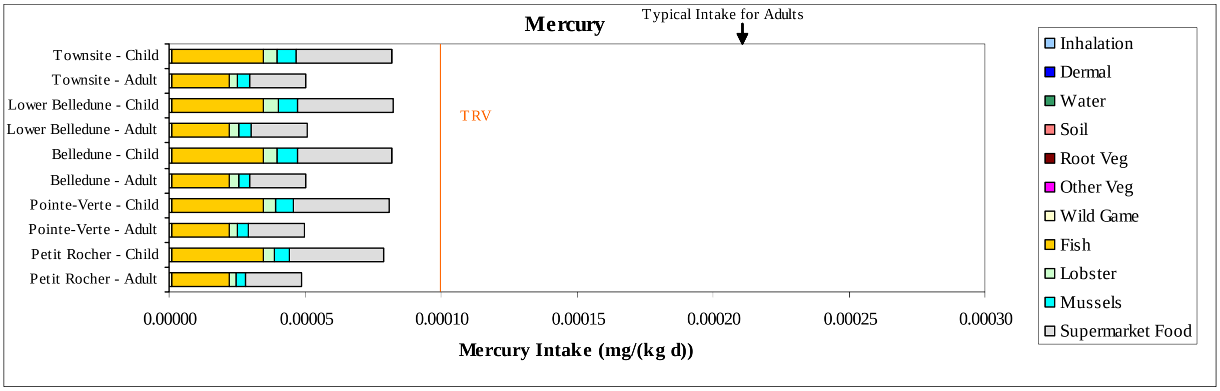
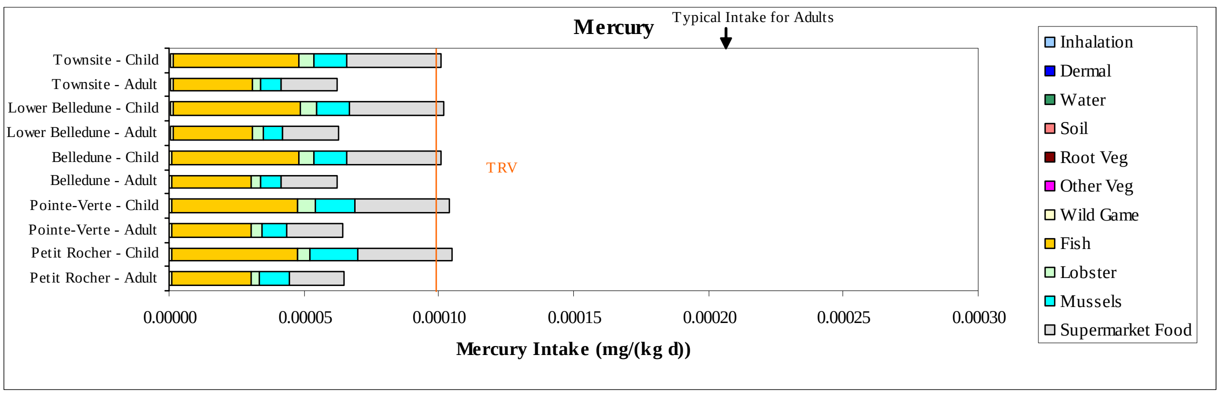


Figure 7.19: Predicted Intakes of Mercury (Upper Bound) – Current



7.4.6 Current exposure to thallium

Current exposure estimates based on best estimate (average) environmental concentrations for thallium are above the TRV for children and toddlers as seen in Figures 7.20 and 7.21. This is due primarily to the consumption of supermarket foods. This data is uncertain and should be considered in this light when reviewing the results for thallium. Intakes of thallium from local sources other than supermarket foods are well below the TRV. Well water is a significant pathway of exposure in Pointe-Verte and Petit-Rocher; however, this is thought to be misleading since thallium concentrations were measured below the detection limit in all of the study areas. The differences between Pointe-Verte and Petit-Rocher and the other study areas is that the detection limit is 10 times higher in these two areas (1 µg/L) as compared to the other study areas (0.1 µg/L).

Figure 7.20: Predicted Intakes of Thallium (Best Estimate) – Current

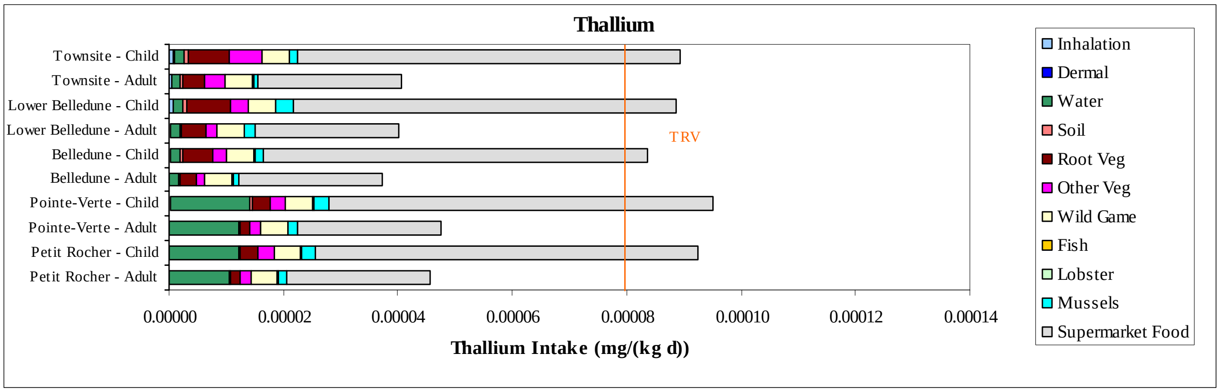
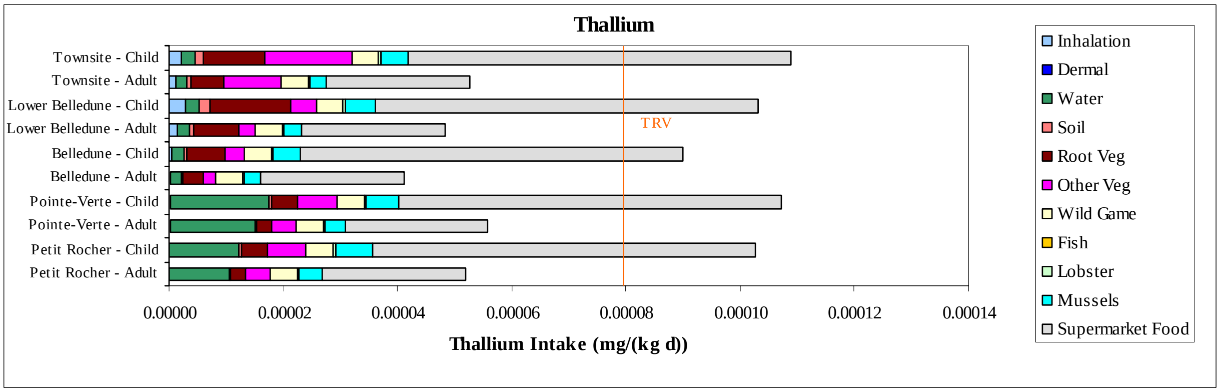


Figure 7.21: Predicted Intakes of Thallium (Upper Bound) – Current



7.4.7 Current exposure to zinc

Current exposure estimates for zinc are totally dominated by the supermarket food pathway and result in exposures for children, toddlers and infants being above the TRV. As seen in Figures 7.22 and 7.23, local intakes of zinc are well below the TRV. As previously mentioned, the supermarket food pathway is uncertain and the figures show that the typical intakes of supermarket foods for children are well above the TRV. This indicates the uncertainty in both the supermarket food estimates and the development of the zinc TRV.

Figure 7.22: Predicted Intakes of Zinc (Best Estimate) – Current

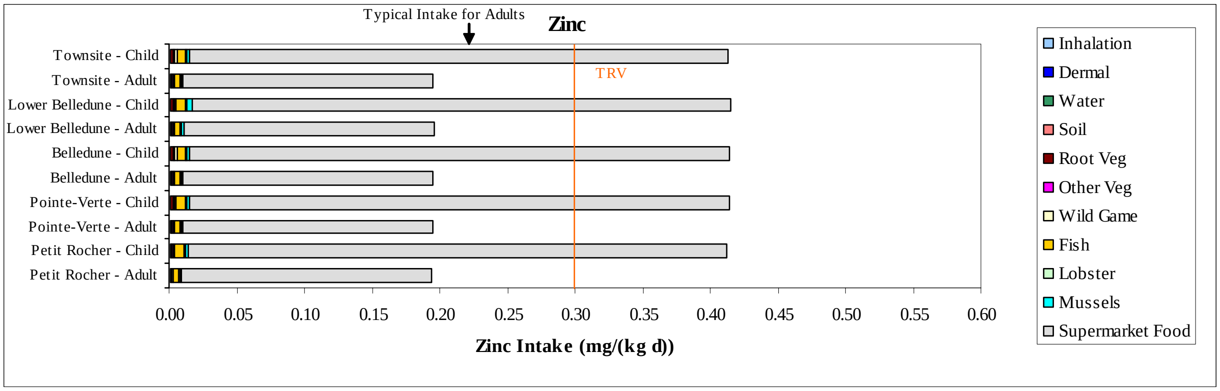
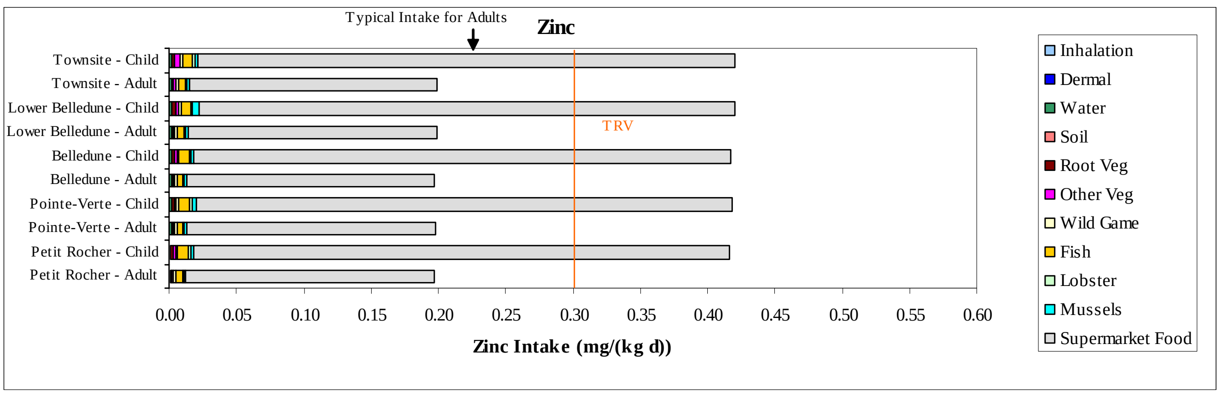


Figure 7.23: Predicted Intakes of Zinc (Upper Bound) – Current



7.4.8 Current exposure to dioxins and furans

Current exposure estimates for dioxins and furans were all well below the TRV as seen in Figures 7.24 and 7.25. Even though there is uncertainty in the EPCs for dioxins and furans due to limited numbers of samples and exposure pathways, the exposure estimates are at least 2 to 3 orders of magnitude lower than the TRV indicating that dioxins and furans are not a cause for concern currently in the GBA.

The interpretations of the dioxin and furan risk is limited by the lack of data regarding concentrations in food, which is the primary pathway of exposure for dioxins and furans. The typical intake of dioxins and furans through intake of air and soil is 5×10^{-11} mg TEQ/(kg d) for adults and 1×10^{-10} mg TEQ/(kg d) for children (Health Canada/Environment Canada 1990). Supermarket food exposures are shown on the graphs and are the dominant pathway of exposure. The intakes shown in Figures 7.24 and 7.25 are well below the values for typical Canadian exposure.

Figure 7.24: Predicted Intakes of Dioxins and Furans (Best Estimate) – Current

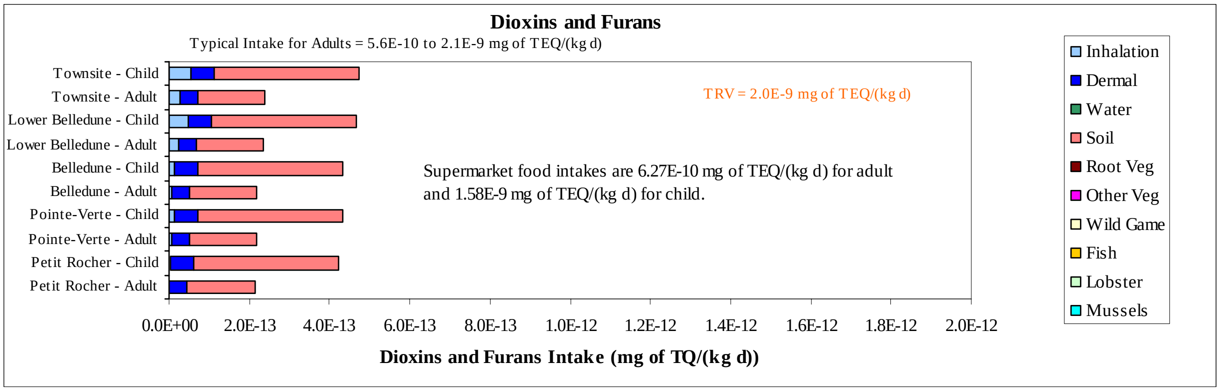
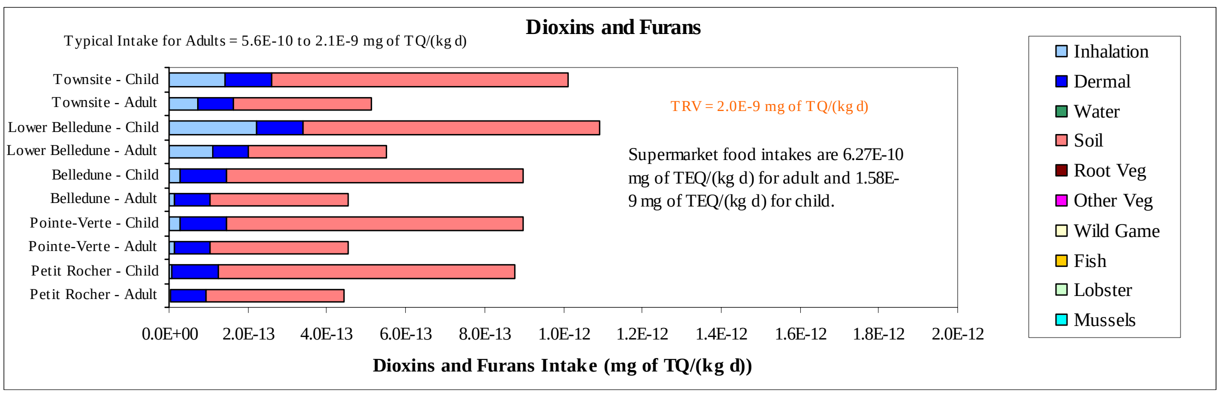


Figure 7.25: Predicted Intakes of Dioxins and Furans (Upper Bound) – Current



7.4.9 Sensitivity analysis for current exposures

In contrast to average local seafood eaters presented above, several other analyses were carried out for residents who eat no local seafood as well as those who consume very large amounts of local seafood. This was to ensure that the varied characteristics of different individuals in the community were captured. This section presents the findings of those analyses.

In addition, other analyses using empirical relationships for backyard vegetables and the CCNB soil data were carried out to ensure that all potential exposures were captured in the HHRA. The findings from these separate analyses do not differ substantially from those presented in this section. Appendix AE provides the results of these calculations. Incremental cancer risks associated with arsenic exposure have been discussed in Section 7.4.1.

7.4.9.1 *Potential risks associated with most exposed areas*

Tables 7.8 and 7.9 show the best estimate and upper bound calculations for adult residents in Townsite #2 and Lower Belledune. Table 7.10 presents the best estimate and upper bound results for children. Appendix AE provides the results for all other life stages and Table 7.11 provides a summary of estimated exposures that exceed TRVs. Tables 7.8 and 7.9 show that for adults at the best estimate COPC concentrations, no exposures are predicted to exceed the any TRV (i.e. HQ<1) for either the average or non-seafood eater with the exception of lead exposure at upper bound concentrations in Lower Belledune. As discussed in Section 7.4.4 above, this is due to the consumption of local wild mussels and fish. For children (Table 7.10), best estimate and upper bound exposures for thallium and zinc exceed TRVs (i..e. HQ>1) due to the dominance of the supermarket food pathway. Cadmium, lead and mercury exposures also exceed the TRV. For cadmium and mercury exposure, supermarket food is the major pathway, with fish also contributing to mercury exposure. The wild mussel pathway is the predominant pathway for lead exposures. Table 7.11 indicates that upper bound exposure to lead for the average local seafood eater and non-local seafood eater toddler and infant in Townsite #2 have exposures that exceed the TRV. This is primarily due to consumption of backyard vegetables. Thallium and zinc intakes in infants and toddlers in Townsite #2 and Lower Belledune also exceed the TRV, the supermarket food pathway dominates this exposure.

When maximum local seafood eaters were considered as receptors, maximum wild mussel eaters (approximately five ½-pound meals per week all year) at the best estimate concentrations had exposure estimates above the cadmium, lead and mercury TRVs in both Townsite #2 and Lower Belledune. In Lower Belledune, thallium exposures at both the best estimate and upper bound concentrations also exceeded the TRV. At the upper bound concentration, thallium exposure also resulted in exposures above the TRV in Townsite #2 in addition to the other COPC discussed. It should be noted that the maximum wild mussels eater is not expected to consume high amounts of mussels all year as has been considered in this assessment. Thus, exposures have been overestimated for the individuals who make up a small proportion of the population.

For maximum local lobster eaters in Townsite #2 and Lower Belledune who consume approximately two to three ½-pound meals per week all year, both best estimate and upper bound concentrations of arsenic and mercury result in exposures that are above the respective TRVs. Again, as for the local mussel eaters, it is unlikely that individuals would consume large amounts of lobster all year; therefore, it is likely that these exposures are overestimated.

Maximum local fish eaters who consume approximately six to seven ½-pound meals per week all year of local fish from the Baie de Chaleur have exposures that exceed the lead and mercury TRVs at both the best estimate and upper bound. The fish concentrations are highly uncertain due to the use of 20 year old data.

Table 7.8: Summary of best estimate risk estimates for adults in Townsite #2 and Lower Belledune for current exposures

Adult	Overall Hazard Quotients									
	Townsite #2					Lower Belledune				
COPC	Non-Seafood	Avg. Seafood	Max Fish	Max Lobster	Max Mussels	Non-Seafood	Avg. Seafood	Max Fish	Max Lobster	Max Mussels
Arsenic	0.37	0.37	0.39	0.40	0.43	0.37	0.37	0.39	0.41	0.44
Cadmium	0.35	0.44	0.56	0.37	2.34	0.36	0.56	0.57	0.38	5.60
Chromium	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Lead	0.17	0.41	2.65	0.23	1.03	0.13	0.84	2.61	0.24	13.96
Mercury	0.21	0.50	2.75	1.70	1.46	0.21	0.50	2.75	1.84	1.46
Thallium	0.49	0.50	0.49	0.57	0.78	0.47	0.50	0.47	0.55	1.13
Zinc	0.63	0.65	0.80	0.72	0.74	0.63	0.65	0.80	0.72	0.85
Dioxins and Furans	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31

Note: Values which exceed the TRV are shaded
NA – Due to lack of seafood data sensitivity analysis could not be completed for chromium, thallium (fish) and dioxins and furans

Table 7.9: Summary of upper bound risk estimates for adults in Townsite #2 and Lower Belledune for current exposures

Adult	Overall Hazard Quotients									
	Townsite #2					Lower Belledune				
COPC	Non-Seafood	Avg. Seafood	Max Fish	Max Lobster	Max Mussels	Non-Seafood	Avg. Seafood	Max Fish	Max Lobster	Max Mussels
Arsenic	0.40	0.41	0.43	0.48	0.49	0.40	0.41	0.43	0.46	0.56
Cadmium	0.39	0.53	0.65	0.43	3.62	0.37	0.68	0.63	0.40	8.49
Chromium	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Lead	0.43	0.78	3.54	0.55	2.87	0.22	1.19	3.33	0.36	19.82
Mercury	0.22	0.62	3.75	1.89	2.29	0.22	0.63	3.75	2.12	2.29
Thallium	0.60	0.64	0.60	0.75	1.64	0.54	0.59	0.54	0.69	1.68
Zinc	0.64	0.66	0.83	0.82	0.80	0.64	0.66	0.82	0.73	0.91
Dioxins and Furans	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31

Note: Values which exceed the TRV are shaded
NA – Due to lack of seafood data sensitivity analysis could not be completed for chromium, thallium (fish) and dioxins and furans

Table 7.10: Summary of risk estimates for children in Townsite #2 and Lower Belledune for current exposures

Child	Overall Hazard Quotients							
	Townsite #2				Lower Belledune			
	Best Estimate		Upper Bound		Best Estimate		Upper Bound	
COPC	Non-Seafood	Avg. Seafood	Non-Seafood	Avg. Seafood	Non-Seafood	Avg. Seafood	Non-Seafood	Avg. Seafood
Arsenic	0.62	0.62	0.66	0.68	0.62	0.63	0.66	0.68
Cadmium	0.80	0.94	0.87	1.09	0.82	1.15	0.84	1.34
Chromium	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
Lead	0.29	0.67	0.66	1.21	0.22	1.35	0.35	1.89
Mercury	0.36	0.82	0.36	1.00	0.36	0.82	0.36	1.01
Thallium	1.09	1.11	1.27	1.33	1.06	1.10	1.18	1.25
Zinc	1.35	1.38	1.36	1.40	1.35	1.38	1.36	1.40
Dioxins and Furans	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79

Note: Values which exceed the TRV are shaded

Table 7.11: Summary of estimated current exposures exceeding TRVs in most exposed area

	NO LOCAL SEAFOOD		AVERAGE LOCAL SEAFOOD		MAXIMUM LOCAL FISH EATER		MAXIMUM LOCAL LOBSTER EATER		MAXIMUM WILD MUSSELS EATER	
	BEST ESTIMATE	*UPPER BOUND*	*BEST ESTIMATE*	*UPPER BOUND*	*BEST ESTIMATE*	*UPPER BOUND*	*BEST ESTIMATE*	*UPPER BOUND*	*BEST ESTIMATE*	*UPPER BOUND*
Townsite #2										
Arsenic										
Cadmium				Child					Adult	Adult
Chromium										
Lead		Infant Toddler		Infant Toddler Child	Adult	Adult			Adult	Adult
Mercury				Child	Adult	Adult	Adult	Adult	Adult	Adult
Thallium	Toddler Child	Infant Toddler Child	Toddler Child	Infant Toddler Child		Adult				Adult
Zinc	Infant Toddler Child	Infant Toddler Child	Infant Toddler Child	Infant Toddler Child						
Dioxins and furans										
Lower Belledune										
Arsenic										
Cadmium			Child	Child					Adult	Adult
Chromium										
Lead			Child	Toddler Child Teen	Adult	Adult			Adult	Adult
Mercury				Child	Adult	Adult	Adult	Adult	Adult	Adult
Thallium	Infant Toddler Child	Infant Toddler Child	Toddler Child	Infant Toddler Child		Adult			Adult	Adult
Zinc	Infant Toddler Child	Infant Toddler Child	Infant Toddler Child	Infant Toddler Child						
Dioxins and furans										

Note:
- Thallium and zinc exposures for no local seafood and average local seafood eaters are dominated by supermarket food intakes. All local exposures are well below TRV.
- Cadmium and mercury exposure in the child is also primarily due to the supermarket food pathway.
- Maximum local seafood eaters are only considered to be adults since data were not available for children.

7.4.9.2 Potential risks associated with the core study area

Tables 7.12 and 7.13 show the best estimate and upper bound calculations for adult residents in the core communities of Belledune, Pointe-Verte and Petit-Rocher. Table 7.14 presents the best estimate and upper bound results for children in these same core communities and Table 7.15 provides a summary of all life stages that exceed the TRVs in the core communities. The tables show that thallium and zinc estimates are predicted to exceed TRVs due to the predominant supermarket food pathway. . At the upper bound estimate, exposures to cadmium and mercury for the child average seafood eater in Belledune and Pointe-Verte marginally exceed the TRVs. This is due to the supermarket food pathway. At the upper bound lead concentrations in Pointe-Verte, the child is predicted to exceed the TRV (i.e. HQ>1).

When maximum local seafood eaters were considered as receptors, similar trends were observed as in the maximum exposed areas. For example, maximum wild mussel eaters (approximately five ½-pound meals per week all year) at the best estimate and upper bound concentrations had exposure estimates above the cadmium, lead, mercury and thallium TRVs in Belledune, Pointe-Verte and Petit-Rocher. As discussed previously, it is likely that for this small group of individuals exposures have been overestimated.

For maximum local lobster eaters in the three core areas who consume approximately two to three ½-pound meals per week all year, both best estimate and upper bound concentrations of mercury result in exposures that are above the TRV. This is also likely an overestimate as discussed in the previous section.

Maximum local fish eaters in the three core areas who consume approximately six to seven ½-pound meals per week all year of local fish from the Baie de Chaleurs have exposures that exceed the lead and mercury TRVs at the best estimate and upper bound. As discussed in the previous section, this is also likely an overestimate as discussed in the previous section.

Table 7.12: Summary of best estimate risk estimates for adults in Belledune, Pointe-Verte and Petit-Rocher for current exposures

Adult	Overall Hazard Quotients														
	Belledune					Pointe-Verte					Petit-Rocher				
COPC	Non-Seafood	Avg. Seafood	Max Fish	Max Lobster	Max Mussels	Non-Seafood	Avg. Seafood	Max Fish	Max Lobster	Max Mussels	Non-Seafood	Avg. Seafood	Max Fish	Max Lobster	Max Mussels
Arsenic	0.37	0.37	0.39	0.40	0.44	0.35	0.35	0.37	0.38	0.41	0.32	0.33	0.34	0.35	0.38
Cadmium	0.35	0.45	0.56	0.38	2.81	0.34	0.45	0.55	0.36	2.83	0.34	0.43	0.55	0.36	2.28
Chromium	0.13	0.13	0.13	0.13	0.13	0.19	0.19	0.19	0.19	0.19	0.22	0.22	0.22	0.22	0.22
Lead	0.13	0.44	2.61	0.23	3.02	0.15	0.56	2.63	0.22	5.63	0.15	0.40	2.62	0.21	1.42
Mercury	0.21	0.50	2.75	1.80	1.46	0.21	0.50	2.75	1.64	1.35	0.21	0.49	2.75	1.40	1.20
Thallium	0.45	0.46	0.45	0.52	0.80	0.57	0.59	0.57	0.64	1.17	0.55	0.57	0.55	0.62	1.05
Zinc	0.63	0.65	0.80	0.72	0.76	0.63	0.65	0.80	0.73	0.79	0.63	0.65	0.79	0.73	0.74
Dioxins and Furans	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31

Note: Values which exceed the TRV are shaded

Table 7.13: Summary of upper bound risk estimates for adults in Belledune, Pointe-Verte and Petit-Rocher for current exposures

Adult	Overall Hazard Quotients														
	Belledune					Pointe-Verte					Petit-Rocher				
COPC	Non-Seafood	Avg. Seafood	Max Fish	Max Lobster	Max Mussels	Non-Seafood	Avg. Seafood	Max Fish	Max Lobster	Max Mussels	Non-Seafood	Avg. Seafood	Max Fish	Max Lobster	Max Mussels
Arsenic	0.39	0.40	0.42	0.44	0.55	0.37	0.38	0.40	0.46	0.45	0.33	0.34	0.36	0.42	0.46
Cadmium	0.36	0.49	0.62	0.39	3.46	0.36	0.49	0.61	0.40	3.38	0.36	0.47	0.61	0.40	2.88
Chromium	0.13	0.13	0.13	0.13	0.13	0.20	0.20	0.20	0.20	0.20	0.28	0.28	0.28	0.28	0.28
Lead	0.18	0.61	3.29	0.30	4.73	0.26	0.78	3.37	0.37	7.31	0.26	0.62	3.37	0.38	2.93
Mercury	0.22	0.62	3.75	2.01	2.29	0.22	0.64	3.75	2.18	2.76	0.21	0.65	3.75	1.56	3.31
Thallium	0.47	0.51	0.47	0.55	1.52	0.65	0.70	0.65	0.80	1.88	0.59	0.65	0.59	0.74	2.02
Zinc	0.63	0.66	0.82	0.73	0.79	0.63	0.66	0.82	0.83	0.81	0.63	0.66	0.82	0.84	0.77
Dioxins and Furans	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31

Note: Values which exceed the TRV are shaded

Table 7.14: Summary of risk estimates for children in Belledune, Pointe-Verte and Petit-Rocher for current exposures

Child	Overall Hazard Quotients											
	Belledune				Pointe-Verte				Petit-Rocher			
	Best Estimate		Upper Bound		Best Estimate		Upper Bound		Best Estimate		Upper Bound	
COPC	Non-Seafood	Avg. Seafood	Non-Seafood	Avg. Seafood	Non-Seafood	Avg. Seafood	Non-Seafood	Avg. Seafood	Non-Seafood	Avg. Seafood	Non-Seafood	Avg. Seafood
Arsenic	0.61	0.62	0.65	0.66	0.59	0.60	0.63	0.64	0.56	0.57	0.58	0.60
Cadmium	0.80	0.97	0.82	1.03	0.78	0.96	0.81	1.02	0.78	0.92	0.82	1.00
Chromium	0.27	0.27	0.27	0.27	0.34	0.34	0.36	0.36	0.37	0.37	0.44	0.44
Lead	0.22	0.72	0.28	0.96	0.25	0.89	0.41	1.23	0.24	0.64	0.40	0.97
Mercury	0.36	0.82	0.36	1.01	0.36	0.81	0.36	1.04	0.36	0.79	0.36	1.05
Thallium	1.02	1.04	1.06	1.12	1.15	1.19	1.26	1.34	1.13	1.16	1.20	1.28
Zinc	1.35	1.38	1.35	1.39	1.34	1.38	1.35	1.39	1.34	1.37	1.35	1.39
Dioxins and Furans	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79

Note: Values which exceed the TRV are shaded

Table 7.15: Summary of estimated current exposures exceeding TRVs in the core study area

	NO LOCAL SEAFOOD		AVERAGE LOCAL SEAFOOD		MAXIMUM LOCAL FISH EATER		MAXIMUM LOCAL LOBSTER EATER		MAXIMUM WILD MUSSELS EATER	
	BEST ESTIMATE	*UPPER BOUND*	*BEST ESTIMATE*	*UPPER BOUND*	*BEST ESTIMATE*	*UPPER BOUND*	*BEST ESTIMATE*	*UPPER BOUND*	*BEST ESTIMATE*	*UPPER BOUND*
Belledune										
Arsenic										
Cadmium				Child					Adult	Adult
Chromium										
Lead					Adult	Adult			Adult	Adult
Mercury				Child	Adult	Adult	Adult	Adult	Adult	Adult
Thallium	Toddler Child	Toddler Child	Toddler Child	Toddler Child						Adult
Zinc	Infant Toddler Child	Infant Toddler Child	Infant Toddler Child	Infant Toddler Child						
Dioxins and furans										
Pointe-Verte										
Arsenic										
Cadmium				Child					Adult	Adult
Chromium										
Lead				Child	Adult	Adult			Adult	Adult
Mercury				Child	Adult	Adult	Adult	Adult	Adult	Adult
Thallium	Toddler Child	Infant Toddler Child	Toddler Child	Infant Toddler Child					Adult	Adult
Zinc	Infant Toddler Child	Infant Toddler Child	Infant Toddler Child	Infant Toddler Child						
Dioxins and furans										
Petit-Rocher										
Arsenic										
Cadmium									Adult	Adult
Chromium										
Lead					Adult	Adult			Adult	Adult
Mercury				Child	Adult	Adult	Adult	Adult	Adult	Adult
Thallium	Toddler Child	Toddler Child	Toddler Child	Toddler Child					Adult	Adult
Zinc	Infant Toddler Child	Infant Toddler Child	Infant Toddler Child	Infant Toddler Child						
Dioxins and furans										

Note:
- Thallium and zinc exposures for no local seafood and average local seafood eaters are dominated by supermarket food intakes. All local exposures are well below TRV.
- Cadmium and mercury exposure in the child is also primarily due to the supermarket food pathway.
- Maximum local seafood eaters are only considered to be adults since data were not available for children.

7.4.9.2 Potential risks associated with the Greater Belledune Area (GBA)

In calculating the potential risks associated with the GBA to provide a linkage with the CHSA, the risks for the three different core areas were pro-rated on a population basis to obtain a weighted average. Appendix AE provides these calculations. As expected, the results for the GBA are similar to those of the core areas.

Tables 7.16 and 7.17 show the best estimate and upper bound calculations for adult residents in the core communities of Belledune, Pointe-Verte and Petit-Rocher. Table 7.18 presents the best estimate and upper bound results for children in these same core communities. The results are similar to those discussed in the previous sections with supermarket foods being the primary pathway of exposure for all COPC that exceed TRVs with the exception of lead.

Maximum wild mussel eaters at the best estimate concentrations had exposure estimates above the cadmium, lead and mercury TRVs. At the upper bound concentrations, cadmium, lead, mercury and thallium exposure resulted in exposures above the TRV. As discussed previously, it is likely that these exposures are overestimated.

For maximum local lobster eaters, both best estimate and upper bound concentrations of mercury result in exposures that are above the respective TRV. This is also likely an overestimate as discussed previously.

Maximum local fish eaters had exposures that exceed the lead and mercury TRVs at the best estimate and the upper bound. This is also likely an overestimate as discussed previously.

Table 7.19 provides a summary of the estimated current exposures that exceed TRVs for the GBA.

Table 7.16: Summary of best estimate risk estimates for adults in Greater Belledune Area (GBA) for current exposures

Adult	Overall Hazard Quotients				
	Greater Belledune Area				
COPC	Non-Seafood	Avg. Seafood	Max Fish	Max Lobster	Max Mussels
Arsenic	0.34	0.35	0.36	0.38	0.41
Cadmium	0.34	0.44	0.56	0.37	2.59
Chromium	0.18	0.18	0.18	0.18	0.18
Lead	0.14	0.45	2.62	0.22	2.90
Mercury	0.21	0.49	2.75	1.61	1.33
Thallium	0.52	0.53	0.52	0.59	0.98
Zinc	0.63	0.65	0.80	0.72	0.76
Dioxins and Furans	0.31	0.31	0.31	0.31	0.31

Note: Values which exceed the TRV are shaded

Table 7.17: Summary of upper bound risk estimates for adults in Greater Belledune Area (GBA) for current exposures

Adult	Overall Hazard Quotients				
	Greater Belledune Area				
COPC	Non-Seafood	Avg. Seafood	Max Fish	Max Lobster	Max Mussels
Arsenic	0.36	0.37	0.39	0.44	0.49
Cadmium	0.36	0.48	0.61	0.40	3.20
Chromium	0.21	0.21	0.21	0.21	0.21
Lead	0.23	0.65	3.34	0.35	4.52
Mercury	0.22	0.64	3.75	1.86	2.81
Thallium	0.56	0.61	0.56	0.68	1.80
Zinc	0.63	0.66	0.82	0.79	0.78
Dioxins and Furans	0.31	0.31	0.31	0.31	0.31

Note: Values which exceed the TRV are shaded

Table 7.18: Summary of risk estimates for children in Greater Belledune Area (GBA) for current exposures

Child	Overall Hazard Quotients			
	Greater Belledune Area			
	Best Estimate		Upper Bound	
COPC	Non-Seafood	Avg. Seafood	Non-Seafood	Avg. Seafood
Arsenic	0.59	0.60	0.62	0.63
Cadmium	0.79	0.95	0.82	1.02
Chromium	0.32	0.32	0.35	0.35
Lead	0.23	0.73	0.36	1.02
Mercury	0.36	0.81	0.36	1.03
Thallium	1.09	1.12	1.15	1.23
Zinc	1.34	1.38	1.35	1.39
Dioxins and Furans	0.79	0.79	0.79	0.79

Note: Values which exceed the TRV are shaded

Table 7.19: Summary of estimated current exposures exceeding TRVs in the GBA

	NO LOCAL SEAFOOD		AVERAGE LOCAL SEAFOOD		MAXIMUM LOCAL FISH EATER		MAXIMUM LOCAL LOBSTER EATER		MAXIMUM WILD MUSSELS EATER	
	BEST ESTIMATE	*UPPER BOUND*	*BEST ESTIMATE*	*UPPER BOUND*	*BEST ESTIMATE*	*UPPER BOUND*	*BEST ESTIMATE*	*UPPER BOUND*	*BEST ESTIMATE*	*UPPER BOUND*
Greater Belledune Area										
Arsenic										
Cadmium				Child					Adult	Adult
Chromium										
Lead				Child	Adult	Adult			Adult	Adult
Mercury				Child	Adult	Adult	Adult	Adult	Adult	Adult
Thallium	Toddler Child	Toddler Child	Toddler Child	Toddler Child						Adult
Zinc	Infant Toddler Child	Infant Toddler Child	Infant Toddler Child	Infant Toddler Child						
Dioxins and furans										

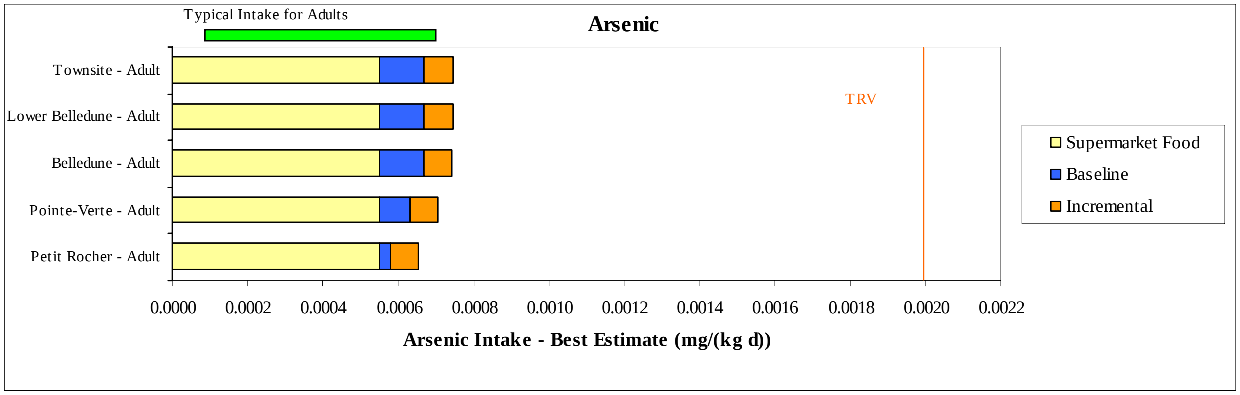
Note:
- Thallium and zinc exposures for no local seafood and average local seafood eaters are dominated by supermarket food intakes. All local exposures are well below TRV.
- Cadmium and mercury exposure in the child is also primarily due to the supermarket food pathway.
- Maximum local seafood eaters are only considered to be adults since data were not available for children.

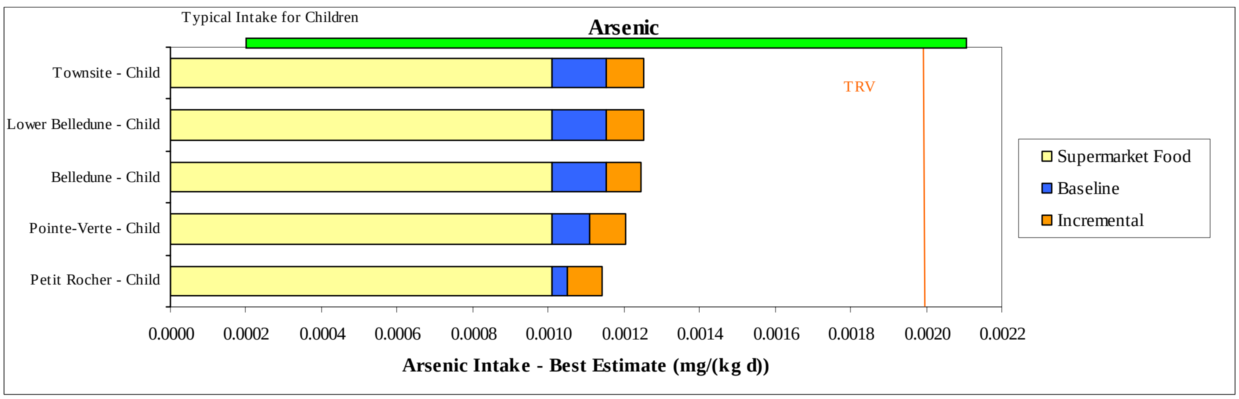
7.4.10 Incremental contributions from the industrial facilities

One question that the study team was asked to answer involved assessing the incremental impacts from the industrial facilities. As seen in the above sections, arsenic, cadmium and lead were the key COPC. This section focuses on these three COPC and provides an analysis of the incremental contribution from the industrial facilities.

Figure 7.26 illustrates the incremental contribution from the industrial facilities due to arsenic exposures. As seen from this figure, the baseline exposures and supermarket food exposures are the major contributors to arsenic exposure. The exposure due to the industrial facilities is about 1/6 of the total indicating that the industrial facilities are not a significant contributor to arsenic in the surrounding environment. For example, the exposures due to the industrial facilities range from 7% of the total exposure for adults and children in Petit-Rocher to 11% of the total exposures in Townsite #2. In fact the incremental exposures have been over estimated since the incremental exposures are mainly due to exposure to backyard vegetables and there are no baseline concentrations of backyard vegetables.

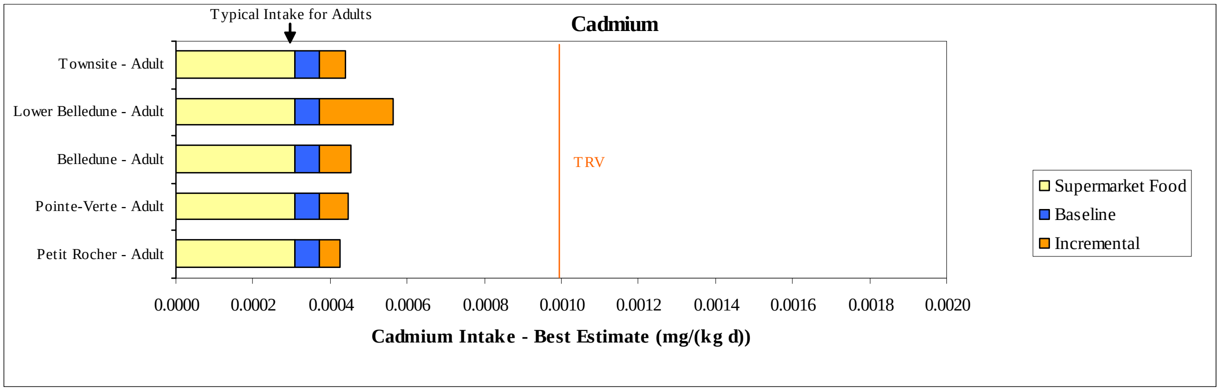
Figure 7.26: Predicted Incremental Contributions for Arsenic Exposure from the Industrial facilities (Best Estimate) – Current

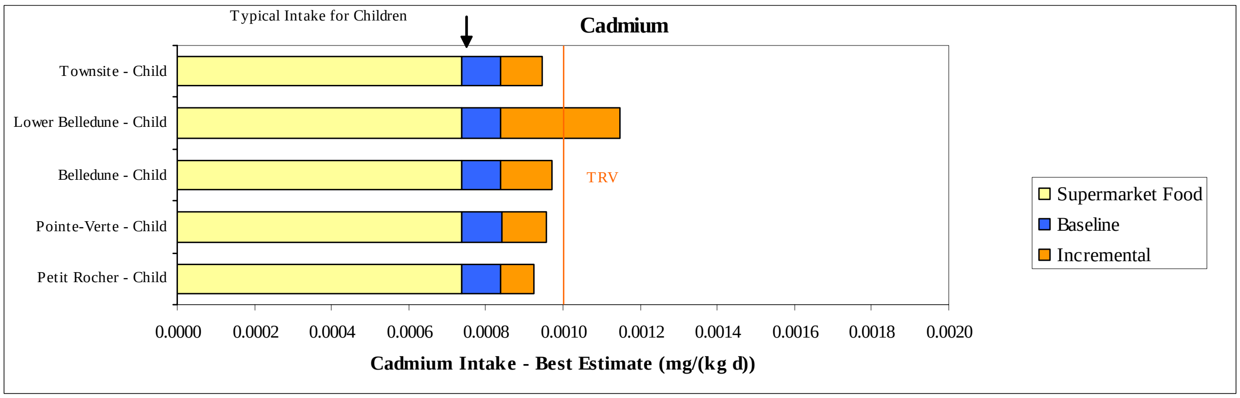




For cadmium exposures (Figure 7.27), baseline and supermarket foods are still a significant contributor to exposure; however, the industrial facilities account for about 1/3 of the total exposure, indicating that cadmium from the industrial facilities contributes to increased environmental concentrations. For example, the exposures attributable to the industrial facilities range from 9% of the exposure in Petit-Rocher to 34% of the total exposure in Lower Belledune.

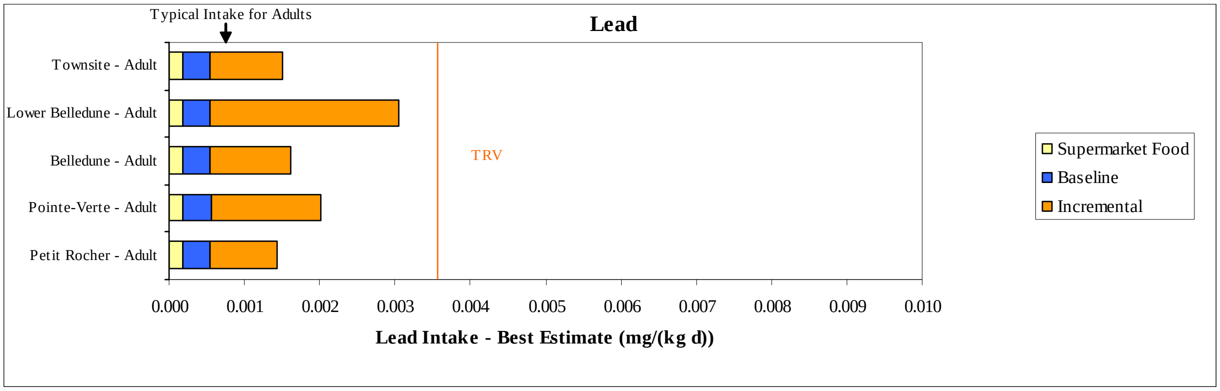
Figure 7.27: Predicted Incremental Contributions for Cadmium Exposure from the Industrial facilities (Best Estimate) – Current

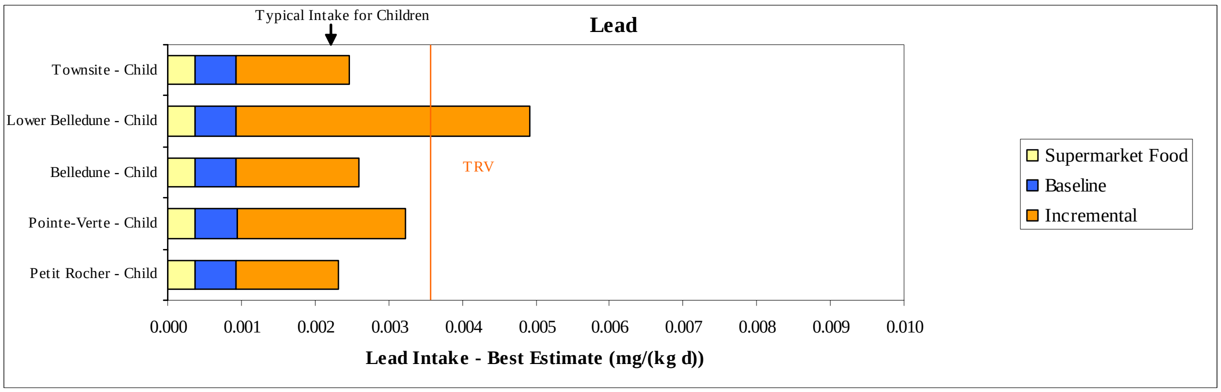




The contributions of lead from the industrial facilities to exposure (Figure 7.28) show and entirely different pattern as compared to arsenic and cadmium. In this case, the contributions of baseline and supermarket foods are very low and the contribution of the industrial facilities to the lead exposure accounts for more than 2/3 of the exposure estimates indicating that the industrial facilities are a significant contributor to lead concentrations in the community. For example, the exposures due to industrial facilities range from 62% of the total exposure in Petit-Rocher to 82% of the total exposure in Lower Belledune.

Figure 7.28: Predicted Incremental Contributions for Lead Exposure from the Industrial facilities (Best Estimate) – Current





7.4.11 Current exposures at specific locations

Over the course of examining the data for soil, it became apparent that there were a few specific locations that were not residential where there were high concentrations of arsenic, lead and zinc that were not have been addressed in the assumptions used in the risk assessment. These locations were the Pointe-Verte Bus stop, the school yard and the Soil 9 location from the Noranda EMP data. A separate analysis was thus carried out for these specific locations.

As described above, these locations were not residential and thus individuals at these locations would not be present for 24 hrs a day, 7 days a week. At the Soil 9 location, the study team was informed that some boat maintenance may be ongoing and thus an adult present at the site 8 hrs/day for 5 days of the week was considered. The maximum COPC concentrations in soil measured at the site were: arsenic 625 mg/kg; cadmium 32.5 mg/kg; lead 8000 mg/kg and zinc 1250 mg/kg. The assessment considered dermal contact and incidental ingestion of soil at a rate of 20 mg/d. The assessment also considered that all the metals present in the soil were available for uptake and gut transfer. This is a conservative assumption and results in an overestimate of exposure. Table 7.20 provides a summary of the results. As seen from the table, all the incremental exposures due to being present at this site are below the respective TRV. However, the lead exposure begins to approach the TRV. If combined with lead exposures from other sources such as local seafood, it may be possible that the TRV for lead may be exceeded; however, the TRV for lead is based on neurological effects in children.

The results of this analysis indicate a need for further study of this given location. It is the understanding of the study team that New Brunswick DELG is already conducting studies at this site.

Table 7.20: Summary of dermal and soil ingestion exposures at Soil 9 Location

COPC	Intakes (mg/kg-d)			Toxicity Reference Value (mg/kg-d)
	Dermal Contact	Soil Ingestion	Total	
Arsenic	4.8×10^{-5}	1.8×10^{-4}	2.3×10^{-4}	2×10^{-3}
Cadmium	1.1×10^{-5}	9.2×10^{-6}	2.1×10^{-5}	1×10^{-3}
Lead	1.2×10^{-4}	2.3×10^{-3}	2.4×10^{-3}	3.6×10^{-3}
Zinc	6.1×10^{-5}	3.5×10^{-4}	4.2×10^{-4}	0.3

The other areas of interest (bus stop and school yard) were also not residential areas but were areas where children could potentially come in contact with chemicals in the soil. A comparison of measurements at the bus stop and school yard indicated that the concentrations of COPC in the school yard were higher than those at the bus stop. For example, lead concentrations at the bus stop were 1095 mg/kg where as at the school it was up to 2800 mg/kg. Therefore, the analysis was carried out using the maximum measured concentrations in the schoolyard; this would also cover exposures experienced at the bus stop. It was assumed that children 6 to 11 years of age would be present at these locations 5 days a week and that all the COPC in the soil were available for uptake. Table 7.21 provides a summary of this analysis. As seen from the table, all predicted exposures are well below the respective TRVs with the exception of lead where the soil exposure accounts for about ½ of the TRV. This indicates that more studies are needed in the school with respect to lead exposure. It is unlikely that exposures at the Pointe-Verte bus stop would be as high as at the school yard since children would not be expected to be digging in the soil at the bus stop.

Table 7.21: Summary of dermal and soil ingestion exposures at the Pointe-Verte Bus Stop and School location

COPC	Maximum Measured Concentration (mg/kg)	Intakes (mg/kg-d)			Toxicity Reference Value (mg/kg-d)
		Dermal Contact	Soil Ingestion	Total	
Antimony	85	2.7×10^{-5}	5.2×10^{-5}	7.9×10^{-5}	2.0×10^{-4}
Arsenic	78	7.9×10^{-6}	4.7×10^{-5}	5.5×10^{-5}	2×10^{-3}
Cadmium	12.4	5.5×10^{-6}	7.5×10^{-6}	1.3×10^{-5}	1×10^{-3}
Chromium	49	1.4×10^{-5}	3.0×10^{-5}	4.4×10^{-5}	3.0×10^{-3}
Lead	2800	5.3×10^{-5}	1.7×10^{-3}	1.76×10^{-3}	3.6×10^{-3}
Mercury	0.12	1.9×10^{-8}	7.3×10^{-8}	9.2×10^{-8}	1×10^{-4}
Thallium	2.97	9.4×10^{-8}	1.8×10^{-6}	1.9×10^{-6}	8×10^{-5}
Zinc	1055	6.7×10^{-5}	6.4×10^{-4}	7.1×10^{-4}	0.3

In summary, the results of this side bar analysis indicate the need for more studies at the Soil 9 location and in the school yard. It is the understanding of the study team that remedial activities have been undertaken at the school in 2004.

7.4.12 Exposures to combustion products

In addition to the eight COPC discussed in the previous section, the assessment also considered the potential exposures due to combustion products such as sulphur dioxide (SO_2) and nitrogen oxides (NO_x). The air dispersion model was used to predict concentrations of sulphur dioxide and nitrogen oxides. As discussed in Section 4.2.1, the air dispersion model over-predicted the sulphur dioxide concentrations and as such the predicted concentrations were adjusted to reflect the measured concentrations. There were no measured data available for nitrogen oxides so that the same adjustment factor was used to predict nitrogen oxide concentrations. This adds to the uncertainty in the assessment. It can be noted that predicted concentrations were adjusted to the measured data which include baseline concentrations.

Tables 4.7 and 4.8 provide the best estimate and upper bound concentrations of sulphur dioxide and nitrogen oxides respectively. The maximum measured concentrations generally occurred in Lower Belledune. This is not surprising since Lower Belledune is downwind of the Belledune Industrial Area. The upper bound estimate of sulphur dioxide was 10.9 $\mu g/m^3$ and the best estimate was 4.5 $\mu g/m^3$. These predicted concentrations are well below the World Health Organization health based criterion of 50 $\mu g/m^3$ and as such the population of the GBA should not experience adverse health effects related to exposure to sulphur dioxide. Similarly, the upper bound and best estimate predicted concentrations for nitrogen oxide are 1.0 $\mu g/m^3$ and 0.45 $\mu g/m^3$. These concentrations are well below the World Health Organization health based criterion of 40 $\mu g/m^3$. Even with the uncertainties surrounding the predicted concentrations of the combustion products, it is unlikely that sulphur dioxide or nitrogen oxides are exerting adverse effects on the community in the GBA.

7.5 Uncertainty

Risk assessment is inherently an uncertain process and as such many assumptions are made to quantitate risk. Uncertainty is present in the assessment since assumptions needed to be made due to gaps in the available monitoring data and from incomplete understanding of the characteristics (including variable dietary habits) of people in the Belledune area. The use of these assumptions led to uncertainties in the calculated exposures and risk. In general, the risk assessment used assumptions that tended to overestimate exposure so that the potential for adverse effects was not underestimated. These assumptions are generally based on scientific judgment and experience gleaned from conducting previous risk assessments.

In this assessment, there were many areas where assumptions were made. These are outlined below and many of them were discussed in detail in Table 5.13 in Section 5.0. The uncertainties relate to:

- Availability of monitoring data in various media – as discussed in Section 4, the available data were substantial for some media and time periods and not for others. Section 4 provided a discussion on the uncertainties encompassing:
    - COPC concentrations in air;
    - COPC concentrations in soil;
    - COPC concentrations in domestic well water;
    - COPC concentrations in backyard garden vegetables;
    - COPC concentrations in local fish, local lobster and local wild mussels;
    - COPC concentrations in wild game.

- Receptor characteristics - In this assessment single point estimates were used to calculate exposures. The use of single values for the receptor characteristics does not account for the range of differences between individuals. Section 5.0 provided detailed discussion on the uncertainties associated with the following pathways:
    - Consumption of local fish, local lobster and local wild mussels;
    - Consumption of wild game;
    - Consumption of backyard garden vegetables;
    - Dermal contact with soil.

- **Exposure assessment** – In calculating the exposure for the dermal pathway, relative absorption factors were applied. The uncertainties surrounding the use of these values were discussed in Section 5.0.

- **Toxicity Reference Values** – As mentioned in Section 6, the TRV values from Health Canada and the U.S. EPA were selected for use in this assessment. The most conservative TRVs from these two agencies were selected for the assessment as long as there was a rationale discussing the endpoint. This ensures that the risks that were calculated were overestimated.

Table 7.22 summarizes the major assumptions used in the Greater Belledune Area human health risk assessment. Each assumption was reviewed to determine whether it was likely to lead to under-estimation or over-estimation of risks. The resulting table allows the overall effect of these assumptions to be examined. It is clear that the majority of assumptions lead to “over-estimation” of risks.

Table 7.22: Summary of uncertainties in assessment of human health risks

Assumption	Effect of Assumption			
	Likely Leads to Under-estimation of Risks	Leads to Neither Over- nor Under-estimation	Likely Leads to Over-Estimation of Risks	Unknown Effect
Concentrations for Various Media				
- Assumed that receptors ingested, inhaled or dermally exposed to media at a range of concentrations between the mean and the upper bound.			x	
- Soil concentrations from Noranda and CCNB assessed separately to determine the range of soil exposures residents encounter		x		
- Assumed that receptors always exposed to outdoor, not indoor, air . Assumed that COPC concentrations in outdoor air were those associated with incremental exposure from Belledune industries, and were higher in outdoor than indoor air.			x	
- Assumed well water concentrations equal to ½ detection limit despite large variations in detection limits for some COPC, and despite the fact that many samples below the detection limit			x	
- Assumed that fish concentrations from 1972-1980 were representative of concentrations after 1980			x	
- Data were not available for some COPC for all media (chromium in vegetation and seafood, thallium in fish and dioxins and furans in food) and the pathway could not be assessed.	x			
- Infilled lobster data with concentrations from preceding or subsequent time periods and/or nearby study areas.				x
- Combined fish, lobster and mussel concentrations from different laboratories				x
- Very small sample size used to represent current concentrations in wild game				x
- Calculated concentrations of garden vegetables for current period based on smaller sample size				x
- Very small sample size used to represent current concentrations of cadmium in garden vegetables for Townsite #2				x
- Garden vegetable data for Petit-Rocher only available for 1975-1984. These same concentrations used for 1967-1974.				x
- Garden vegetable data for Pointe-Verte used to infill missing data for Petit-Rocher from 1985-1999 and current time periods			x	

Assumption	Effect of Assumption			
	Likely Leads to Under-estimation of Risks	Leads to Neither Over- nor Under-estimation	Likely Leads to Over-Estimation of Risks	Unknown Effect
Air Dispersion Modeling				
- Air dispersion modeling used to predict air concentrations. Model was validated using measured data, and adjustment factors were applied.		x		
Empirical Modeling				
- Predicted mussel concentrations using relationship between mussel concentrations and distance from Belledune Harbour		x		
Predicted soil concentrations using empirical relationship between measured soil concentrations and air concentrations modeled using air dispersion modeling		x		
Exposure Assessment				
Residency Time Assumed to be present for a full 70-year lifetime at each location			x	
Soil Ingestion - Assumed soil ingestion constant every day for 70 years - Assumed that COPC 100% bioavailable - Assumed that soil ingestion occurs from the top 5 to 10 cm of soil		 x	 x x	
Inhalation of Air - Assumed that COPC in air are 100% bioavailable via inhalation			x	
Drinking Water Intake - Assumed drinking water came from well water every day for 70 years			x	
Skin Contact with Soil - Assumed skin contact with soil would occur every day for 70 years - Relative absorption factors from Health Canada and U.S. EPA used for COPC uptake via skin			 x	 x

Assumption	Effect of Assumption			
	Likely Leads to Under-estimation of Risks	Leads to Neither Over- nor Under-estimation	Likely Leads to Over-Estimation of Risks	Unknown Effect
Consumption of Local Seafood				
- Assumed seafood consumed occurred at same rate for 70 years			x	
- Assumed that intakes from 24-hour dietary recall methods and food frequency questionnaires were appropriate for estimating long-term consumption patterns		x		
- Assumed that seafood intake rates were same as those given in the New Brunswick Nutrition Survey		x		
- Assumed that shellfish consisted entirely of mussels			x	
- Assumed that residents do not typically consume lobster hepatopancreas	x			
Consumption of Wild Game				
- Assumed that wild game consumed at rates from 24-hour dietary recall studies for First Nations people every day for 70 years			x	
- Assumed that all GBA residents consuming wild game caught in the Belledune Industrial Area			x	
(Delete Row)				
Consumption of Backyard Garden Vegetables - Assumed				
Backyard Garden Vegetables - Assumed to be ingested every day year-round for 70 years. - Portion of vegetables obtained from backyard vegetables based on MOE Ontario data			x	
Toxicity Reference Values - The most conservative and scientifically-defensible toxicity reference value was selected from Health Canada or U.S. EPA			x	

8.0 Conclusions and recommendations

During the planning stage of the study, a number of research questions were posed that took into account residents' concerns as well as overall study objectives. This section provides the overall conclusions of the HHRA according to these initial research questions.

8.1 Conclusions according to study research questions

8.1.1 What are the potential types and sources of contamination?

The initial question that was posed to the study team was what were the potential types and sources of contamination. While the study considered eight different COPC as well as combustion products (sulphur dioxide and nitrogen oxide), the findings indicated that the key potential issues in the community were related to concentrations of lead, cadmium and arsenic in the environment. The assessment determined that lead and to a lesser extent cadmium exposures were a result of the industrial activity in the GBA. The industrial activities contributed only a small portion to arsenic exposures, the majority of the exposure was due to baseline concentrations.

8.1.2 How are residents exposed to the contamination?

The assessment considered both historical and current exposures to arsenic, cadmium and lead. In terms of historical exposure, lead exposure via the inhalation pathway was significant in the 1967 to 1974 time period and has reduced significantly since that time. Another important pathway during that time period was the ingestion of local seafood. It must be pointed out that the assessment considered that residents in the GBA obtained all the seafood that they consumed from local sources. These included the wild mussels along the shoreline, local lobster along the shoreline and fish in the local area in the Baie des Chaleurs. Wild mussels were used as a surrogate for other local shellfish. It is unlikely that the entire seafood diet of residents would be from the local area but this was done to ensure that exposures in the community were not underestimated.

Current exposures are also mainly associated with the consumption of local seafood. The main exposure pathways for cadmium and lead are associated with the consumption of wild mussels along the shoreline. Another important pathway is the consumption of local fish caught in the Baie des Chaleurs in close proximity to the GBA.

The exposures due to the consumption of local fish should be viewed with caution as the fish concentrations used in this assessment were twenty five years old. Sampling of fish in the Baie des Chaleurs is necessary in order to reduce the uncertainty associated with exposures to local fish.

Another potentially important pathway of exposure for cadmium in Townsite #2 was the ingestion of root vegetables from the backyard garden. The data available for backyard vegetables in Townsite #2 and other areas of the GBA are sparse and efforts need to be made to collect more data to reduce the uncertainty in this pathway of exposure.

One interesting finding from this study was that soil was not a major pathway of exposure at the best estimate concentration. At the upper bound estimate, infants and toddlers exposed to lead in Townsite #2 had exposures that were above the TRV; the backyard vegetable pathway was the major pathway of exposure followed by the soil pathway. In Lower Belledune, the upper bound estimate of lead results in toddler exposure above the TRV and only in this case is the soil pathway dominant.

Environmental concentrations in Lower Belledune are higher than other areas in the GBA. Therefore, residents in Lower Belledune are the highest exposed individuals followed by Townsite #2. In general, children and toddlers have the highest potential exposure. Residents who consume local mussels from along the shoreline also experience higher exposure and it may be prudent to reduce consumption of local mussels to reduce exposures.

Maximum local seafood eaters, such as maximum wild mussel eaters (approximately five ½-pound meals per week all year); maximum local lobster eaters who consume approximately two to three ½-pound meals per week all year, and maximum local fish eaters who consume approximately six to seven ½-pound meals per week all year of local fish from the local shoreline and area have the highest exposure. These individuals would most likely be a small portion of the population. It is likely that exposures have been overestimated due to the assumptions in the report.

8.1.3 What are the potential health risks for residents as a result of the exposure to the contamination?

The potential health risks associated with exposure to lead and cadmium are outlined below. Both lead and cadmium are considered to be non-cancer causing chemicals via the oral route of exposure. The health effects associated with lead exposure are most severe in children and involve neurocognitive and behavioural developmental effects with exposure *in utero* and in early childhood. The health effects associated with oral ingestion of cadmium is significant proteinurea, a reflection of abnormal kidney function.

For the population in the highest exposed area (Lower Belledune and Townsite #2) the assessment showed that, based on the best estimate, the intakes are below toxicity reference values with the exception of cadmium and lead exposure for a child in Lower Belledune. The intake for this receptor is influenced by the assumed consumption of local wild mussels and fish. Thallium and zinc exposures for infants, toddlers and children are predicted to be above the TRV; however, supermarket food is the dominant pathway. Local exposures to zinc and thallium are well below the toxicity reference value. The supermarket food intakes are obtained for the Canadian population and may not be appropriate for Northern New Brunswick.

The upper bound estimate for this population suggested that exposures to cadmium, lead and mercury for infants, toddlers and children may exceed the toxicity reference value. These exposures are mainly due to the consumption of local mussels, fish and backyard vegetables. In Lower Belledune, the toddler exposure is due to soil ingestion. Again, thallium and zinc exposure are above the toxicity reference value due to supermarket food consumption.

The best estimate calculations for residents in the core communities of Belledune, Pointe-Verte and Petit-Rocher show that exposures to cadmium, lead and mercury are predicted to be below toxicity reference values. At the upper bound estimate calculations, children exposed to cadmium, lead and mercury in Pointe-Verte are predicted to be above the TRV. In Petit-Rocher, child exposures to mercury are above the TRV and in Belledune child exposures to cadmium and mercury are above the TRV. This is primarily due to the consumption of local wild mussels and fish. Thallium and zinc exposures are also predicted to be above the toxicity reference values due to the dominance of the supermarket food pathway.

A sensitivity analysis was conducted for individuals who may consume a significant quantity of seafood (fish, wild mussels or lobster) from the local area on a continuous basis. The results show that the intakes for these individuals may be above toxicity reference values for cadmium, lead, mercury and thallium. It should be emphasized that this is an extreme estimate and would apply to only a very small portion of the population.

In summary, the HHRA described above is only a tool for determining the <u>risk of health effects</u>, it is important to note that it does not provide an absolute statement on the <u>experienced health effects</u> measurable in a population. Therefore, the findings from this HHRA need to be considered with the results of the CHSA to determine, where possible, whether adverse health impacts are actually occurring in the community. This linkage has been provided in the Summary Report.

8.2 Limitations

Risk assessment is intrinsically an uncertain process with uncertainty arising not only from environmental characterization but also from inter-individual variability and uncertainty associated with exposure point concentration, exposure factors and toxicity assessment. The inferences and assumptions selected in this risk assessment were such that they are likely to overestimate exposures and hence likely to overestimate risk. Detailed discussion on the specific uncertainties in the assessment have been discussed in many of the preceeding sections. The most notable uncertainties with this assessment are listed below.

- *Historical emissions data* – The study team assessed that the most uncertainty exists for the earliest time period studied (namely 1967-1974). Environmental monitoring data for the emissions, soil, and other media during this period for arsenic, cadmium and lead are limited. As well, there is likely less accuracy in measurement during this time period due in part to the monitoring technology of the time period. Given that the historical time periods were only used to provide a perspective on past exposures, reduction in this uncertainty is not warranted.

- *Limited information for some COPC* – Over the various time periods and in current monitoring, some COPC have had less focus than others. The COPC of lead, arsenic, and cadmium have been regularly measured throughout various media and through various time periods. Other COPC such as chromium, dioxins and furans, and mercury have been of less focus, and as a result have much smaller data sets associated with their levels in the environment. However, the findings have indicated that the uncertainty in these COPC does not affect the outcome of the assessment.

- *Current levels of COPC in Baie de Chaleurs fish* – The study team was not able to locate any current data related to metals in local fish from the Baie de Chaleurs. As a result, the HHRA used fish data collected in the 1980's to estimate current exposure to COPC such as lead and arsenic. It is likely that current fish concentrations may be lower than these estimates, however, it is impossible for the study team to assume this without some data on actual levels.

- *Current levels of COPC in backyard vegetables* – There are limited data available on current levels of COPC in backyard vegetables. The data are also limited in terms of locations. For example, there were no current backyard vegetable data for Petit-Rocher. This pathway becomes significant for some of the COPC, for example cadmium and lead. The certainty in the significance of this pathway would be greatly improved by the collection of more data.

8.3 Recommendations

Based on the above discussion, uncertainties surrounding the concentrations of COPC in fish from the Baie des Chaleurs and in backyard garden vegetables are large enough to influence the outcome of this assessment. Therefore, it is recommended that programs be implemented in the GBA to collect data on fish from the Baie des Chaleurs, and to obtain data on garden vegetables across the GBA.

Local wild mussel consumption was a significant pathway of exposure for a number of the COPC and there are enough data collected on local mussels to be confident in the results of this analysis. Local wild mussels were used as a surrogate for other local shellfish in the study area. Limited data are available on clams and the concentrations of COPC were lower in clams than in the wild mussels. There were no data available on oysters. It is recommended to collect data on other shellfish such as clams and oysters to confirm that the local wild mussels contained the highest concentrations of COPC. It may also be prudent for individuals who consume local wild mussels to limit their intakes.

The side bar analysis on specific sites in the GBA, for example, the Soil 9 location from the Noranda EMP and the school, indicate that further studies on soil quality should be conducted on both of these sites. The study team is aware of ongoing activities by DELG at the Soil 9 location and also believes that remedial activities have been conducted at the school in 2004.

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