SARA GROUP

Sudbury Area Risk Assessment
Volume II

Appendix D:

Market Basket Estimated Daily Intake (EDI)

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SUDBURY AREA RISK ASSESSMENT
VOLUME II

APPENDIX D: MARKET BASKET EXPOSURE

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EXECUTIVE SUMMARY

Food represents a critical pathway of exposure to the chemicals of concern (COC) for the residents of the Greater Sudbury Area (GSA). Foods consumed and purchased from grocery stores, supermarkets, butchers, *etc*, are considered background sources of exposure and contribute to an individuals' total level of exposure to COC. The exposures to COC through the consumption of store-bought foods is termed the market basket estimated daily intake or EDI. As part of the Human Health Risk Assessment (HHRA), a literature review was conducted to obtain published data on the concentrations of COC in store-bought foods (*i.e.*, supermarket or market basket food items).

Available food data were grouped into several separate categories (*i.e.*, fish and shellfish, milk and dairy products, *etc*). The different food categories used for the Sudbury HHRA exposure model are described in this report.

The report identifies all the potential sources of information reviewed on the concentration of the COC in each of the different food categories. The data selected as the most appropriate for use in the Sudbury HHRA are identified. Preference was given to recent, reliable, Canadian data. Only in the case of selenium were Canadian data not available.

For each COC and food category, the mean concentration and 95% Upper Confidence Limit on the Mean (UCLM) was calculated. These values were then used to calculate the EDI for the market basket component of the HHRA exposure model. The data presented in this report are used to support the Sudbury HHRA.

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APPENDIX D: MARKET BASKET EXPOSURE

D-1.0 INTRODUCTION

A literature review was conducted for food concentrations of the COC for use in the Sudbury-area human health risk assessment (Sudbury HHRA). These COC are: arsenic (As), cobalt (Co), copper (Cu), nickel (Ni), lead (Pb), and selenium (Se). The purpose of the literature review was to identify the most appropriate food data to characterize Sudbury area residents' background exposure to store-bought foods. In Canada, most supermarkets foods are distributed across North America and are generally not specific to any given location. Thus, food purchased in Sudbury should resemble the food purchased in other cities in Canada, particularly Ontario. An exception is the locally grown fruit and vegetables that are seasonally available in Sudbury. In order to incorporate data on levels of COC in Sudbury-specific produce into the HHRA, locally-grown residential and commercial gardens were sampled for a variety of fruits and vegetables. Local wild mushrooms and blueberries were also sampled and analyzed for COC. The results of that survey are provided separately in the Sudbury 2003 Vegetable Garden Survey report (refer to Appendix E).

D-2.0 DEVELOPMENT OF THE ESTIMATED DAILY INTAKE (EDI)

The purpose of the current *market basket* review was three-fold: i) identify the key food item categories making up the diet of Sudbury residents; ii) determine the EDI rates for each food category; and, iii) determine the range of COC concentrations in each food category. The information generated from this phase of the study was incorporated into the exposure pathway model of the HHRA as the EDI for each COC.

D-2.1 Criteria for Selection of Databases

In order to determine the most appropriate data to use in the Sudbury HHRA, the following criteria were used:

- Food concentration data were Canadian-specific (if Canadian data were unavailable, the literature search extended to international studies, preferably American);
- Food was purchased from a supermarket or other public point-of-purchase (*e.g.*, bakery, butcher);
- Food was prepared and/or cooked for normal consumption;
- Data were reported with adequate summary statistics (raw data, or at a minimum, the sample number, mean concentration and range); and,
- The method detection limits were adequately low to detect the metal in most of the food items.

When selecting the most appropriate food concentration dataset, there are additional issues to consider for each COC. These issues are outlined for each COC in the following sections.

D-2.2 Background on Food Categories

Estimates of Canadian's food intake are readily available with food grouped into categories of similar food items. The food data available were grouped into separate categories based on the categories outlined in Richardson (1997):

- fish and shellfish;
- milk and dairy products;
- meat, poultry and eggs (excluding organ meats);

- cereals and grains;
- root vegetables;
- other vegetables;
- fruit and fruit juices;
- fats and oils;
- nuts;
- sugars and sweets;
- alcoholic beverages; and,
- non-alcoholic beverages.

We recommend the use of the categorization approach in Richardson (1997) because:

1. Fish COC concentrations can be significantly different compared to other meat items (*i.e.*, As);
2. Fish consumption for Canadian is significantly lower than other meats when non-eaters are taken into account;
3. The Sudbury HHRA Market basket Estimated Daily Intake (EDI_{MB}) calculation were based on the Richardson (1997) intake rates; and,
4. Recent Health Canada guidelines (HC, 2004a) recommends the use of Richardson (1997) intake rates.

During the review of the data, a few changes of note were made by the SARA Group to the Richardson (1997) groupings to allow for more appropriate use within the HHRA. These were:

1. Organ meats were removed from the meat, poultry and eggs category (see below);
2. Nuts and seeds were removed from the fats and oils category and included as an additional new category; and,
3. Many new food items were added to the grouping (*e.g.*, butter, hamburger).

For a complete list of food categories identified for the Sudbury HHRA, refer to Appendix D.A of this Appendix.

Organ meats were excluded from the meat, poultry and eggs category because the inclusion of this data was causing an unacceptable uncertainty in the estimated 95% upper confidence limit (UCL) on the mean COC concentration for the category (refer to the Uncertainty discussion in the main HHRA report for further detail). In particular, the copper concentration in organ meats was causing an unacceptable skewing of the data. For example, the standard deviations (SD) for copper in the meat, poultry and eggs category without and with the organ meats were 12,256 and 413 ng/g wet weight (ww), respectively (Table D.1). Depending on the metal, the magnitude of the change in the UCL was variable (for example, the UCL for Ni is slightly increased with the removal of organ meats). In all cases the SD (except Ni, where it remained the same) was reduced by removing the organ meats from the meat, poultry and eggs category (Table D.1).

Table D.1 95% UCLM COC Concentration for the Meat, Poultry and Eggs Food Category, with and without Organ Meats

Meat, Poultry and Eggs Food Category	Arsenic	Cobalt	Copper	Lead	Nickel	Selenium
With organ meats	33.6 (77.6)	13.6 (11.6)	7,261.7 (12 256.1)	7.7 (4.5)	20.6 (9.1)	263.9 (141.7)
Without organ meats	15.2 (14.9)	10.8 (8.2)	1060.2 (412.7)	6.6 (4.2)	22.4 (9.1)	247.1 (114.8)

Note: Standard deviations are in brackets ( ).
Concentrations are expressed in ng/g wet weight.

In addition, the method selected to predict food intake assumed that each food item within the category was weighted equally. However, organ meat consumption is not comparable to that of other meats, poultry and eggs (Richardson, 2005 pers. comm. on compendium data). In fact, only 3% of respondents reported consumption of organ meats. It was hypothesized that the removal of organ meats, while reducing the uncertainty in the meat, poultry and eggs category, did not inappropriately lower the EDI for the metals. In order to test this hypothesis, the intake of two metals with the highest concentrations in organ meats were modeled using organ specific intake rates on a per capita basis (meat non-eaters were included). It was found that the removal of organ meats, while reducing the uncertainty in the meat, poultry and eggs category, did not significantly lower the EDI. Consumption of organ meats accounted for 0.1 and 0.2% of the total EDI for copper and arsenic, respectively. Therefore, organ meats were not included in the derivation of the EDI_{MB} for the Sudbury HHRA.

Nuts and seeds were removed from the oils and fats category and included as a separate category. Nuts and seeds were included in the EDI calculation using separate intake rate data for nuts and seeds (Richardson, 1997).

Many new items have been added to the roster of food items tested in the Canadian Total Diet Study. To accommodate these new items, many of these items have been added to the categories established by Richardson (1997). Appendix D.A provides a list of the original items included in each category and the additional items added. Depending on the source of the data, the list of food items included in the category will vary. Appendix D.B provides a complete list of all the data included for each COC.

D-2.3 Selection of the Databases

The databases selected for use in the Sudbury EDI_{MB} are summarized in Table D.2 (refer to Appendix D.B for the complete datasets).

Table D.2 Summary of Databases Selected for Use in the Development of the EDI_{MB}

COC	Location	Date	Description	Reference
As	Six Canadian cities	1985 and 1988	Canadian Total Diet Study[1]: Total As analyzed in supermarket foods	Dabeka *et al*. 1993
Co	8 Canadian cities	1993 to 1999; and 2000; 2002	Canadian Total Diet Study[1]: Total Co analyzed in supermarket foods, Supplemented with green leafy vegetable data from Port Colborne	HC, 2004b; Dabeka and McKenzie, 2005 pers. comm.; JWEL, 2004
Cu	8 Canadian cities	1993 to 1999 and 2000	Canadian Total Diet Study[1]: Total Cu analyzed in supermarket foods	HC, 2004b; Dabeka and McKenzie, 2005 pers. comm.
Ni	Port Colborne	2002	Total Ni analyzed in foods from local supermarkets, food outlets, butchers eateries, and markets[2]	JWEL, 2004
Pb	Canada	2000	Canadian Total Diet Study[1]: Total Pb analyzed in supermarket foods	Dabeka and McKenzie, 2005 pers. comm.
Se	United States	1991 to 2002	U.S. FDA Total Diet Study[3]: Total Se analyzed in supermarket foods	U.S. FDA, 2004

[1] All non-detected food concentrations were assumed by the authors to be the full detection limit.
[2] All non-detected food concentrations were assumed to be ½ the detection limit.
[3] All non-detected food concentrations were assumed to be ½ the detection limit.

It is important to note that the following tables reflect the concentrations of COC in food that are readily available or in the published literature. The authors of the data applied different assumptions to data with values below the detection limit (*i.e.*, non-detects), when averaging either the food item concentration or the food category (*e.g.*, non-detects equal zero concentration, ½ the detection limit, or the detection limit itself). For the purposes of applying the food concentrations to the EDI_{MB}, the raw data was obtained and the non-detects were assumed to be half the detection limit and the 95% upper confidence limit (UCL) on the mean of the food categories was calculated. The data used in the derivation of the EDI_{MB} are summarized in Appendices D.B-I.

D-3.0 RESULTS

D-3.1 Arsenic

Arsenic is commonly detected in most foods; however, the chemical forms differ and concentrations may vary considerably by food type. For example, much of the arsenic in fish is present in a highly complexed, non-bioavailable form, or as organoarsenicals (*e.g.*, arsenobetaine, arsenocholine) that are rapidly excreted from the body. Inorganic arsenic, specifically the soluble inorganic As(III) and As(V) species, are the most bioavailable and are the arsenic species of most interest and concern in any human health risk assessment including the Sudbury HHRA

Based on limited data, the percentage of inorganic arsenic in various foods has been reported to typically range from 0 to 1% in saltwater fish, 5% in vegetables, 10 to 15% in freshwater fish, 15% in potatoes and fruits, 73% in apple juice, 35 to 43% in rice, 49 to 69% in cereals, flour and breads, 15 to 41% in poultry, and as much as 75 to 100% in milk, dairy products, and meats (Weiler, 1987; MOE, 1987). For a typical mixed diet, approximately 20 to 40% of the estimated daily dietary intake of arsenic is inorganic (Borum and Abernathy, 1994; Yost *et al.* 1998). Inorganic forms predominate in meat and poultry, dairy products and rice.

Selection of Food Database

There were a number of Canadian market basket surveys available for arsenic (JWEL, 2004; Dabeka *et al.* 1993; MOE, 1987; Smith, 1971) (Table D.1). Some of the market basket studies analyzed total arsenic (*e.g.*, JWEL, 2004; Dabeka *et al.*, 1993; DNHW, 1983), while others analyzed both total and inorganic forms (MOE, 1987).

The database selected for use in the Sudbury HHRA was the Dabeka *et al*. (1993) Canadian Total Diet Study (TDS) because it fulfilled all of the selection criteria and was found to be the most appropriate for arsenic. In this survey, food was sampled from supermarkets in six Canadian cities and prepared as for normal consumption by Canadians (Dabeka *et al*. 1993). Raw data and summary statistics were available and the detection limits were appropriate, ranging from 0.3 to 1.1 ng/g ww. Unfortunately, arsenic was not analyzed in the Canadian TDS data for the period 1993 to 1999, and 2000 due to limited government resources (Dabeka, 2005 pers. comm.). Therefore, the available data are greater than 10 years old.

The more recent Port Colborne database (*i.e.*, JWEL, 2004) was not selected because it had inappropriately high detection limits (*i.e.*, arsenic was non-detectable in 97% of food samples; detection limit was ~50 ng/g dw (~10 ng/g ww for vegetables[1])); resulting in highly uncertain estimates of food concentrations. For that analyses, non-detectable arsenic concentrations were assumed to be equal to half the detection limit (JWEL, 2004), an assumption that is typically conservative. This may explain why the mean concentrations for the food categories in the JWEL (2004) data are consistently higher than those in the Dabeka *et al*. (1993) study. In addition the MOE (1987) and DNHW (1983) databases were not selected because they did not sample an adequate variety of foods. For example, the MOE (1987) study sampled only apple juice in the fruit and fruit products category, and the DNHW (1983) studied only marine fish and meat products. The MOE (1987) study will be used to provide assumptions of the inorganic arsenic content of the Dabeka *et al*. (1993) food data. The Smith (1971) database was not used because the data and summary statistics were not readily available and the data is likely no longer reflective of current arsenic food concentrations.

The available information on the concentration of arsenic in major food categories is presented in Table D.3. However, only data from Dabeka *et al*. (1993) were used to calculate the EDI for arsenic for the Sudbury HHRA.

Table D.3 Typical Total Arsenic Concentrations in Canadian Foods

Food Type	Location	Description	Concentration[Φ]	Reference
Fish and seafood				
Fish and shellfish	Port Colborne	186 food samples[* +]	mean: 1,600	JWEL, 2004
Fish and shellfish	6 Canadian cities btw 1985 and 1988	total arsenic in samples collected	mean: 1,662.46 max: 4,830.0	Dabeka *et al*., 1993[b]
Marine fish	Canada	marine fish sold for human consumption	range: 400 to 118,000	DNHW, 1983
Fish (saltwater)	Ontario	total arsenic concentrations and % inorganic	1,100 to 4,000 (1% inorganic) average: 2550	MOE, 1987[a]
Fish (freshwater)	Ontario	total arsenic concentrations and % inorganic	140 (15% inorganic)	MOE, 1987[a]
Shrimp	Ontario	total arsenic concentrations and % inorganic	650 (16% inorganic)	MOE, 1987[a]
Meat / poultry products				
Meat, poultry and eggs	Port Colborne	186 food samples	mean: 30.6 max: 43	JWEL, 2004

[1] Calculated for illustrative purposed only, and assumes an 80% moisture content for vegetables.

Table D.3 Typical Total Arsenic Concentrations in Canadian Foods

Food Type	Location	Description	Concentration[Φ]	Reference
Meat and poultry	Canada, btw 1985 and 1988	total arsenic in samples collected	mean: 24.3 max: 536.0	Dabeka *et al*. 1993[b]
Meat and poultry	Canada	sold for human consumption	range: non-detect to 440	DNHW, 1983
Red meat	Ontario	total arsenic concentrations and % inorganic	13 to 26 (100% inorganic)	MOE, 1987[a]
Poultry	Ontario	total arsenic concentrations and % inorganic	21 to 23 (41% inorganic)	MOE, 1987[a]
Meats	Canada, Ottawa-Hull area	food purchased	50	Smith, 1971
Milk and dairy products				
Milk and milk Products	Port Colborne	186 food samples	mean: 21 max: 24	JWEL, 2004
Vanilla ice cream	Ontario	total arsenic concentrations and % inorganic	16 (26% inorganic)	MOE, 1987[a]
Milk and dairy products	6 Canadian cities, btw 1985 and 1988	total arsenic in samples collected	mean: 3.8 max: 26.0	Dabeka *et al*. 1993[b]
Dairy	Canada, Ottawa-Hull area	food purchased	200	Smith, 1971
Rice				
Cooked rice	Ontario	total arsenic concentrations and % inorganic	230 to 240 (43% inorganic)	MOE, 1987[a]
Rice cereal, dry	6 Canadian cities, btw 1985 and 1988	total arsenic in samples collected	mean: 284.1 max: 365	Dabeka *et al*. 1993[b]
Cereals, grains and baked goods				
Cereals, grains and baked goods	Port Colborne	186 food samples	mean: 18.5 max: 28	JWEL, 2004
Cereals and baked goods	6 Canadian cities, btw 1985 and 1988	total arsenic in samples collected	mean: 24.5 max: 365	Dabeka *et al*. 1993[b]
Cereals	Ontario	total arsenic concentrations and % inorganic	230 to 300 (49% inorganic)	MOE, 1987[a]
Bread	Ontario	total arsenic concentrations and % inorganic	mean: 24 (50% inorganic)	MOE, 1987[a]
Pastry flour	Ontario	total arsenic concentrations and % inorganic	11 (69% inorganic)	MOE, 1987[a]
Cereals	Canada; Ottawa-Hull area	food purchased	50	Smith, 1971

Table D.3 Typical Total Arsenic Concentrations in Canadian Foods

Food Type	Location	Description	Concentration[Φ]	Reference
Fruits and fruit juices				
Fruits and fruit Juices	Port Colborne	186 food samples	mean: 14.9 max: 37	JWEL, 2004
Fruit and fruit juices	6 Canadian cities, btw 1985 and 1988	total arsenic in samples collected	mean: 4.5 max: 37	Dabeka *et al*. 1993[b]
Apple juice	Ontario	total arsenic concentrations and % inorganic	12 (73% inorganic)	MOE, 1987[a]
Garden fruits	Canada, Ottawa-Hull area	food purchased	20	Smith, 1971
Fruits	Canada, Ottawa-Hull area	food purchased	<100	Smith, 1971
Root vegetables				
Potatoes	Port Colborne	186 food samples	mean: 18.5	JWEL, 2004
Root vegetables	6 Canadian cities, btw 1985 and 1988	total arsenic in samples collected	mean: 7.8	Dabeka *et al*. 1993[b]
Root vegetables	Canada, Ottawa-Hull area	food purchased	<20	Smith, 1971
Potatoes	Canada, Ottawa-Hull area	food purchased	<100	Smith, 1971
Other vegetables				
Other vegetables	Port Colborne	186 food samples	mean: 1.16 max: 2.7	JWEL, 2004
Vegetables	6 Canadian cities, btw 1985 and 1988	total arsenic in samples collected	mean: 7.0 max: 84.0	Dabeka *et al*. 1993[b]
Leafy vegetables	Canada, Ottawa-Hull area	food purchased	<100	Smith, 1971
Legumes	Canada, Ottawa-Hull area	food purchased	<20	Smith, 1971
Fats and oils				
Fats, oils, nuts and Seeds	Port Colborne	186 food samples	mean: 38.5 max: 54	JWEL, 2004
Fats and oils	6 Canadian cities, btw 1985 and 1988	total arsenic in samples collected	mean: 19.0 max: 57.0	Dabeka *et al*. 1993[b]
Sugars and sweets				
Sugars and sweets	Port Colborne	186 food samples	mean: 35.7 max: 48	JWEL, 2004
Sugar and candies	6 Canadian cities, btw 1985 and 1988	total arsenic in samples collected	mean: 10.9 max: 105	Dabeka *et al*. 1993[b]
Sugar products	Canada, Ottawa-Hull area	food purchased	80	Smith, 1971

Table D.3 Typical Total Arsenic Concentrations in Canadian Foods

Food Type	Location	Description	Concentration[Φ]	Reference
Miscellaneous				
Miscellaneous	6 Canadian cities, btw 1985 and 1988	total arsenic in samples collected	mean: 12.5 max: 41.0	Dabeka *et al*. 1993[b]
Beverages				
Alcoholic beverages	Port Colborne	186 food samples	mean: 6.9	JWEL, 2004
Non-alcoholic beverages	Port Colborne	186 food samples	mean: 9.7	JWEL, 2004
Beverages	6 Canadian cities, btw 1985 and 1988	total arsenic in samples collected	mean: 3.0 max: 9.0	Dabeka *et al*. 1993[b]
Tea	Ontario	total arsenic concentrations and % inorganic	35 (26% inorganic)	MOE, 1987[a]
Drinks	Canada, Ottawa-Hull area	food purchased	20	Smith, 1971

Φ All food concentrations are expressed in units of ng/g wet weight, unless otherwise stated.
* includes replicates and duplicates
+ 97% of all food data is below the MDL (50 ng/g dw). All food items analyzed as dry weight and then converted to wet weight using moisture content (measured by laboratory). Samples detected at, or below, the MDL were assumed to be ½ the detection limit.
[a] All food samples in this study were comprised of one homogenized sample, analyzed in duplicate or triplicate, except for saltwater fish and apple juice. Percent inorganic arsenic was calculated by dividing measured average inorganic concentration in foods by the average measured total arsenic concentration.
[b] All food samples in this study were prepared as for normal consumption and then homogenized.

D-3.2 Cobalt

Cobalt is an essential nutrient and a component of vitamin B-12. However, vitamin B-12 constitutes only a very small fraction of cobalt intake and most ingested cobalt is in the inorganic form (ATSDR, 2004). Food concentrations of cobalt are generally thought to be low; however, food is considered to be the largest source of exposure in the general population (ATSDR, 2004).

Cobalt is found in the highest concentrations in grains and vegetables, particularly, green leafy vegetables, with the lowest concentrations in dairy products, refined cereals and sugar (Barceloux, 1999). Analysis conducted as part of the Canadian Total Diet Study found the highest concentrations of cobalt in the following food categories: grains and baked goods; fats, oils and nuts; and, sugar, candy and desserts (Dabeka and McKenzie, 2005 pers. comm.; HC, 2004b; Dabeka and McKenzie, 1995).

Selection of Food Database

A number of Canadian market basket studies, summarized in Table D.4, are available for cobalt (Dabeka and McKenzie, 2005 pers. comm.; HC, 2004b; JWEL, 2004; Dabeka and McKenzie, 1995). The cobalt concentrations reported by these different studies are comparable; however, the databases do not include an analysis of green leafy vegetables (Table D.4).

The datasets selected for use in the Sudbury HHRA were the consecutive years (1993 to 2000) of the Canadian Total Diet Studies (Dabeka and McKenzie, 2005 pers. comm.; HC, 2004b) because they fulfilled all of the selection criteria and were the most appropriate for cobalt. The datasets were combined to increase the Canadian coverage (eight cities) and the statistical robustness of the data. The Canadian Total Diet Study results for 1986 to 1988 were not included because cobalt concentrations in approximately half of the samples were not detected. In order to include all important sources of cobalt, the results for green leafy vegetables provided in JWEL (2004) were also integrated into the database. The other Port Colborne data were not used because 25% of the food samples analyzed were below the detection limit (1.2 ng/g dw; or ~0.96 ng/g ww for vegetables) (JWEL, 2004). In contrast, <5% of the most recent Total Diet Study samples were below the detection limit (~0.3 ng/g ww) (Dabeka and McKenzie, 2005 pers. comm.).

Table D.4 Typical Total Cobalt Concentrations in Canadian Foods

Food Type	Location	Description	Concentration Φ	Reference
Fish and seafood				
Fish and shellfish	Canada	unpublished data from the 2000 TDS	5.0 [a]	Dabeka and McKenzie, 2005 pers. comm
Fish and shellfish	8 Canadian cities: Toronto, Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Whitehorse and Calgary between 1993 and 1999	137 food items collected	mean: 7.69 max: 11.52	HC, 2004b
Fish and shellfish	Port Colborne	186 food samples (includes replicates and duplicates)	mean: 3.2[a]	JWEL, 2004
Fish	Canada, Montreal between 1986 and 1988	6 samples purchased	mean: 19.9 max: 29.4	Dabeka and McKenzie, 1995
Meat / poultry products				
Meat, poultry and eggs	Canada	unpublished data from the 2000 TDS	10.7 ng/g [a]	Dabeka and McKenzie, 2005 pers. comm

Table D.4 Typical Total Cobalt Concentrations in Canadian Foods

Food Type	Location	Description	Concentration Φ	Reference
Meat, poultry and eggs	8 Canadian cities, Toronto, Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Whitehorse and Calgary between 1993 and 1999	137 food items collected	mean: 10.39 max: 40.96 (organ meats)	HC, 2004b
Meat, poultry and eggs	Port Colborne	186 food samples (includes replicates and duplicates)	mean: 14.2[a] max: 83 (organ meats)	JWEL, 2004
Meat and poultry	Canada, Montreal between 1986 and 1988	18 samples purchased in	mean: 8.7 max: 38.2	Dabeka and McKenzie, 1995
Meat, fish and poultry	Canada, Ottawa-Hull area in 1969	foods purchased	100	Méranger and Smith, 1972
Meat, fish and poultry	Canada, Winnipeg area in 1972	foods purchased	10	Kirkpatrick and Coffin, 1977
Milk and dairy products				
Dairy	Canada	unpublished data from the 2000 TDS	5.9[a]	Dabeka and McKenzie, 2005 pers. comm
Milk and milk products	8 Canadian cities, Toronto, Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Whitehorse and Calgary between 1993 and 1999	137 food items collected	mean: 7.42 max: 24.28	HC, 2004b
Milk and milk Products	Port Colborne	186 food samples (includes replicates and duplicates)	mean: 2.0[a] max: 9.4	JWEL, 2004
Milk and milk products	Canada, Montreal between 1986 and 1988	13 samples purchased	mean: 5.2 max: 19.8	Dabeka and McKenzie, 1995
Milk and dairy	Canada, Ottawa-Hull area in 1969	foods purchased	60	Méranger and Smith, 1972
Milk and dairy	Canada, Winnipeg area in 1972	foods purchased	20	Kirkpatrick and Coffin, 1977
Infant Formula				
Infant formula	Canada	unpublished data from the 2000 TDS	2.1[a]	Dabeka and McKenzie, 2005 pers. comm
Infant formula	Canada, Toronto, Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Whitehorse and Calgary between 1993 and 1999	137 food items collected	mean: 4.01 max: 5.27	HC, 2004b
Ready to use, milk based	Canada	33 samples	median: 0.40 max: 0.99	Dabeka, 1989
Ready to use, soy based	Canada	16 samples	median: 2.27 max: 5.2	Dabeka, 1989

Table D.4 Typical Total Cobalt Concentrations in Canadian Foods

Food Type	Location	Description	Concentration Φ	Reference
Concentrated, milk based	Canada	34 samples	median: 1.57 max: 3.11	Dabeka, 1989
Concentrated, soy based	Canada	16 samples	median: 4.33 max: 11.8	Dabeka, 1989
Powdered, milk based	Canada	36 samples	median: 4.96 max: 10.6	Dabeka, 1989
Powdered, soy based	Canada	28 samples	median: 20.0 max: 53	Dabeka, 1989
Cereals, grains and baked goods				
Cereal and grain products	Canada	unpublished data from the 2000 TDS	12.5[a]	Dabeka and McKenzie, 2005 pers. comm
Cereals, grains and baked goods	8 Canadian cities, Toronto, Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Whitehorse and Calgary between 1993 and 1999	137 food items collected	mean: 15.08 max: 69.83	HC, 2004b
Cereals, grains and baked goods	Port Colborne	186 food samples (includes replicates and duplicates)	mean: 7.6[a] max: 25	JWEL, 2004
Bakery goods and cereals	Canada, Montreal between 1986 and 1988	24 samples purchased	mean: 17.9 max: 75.7	Dabeka and McKenzie, 1995
Cereals	Canada, Ottawa-Hull area in 1969	foods purchased	140	Méranger and Smith, 1972
Cereals	Canada, Winnipeg area in 1972	foods purchased	30	Kirkpatrick and Coffin, 1977
Fruits and fruit juices				
Fruit and fruit products	Canada	unpublished data from the 2000 TDS	7.4 [a]	Dabeka and McKenzie, 2005 pers. comm
Fruit and fruit products	8 Canadian cities, Toronto, Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Whitehorse and Calgary between 1993 and 1999	137 food items collected	mean: 10.26 max: 96.89	HC, 2004b
Fruits and fruit juices	Port Colborne	186 food samples (includes replicates and duplicates)	mean: 3.1[a] max: 8.9	JWEL, 2004
Fruits and fruit juices	Canada, Montreal between 1986 and 1988	25 samples purchased	mean: 4.6 max: 18.1	Dabeka and McKenzie, 1995
Garden fruits	Canada, Ottawa-Hull area in 1969	foods purchased	<40	Méranger and Smith, 1972
Garden fruits	Canada, Winnipeg area in 1972	foods purchased	20	Kirkpatrick and Coffin, 1977
Fruits	Canada, Ottawa-Hull area in 1969	foods purchased	<40	Méranger and Smith, 1972

Table D.4 Typical Total Cobalt Concentrations in Canadian Foods

Food Type	Location	Description	Concentration Φ	Reference
Fruits	Canada, Winnipeg area in 1972	foods purchased	20	Kirkpatrick and Coffin, 1977
Root vegetables				
Root vegetables	Canada	unpublished data from the 2000 TDS	7.4[a]	Dabeka and McKenzie, 2005 pers. comm
Root vegetables	8 Canadian cities, Toronto, Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Whitehorse and Calgary between 1993 and 1999	137 food items collected	mean: 17.70 max: 63.67	HC, 2004b
Potatoes	Port Colborne	186 food samples (includes replicates and duplicates)	mean: 11.6[a]	JWEL, 2004
Potatoes	Canada, Ottawa-Hull area in 1969	foods purchased	<90	Méranger and Smith, 1972
Potatoes	Canada, Winnipeg area in 1972	foods purchased	20	Kirkpatrick and Coffin, 1977
Root vegetables	Canada, Ottawa-Hull area in 1969	foods purchased	<50	Méranger and Smith, 1972
Root vegetables	Canada, Winnipeg area in 1972	foods purchased	30	Kirkpatrick and Coffin, 1977
Other vegetables				
Other vegetables	Canada	unpublished data from the 2000 TDS	5.2[a]	Dabeka and McKenzie, 2005 pers. comm
Other vegetables	8 Canadian cities, Toronto, Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Whitehorse and Calgary between 1993 and 1999	137 food items collected	mean: 8.79 max: 17.32	HC, 2004b
Other vegetables	Port Colborne	186 food samples (includes replicates and duplicates)	mean: 16.8[a] max: 43	JWEL, 2004
Vegetables	Canada, Montreal between 1986 and 1988	38 samples purchased	mean: 9.7 max: 70.2	Dabeka and McKenzie, 1995
Leafy vegetables	Canada, Ottawa-Hull area in 1969	foods purchased	<50	Méranger and Smith, 1972
Leafy vegetables	Canada, Winnipeg area in 1972	foods purchased	10	Kirkpatrick and Coffin, 1977
Legumes	Canada, Ottawa-Hull area in 1969	foods purchased	<50	Méranger and Smith, 1972
Legumes	Canada, Winnipeg area in 1972	foods purchased	30	Kirkpatrick and Coffin, 1977

Table D.4 Typical Total Cobalt Concentrations in Canadian Foods

Food Type	Location	Description	Concentration Φ	Reference
Mixed Foods				
Miscellaneous (including soups)	8 Canadian cities, Toronto, Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Whitehorse and Calgary between 1993 and 1999	137 food items collected	mean: 12.03 max: 17.58	HC, 2004b
Soups	Canada, Toronto, Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Whitehorse and Calgary between 1993 and 1999	foods collected	3.4[a]	HC, 2004b
Soups	Canada, Montreal between 1986 and 1988	4 samples purchased	mean: 6.1 max: <8.5	Dabeka and McKenzie, 1995
Miscellaneous	Canada, Montreal between 1986 and 1988	7 samples purchased	mean: 4.6 max: 9.1	Dabeka and McKenzie, 1995
Fats and oils				
Fats, oils and peanuts	Canada	unpublished data from the 2000 TDS	9.8 [a]	Dabeka and McKenzie, 2005 pers. comm
Fats, oils and peanuts	8 Canadian cities, Toronto, Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Whitehorse and Calgary between 1993 and 1999	137 food items collected	mean: 21.82 max: 51.79	HC, 2004b
Fats, oils, nuts and seeds	Port Colborne	186 food samples (includes replicates and duplicates)	mean: 10.6[a] max: 37	JWEL, 2004
Fats and oils	Canada, Montreal between 1986 and 1988	3 samples purchased	mean: 16.1 max: 35.7	Dabeka and McKenzie, 1995
Fats and oils	Canada, Ottawa-Hull area in 1969	foods purchased	<40	Méranger and Smith, 1972
Fats and oils	Canada, Winnipeg area in 1972	foods purchased	10	Kirkpatrick and Coffin, 1977
Sugars and sweets				
Sugar, candy and desserts	Canada	unpublished data from the 2000 TDS	26.7 [a]	Dabeka and McKenzie, 2005 pers. comm
Sugar, candy and desserts	8 Canadian cities, Toronto, Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Whitehorse and Calgary between 1993 and 1999	137 food items collected	mean: 13.53 max: 59.89	HC, 2004b
Sugars and sweets	Port Colborne	186 food samples (includes replicates and duplicates)	mean: 35.7 [a] max: 48	JWEL, 2004

Table D.4 Typical Total Cobalt Concentrations in Canadian Foods

Food Type	Location	Description	Concentration Φ	Reference
Sugar and candies	Canada, Montreal between 1986 and 1988	7 samples purchased	mean: 9.1 max: 37.6	Dabeka and McKenzie, 1995
Sugars	Canada, Ottawa-Hull area in 1969	foods purchased	190	Méranger and Smith, 1972
Sugars	Canada, Winnipeg area in 1972	foods purchased	40	Kirkpatrick and Coffin, 1977
Beverages				
Non-alcoholic drinks	Canada	unpublished data from the 2000 TDS	2.1[a]	Dabeka and McKenzie, 2005 pers. comm
Alcoholic drinks	Canada	unpublished data from the 2000 TDS	1.6 [a]	Dabeka and McKenzie, 2005 pers. comm
Non-alcoholic drinks	8 Canadian cities, Toronto, Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Whitehorse and Calgary between 1993 and 1999	137 food items collected	mean: 2.61 max: 6.9	HC, 2004b
Alcoholic drinks	8 Canadian cities, Toronto, Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Whitehorse and Calgary between 1993 and 1999	137 food items collected	mean: 2.77 max: 4.72	HC, 2004b
Alcoholic beverages	Port Colborne	186 food samples (includes replicates and duplicates)	mean: 4.1 [a]	JWEL, 2004
Non-alcoholic beverages	Port Colborne	186 food samples (includes replicates and duplicates)	mean: 0.2[a]	JWEL, 2004
Beverages	Canada, Montreal between 1986 and 1988	7 samples purchased	mean: 1.1 max: 3.5	Dabeka and McKenzie, 1995
Drinks	Canada, Ottawa-Hull area in 1969	foods purchased	<40	Méranger and Smith, 1972
Drinks	Canada, Winnipeg area in 1972	foods purchased	10	Kirkpatrick and Coffin, 1977

Φ All food concentrations are expressed in units of ng/g wet weight, unless otherwise stated.
[a] Calculated from raw data in original study.

D-3.3 Copper

Copper is an essential micronutrient and is found in all foods (ATSDR, 2004). Typical food items that are high in copper include shellfish, organ meats (*e.g.*, liver and kidney), legumes, and nuts (ATSDR, 2004; Dabeka and McKenzie, 2005, pers. comm.; Dabeka and McKenzie, 1995).

Selection of Food Database

Canadian market basket data available for copper are summarized in Table D.5 (Dabeka and McKenzie, 2005 pers. comm.; HC, 2004b; JWEL, 2004). There was good agreement among the results for the Canadian Total Diet Study (CTDS) (Dabeka and McKenzie, 2005 pers. comm.; HC, 2004b). The Port Colborne results were lower than the other databases but within the same order of magnitude (JWEL, 2004).

The copper levels for organ meats were significantly higher than the rest of the meat and poultry samples for all three studies. For example, the mean copper concentrations for the meat category with and without the organ meats for three different studies were: 10,911 and 1,342 ng/g in the 2000 CTDS; 3,496 and 1,006 ng/g in the 1993 to 1999 CTDS; and, 21,935 and 685 ng/g in the Port Colborne study (refer to section D.2.1 for further discussion on organ meats).

The databases selected for use in the Sudbury HHRA were the consecutive years (1993 to 2000) of the Canadian Total Diet Studies (Dabeka and McKenzie, 2005 pers. comm.; HC, 2004b) because they fulfilled all of the selection criteria and were the most appropriate for copper. The datasets were combined to increase the Canadian coverage (eight cities) and the statistical robustness of the data.

Table D.5 Typical Total Copper Concentrations in Canadian Foods

Food Type	Location	Description	Concentration [Φ]	Reference
Fish and seafood				
Fish and shellfish	Canada	unpublished data from the 2000 TDS	992.4[a]	Dabeka and McKenzie, 2005 pers. comm
Fish and shellfish	8 Canadian cities, Toronto, Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Whitehorse and Calgary between 1993 and 1999	137 food items collected	mean: 811.68 max: 1,972.4	HC, 2004b
Fish and shellfish	Port Colborne	186 food samples (includes replicates and duplicates)	mean: 240[a]	JWEL, 2004
Meat / poultry products				
Meat, poultry and eggs	Canada	unpublished data from the 2000 TDS	10,910.6 [a,b]	Dabeka and McKenzie, 2005 pers. comm

Table D.5 Typical Total Copper Concentrations in Canadian Foods

Food Type	Location	Description	Concentration Φ	Reference
Meat, poultry and eggs	8 Canadian cities, Toronto, Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Whitehorse and Calgary between 1993 and 1999	137 food items collected	mean: 3,495.75 max: 33,372.87 (organ meats)	HC, 2004b
Meat, poultry and eggs	Port Colborne	186 food samples (includes replicates and duplicates)	mean: 21 935[a] max: 170,000 (organ meats)	JWEL, 2004
Meat, fish and poultry	Canada, Ottawa-Hull area in 1969	foods purchased	1490	Méranger and Smith, 1972
Meat, fish and poultry	Canada, Winnipeg area in 1972	foods purchased	1130	Kirkpatrick and Coffin, 1977
Milk and dairy products				
Dairy	Canada	unpublished data from the 2000 TDS	221.0[a]	Dabeka and McKenzie, 2005 pers. comm
Milk and milk products	8 Canadian cities, Toronto, Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Whitehorse and Calgary between 1993 and 1999	137 food items collected	mean: 200.93 max: 843.13	HC, 2004b
Milk and milk Products	Port Colborne	186 food samples (includes replicates and duplicates)	mean: 179 [a] max: 230	JWEL, 2004
Milk and dairy	Canada, Ottawa-Hull area in 1969	foods purchased	170	Méranger and Smith, 1972
Milk and dairy	Canada, Winnipeg area in 1972	foods purchased	190	Kirkpatrick and Coffin, 1977
Infant formula				
Infant formula	Canada	unpublished data from the 2000 TDS	783.5 [a]	Dabeka and McKenzie, 2005 pers. comm
Infant formula	Canada	137 food items	mean: 789.76 max: 817.44	HC, 2004b
Cereals, grains and baked goods				
Cereal and grain products	Canada	unpublished data from the 2000 TDS	1,367.0 [a]	Dabeka and McKenzie, 2005 pers. comm
Cereals, grains and baked goods	8 Canadian cities, Toronto, Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Whitehorse and Calgary between 1993 and 1999	137 food items collected	mean: 1300.04 max: 4574.87	HC, 2004b

Table D.5 Typical Total Copper Concentrations in Canadian Foods

Food Type	Location	Description	Concentration Φ	Reference
Cereals, grains and baked goods	Port Colborne	186 food samples (includes replicates and duplicates)	mean: 1006 [a] max: 1700	JWEL, 2004
Cereals	Canada, Ottawa-Hull area in 1969	foods purchased	2790	Méranger and Smith, 1972
Cereals	Canada, Winnipeg area in 1972	foods purchased	2260	Kirkpatrick and Coffin, 1977
Fruits and fruit juices				
Fruit and fruit products	Canada	unpublished data from the 2000 TDS	814.2 [a]	Dabeka and McKenzie, 2005 pers. comm
Fruit and fruit products	8 Canadian cities, Toronto, Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Whitehorse and Calgary between 1993 and 1999	137 food items collected	mean: 911.28 max: 5305.59	HC, 2004b
Fruits and fruit juices	Port Colborne	186 food samples (includes replicates and duplicates)	mean: 687[a] max: 3100 (dried fruits)	JWEL, 2004
Garden fruits	Canada, Ottawa-Hull area in 1969	foods purchased	900	Méranger and Smith, 1972
Garden fruits	Canada, Winnipeg area in 1972	foods purchased	810	Kirkpatrick and Coffin, 1977
Fruits	Canada, Ottawa-Hull area in 1969	foods purchased	520	Méranger and Smith, 1972
Fruits	Canada, Winnipeg area in 1972	foods purchased	540	Kirkpatrick and Coffin, 1977
Root vegetables				
Root vegetables	Canada	unpublished data from the 2000 TDS	774.3[a]	Dabeka and McKenzie, 2005 pers. comm
Root vegetables	8 Canadian cities, Toronto, Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Whitehorse and Calgary between 1993 and 1999	137 food items collected	mean: 839.74 max: 2650.79	HC, 2004b
Potatoes	Port Colborne	186 food samples (includes replicates and duplicates)	mean: 675[a]	JWEL, 2004
Potatoes	Canada, Ottawa-Hull area in 1969	foods purchased	2530	Méranger and Smith, 1972
Potatoes	Canada, Winnipeg area in 1972	foods purchased	1180	Kirkpatrick and Coffin, 1977
Root vegetables	Canada, Ottawa-Hull area in 1969	foods purchased	880	Méranger and Smith, 1972

Table D.5 Typical Total Copper Concentrations in Canadian Foods

Food Type	Location	Description	Concentration Φ	Reference
Root vegetables	Canada, Winnipeg area in 1972	foods purchased	680	Kirkpatrick and Coffin, 1977
Other vegetables				
Other vegetables	Canada	unpublished data from the 2000 TDS	782.8[a]	Dabeka and McKenzie, 2005 pers. comm
Other vegetables	8 Canadian cities, Toronto, Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Whitehorse and Calgary between 1993 and 1999	137 food items collected	mean: 836.84 max: 3715.39	HC, 2004b
Other vegetables	Port Colborne	186 food samples (includes replicates and duplicates)	mean: 1,259[a] max: 4300	JWEL, 2004
Leafy vegetables	Canada, Ottawa-Hull area in 1969	foods purchased	840	Méranger and Smith, 1972
Leafy vegetables	Canada, Winnipeg area in 1972	foods purchased	920	Kirkpatrick and Coffin, 1977
Legumes	Canada, Ottawa-Hull area in 1969	foods purchased	1480	Méranger and Smith, 1972
Legumes	Canada, Winnipeg area in 1972	foods purchased	1170	Kirkpatrick and Coffin, 1977
Mixed Foods or Miscellaneous				
Miscellaneous (including soup)	8 Canadian cities, Toronto, Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Whitehorse and Calgary between 1993 and 1999	137 food items collected	mean: 1528.76 max: 15 344.29 (seeds shelled)	HC, 2004b
Soups	Canada, Toronto, Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Whitehorse and Calgary between 1993 and 1999	foods collected	256. [a]	HC, 2004b
Fats and oils				
Fats, oils and peanuts	Canada	unpublished data from the 2000 TDS	1,276.3[a]	Dabeka and McKenzie, 2005 pers. comm
Fats, oils and peanuts	8 Canadian cities, Toronto, Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Whitehorse and Calgary between 1993 and 1999	137 food items collected	mean: 2044.04 max: 5911.07	HC, 2004b

Table D.5 Typical Total Copper Concentrations in Canadian Foods

Food Type	Location	Description	Concentration Φ	Reference
Fats, oils, nuts and seeds	Port Colborne	186 food samples (includes replicates and duplicates)	mean: 2514[a] max: 9800 (nuts and seeds)	JWEL, 2004
Fats and oils	Canada, Ottawa-Hull area in 1969	foods purchased	1890	Méranger and Smith, 1972
Fats and oils	Canada, Winnipeg area in 1972	foods purchased	1560	Kirkpatrick and Coffin, 1977
Sugars and sweets				
Sugar, candy and desserts	Canada	unpublished data from the 2000 TDS	727.4[a]	Dabeka and McKenzie, 2005 pers. comm
Sugar, candy and desserts	8 Canadian cities, Toronto, Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Whitehorse and Calgary between 1993 and 1999	137 food items collected	mean: 647.06 max: 2896.88	HC, 2004b
Sugars and sweets	Port Colborne	186 food samples (includes replicates and duplicates)	mean: 487 [a] max: 1400	JWEL, 2004
Sugars	Canada, Ottawa-Hull area in 1969	foods purchased	2360	Méranger and Smith, 1972
Sugars	Canada, Winnipeg area in 1972	foods purchased	1450	Kirkpatrick and Coffin, 1977
Beverages				
Non-alcoholic drinks	Canada	unpublished data from the 2000 TDS	56.1[a]	Dabeka and McKenzie, 2005 pers. comm
Non-alcoholic drinks	8 Canadian cities, Toronto, Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Whitehorse and Calgary between 1993 and 1999	137 food items collected	mean: 108.00 max: 193.32	HC, 2004b
Non-alcoholic beverages	Port Colborne	186 food samples (includes replicates and duplicates)	mean: 35.4[a]	JWEL, 2004
Alcoholic drinks	Canada	unpublished data from the 2000 TDS	66.2[a]	Dabeka and McKenzie, 2005 pers. comm
Nlcoholic drinks	8 Canadian cities, Toronto, Montreal, Halifax, Winnipeg, Vancouver, Ottawa, Whitehorse and Calgary between 1993 and 1999	137 food items collected	mean: 88.5 max: 134.28	HC, 2004b

Table D.5 Typical Total Copper Concentrations in Canadian Foods

Food Type	Location	Description	Concentration Φ	Reference
Alcoholic beverages	Port Colborne	186 food samples (includes replicates and duplicates)	mean: 27.3[a]	JWEL, 2004
Drinks	Canada, Ottawa-Hull area in 1969	foods purchased	270	Méranger and Smith, 1972
Drinks	Canada, Winnipeg area in 1972	foods purchased	170	Kirkpatrick and Coffin, 1977

Φ All food concentrations are expressed in units of ng/g wet weight, unless otherwise stated.

[a] Calculated from raw data in original study.

[b] High levels in the year 2000 data for meat, poultry and eggs can be largely attributed to the extremely high copper concentrations reported for organ meats. Organ meats were included in previous years' studies, but the average concentration in organ meats between 1993 and 1999 was four fold lower than the 2000 value. Values for meat, poultry and eggs, excluding organ meats, are 1006 and 1,342 ng/g for 1993 to 1999 and 2000, respectively.

[c] All food concentrations are expressed in units of ng/g wet weight, unless otherwise stated.

D-3.4 Nickel

Nickel is present in most foods. In general, nuts, oatmeal, chocolate, legumes, and grains and grain products are high in nickel concentrations (ATSDR, 2003). In particular, nickel has been found in high concentrations in peanuts, peanut butter and other nuts (*e.g.*, JWEL, 2004; Dabeka and McKenzie, 1995).

Selection of Food Database

There are two Canadian market basket studies available for nickel (JWEL, 2004; Dabeka and McKenzie, 1995). Refer to Table D.6 for an overview of these studies, as well as other non-Canadian surveys not used in the HHRA. While food products were analyzed for nickel as part of the Canadian Total Diet Study (CTDS) conducted in 2000, the data were accidentally contaminated by nickel-coated skimming (sampling) cones during analyses (Dabaka, 2005 pers. comm.). As such the 2000 CTDS concentration data for nickel was not usable for the current study.

There was good agreement in nickel concentrations between the 1986-1988 Total Diet Study (Dabeka and McKenzie, 1995) and Port Colborne market basket study (JWEL, 2004) for the categories that were not cooked (*i.e.*, other vegetables; sugars and sweets; fats, nuts and oils; and, beverages) (refer to Table D.6). However, the Port Colborne mean nickel concentrations in the cooked food categories were approximately three times lower than those calculated for those reported in the Canadian Total Diet Study by Dabeka and McKenzie (1995).

However, concern has been expressed (*i.e.*, JWEL, 2004) with the interpretation of the nickel concentrations in the cooked food analyzed in the 1986 to 1988 Canadian Total Food Study (*i.e.*, Dabeka and McKenzie, 1995). The food samples were prepared using new stainless steel frying and roasting pans. Food was analyzed before and after cooking and the results indicated that significant nickel contamination occurred, particularly by roasting some of the meat samples (Dabeka and McKenzie, 1995). Jacques Whitford (JWEL, 2004) conducted an extensive literature review and a series of experiments to explore the role of cooking with stainless steel utensils on the leaching of nickel into food samples. Their review revealed that significant nickel is leached during cooking; however, this contamination decreases to negligible amounts after the first few uses of the utensil (JWEL, 2004). They also conducted a screening-level cooking study with a well-used stainless steel frying pan and ceramic pan. This study demonstrated that the foods were not contaminated by nickel during normal preparation and cooking (use of "well used" stainless steel pan) (JWEL, 2004). Thus, they concluded that contamination of the food items in the Dabeka and McKenzie (1995) study does not appropriately characterize the long term contribution of nickel to the general public from cooking using stainless steel utensils.

The U.S. FDA (2004) also conducted an analysis for nickel in market basket foods. Approximately 320 different food items were sampled for the period 1991 to 2002, from over 36 cities across the United States. The foods were prepared as they would be consumed (table-ready), and twenty samples per food item were combined to form a single analytical composite for each food item. Details of the nature of the cooking of the samples were not available. Nickel was not detected in 23% of the 6,459 samples evaluated. In the calculation of the mean values for each food item, U.S. FDA (2004) used a value of zero for samples with nickel levels below detection. The results of this study were also lower than the Dabeka and McKenzie (1995) analysis, but higher than the Port Colborne analysis (JWEL, 2004). There was good agreement between the JWEL and the U.S. FDA dataset for fish and shellfish, dairy products, root vegetables, other vegetables and fats and oils. For cereals and grains the U.S. FDA data has good agreement with the Dabeka and McKenzie database. All three databases have good agreement for other vegetables.

JWEL (2004) cooked their food samples using ceramic and well used stainless steel cooking utensils. Based on this review, the Port Colborne data was determined to be the most recent and reliable food dataset for a Canadian population. Therefore, the dataset selected for use in the Sudbury HHRA was market basket data sampled from the Port Colborne area (JWEL, 2004) because it fulfilled all of the selection criteria and was found to be the most appropriate for nickel. The Port Colborne data was

sampled in 2002 and for each food item there are between one and 10 samples (this number also includes replicated and duplicates). The Port Colborne market basket study found 16.5% of food items were below the MDL (0.0091 mg/kg dw) (JWEL, 2004). Most samples with non-detectable concentrations of nickel were in the meat, poultry and eggs and the milk and milk products food categories.

Table D.6 Typical Total Nickel Concentrations in Canadian Foods

Food Type	Location	Description	Concentration [Φ]	Reference
Fish and seafood				
Fish and shellfish	Port Colborne	186 food samples (includes replicates and duplicates)	mean: 37 [b]	JWEL, 2004
Fish	Canada, Montreal between 1986 and 1988	6 samples purchased	mean: 125[c] max: 232[c]	Dabeka and McKenzie, 1995
Fish and shellfish	1991 to 2002 Over 36 Cities across U.S.	6459 total food samples	mean: 40 max: 105	U.S. FDA, 2004
Meat / poultry products				
Meat, poultry and eggs (with organ meats)	Port Colborne	186 food samples (includes replicates and duplicates)	mean: 14.5 [b] max: 31	JWEL, 2004
Meat, poultry and eggs (without organ meats	Port Colborne	186 food samples (includes replicates and duplicates)	mean: 15.7 [b] max: 31.0	JWEL, 2004
Meat and poultry	Canada, Montreal between 1986 and 1988	18 samples purchased	mean: 385[c] max: 2,521[c]	Dabeka and McKenzie, 1995
Meat, poultry and eggs	1991 to 2002 Over 36 Cities across U.S.	6459 total food samples	mean: 39 max: 116	U.S. FDA, 2004
Organ meats	1991 to 2002 Over 36 Cities across U.S.	6459 total food samples	mean: 1	U.S. FDA, 2004
Meat, fish and poultry	Canada, Winnipeg area in 1972	foods purchased	240	Kirkpatrick and Coffin, 1977
Milk and dairy products				
Milk and milk products	Port Colborne	186 food samples (includes replicates and duplicates)	mean: 20.5 [b] max: 91	JWEL, 2004
Milk and milk products	Canada, Montreal between 1986 and 1988	13 samples purchased	mean: 63[c] max: 323[c]	Dabeka and McKenzie, 1995
Milk and milk products	1991 to 2002 Over 36 Cities across U.S.	6459 total food samples	mean: 15 max: 101 (chocolate shake)	U.S. FDA, 2004
Milk and dairy	Canada, Winnipeg area in 1972	foods purchased	90	Kirkpatrick and Coffin, 1977
Infant formula				
Milk based	Canada	ready to use	5.8 to 28.9 µg/L	Dabeka, 1989
Soy based	Canada	ready to use	31.2 to 187 µg/L	Dabeka, 1989
Infant formula	1991 to 2002 Over 36 Cities across U.S.	6459 total food samples	mean: 11 max: 23	U.S. FDA, 2004
Cereals, grains and baked goods				

Table D.6 Typical Total Nickel Concentrations in Canadian Foods

Food Type	Location	Description	Concentration Φ	Reference
Cereals, grains and baked goods	Port Colborne	186 food samples (includes replicates and duplicates)	mean: 106 [b] max: 320	JWEL, 2004
Bakery goods and cereals	Canada, Montreal between 1986 and 1988	24 samples purchased	mean: 256[c] max: 1,273[c]	Dabeka and McKenzie, 1995
Cereals, grains and baked goods	1991-2002 Over 36 Cities across U.S.	6459 total food samples	mean: 243 max: 2270 (oat ring cereal)	U.S. FDA, 2004
Cereals	Canada, Winnipeg area in 1972	foods purchased	330	Kirkpatrick and Coffin, 1977
Fruits and fruit juices				
Fruits and fruit juices	Port Colborne	186 food samples (includes replicates and duplicates)	mean: 30.9 [b] max: 130	JWEL, 2004
Fruits and fruit juices	Canada, Montreal between 1986 and 1988	25 samples purchased	mean: 123[c] max: 505[c]	Dabeka and McKenzie, 1995
Fruits and fruit juices	1991-2002 Over 36 Cities across U.S.	6459 total food samples	mean: 85 max: 423	U.S. FDA, 2004
Garden fruits	Canada, Winnipeg area in 1972	foods purchased	540	Kirkpatrick and Coffin, 1977
Fruits	Canada, Winnipeg area in 1972	foods purchased	150	Kirkpatrick and Coffin, 1977
Root vegetables				
Potatoes	Port Colborne	186 food samples (includes replicates and duplicates)	mean: 75 [b]	JWEL, 2004
Root vegetables	1991-2002 Over 36 Cities across U.S.	6459 total food samples	mean: 91 max: 224	U.S. FDA, 2004
Potatoes	Canada, Winnipeg area in 1972	foods purchased	180	Kirkpatrick and Coffin, 1977
Root vegetables	Canada, Winnipeg area in 1972	foods purchased	220	Kirkpatrick and Coffin, 1977
Other vegetables				
Other vegetables	Port Colborne	186 food samples (includes replicates and duplicates)	mean: 173 [b] max: 430	JWEL, 2004
All vegetables	Canada, Montreal between 1986 and 1988	38 samples purchased	mean: 195[c] max: 982[c]	Dabeka and McKenzie, 1995
Other vegetables	1991-2002 Over 36 Cities across U.S.	6459 total food samples	mean: 145 max: 698	U.S. FDA, 2004
Garden vegetables	Canada, 1 rural garden in Fredericton, NB	lettuce, beet tops, carrots and potatoes sampled	means: 500 to 1500 (dw)	Pilgrim and Schroeder, 1997
Garden vegetables	Canada, 9 urban gardens in 2 New Brunswick cities	beet tops sampled	means: 1200 to 3100 (dw)	Pilgrim and Schroeder, 1997
Radishes	Canada, rural gardens in N. Manitoba	sampled	500 to 700	Yee, 2004

Table D.6 Typical Total Nickel Concentrations in Canadian Foods

Food Type	Location	Description	Concentration Φ	Reference
Garden produce	Canada, rural gardens in N. Manitoba	potatoes, carrots, turnips, strawberries, blueberries and mossberries sampled	<100	Yee, 2004
Leafy vegetables	Canada, Winnipeg area in 1972	foods purchased	190	Kirkpatrick and Coffin, 1977
Legumes	Canada, Winnipeg area in 1972	foods purchased	500	Kirkpatrick and Coffin, 1977
Mixed foods				
Soups	Canada, Montreal between 1986 and 1988	4 samples purchased	mean: 291[c] max: 689[c]	Dabeka and McKenzie, 1995
Miscellaneous	Canada, Montreal between 1986 and 1988	7 samples purchased	mean: 101[c] max: 213[c]	Dabeka and McKenzie, 1995
Mixed foods and soups	1991 to 2002 Over 36 Cities across U.S.	6459 total food samples	mean: 131 max: 213	U.S. FDA, 2004
Fats and oils				
Fats and oils	Port Colborne	186 food samples (includes replicates and duplicates)	Range: 15 to 57[b]	JWEL, 2004
Nuts and seeds	Port Colborne	186 food samples (includes replicates and duplicates)	Range: 31 to 2000[b]	JWEL, 2004
Fats and oils	Canada, Montreal between 1986 and 1988	3 samples purchased	mean: 566[c] max: 1,467[c]	Dabeka and McKenzie, 1995
Fats and oils	1991 to 2002 Over 36 Cities across U.S.	6459 total food samples	mean: 27 max: 91	U.S. FDA, 2004
Nuts	1991 to 2002 Over 36 Cities across U.S.	6459 total food samples	mean: 1449 max: 3030	U.S. FDA, 2004
Fats and oils	Canada, Winnipeg area in 1972	foods purchased	1500	Kirkpatrick and Coffin, 1977
Sugars and sweets				
Sugars and Sweets	Port Colborne	186 food samples (includes replicates and duplicates)	mean: 107[b] max: 310 (candy)	JWEL, 2004
Sugar and candies	Canada, Montreal between 1986 and 1988	7 samples purchased	mean: 143[c] max: 577[c]	Dabeka and McKenzie, 1995
Sugars and sweets	1991-2002 Over 36 Cities across U.S.	6459 total food samples	mean: 174 max: 979	U.S. FDA, 2004
Sugars	Canada, Winnipeg area in 1972	foods purchased	300	Kirkpatrick and Coffin, 1977
Beverages				
Alcoholic beverages	Port Colborne	186 food samples (includes replicates and duplicates)	mean: 11.5[b]	JWEL, 2004
Non-alcoholic beverages	Port Colborne	186 food samples (includes replicates and duplicates)	mean: 6.0[b]	JWEL, 2004
Beverages	Canada, Montreal between 1986 and 1988	7 samples purchased	mean: 16[c] max: 52[c]	Dabeka and McKenzie, 1995

Table D.6 Typical Total Nickel Concentrations in Canadian Foods

Food Type	Location	Description	Concentration Φ	Reference
Alcoholic beverages	1991-2002 Over 36 Cities across U.S.	6459 total food samples	mean: 8 max: 25	U.S. FDA, 2004
Non-alcoholic beverages	1991-2002 Over 36 Cities across U.S.	6459 total food samples	mean: 10 max: 39	U.S. FDA, 2004
Drinks	Canada, Winnipeg area in 1972	foods purchased	140	Kirkpatrick and Coffin, 1977

Φ All food concentrations are expressed in units of ng/g wet weight, unless otherwise stated.
[a] All food concentrations are expressed in units of ng/g wet weight, unless otherwise stated.
[b] Calculated from raw data in original study.
c Stainless steel cookware was used extensively in the preparation and cooking of samples, and may have contributed to the reported nickel concentrations.

D-3.5 Lead

Due to it past commercial use patterns, lead is found in most food items (ATSDR, 1999). As a result of the phasing out of leaded gasoline sales in the early 1980s, and the virtual elimination of the use of lead-soldered cans for food storage, lead concentrations in environmental media and food are generally much lower today than in the 1970s and 1980s (ATSDR, 1999).

Selection of Food Database

There were a number of Canadian datasets available for lead, all conducted as part of the Canadian Total Diet Study (CTDS) (Dabeka and McKenzie, 2005 pers. comm.; HC, 2004b; Dabeka and McKenzie, 1995; 1992). Data from these surveys are summarized in Table D.7. The databases selected for use in the Sudbury HHRA were Dabeka and McKenzie (2005, pers. comm.) because it fulfills all of the selection criteria and was found to be the most appropriate for lead.

The CTDS lead results for 1993 through to 1999 (HC, 2004b) could not be used because the accuracy of the data at near-detection limit measurements was poor due to the accidental contamination of the samples (Dabeka, 2005 pers. comm.). The older Total Diet Study results were also not used because lead concentrations in environmental media and biological tissues/fluids are generally much lower today than in the 1970s and 1980s (ATSDR, 1999). In addition, older Canadian diet studies (and presumably other studies in which lead was measured in various media) used analytical techniques that may not have been sensitive enough for the prescribed purpose.

Table D.7 Typical Lead Concentrations in Canadian Foods

Food Type	Location	Description	Concentration Φ	Reference
Fish and seafood				
Fish and shellfish	Canada	mean of 4 food composites	mean: 3.0	Dabeka and McKenzie, 2005 pers. comm.
Fish and shellfish	8 Canadian cities sampled in 1993 to 1999	137 food items	mean: 10.68 max: 20.69	HC, 2004a
Fish	5 Canadian cities sampled in 1986 to 1988	113 composites of 39 foods	mean: 19.3 max: 72.8	Dabeka and McKenzie, 1995
Fish	Canada, Ottawa/Hull region, Ottawa/Hull area	2 x 105 food composites sampled	mean: 21.2	Dabeka and McKenzie, 1992
Meat / poultry products				
Meat, poultry and eggs	Canada sampled in 2000	mean of 14 food composites	mean: 5.2	Dabeka and McKenzie, 2005 pers. comm.
Meat, poultry and eggs	8 Canadian cities sampled in 1993 to 1999	137 food items	mean: 13.11 max: 35.33	HC, 2004a
Meat and poultry	5 Canadian cities sampled in 1986 to 1988	113 composites of 39 foods	mean: 20.2 max: 523.4	Dabeka and McKenzie, 1995
Canned luncheon meat	5 Canadian cities sampled in 1986 to 1988		mean: 163	Dabeka and McKenzie, 1995
Meat and poultry	Canada, Ottawa/Hull region in 1985	2 x 105 food composites sampled	mean: 18.5	Dabeka and McKenzie, 1992
Milk and dairy products				
Milk and milk products	Canada	mean of 12 food composites	mean: 2.8	Dabeka and McKenzie, 2005 pers. comm.
Milk and milk products	8 Canadian cities	137 food items	mean: 4.87 max: 14.22	HC, 2004a
Milk and milk products	5 Canadian cities sampled in 1986 to 1988	113 composites of 39 foods	mean: 7.7 max: 44.7	Dabeka and McKenzie, 1995
Milk and Dairy Products	Canada, Ottawa/Hull region in 1985	2 x 105 food composites sampled	mean: 6.58	Dabeka and McKenzie, 1992
Infant formula	Canada	mean of 2 food composites	mean: 1.6	Dabeka and McKenzie, 2005 pers. comm.
Infant formula	Canada	137 food items	mean: 3.7 max: 4.99	HC, 2004a
Infant formula (ready-to-use)	Canada	49 samples	mean: 1.58 max: 6.08	Dabeka, 1989
Infant formula (concentrated)	Canada	50 samples	mean: 3.67 max: 75.3	Dabeka, 1989
Infant formula (powdered)	Canada	64 samples	mean: 12.56 max: 57.3	Dabeka, 1989
Evaporated milk (lead-free solder)	Canada	8 samples	mean: 2.83 max: 5.17	Dabeka, 1989

Table D.7 Typical Lead Concentrations in Canadian Foods

Food Type	Location	Description	Concentration Φ	Reference
Evaporated milk (lead-soldered)	Canada	13 samples	mean: 94.9 max: 300	Dabeka, 1989
Cereals, grains and baked goods				
Cereal/grain products and baked goods	Canada	mean of 21 food composites	mean: 7.5	Dabeka and McKenzie, 2005 pers. comm.
Cereals, grains and baked goods	8 Canadian cities	137 food items	mean: 11.94 max: 33.51	HC, 2004a
Bakery goods and cereals	5 Canadian cities sampled in 1986 to 1988	113 composites of 39 foods	mean: 13.7 max: 66.4	Dabeka and McKenzie, 1995
Bakery goods and cereals	Canada, Ottawa/Hull region in 1985	2 x 105 food composites sampled	mean: 23.5	Dabeka and McKenzie, 1992
Fruits and fruit juices				
Fruit and fruit products	Canada	mean of 20 food composites	mean: 6.9	Dabeka and McKenzie, 2005 pers. comm.
Fruit and fruit Products	8 Canadian cities	137 food items	mean: 11.10 max: 63.97	HC, 2004a
Fruits and fruit juice	5 Canadian cities sampled in 1986 to 1988	113 composites of 39 foods	mean: 44.4 max: 372.7	Dabeka and McKenzie, 1995
Canned and raw cherries	5 Canadian cities sampled in 1986 to 1988		mean: 203	Dabeka and McKenzie, 1995
Canned citrus	5 Canadian cities sampled in 1986 to 1988		mean: 126	Dabeka and McKenzie, 1995
Fruits and fruit juices	Canada, Ottawa/Hull region in 1985	2 x 105 food composites sampled	mean: 60.7	Dabeka and McKenzie, 1992
Root vegetables				
Root vegetables	Canada	mean of 6 food composites	mean: 5.6	Dabeka and McKenzie, 2005 pers. comm.
Root vegetables	8 Canadian cities	137 food items	mean: 5.46 max: 9.41	HC, 2004a
Other vegetables				
Other vegetables	Canada	mean of 15 food composites	mean: 4.7	Dabeka and McKenzie, 2005 pers. comm.
Other vegetables	8 Canadian cities	137 food items	mean: 9.38 max: 35.65	HC, 2004a
Vegetables	5 Canadian cites sampled in 1986 to 1988	113 composites of 39 foods	mean: 24.4 max: 331.7	Dabeka and McKenzie, 1995
Canned beans	5 Canadian studies sampled in 1986 to 1988		mean: 158	Dabeka and McKenzie, 1995

Table D.7 Typical Lead Concentrations in Canadian Foods

Food Type	Location	Description	Concentration Φ	Reference
Vegetables	Canada, Ottawa/Hull region in 1985	2 x 105 food composites sampled	mean: 29.3	Dabeka and McKenzie, 1992
Fats and oils				
Fats, oils and peanut butter	Canada	mean of 4 food composites	4.6	Dabeka and McKenzie, 2005 pers. comm.
Fats, oils and peanuts	8 Canadian cities	137 food items	mean: 18.20 max: 23.88	HC, 2004a
Fats and oils	5 Canadian cities sampled in 1986 to 1988	113 composites of 39 foods	mean: 9.6 max: 19.7	Dabeka and McKenzie, 1995
Fats and Oils	Canada, Ottawa/Hull region	2 x 105 food composites sampled in 1985 in Ottawa/Hull area	mean: 8.1	Dabeka and McKenzie, 1992
Sugars and sweets				
Sugar, candy and desserts	Canada	mean of 9 food composites	mean: 18.0	Dabeka and McKenzie, 2005 pers. comm.
Sugar, candy and desserts	8 Canadian cities	137 food items	mean: 8.17 max: 17.72	HC, 2004a
Sugar and candies	5 Canadian cites sampled in 1986 to 1988	113 composites of 39 foods	mean: 18.3 max: 111.6	Dabeka and McKenzie, 1995
Sugar and candies	Canada, Ottawa/Hull region in 1985	2 x 105 food composites sampled	mean: 32.8	Dabeka and McKenzie, 1992
Beverages				
Non-alcoholic drinks	Canada	mean of 4 food composites	mean: 1.5	Dabeka and McKenzie, 2005 pers. comm.
Alcoholic drinks	Canada	mean of 2 food composites	mean: 9.0	Dabeka and McKenzie, 2005 pers. comm.
Non-alcoholic drinks	8 Canadian cities	137 food items	mean: 1.64 max: 2.83	HC, 2004a
Alcoholic drinks	8 Canadian cities	137 food items	mean: 15.51 max: 29.46	HC, 2004a
Beverages	5 Canadian cites sampled in 1986 to 1988	113 composites of 39 foods	mean: 9.9 max: 88.8	Dabeka and McKenzie, 1995
Beverages	Canada, Ottawa/Hull region in 1985	2 x 105 food composites sampled	mean: 47.4	Dabeka and McKenzie, 1992
Other				

Table D.7 Typical Lead Concentrations in Canadian Foods

Food Type	Location	Description	Concentration Φ	Reference
Miscellaneous	8 Canadian cities	137 food items	mean: 55.37 max: 704.48 (Frozen beef dinner)	HC, 2004a
Miscellaneous	5 Canadian cites sampled in 1986 to 1988	113 composites of 39 foods	mean: 41.7 max: 178.9	Dabeka and McKenzie, 1995
Soups	5 Canadian cities sampled in 1986 to 1988	113 composites of 39 foods	mean: 15.5 max: 48.7	Dabeka and McKenzie, 1995
Soups	Canada, Ottawa/Hull region in 1985	2 x 105 food composites sampled	mean: 26.3	Dabeka and McKenzie, 1992

Φ All food concentrations are expressed in units of ng/g wet weight, unless otherwise stated.
[a] All food concentrations are expressed in units of ng/g wet weight, unless otherwise stated.

D-3.6 Selenium

The most important pathway for selenium exposure to the general public is food, followed by water, then air (ATSDR, 2003). Selenium is a micronutrient and is found in many food items. Selenium supplements are also available and commonly used by a portion of the general population. These supplements generally contain 10 to 25 µg Se/tablet as inorganic selenium or selenomethionine, although some tablets with up to 200 µg/tablet are available (Goodman *et al*., 1990). In general, fish and seafood, and meats contain the highest concentrations of selenium, cereals have intermediate levels, and fruits and vegetables generally contain the lowest levels (ATSDR, 2003). Brazil nuts are reported to contain very high levels of selenium since they grow in the foothills of the Andes Mountains, where the soils are high in selenium (Secor and Lisk, 1989).

Selection of Food Database

No Canadian food data for selenium were found in the published literature. A recent survey conducted by the U.S. FDA, which analyzed foods consumed in the United States during the period of 1991 to 2004, detected selenium in 5,586 out of 10,026 food samples (U.S. FDA, 2004) (see Table D.8). The Canadian Nutrient File (2001) contained data on the selenium content of foods; however, the data were derived from American sources (*i.e*., United States Department of Agriculture) and were reported in a manner that is inconsistent with the purpose of the Sudbury HHRA (*e.g.*, g/cup; g/8 nuts; g/sandwich). Thus, the FDA (2004) data were selected as the dataset to use in the Sudbury HHRA because of the robustness of the dataset (>10,000 food samples) and the lack of suitable Canadian alternatives. The mean selenium values reported by the FDA assumed that any non-detectable values were equal to zero concentration of

selenium. For the purpose of this study, the recalculated UCLs on the mean assumed that non-detectable values were equal to half the detection limit.

Table D.8 Typical Selenium Concentrations in Canadian Foods

Food Type	Location	Description	Concentration [a]	Reference
Fish and seafood				
Fish and seafood	U.S., 1991 to 2004	mean of fish and seafood samples collected; 5 different foods	mean: 388	U.S. FDA, 2004 [b]
Meat / poultry products				
Meat, poultry and eggs	U.S., 1991 to 2004	mean of meat *etc*. samples collected; 23 different foods	mean: 268	U.S. FDA, 2004
Milk and dairy products				
Dairy	U.S., 1991 to 2004	mean of dairy samples collected; 17 different foods	mean: 64	U.S. FDA, 2004
Infant formula	U.S., 1991 to 2004	mean of dairy samples collected; 2 different foods	mean: 20	U.S. FDA, 2004
Cereals, grains and baked goods				
Cereals, grains and baked goods	U.S., 1991 to 2004	mean of cereal *etc*. samples collected; 33 different foods	mean: 130	U.S. FDA, 2004
Fruits and fruit juices				
Fruit and fruit juices	U.S., 1991 to 2004	mean of fruit samples collected; 28 different foods	mean: 0.8	U.S. FDA, 2004
Root vegetables				
Root vegetables	U.S., 1991 to 2004	mean of root vegetable samples collected; 16 different foods	mean: 3.2	U.S. FDA, 2004
Other vegetables				
All types of vegetables	U.S., 1991 to 2004	mean of vegetables samples collected; 45 different foods	mean: 10	U.S. FDA, 2004
Fats and oils				
Fats, oils and peanuts	U.S., 1991 to 2004	mean of samples collected; 9 different foods	mean: 28	U.S. FDA, 2004
Sugars and sweets				
Sugar, desserts and candy	U.S., 1991 to 2004	mean of samples collected; 24 different foods	mean: 29	U.S. FDA, 2004
Beverages				
Alcoholic beverages	U.S., 1991 to 2004	means of samples collected; 4 different foods	mean: 0.8	U.S. FDA, 2004
Non-alcoholic beverages	U.S., 1991 to 2004	means of samples collected; 9 different foods	mean: 0.6	U.S. FDA, 2004
Other				
Mixed foods (*e.g.*, soup, casserole, pizza)	U.S., 1991 to 2004	mean of mixed food samples collected; 28 different foods	mean: 120	U.S. FDA, 2004

Table D.8 Typical Selenium Concentrations in Canadian Foods

Food Type	Location	Description	Concentration [a]	Reference

[a] All food concentrations are expressed in units of ng/g wet weight, unless otherwise stated.
[b] Analyses have been performed on foods that are prepared as they would be consumed (table-ready)

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Appendix D1:

Food Categories Used In The Derivation Of The EDI_{MB}

APPENDIX D1: FOOD CATEGORIES USED IN THE DERIVATION OF THE EDI_{MB}

Composite Food items included in Food Categories φ*

φ Categorization of food items are based on Richardson (1997); all additional items are highlighted

* Codes are primarily based on Dabeka and McKenzie (1995). All items that have since been added to the Canadian Total Diet Study are highlighted in grey and the new code is listed.

Dairy Products	**Fish/Shellfish**
1 Milk, whole	24 Marine fish, cooked
2 Milk, 2%	25 Freshwater fish, cooked
3 Milk, skim	26 Fish, canned
4 Evaporated milk, canned	27 Shellfish
5 Cream	
6 Ice cream, mixed	
7 Yogurt, mixed	
8 Cheese	
9 Cottage cheese	
10 Cheese, processed	
11 Butter	
AA03 milk, 1%	

Other Vegetables	**Sugar and Candies**
51 Corn, raw and canned, cooked	95 Sugar
58 Cabbage, cooked and coleslaw	96 Syrup
59 Celery	97 Jams
60 Peppers, green and red	98 Honey
61 Lettuce	99 Pudding, chocolate from powder
62 Cauliflower, raw and cooked	100 Candy, chocolate
63 Broccoli, raw and cooked	101 Candy, other
64 Beans, raw and canned, cooked	111 Gelatin, dessert
65 Peas, raw and canned, cooked	LL02 Infants: dessert
69 Tomatoes, raw and cooked	
71 Tomatoes, canned, ketchup, sauce	
72 Mushrooms, raw	
73 Cucumber, raw, pickled	
108 Baked beans	
MM01 popcorn	
LL09 Infant: Veg, peas	
Fats and Oils	**Nuts and Seeds**
92 Cooking fats and salad oils	94 Peanut butter and peanuts
93 Margarine	J10 Seeds, shelled

Bakery Goods and Cereals	**Meat, Poultry and Eggs**
32 White bread, all	12 Beef steak, cooked
33 Bread, whole wheat and rye	13 Roast beef
34 Bread rolls and biscuits	14 Ground beef, cooked
35 Wheat flour	15 Pork, cooked
36 Cake, white, yellow, chocolate	16 Pork, cured
37 Cookies, all	17 Veal, cooked
38 Danish and donuts	18 Lamb, cooked
39 Crackers	19 Poultry, cooked
40 Waffles and pancakes	20 Eggs
41 Cooked wheat cereal	22 Cold cuts, luncheon meats
42 Oatmeal cereal	23 Luncheon meat, canned
43 Corn cereal	110 Wieners
44 Wheat and bran cereals	NN03 hamburger
45 Rice cereal, cooked	NN04 chicken burger
49 Pasta, canned	NN05 hotdog
50 Pasta, plain, cooked	NN06 chicken, nuggets
107 Bran muffins, plain	CC03 Poultry pate
LL01 Infant:Cereal mixed	LL08 Infant: Meat, poultry, eggs
Formulae	
LL05 Formulae, milk-based	
LL05 Formulae, soya-based	

Root Vegetables	Fruit and Fruit Juices
52 Potatoes, raw	74 Citrus fruit, raw
53 Potatoes, baked	75 Citrus fruit, canned
54 Potatoes, boiled, skins	76 Citrus juice
55 Potatoes, peeled, boiled	77 Citrus juice, canned
56 French fries	78 Apples
57 Potato chips	79 Apple juice, canned
66 Carrots cooked	80 Apple sauce
67 Onions, cooked	81 Bananas
68 Turnips, rutabagas	82 Grapes
112 Beets, raw and canned, cooked	83 Grape juice, bottled
	84 Peaches, canned and raw
	85 Pears, raw, canned
	86 Plums, prunes, dried, canned
	87 Cherries, raw and canned
	88 Melons
	89 Strawberries
	90 Blueberries
	91 Pineapple, canned
	46 Apple pie
	47 Pie, others, mix
	109 Raisins
	LL07 Infant: fruit, apple or peach

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Appendix D2:

Summary Statistics Used In The Derivation Of The Sudbury Market Basket EDI

APPENDIX D2: SUMMARY STATISTICS USED IN THE DERIVATION OF THE SUDBURY MARKET BASKET EDI

The following tables (D2.1 through D2.6) provide the summary statistics used in the derivation of the Sudbury Market Basket EDI for each of the COC. The actual raw data used to generate these statistics are provided in detailed tables on the CD attached to this Volume.

Table D2.1 Summary Statistics for Arsenic used in the Derivation of the Sudbury Market Basket EDI

Sample Statistics	Dairy Products	Meat, Poultry and Eggs	Meat, Poultry and Eggs (without organ meats)	Fish/Shellfish	Bakery Goods and Cereals	Root Vegetables	Other Vegetables	Fruit and Fruit Juices	Fats and Oils	Nuts and Seeds	Sugar and Candies
UCL on mean (ng/g)	**6.7**	**33.6**	**15.2**	**2071.7**	**28.1**	**10.2**	**22.1**	**6.7**	**26.7**	**21.4**	**22.6**
Recommendation 1	Data are Non-parametric (0.05)	Data are lognormal (0.05)	Data follow gamma distribution (0.05)	Data are normal (0.05)	Data are Non-parametric (0.05)	Assuming gamma distribution (0.05)	Data are Non-parametric (0.05)	Data follow gamma distribution (0.05)	Data are normal (0.05)	Data are normal (0.05)	Data are Non-parametric (0.05)
Recommendation 2	Use 97.5% Chebyshev (Mean, Sd) UCL	Use H-UCL	Use Approximate Gamma UCL	Use Student's-t UCL	Use 97.5% Chebyshev (Mean, Sd) UCL	Use Approximate Gamma UCL	Use 97.5% Chebyshev (Mean, Sd) UCL	Use Approximate Gamma UCL	Use Student's-t UCL	Use Student's-t UCL	Use 97.5% Chebyshev (Mean, Sd) UCL
Number of Valid Samples	74.0	87.0	80.0	28.0	117.0	65.0	94.0	139.0	14.0	6.0	52.0
Number of Unique Samples	42.0	57.0	51.0	27.0	74.0	45.0	57.0	87.0	13.0	6.0	35.0
Minimum	0.1	0.7	0.7	77.0	0.1	0.1	0.1	0.1	0.6	6.6	1.3
Maximum	26.0	536.0	100.0	4830.0	121.0	44.0	206.0	41.0	57.0	26.0	105.0
Mean	3.4	29.3	12.6	1683.6	15.2	7.8	8.0	5.7	18.7	15.4	9.0
Median	1.5	8.9	8.8	1360.0	9.0	5.2	3.4	3.8	16.5	14.0	4.4
Standard Deviation	4.6	77.6	14.9	1205.9	22.4	8.4	21.9	6.8	16.9	7.4	15.8
Variance	20.8	6026.6	222.7	1 454 187.7	501.1	71.1	481.6	46.3	285.2	54.4	248.7
Coefficient of Variation	1.3	2.7	1.2	0.7	1.5	1.1	2.7	1.2	0.9	0.5	1.8
Skewness	2.8	5.0	3.5	0.9	3.4	2.1	8.1	2.6	0.9	0.5	4.8

Table D2.2 Summary Statistics for Cobalt used in the Derivation of the Sudbury Market Basket EDI

Sample Statistics	Dairy Products	Meat, Poultry and Eggs	Meat, Poultry and Eggs (without organ meats)	Fish/Shellfish	Bakery Goods and Cereals	Root Vegetables	Other Vegetables	Fruit and Fruit Juices	Fats and Oils	Nuts and Seeds	Sugar and Candies	Infant Formula

UCL on mean (ng/g)	**10.4**	**13.6**	**10.8**	**9.3**	**24.8**	**32.9**	**13.4**	**25.5**	**22.4**	**62.9**	**23.8**	**4.6**
Recommendation 1	Data are Non-parametric (0.05)	Data are Non-parametric (0.05)	Data are Non-parametric (0.05)	Data follow gamma distribution (0.05)	Data are Non-parametric (0.05)	Data are Non-parametric (0.05)	Data are Non-parametric (0.05)	Data are Non-parametric (0.05)	Data are Non-parametric (0.05)	Data are normal (0.05)	Data are Non-parametric (0.05)	Data are normal (0.05)
Recommendation 2	Use 95% Chebyshev (Mean, Sd) UCL	Use 95% Chebyshev (Mean, Sd) UCL	Use 95% Chebyshev (Mean, Sd) UCL	Use Approximate Gamma UCL	Use 95% Chebyshev (Mean, Sd) UCL	Use 97.5% Chebyshev (Mean, Sd) UCL	Use 95% Chebyshev (Mean, Sd) UCL	Use 95% Chebyshev (Mean, Sd) UCL	Use 95% Chebyshev (Mean, Sd) UCL	Use Student's-t UCL	Use 95% Chebyshev (Mean, Sd) UCL	Use Student's-t UCL
Number of Valid Samples	107.0	169.0	161.0	43.0	155.0	85.0	150.0	192.0	16.0	18.0	80.0	18.0
Number of Unique Samples	107.0	169.0	161.0	43.0	149.0	85.0	150.0	189.0	14.0	18.0	75.0	18.0
Minimum	0.0	0.0	0.0	2.9	0.0	0.8	0.0	0.0	0.0	36.6	0.0	1.5
Maximum	46.3	87.5	87.5	19.7	109.2	176.3	110.2	716.4	49.3	85.8	79.2	8.2
Mean	7.3	9.7	8.0	8.2	17.4	17.4	9.3	9.2	8.4	57.1	13.6	3.8
Median	3.6	6.5	6.1	7.3	8.8	12.5	5.8	3.0	3.9	56.8	5.3	3.3
Standard Deviation	7.4	11.6	8.2	4.0	21.2	22.9	11.5	51.7	12.8	14.2	20.9	1.9
Variance	55.4	133.6	67.1	15.8	448.5	525.8	131.6	2670.1	164.9	201.2	437.6	3.5
Coefficient of Variation	1.0	1.2	1.0	0.5	1.2	1.3	1.2	5.6	1.5	0.2	1.5	0.5
Skewness	2.1	3.8	6.2	1.2	2.4	4.5	5.2	13.6	2.5	0.5	2.1	0.8

Table D2.3 Summary Statistics for Copper used in the Derivation of the Sudbury Market Basket EDI

Sample Statistics	**Dairy Products**	**Meat, Poultry and Eggs**	**Meat, Poultry and Eggs (without organ meats)**	**Fish/ Shellfish**	**Bakery Goods and Cereals**	**Root Vegetables**	**Other Vegetables**	**Fruit and Fruit Juices**	**Fats and Oils**	**Nuts and Seeds**	**Sugar and Candies**	**Infant Formula**
UCL on mean (ng/g)	**357.0**	**7261.7**	**1060.2**	**1320.9**	**1788.3**	**1069.4**	**1238.9**	**1743.0**	**251.1**	**13990.1**	**1397.3**	**899.2**
Recommendation 1	Data are Non-parametric (0.05)	Data are Non-parametric (0.05)	Data follow gamma distribution (0.05)	Data are Non-parametric (0.05)	Data are Non-parametric (0.05)	Assuming gamma distribution (0.05)	Data are Non-parametric (0.05)	Data are Non-parametric (0.05)	Data follow gamma distribution (0.05)	Assuming gamma distribution (0.05)	Data are Non-parametric (0.05)	Data are Non-parametric (0.05)

Recommendation 2	Use 97.5% Chebyshev (Mean, Sd) UCL	Use 95% Chebyshev (Mean, Sd) UCL	Use Approximate Gamma UCL	Use 95% Chebyshev (Mean, Sd) UCL	Use 95% Chebyshev (Mean, Sd) UCL	Use Approximate Gamma UCL	Use 95% Chebyshev (Mean, Sd) UCL	Use 95% Chebyshev (Mean, Sd) UCL	Use Approximate Gamma UCL	Use Approximate Gamma UCL	Use 97.5% Chebyshev (Mean, Sd) UCL	Use Student's-t UCL or Modified-t UCL
Number of Valid Samples	107.0	169.0	161.0	43.0	155.0	85.0	149.0	192.0	16.0	18.0	80.0	18.0
Number of Unique Samples	106.0	169.0	161.0	43.0	155.0	85.0	149.0	192.0	16.0	18.0	80.0	18.0
Minimum	20.4	316.9	316.9	288.6	303.6	157.5	138.1	43.5	1.3	4570.3	23.5	547.5
Maximum	1717.8	135 302.0	3331.7	2869.9	8642.9	5414.7	6950.0	38 571.4	640.3	23 887.5	4593.5	1622.1
Mean	204.4	3152.3	1008.9	854.9	1399.3	930.5	904.0	848.7	137.7	11 027.8	658.3	789.1
Median	91.2	965.2	947.8	604.2	1084.3	707.7	572.7	470.3	93.2	10 109.4	224.5	723.8
Standard Deviation	252.8	12256.1	412.7	701.1	1110.9	852.1	937.8	2842.8	165.7	5953.0	1058.4	254.9
Variance	6.4E+04	1.5E+08	1.7E+05	4.9E+05	1.2E+06	7.3E+05	8.8E+05	8.1E+06	2.7E+04	3.5E+07	1.1E+06	6.5E+04
Coefficient of Variation	1.2	3.9	0.4	0.8	0.8	0.9	1.0	3.3	1.2	0.5	1.6	0.3
Skewness	2.8	8.4	2.0	1.5	2.9	2.7	3.0	12.4	2.1	0.5	2.3	2.4

Note: ProUCL disregarded zero values. Fats and Oils had two zero values.

Table D2.4 Summary Statistics for Nickel used in the Derivation of the Sudbury Market Basket EDI

Summary Statistics	Dairy Products	Meat, Poultry and Eggs	Meat, Poultry and Eggs (without organ meats)	Fish/Shellfish	Bakery Goods and Cereals	Root Vegetables	Other Vegetables	Fruit and Fruit Juices	Fats and Oils	Nuts and Seeds	Sugar and Candies	Formula
UCL on mean (ng/g)	**15.0***	**20.6**	**22.4**	**37.0**	**165.0**	**75.0**	**280.0**	**79.5**	**57.0**	**2000.0**	**272.2**	**11.0**
Recommendation 1	**Data are Non-parametric (0.05)**	Data are normal (0.05)	Data are normal (0.05)	Too Few Observations To Calculate UCLs	Data are normal (0.05)	Too Few Observations To Calculate UCLs	Data are normal (0.05)	Data follow gamma distribution (0.05)	Too Few Observations To Calculate UCLs	Too Few Observations To Calculate UCLs	Data are normal (0.05)	Too Few Observations To Calculate UCLs
Recommendation 2	Use 95% Chebyshev (Mean, Sd) UCL	Use Student's-t UCL	Use Student's-t UCL		Use Student's-t UCL		Use Student's-t UCL	Use Approximate Gamma UCL	Used Max	Used Max	Use Student's-t UCL	
Number of Valid Samples	5.0	8.0	7.0		9.0		8.0	8.0	2.0	11.0	4.0	
Number of Unique Samples	3.0	7.0	6.0		8.0		7.0	8.0	2.0	11.0	4.0	
Minimum	4.3	5.9	7.7		1.2		5.7	3.4	15.0	31.0	4.5	
Maximum	15.0	31.0	31.0		320.0		430.0	130.0	57.0	2000.0	310.0	
Mean	6.5	14.5	15.7		105.7		173.0	30.9	36.0	1015.5	102.9	
Median	4.3	10.2	12.0		81.0		152.0	11.6			48.6	
Standard Deviation	4.8	9.1	9.1		95.7		159.7	42.9			143.9	
Variance	22.8	83.7	83.7		9 166.3		25 512.6	1842.8			20 694.9	
Coefficient of Variation	0.7	0.6	0.6		0.9		0.9	1.4			1.4	
Skewness	2.2	1.0	0.8		1.5		0.6	2.2			1.6	

Note: All original data is the mean for the food item reported by JWEL (2004). Non-detects = 1/2 dl
* The maximum value (shaded in grey) was used in the model when the 95% UCL on the arithmetic mean was greater than the maximum value reported for the food group.

Table D2.5 Summary Statistics for Lead used in the Derivation of the Sudbury Market Basket EDI

Summary Statistics	Dairy Products	Meat, Poultry and Eggs	Meat, Poultry and Eggs (without organ meats)	Fish/Shellfish	Bakery Goods and Cereals	Root Vegetables	Other Vegetables	Fruit and Fruit Juices	Fats and Oils	Nuts and Seeds	Sugar and Candies
UCL on mean (ng/g)	**6.0**	**7.2**	**6.6**	6.9*	**12.0**	**7.3**	**5.0**	**14.3**	0.4	13.5	**40.5**
Recommendation 1	Assuming gamma distribution (0.05)	Data follow gamma distribution (0.05)	Data follow gamma distribution (0.05)	Data follow gamma distribution (0.05)	Assuming gamma distribution (0.05)	Data are normal (0.05)	Data are normal (0.05)	Data are lognormal (0.05)	Too Few Observations To Calculate UCLs	Too Few Observations To Calculate UCLs	Data follow gamma distribution (0.05)
Recommendation 2	Use Approximate Gamma UCL	Use Approximate Gamma UCL	Use Approximate Gamma UCL	Use Approximate Gamma UCL	Use Approximate Gamma UCL	Use Student's-t UCL	Use Student's-t UCL	Use 95% Chebyshev (MVUE) UCL	Used Max	Used Max	Use Approximate Gamma UCL
Number of Valid Samples	12.0	19.0	18.0	4.0	16.0	7.0	16.0	18.0	2.0	2.0	8.0
Number of Unique Samples	11.0	18.0	17.0	4.0	16.0	7.0	16.0	18.0	2.0	2.0	8.0
Minimum	0.2	0.7	0.7	1.4	1.8	2.1	1.0	1.0	0.4	1.9	0.6
Maximum	11.8	17.4	17.4	6.9	33.6	10.4	7.4	41.0	0.4	13.5	47.8
Mean	2.8	5.1	4.7	3.0	7.9	4.9	4.2	7.1	0.4	7.7	14.2
Median	0.9	3.5	3.5	1.8	4.7	3.6	4.1	3.1			5.0
Standard Deviation	3.9	4.5	4.2	2.7	8.5	3.3	1.8	10.5			18.0
Variance	15.3	20.6	17.7	7.1	71.9	10.9	3.2	110.0			323.1
Coefficient of Variation	1.4	0.9	0.9	0.9	1.1	0.7	0.4	1.5			1.3
Skewness	1.6	1.7	2.1	1.9	2.2	1.0	0.2	2.5			1.4

* The maximum value (shaded in grey) was used in the model when the 95% UCL on the arithmetic mean was greater than the maximum value reported for the food group.

Table D2.6 Summary Statistics for Selenium used in the Derivation of the Sudbury Market Basket EDI

Summary Statistics	Dairy Products	Meat, Poultry and Eggs	Meat, Poultry and Eggs (without organ meats)	Fish/Shellfish	Bakery Goods and Cereals	Root Vegetables	Other Vegetables	Fruit and Fruit Juices	Fats and Oils	Nuts and Seeds	Sugar and Candies	Formula
UCL on mean (ng/g)	**71.6**	**263.9**	**247.1**	**425.6**	**134.0**	**13.9**	**23.3**	**9.2**	**25.3**	**315.8**	**20.7**	**23.0**
Recommendation 1	Data are Non-parametric (0.05)	Data are Non-parametric (0.05)	Data are Non-parametric (0.05)	Data are Non-parametric (0.05)	Data are Non-parametric (0.05)	Data are Non-parametric (0.05)	Data are Non-parametric (0.05)	Data are Non-parametric (0.05)	Data are Non-parametric (0.05)	Data are lognormal (0.05)	Data are Non-parametric (0.05)	
Recommendation 2	Use 95% Chebyshev (Mean, Sd) UCL	Use 95% Chebyshev (Mean, Sd) UCL	Use 95% Chebyshev (Mean, Sd) UCL	Use 95% Chebyshev (Mean, Sd) UCL	Use 95% Chebyshev (Mean, Sd) UCL	Use 95% Chebyshev (Mean, Sd) UCL	Use 95% Chebyshev (Mean, Sd) UCL	Use 95% Chebyshev (Mean, Sd) UCL	Use 95% Chebyshev (Mean, Sd) UCL	Use H-UCL	Use 95% Chebyshev (Mean, Sd) UCL	
Number of Valid Samples	689.0	1161.0	1123.0	193.0	1720.0	599.0	1601.0	1385.0	312.0	114.0	546.0	115.0
Number of Unique Samples	164.0	423.0	394.0	150.0	361.0	34.0	131.0	38.0	52.0	91.0	57.0	25.0
Minimum	5.0	13.0	13.0	76.0	0.0	4.0	3.5	3.0	5.0	23.0	4.5	5.0
Maximum	369.0	1220.0	836.0	1043.0	564.0	217.0	457.0	54.0	184.0	1800.0	110.0	37.0
Mean	60.7	245.8	232.2	357.7	123.2	11.7	19.9	8.3	20.8	247.3	17.8	22.0
Median	31.0	219.0	214.0	289.0	90.0	6.0	5.0	5.0	10.0	143.5	10.0	22.0
Standard Deviation	65.5	141.7	114.8	216.5	102.3	12.6	30.9	7.2	18.0	285.2	15.4	6.0
Variance	4283.8	20092.6	13180.1	46866.6	10467.2	158.2	956.5	51.3	324.6	81366.0	238.1	36.6
Coefficient of Variation	1.1	0.6	0.5	0.6	0.8	1.1	1.6	0.9	0.9	1.2	0.9	0.3
Skewness	1.9	2.0	1.2	1.1	1.1	8.2	4.6	2.0	3.2	2.5	1.8	-0.7