2019 Garden Produce Sampling Program

Analysis of Pb in Homegrown Produce in Trail, BC

Prepared for:

Teck Metals Ltd.

January 12, 2021

Internal Ref: 655246 › Final

Signature Page

Prepared By:

Andrea McCormick, BSc, P.Ag.
Project Scientist

Environment & Geoscience
Engineering, Design & Project Management

Bruce Enns, BSc
Trail Operations Manager / Specialist

Environment & Geoscience
Engineering, Design & Project Management

Reviewed By:

Tony Gillett, P.Eng., CSAP
Senior Environmental Engineer, Site Assessment & Remediation

Environment & Geoscience
Engineering, Design & Project Management

Tara Siemens-Kennedy, MET, PChem, CSAP
Senior Risk Assessment and Toxicologist

Environment & Geoscience
Engineering, Design & Project Management

Executive Summary

The 2019 Garden Produce Sampling Program was completed to obtain updated garden produce lead (Pb) concentrations in Trail, BC. The updated results show that there has been a statistically significant decrease in the mean Pb concentration in fruit and leafy homegrown garden produce compared with previous studies conducted between 2007 and 2013. A similar comparison of mean Pb in root produce did not show a statistically significant decline when compared to the earlier results.

Previous studies of garden produce Pb concentrations did not determine the relative influence of Pb from ambient air (i.e., deposition of contemporary smelter air emissions directly onto plants) versus Pb in soil (from historical deposition of smelter emissions onto soils). The notably higher levels in leaf vegetables in previous studies raised the hypothesis that ambient air concentrations may be influencing produce concentrations. With ongoing improvements to air quality in Trail and the implementation of Fugitive Dust Reduction Programs (FDRP) in 2012 there was an opportunity to obtain updated data to evaluate if Pb concentrations in garden produce have improved in recent years as a result of improved air quality. Based on the findings in the 2019 Garden Produce Sampling Program, it appears that the significantly lower Pb concentrations in leaf and fruit produce are the result of substantial air quality improvements made by Teck.

While soil Pb concentrations were found to be correlated to garden produce Pb concentrations, this relationship only explains a small amount (1 to 14%) of the variation seen in the produce Pb concentrations. When produce Pb is considered along with soil phosphorus (P), P helped explain up to 30% of produce Pb variation in root crops but was less important for fruit (15%) and no relationship was found for leaf crops. These observations are consistent with the hypothesis that Pb in locally grown produce is derived primarily from deposition of contemporary air emissions, rather than uptake from soil, particularly in the case of fruit and leaf crops.

Overall, the available data are not sufficient to draw firm conclusions on whether garden produce is a key contributor to blood Pb concentrations in Trail, BC; however, the Pb concentrations in the garden produce tested do exceed the maximum levels (MLs) recommended by the Food and Agriculture Organization of the United Nations/World Health Organization (FAO/WHO, 2015) and the European Community (EC, 2006). By comparison, locally available commercial produce had lower produce Pb concentrations, with concentrations below the WHO and EC MLs.

Preliminary exposure calculations based on the 2019 data indicate the potential for the measured produce Pb concentrations to contribute to blood Pb where children are consuming garden produce, particularly select root crops (i.e., carrots and potentially other expanded hypocotyl root vegetables such as radishes, turnips and beets), on a sustained basis (i.e. over several months). There is much uncertainty around the relative importance and potential contribution of produce consumption to blood Pb levels in Trail. Produce consumption should be further considered when evaluating potential exposure pathways.

Teck and Trail Area Health and Environment Program (THEP) communicate regularly with the community on ways to limit Pb exposure in their home and yard environments. The information provided to residents about soil exposure and produce continues to follow previous messaging with the following recommended additions:

- Air quality appears to have a significant effect on leaf and fruit produce as evidenced by significantly lower produce Pb concentrations following the implementation of the FDRP;
- Soil remediation helps limit potential exposure to Pb in garden soils, but may not significantly lower produce Pb;

- It is known that different crops take up metals differently; however, select root crops, specifically root vegetables such as carrots, radishes, turnips and beets, that may accumulate more Pb from soil than other root crops (Brown et al., 2016). The extent to which this factor is important in Trail is not resolved with current dataset; and
- Locally available commercial produce has lower Pb concentrations than homegrown produce grown in Trail. This may be an important consideration for residents looking for ways to reduce Pb exposure.

In Trail, residents can continue to access the ongoing programs of the THEP for information on soil testing and remediation, as well as other supports to reduce possible exposure to Pb in their home and yard.

Table of Contents

Table of Contents (Cont'd)

In-Text Figures

In-Text Tables

Appendices

P:\CP\TECK METALS\655246 - TRAIL WARP\50_DEL\53_FINAL\20210112_655246_RPT_2019_GARDEN_PRODUCE_SAMPLING_PROGRAM_FINAL.DOCX

1 Introduction

1.1 Background

Since 1990 the Trail Community Lead Task Force has studied children's lead (Pb) exposure and developed actions based on the best and latest science, including the evolving science around Pb toxicity. The results of the studies indicate that the potential contribution of the garden produce consumption pathway to overall Pb exposure has changed over time as measures have been implemented to address historically significant sources of Pb exposure. A Pb exposure pathway study involving 241 children living on 176 properties in Trail was conducted in 1992; the results of the study indicated that there was no difference in blood Pb levels between children that consumed home grown garden produce and those that did not (Hilts et al., 1995). The 1992 study indicated that incidental ingestion of Pb in soil, dust and drinking water, as well as the inhalation of airborne Pb from smelter emissions, were the primary contributors to Pb exposure in children in Trail (Hilts et al., 1995).

In 2007, home grown produce samples were collected from gardens in Trail; while the assessment was limited, it indicated uncertainty in the extent to which metal concentrations in produce are dependent on the soil Pb concentrations and the extent to which they are influenced by metals in dust/smelter emissions (Hilts, 2007).

As a result of the various programs implemented by Teck to reduce exposures to Pb, including programs to reduce fugitive dust from the smelter, and the residential soil remediation program, Pb exposures and blood Pb levels in children in Trail have been dramatically reduced. In the 1992 study, the geomean of blood Pb level in the children that participated in the above referenced study was 10.8 µg/dL (Hilts et al., 1995), while the current blood Pb level geomean in children in Trail is 2.3 µg/dL (Interior Health, 2020). These programs have helped reduced Pb exposures in soil and dust, which has the potential to result in other pathways, such as garden produce consumption, contributing proportionately more to overall exposure.

Previous assessment of garden produce collected in Trail between 2007 and 2013 indicated elevated levels of Pb in garden produce, particularly in root and leaf vegetables[1]. The relative influence of Pb from ambient air (i.e., from dust) versus Pb in soil (from historical deposition of smelter emissions onto soils) on the produce Pb concentration was not determined, but the notably higher levels in leaf vegetables measured at the time raised the hypothesis that ambient air concentrations may be influencing produce concentrations. With the implementation of Fugitive Dust Reduction Program (FDRP) in 2012, and ongoing improvements to air quality, there was an opportunity to obtain updated data to evaluate if Pb concentrations in garden produce have improved.

Based on the above, a garden produce sampling program was completed by SNC-Lavalin as part of the 2019 Workplan[2].

[1] SNC-Lavalin Inc. Results of the Long-Term Soil Monitoring and Garden Produce Sampling Study 2010-2013. Trail, BC. September 20, 2014.

[2] SNC-Lavalin Inc. Trail Area Residential Soil Assessment and Remediation – 2019 Work Plan – Site ID 3250. April 1, 2019. Prepared for: Ministry of Environment and Climate Change Strategy. Internal Reference 655246.

1.2 Objective

The key objective of the 2019 Garden Produce Sampling Program was to obtain updated information on the range of Pb concentrations in homegrown garden produce in the Trail area. Although other metals were analyzed in both soil and produce, the focus of the study was to obtain updated Pb concentrations. The Phase 4 Human Health Risk Assessment[3] evaluated other metals in homegrown produce and concluded there were no unacceptable risk associated with other metals.

The 2019 Garden Produce Sampling Program was intended to be a preliminary evaluation to obtain updated garden produce Pb concentrations. It was expected that this updated information would help guide communications with the Trail community and identify whether a more comprehensive garden produce sampling program is warranted.

1.3 Regulatory Framework

There are currently no Canadian guidelines for Pb in produce. Two international bodies, Food and Agriculture Organization of the United Nations/The World Health Organization (FAO/WHO, 2015) and the European Community (EC, 2006) provide the most relevant and up to date criteria for Pb in produce. These criteria are considered maximum permissible levels and will be referred to herein as maximum levels (MLs). They are included for comparison purposes. Garden soil is compared to the BC *Contaminated Sites Regulation*[4] (BC CSR) soil standard for Pb on residential land (RL) outlined in Schedule 3.1, Part 1 of the CSR.

[3] Intergral Consulting Inc. Phase 4 Human Health Risk Assessment, March 2009. Prepared for Teck Cominco Metals Ltd.
[4] *Contaminated Sites Regulation* (CSR), B.C. Reg. 375/96, including amendments up to B.C. Reg. 13/2019, January 24, 2019.

2 Methods

2.1 Property Selection

The 2019 Garden Produce Sampling Program involved sampling soil and homegrown garden produce from both remediated and un-remediated gardens in Trail, BC. Although participation was voluntary, home owners with vegetable gardens that had received recent remediation, including properties remediated in Spring 2019, were asked to participate in the study. As well, other known properties that had previously received remediation or had participated in previous produce studies through the THEP, were invited to participate. A goal of the 2019 sampling program was to collect at least 20 samples of each produce type from both remediated and un-remediated gardens. In addition to the homegrown produce samples, produce was obtained from four local grocery stores and one commercial farm to determine the presence of Pb in locally available commercial produce.

2.2 Produce Selection

The 2019 Garden Produce Sampling Program focused on collecting the most common types of the produce grown in Trail. As in previous studies produce types were split into categories; leafy greens, fruit crops, root crops. Berries and small fruit were sampled, as before, but were separated from other fruit crops as they have different MLs. Based on previous sampling, within the categories, the main types of produce grown and consumed were determined to be:

- Lettuce and Kale (Leaf);
- Pea and Tomato (Fruit);
- Strawberry and Raspberry (Berries); and
- Potato and Carrot (Root).

Produce had to be ripe and ready to eat and as such, most properties were visited more than once throughout the summer to collect available produce (e.g., leafy greens and berries were collected in July and fruit and root crops in August). Since the study started in July, some crops (e.g., peas and strawberries) were often found to be finished for the season and the number of samples available was lower than desired. Additional produce types were collected at the request of some property owners and to provide information on Pb concentrations in a variety of “other produce types”.

2.3 Field Methods

Both soil and produce samples were collected from properties participating in the study. Samples were collected using methods outlined in Appendix I and described below. Sampling was completed between July 17, 2019 and August 21, 2019.

2.3.1 Produce Samples

Samples of ripe and ready to eat produce were collected from plants by either gently pulling the edible part of the produce off the plant by hand or by cutting it off the stem using clean pruning shears. Samples were placed into a clean Ziploc bag and stored with an air pocket in the bag to avoid damaging or bruising the produce during transport. Samples were stored in a chilled cooler and brought back to the SNC-Lavalin office for sample preparation.

2.3.2 Soil Samples

Composite soil samples were collected from each garden bed and matched with the produce collected in that bed. Samples were collected to a depth of 0.15 m below grade using a clean spade. To make the composite, ten aliquots were collected from across the garden and were placed into a clean Ziploc bag marked with the unique PID (Property Identification) and Garden Bed Identification (e.g., VG1, VG2, etc.) and recorded on the Homeowner Questionnaire.

2.3.3 Homeowner Questionnaire

Following sample collection or as a follow-up over the phone, the homeowner completed a questionnaire as shown in Appendix II. The purpose of the questionnaire was to identify the types and amount of produce being consumed and identify any garden practices that may contribute to high or low Pb uptake in produce (e.g., soil amendments). The questionnaire may help inform communication with gardeners and future studies.

2.3.4 Commercial Produce

To complete the sampling of commercially available produce, the main vegetable types were also collected from local stores and one commercial farm. At the commercial farm, both soil and produce were collected using the methods described above.

2.4 Sample Preparation

After sample collection, field staff prepared the produce at the SNC-Lavalin Trail, BC office. While wearing clean nitrile gloves, produce was washed a minimum of three times or until visible dirt was removed. Tap water or distilled water was used for washing. Tap water represents typical water used by homeowners and Trail tap water is tested regularly and found to satisfy the Health Canada, Canadian Drinking Water Quality Guidelines[5]. The produce was then dried by spinning in a clean salad spinner and/or patted dry with clean paper towel. Raspberries were the only produce that was not washed. The raspberry samples were too delicate to rinse, even with careful handling. Produce was then placed into clean Ziploc bags, labelled with a property identification (PID) number and the produce type and refrigerated until it was submitted to the lab in chilled coolers. Root crops were washed and scrubbed to remove any visible dirt prior to sending to the lab and all root crops (beets, potatoes, carrots, etc.) were then peeled at the laboratory. Sample preparation procedures are outlined in Appendix I.

[5] Canadian Drinking Water Quality Guidelines (CDWQG), Health Canada, August 2012.

SNC · LAVALIN

2.5 Sample Analysis

Samples were submitted promptly (within a few days of sample collection) to ensure fresh, undamaged produce was received by the laboratory. Produce samples were shipped in ice-filled coolers to CARO Analytics Laboratory (CARO) in Richmond, BC. Samples were analyzed for total metals in plant tissue by ICP-MS. Both dry and wet weight were reported in the laboratory certificates. A copy of the laboratory Certificates of Analysis are provided in Appendix III.

2.6 Data Analysis and Interpretation

Following sample analysis, results were reviewed, and statistical analysis was completed. The statistical analysis provides general summary statistics and a comparison to produce testing data that was collected between 2007 and 2013, prior to significant fugitive dust reduction measures. Additional data analysis and exploratory analysis was completed where data variability was present.

3 Results

Data analysis included general summary statistics to describe the variety of samples collected and a comparison to data collected previously in Trail. Additional interpretation is provided in section 3.4 below.

3.1 Summary Results

A total of 40 properties were visited as part of the 2019 Garden Produce Sampling Program, including the Trail Community Garden which is used by several residents. Nineteen of the properties have had vegetable garden remediation previously as part of the THEP soil remediation programs. A total of 55 soil samples were collected from the vegetable gardens, with more than one soil sample collected per property if there were multiple garden beds from which produce was collected. A general summary of the soil concentrations found in the gardens is provided below.

Table 1: Summary of 2019 Soil Data from Trail Gardens

Soil Summary	Number of Soil Samples	Pb Concentration (ppm)			
		Min	Max	Arithmetic Mean	95% UCLM
All Gardens	55	12.2	1560	327	437
Remediated	27	19.1	491	127	167
Un-Remediated	28	12.2	1560	520	709

[refer to Appendix IV-1 – 2019 Soil Pb distributions]

As shown in Table 1, the Pb concentrations measured in garden soil varied substantially, although a smaller range of concentrations was observed in remediated gardens. Analysis of the 2019 garden soil samples shows that remediated soils have a statistically significantly lower mean Pb concentration than non-remediated soils (Appendix IV-2). Nine of the 27 remediated vegetable garden beds have soil Pb concentrations that are above the current BC CSR Residential soil standard for Pb. It is important to note that over the time the program has been remediating gardens in Trail, the CSR Residential soil standard for Pb decreased from 500 ppm to 400 ppm and then further to 120 ppm in 2017, and consequently some of these gardens were remediated to a previous standard.

A total of 156 produce samples were collected from 55 vegetable gardens beds across seven different neighbourhoods in Trail. A summary of the type of produce and the number of samples collected is provided in Table 2.

Table 2: Summary of 2019 Garden Produce Types Sampled

Sample Type	Number of Produce Samples
Root	30
Fruit – excluding berries	70
Berries	17
Leaf	39
Total	156

Each soil sample was matched to the produce collected from the specific garden bed where the produce was growing; in cases where multiple produce types were sampled from a garden, only a single soil sample was collected. A summary of the Pb concentrations measured in the soil samples collected from the gardens and paired with the various produce types is provided in Table 3.

Table 3: 2019 Soil Pb Concentration by Produce Type

Produce Type	Sample Size	Min	Max	Soil Pb Concentration (ppm)		
				Geometric Mean	Arithmetic Mean	95% UCLM
Root	18	31.8	1060	199	307	444
Fruit – all*	44	12.2	1560	159	293	399
Leaf	**26**	**24**	**1560**	**200**	**351**	**511**

Notes:
* Berries and other fruit crops are included together as a given soil sample may be assigned to all three produce types.
[refer to Appendix IV-3]

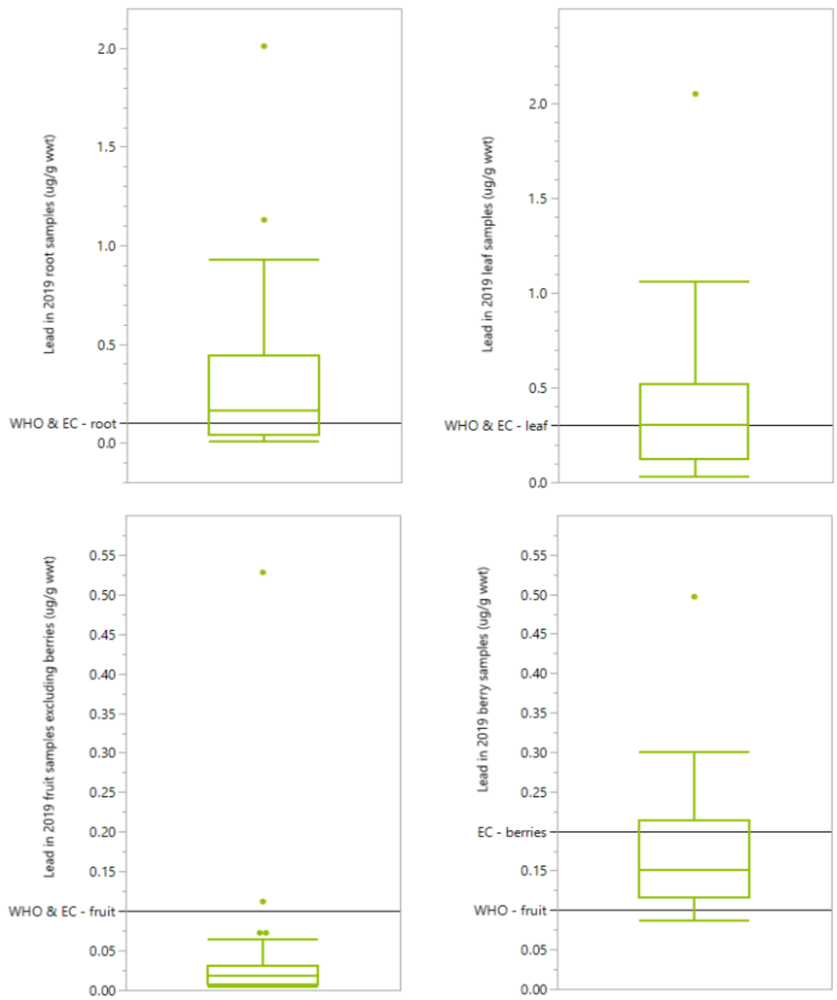
The ranges of produce Pb concentrations from the 2019 data are provided in Table 4 and in Figure 1. These data provide updated concentrations that can be compared to previous data for garden produce samples collected in Trail.

Table 4: 2019 Produce Pb Concentration by Produce Type

Produce Type	Sample Size	Min	Max	Soil Pb Concentration (ppm)			WHO	EC
				Geometric Mean	Arithmetic Mean	95% UCLM	µg/g	(µg/g, wet weight)
Root	30	0.005	2.01	0.15	0.33	0.49	0.1	0.1
Fruit	70	0.004	0.528	0.016	0.031	0.046	0.1	0.1
Berries*	17	0.087	0.497	0.162	0.180	0.231	0.1	0.2
Leaf	39	0.030	2.05	0.27	0.39	0.52	0.3	0.3

Notes: Data distributions appear to be log-normal
* Raspberry samples were not washed
[refer to Appendix IV-4]

Figure 1: Box plots showing the range of 2019 Trail Produce Pb concentration for each produce type compared to WHO and EC MLs.



3.2 Comparison to Previous Trail Data

Previous garden produce and co-located soil samples were collected between 2007 and 2013 by SNC-Lavalin before substantial implementation of the FDRP on the smelter site which began in 2012. Table 5 provides summary statistics for Pb for all produce related garden soil samples taken between 2007 and 2019, by remediation status (yes or no) and timing with respect to the FDRP (before or after). As shown in Appendix IV-5 and IV-6, one-way analyses of each of these factors presents the following:

- Mean soil Pb in remediated gardens is lower than in non-remediated gardens; and
- There is no statistically significant difference between mean soil Pb in the gardens in studies before or after the implementation of the FDRP (i.e., 2007 – 2013 data set vs 2019 data set).

Table 5: 2007-2019 Soil Pb Concentrations by Remediation Status and FDRP

Category	Sample Size	Soil Pb Concentration (µg/g)		
		Geometric Mean	Arithmetic Mean	95% UCLM
Sampled from Remediated Garden?				
No	98	443	667	774
Yes	166	130	180	211
Timing of sample with respect to FDRP				
Before	209	217	370	430
After	55	165	327	437

[refer to Appendix IV-5 and IV 6]

Table 6 provides summary statistics for produce Pb versus remediation status (yes or no) (Appendix IV-7, IV-8, IV-9). A set of one-way analyses of produce Pb versus produce type suggests that, considered alone, the remediation of garden soil does not result in a significant reduction of the amount of Pb in produce for any of the produce types (Appendix IV-10). Soil remediation lowers soil Pb, as shown in Table 5, and as a result will help to limit Pb exposure through direct soil contact; however, the produce data collected to date, while limited, suggests that soil remediation may not have a substantial impact on produce Pb concentrations. Further discussion is provided in section 3.5.1.

Table 6: 2007-2019 Produce Pb Concentrations by Remediation Status

Produce Type	Sample Size	Produce Pb Concentration (µg/g, wet weight)		
		Geometric Mean	Arithmetic Mean	95% UCLM
Garden Soil not Remediated				
Root	34	0.15	0.31	0.45
Fruit	63	0.03	0.06	0.09
Berries	11	0.18	0.20	0.28
Leaf	43	0.86	2.15	3.59
Garden Soil Remediated				
Root	54	0.20	0.35	0.47
Fruit	95	0.04	0.07	0.10
Berries	10	0.28	0.41	0.67
Leaf	53	0.89	2.98	4.59

[refer to Appendix IV-7, IV-8, IV-9]

Table 7 provides summary statistics for the produce samples collected before and after the FDRP. A set of one-way analyses that compared mean Pb concentrations in each category before and after the implementation of the FDRP indicates that there has been a statistically significant reduction in mean Pb concentrations for fruit and leaf produce following the FDRP, but no statistically significant change for root produce was observed (Appendix IV-11). Given that root crops are not directly exposed to fugitive dust, this finding provides further evidence that the decreased Pb concentrations measured in fruit and leaf produce are a result of the FDRP and the significant efforts to improve air quality and reduce dust generated at the smelter.

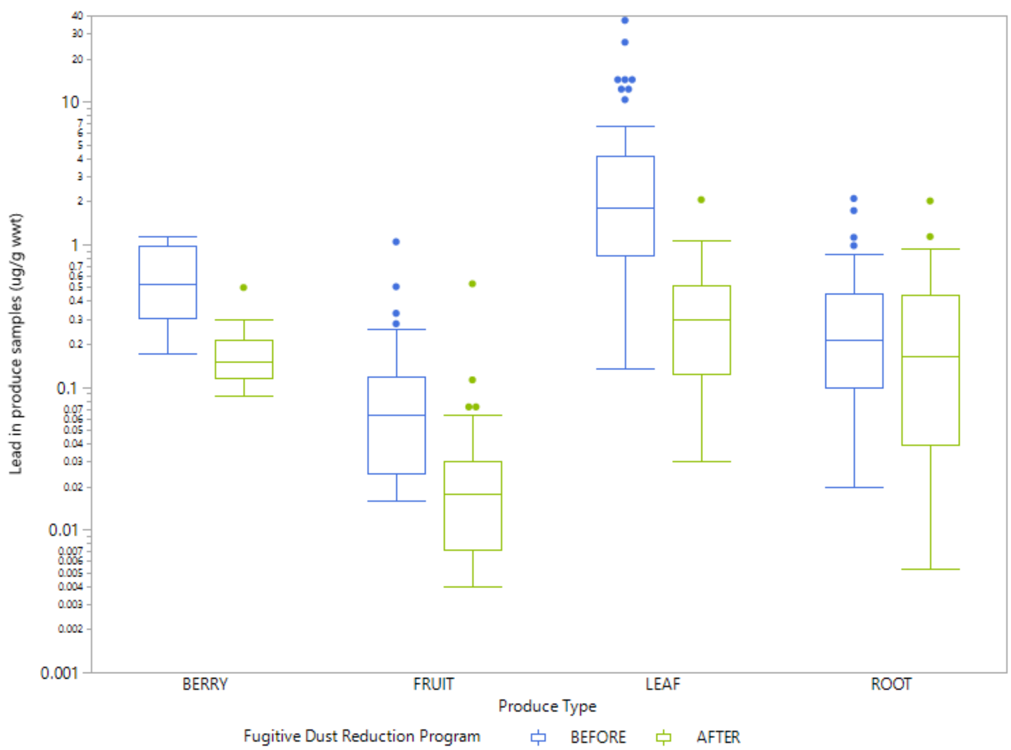
Table 7: 2019 Produce Pb Concentrations compared to 2007-2013 samples

Produce Type	Sample Size	Produce Pb Concentration (µg/g, wet weight)		
		Geometric Mean	Arithmetic Mean	95% UCLM
2007 – 2013 (before Fugitive Dust Reduction Program)				
Root	37	0.20	0.34	0.44
Fruit	93	0.06	0.10	0.12
Berries	6	0.51	0.60	0.98
Leaf	57	1.98	4.12	5.86
2019 (after Fugitive Dust Reduction Program)				
Root	30	0.15	0.33	0.49
Fruit	70	0.02	0.03	0.05
Berries	17	0.16	0.18	0.23
Leaf	39	0.27	0.39	0.52

[refer to Appendix IV-10, IV-11, IV-12]

The following figure displays the reduction in fruit, berries and leaf produce before and after the implementation of the FDRP. The figure shows that there have been significant declines in Pb concentration for some produce types (fruit and leaf).

Figure 2: Comparison of produce Pb concentrations before and after the implementation of FDRP



3.3 Comparison to Commercial Produce

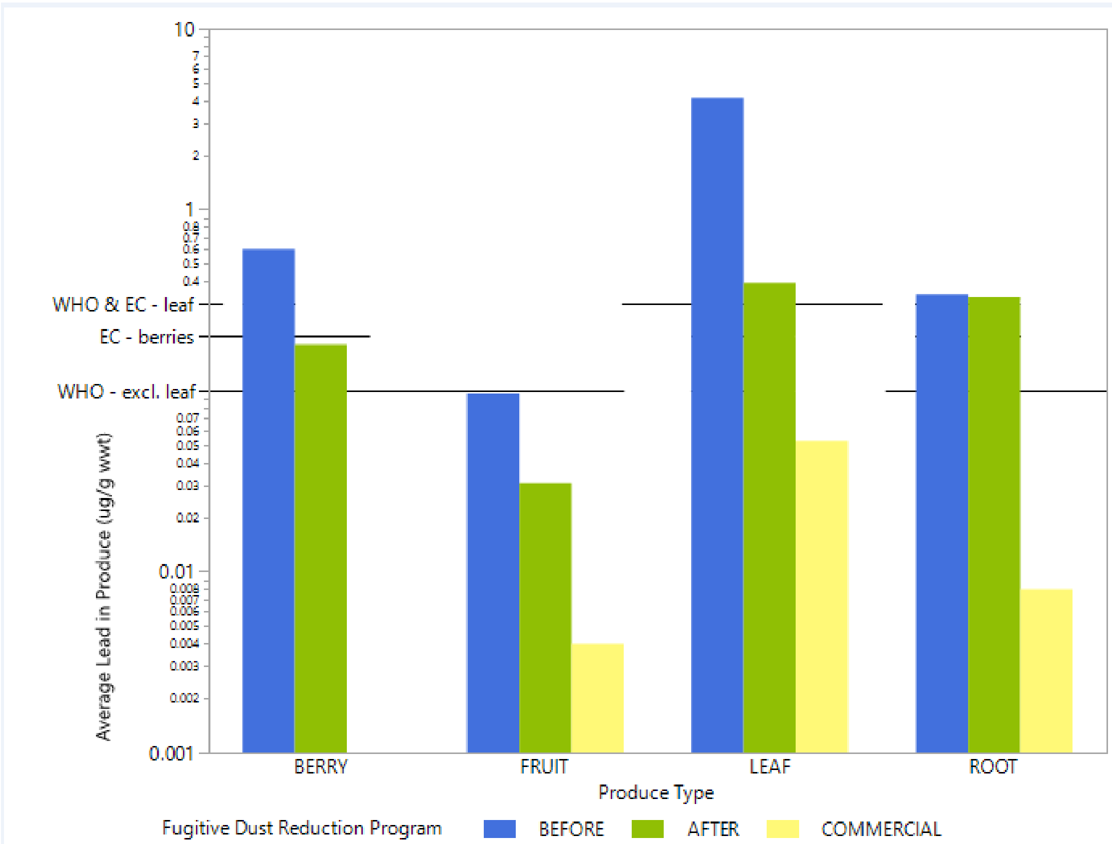
Produce samples were collected from four grocery stores in Trail and from one organic farm that grows and sells produce commercially and is located approximately 10 km southeast of the smelter. Table 8 below, presents a summary of 15 samples collected from commercial sources and compared to Trail homegrown produce collected in 2019. It is important to note that Pb concentrations in homegrown produce remain above MLs and locally available commercial produce, particularly for root and leaf produce. Most homegrown fruit crops were below the MLs. These findings are provided on Figure 3.

Table 8: 2019 Produce Pb Concentrations compared to Commercial Produce

Produce Type	Sample Size	Produce Pb Concentration (µg/g, wet weight)		
		Geometric Mean	Arithmetic Mean	95% UCLM
Commercial (store-bought) Produce				
Root	5	0.007	0.008	0.016
Fruit – excluding berries	5	0.004	0.004	0.004
Leaf	5	0.042	0.053	0.096
2019 Homegrown Produce				
Root	30	0.15	0.33	0.49
Fruit – excluding berries	63	0.03	0.06	0.09
Leaf	39	0.27	0.39	0.52

Note: berries were not collected from commercial sources.

Figure 3: Comparison of produce types following the implementation of FDRP along with a comparison to locally available commercial produce and applicable MLs.



3.4 Evaluation of the Homeowner Questionnaire

An example of the homeowner questionnaire is provided in Appendix II. The summary from the questionnaire confirmed that the target produce was amongst the most common types of produce grown: carrot (16), lettuce (13), pea (10) and tomato (29). Other commonly grown produce were beet (10), beans (13), cucumber (12), pepper (11) squash (13), and zucchini (13). Strawberries (11) and Raspberries (11) were the most common berries. Potatoes, which were a target for the 2019 produce sampling program, were not very common. Only five respondents reported growing potatoes.

Over half the respondents indicate that they preserve produce that is grown in their gardens by canning (21) or freezing (24). Some respondents indicated they also dry homegrown produce (7). Tomatoes were the most common produce that is preserved, and it is typically canned.

Nearly half the respondents (18) noted that they amend soil annually with compost or manure. There were no other actions or soil amendments recorded in the survey that would suggest garden practices that could add metals to the garden soil and/or produce.

3.5 Exploratory Data Analysis

In addition to the relationships between soil Pb and produce Pb discussed above, further analysis of the data was completed to identify potential relationships within the data and to determine important aspects that may affect Pb in produce. The analysis was designed to attempt to answer the following questions:

1. Whether there is a relationship between soil Pb and produce Pb; and
2. If soil P affect produce Pb.

3.5.1 Findings

1. To determine if soil Pb concentrations are a determining factor for produce Pb concentrations, several regression analyses were completed. The results of these are presented in Table 6, which provides summary statistics for produce Pb versus remediation (yes or no). A set of one-way analyses of produce Pb versus produce type suggests that, considered alone, the remediation of garden soil does not result in a significant reduction of the average amount of Pb in produce for any of the three types. For all three produce types, there is a statistically significant least squares regression model with a positive slope that relates produce Pb content to soil Pb content (generally, increased Pb in soil results in increased Pb in produce grown in that soil). However, these models only explain 14% of the total variation in fruit, 5% of the total Pb variation in leaf produce, and 1% of the total variation in root produce, when considered alone.
2. Further analysis showed that if soil phosphorus (P) is added to the model, it has a statistically significant effect for fruit and root vegetables, but not for leaf produce. The regression analyses for this relationship are summarized in Table 9. In leaf produce, the increase in r^2 from 0.05 to 0.15 is erroneous because there isn't a significant effect by the P co-variate. The increase in r^2 is a result of overfitting. There was no evidence of an effect on Pb in produce by an interaction between the concentrations of Pb and P in soil. This is indicated by the high probability values shown in Table 9 for all three produce types. The jump in r^2 value from 0.32 to 0.38 for root produce in the third model is again a result of overfitting because the interaction term is not statistically significant. The bolded regression models below are therefore the most applicable, however they continue to explain only a small to moderate portion of the variance in produce Pb. When phosphorus (P) is added as a factor it has a statistically significant effect of reducing Pb uptake for fruit and root crops, with the variation in produce Pb concentrations explained by the linear regression increases to 15% and 32% respectively. Simply put, soil P appears to reduce the uptake of Pb from soil into fruit and root produce.

Table 9: Regression Analyses for Pb in Produce Samples compared to Pb and P in Soil

Fruit	p<0.0001	-	-	0.14
Fruit	**p=0.0003**	**p=0.0114**	**-**	**0.15**
Fruit	p=0.0053	p=0.0171	p=0.3185	0.16
Leaf	**p=0.0252**	**-**	**-**	**0.05**
Leaf	p=0.0110	p=0.4166	-	0.15
Leaf	p=0.0142	p=0.3760	p=0.7078	0.15
Root	p=0.2980	-	-	0.01
Root	**p=0.0028**	**p=0.0070**	**-**	**0.32**
Root	p=0.0176	p=0.0049	p=0.1347	0.38

Note: [refer to Appendix IV-13, IV-14]

4 Discussion

4.1 2019 Trail Homegrown Produce Pb

The 2019 Garden Produce Sampling Program provided updated concentrations of Pb in homegrown produce. Based on these results SNC-Lavalin concludes there was a statistically significant decrease in produce Pb concentrations in both fruit and leaf type crops since the previous sampling period between 2007 and 2013. There was no significant change in root crops.

Pb concentrations in fruit crops were approximately half of what was reported in 2013. The Pb concentration in three raspberry samples exceeded the ML, as did one strawberry and one pea sample. All other fruit and berry samples tested were less than the MLs. Raspberries were the only produce that was not washed as part of this study, and this may be a contributor to the higher Pb in, or on, raspberries. Leaf crops showed a five-fold decrease in the 2019 sample set compared to the 2007 – 2013 data set; however, Pb concentrations in leaf crops still exceeded the MLs in 48% of the samples.

Concentrations of Pb in root crops did not change from previous sampling events and exceeded the ML in 50% of the samples. Although the sample set for potatoes was small (n=4), results for all potato samples were found to be below the ML, whereas results for all but two of the carrot samples (n=15) were above the ML. Brown et al. (2016) indicate that expanded hypocotyl root vegetables such as carrot, radish, beets and turnips accumulate Pb in their core which is made up of xylem tissue; while in contrast, potatoes do not have a xylem core and do not accumulate Pb to the same degree. While the results of the 2019 program appear to support this finding, the size of the datasets were insufficient to be conclusive.

Although soil Pb in remediated gardens is significantly lower (statistically) than in un-remediated gardens, there appear to be other factors that influence Pb concentrations in produce. Soil Pb, when considered alone, explains up to 14% of the variation in the Pb in fruit crops, 5% in leaf crops and 1 % in root crops. Soil phosphorus (P) amendments also have a statistically significant effect on reducing Pb in fruit and root crops but not in leaf crops, accounting for 15% and 32% of the variability in fruit and root crops, respectively, when considered together. Still, soil Pb, and in the case of fruit and root crops, soil Pb and P amendments together, only explain a small to moderate amount of Pb in the produce samples. While the current study only assessed the influence of soil Pb and P concentrations on the produce Pb concentrations, there appear to be other factors that impact the amount of Pb taken up by produce. Since 2012, Teck's FDRP has resulted in improvements to air quality, and for leaf and fruit produce that are exposed to air, it appears that the lower Pb concentrations in the 2019 data set compared to earlier data are associated with those improvements. This is corroborated by a lack of change in root Pb concentrations which are not exposed to air as they are grown.

Pb concentrations in commercially available produce samples tested were below the MLs, and commercial produce had lower produce Pb concentrations than homegrown produce. This may be important information for residents that are trying to reduce Pb intake.

4.2 Preliminary Risk Evaluation of the Garden Produce Pathway

As noted, the results of the 2019 garden produce sampling program indicate that although Pb concentrations in fruit and leaf vegetables have decreased since the implementation of the FDRP, Pb concentrations in some samples of all produce types remain elevated above the available EC (2006) and FAO/WHO (2015) MLs. The 2019 garden produce sampling program was preliminary and was designed with the objective to evaluate current Pb garden produce concentrations compared to those measured previously. The study was not designed to be comprehensive or for the purpose of assessing the potential for garden produce to influence blood Pb concentrations, and instead was conducted on a somewhat random/opportunistic basis.

While the existing dataset is not adequate to evaluate the potential for garden produce to contribute to blood Pb concentrations in Trail, a preliminary risk evaluation has been conducted based on the measurement of garden produce Pb concentrations in excess of the MLs.

Factors that affect the potential for home grown garden produce to contribute to blood Pb concentrations include: 1) type of produce consumed (e.g., root produce had the highest Pb concentrations, with select types of root produce likely to absorb more Pb from soil [e.g., carrots versus potatoes]); 2) age of person (young children absorb Pb more efficiently and consume more produce when expressed on a per kg body weight basis); 3) rate and frequency of consumption (e.g., servings per week or month); and 4) duration of consumption (i.e., blood Pb levels take several months to approach steady-state concentrations). Based on the responses from the homeowner questionnaire, it is unlikely that homegrown carrots or leaf produce are stored and consumed for a longer period than what is available from the garden; this may be significant because as indicated, blood Pb levels take several months to approach steady-state, and these produce types are likely only available for 1 to 3 months a year in Trail. Tomatoes were all found below the MLs and were also the most common crop that was preserved by homeowners in Trail. The type of produce and the amount of garden produce being consumed by young children was not evaluated as part of the questionnaire.

For this preliminary evaluation, the existing dataset, in particular the 95% UCLM root produce Pb concentration, and produce consumption rates typical of the Canadian population, have been used to estimate the potential for the measured produce Pb concentrations to contribute to blood Pb levels. The hypothetical risk calculations and a cursory review of the primary literature suggest there is the potential for the consumption of garden produce, in particular carrots and other expanded hypocotyl root vegetables (e.g., beets, radishes and turnips), to contribute to blood Pb concentrations, particularly if consumed over extended periods (e.g., over several months) by young children. Using toxicokinetic information provided by the European Food Safety Authority (EFSA) (2013), which assumes sustained (i.e., over several months) consumption of food with elevated Pb concentrations, it has been estimated that blood Pb concentrations in a toddler have the potential to increase by about 1.2 µg/dL for every 0.5 µg/kg bw/day of Pb intake from food[6]. Health Canada (2012) has indicated that a typical Canadian toddler consumes about 105 g per day of root produce, with the CCME (2006) recommending that it should be assumed that 10% of produce consumed comes from home gardens. If it was assumed that 10% of root produce was from a home garden and the owners follow recommendations to peel root crops, with the Pb concentration at the 95% UCLM for peeled root produce of 0.49 µg/g wet weight measured in 2019, the blood Pb level increase

[6] US EPA relationship cited in Brown et al. (2016) is an increase of 0.16 µg/dL per µg ingested which is very similar to EFSA when adjusted for body weight.

would be on the order of 0.75 µg/dL[7] [8]. As discussed, home garden produce consumption must occur on a sustained basis for EFSA and US EPA toxicokinetics to be applicable. Consequently, if root produce consumption only occurred for one month, the increase in blood Pb concentration would be half of the estimated value (i.e., 0.375 µg/dL). This example is hypothetical, is provided as an example only and has only considered root vegetables (i.e., there could also be contribution from leaf vegetables and fruits). While there is uncertainty in the calculation, it has been provided to demonstrate the potential influence of the measured produce Pb concentrations on blood Pb levels.

As noted, there are other variables that are not taken into account in the calculations provided above. Firstly, it is possible that the bioavailability of Pb in produce may not be as high as assumed in using the EFSA toxicokinetics. It has been suggested that the solubility of Pb (and hence plant uptake) may be reduced due to the presence of phytate, calcium, phosphate and fiber in plants (Brown et al., 2016; ATSDR, 2019), which could reduce bioavailability. There is also some evidence that cooking foods may reduce bioaccessibility of some metals (Fu and Cui, 2013). Finally, absorption rates of Pb during meals may be reduced compared to absorption when exposure is not from food (Brown et al., 2016; ATSDR, 2019).

Based on the measurement of produce Pb concentrations in excess of the MLs and the results of the preliminary risk evaluation, produce consumption should be further considered when evaluating potential exposure pathways.

4.3 Recommendations for Home Gardeners

It is recommended that homeowners with backyard produce gardens continue to be supported through the THEP so that they can take precautions to reduce their potential exposure to Pb via this pathway (e.g., reduced soil exposure through remediation and strategies for reducing produce Pb exposure). The recommendations have been provided to the community on an ongoing basis; however, their importance in the context of the garden produce consumption pathway should be emphasized, specifically when dealing with children with elevated blood lead levels. The recommendations are intended to reduce overall exposure to Pb, however; it is anticipated that some level of exposure will still occur (i.e., it should be clear that following these measures may not reduce garden produce to concentrations below those recommended by EC (2006) or FAO/WHO (2015)). It is important to note that air quality appears to have a significant influence on reducing produce Pb concentrations in fruit and leaf produce. Although soil remediation is expected to reduce the direct soil contact pathway, strategies for reducing produce Pb may be more important from a produce consumption standpoint (e.g. peeling root crops, washing produce, etc.)

The US EPA (2014) document titled *Technical Review Workgroup Recommendations Regarding Gardening and Reducing Exposures to Lead-Contaminated Soils* provides several recommendations. We are aware that THEP has provided similar information to homeowners in Trail, BC that have backyard gardens.

The messages are still relevant for home gardeners today with the following recommended additions.

- Air quality appears to have a significant effect on leaf and fruit produce as evidenced by significantly lower produce Pb concentrations following the implementation of the FDRP;
- Soil remediation helps limit potential exposure to Pb in garden soils, but may not significantly lower produce Pb;

[7] Based on the following calculation: 10.5 g of root vegetables per day x 0.49 µg/g / 16.5 kg = blood Pb [0.75 µg/dL].
[8] When using the EFSA relationship of 1.2 µg/dL for every 0.5 µg/kg bw/day of Pb intake from food.

- It is known that different crops take up metals differently; however, select root crops, specifically root vegetables such as carrots, radishes, turnips and beets, may accumulate more Pb from soil than other root crops (Brown et al., 2016). The extent to which this factor is important in Trail is not resolved with current dataset; and
- Locally available commercial produce has lower Pb concentrations than homegrown produce grown in Trail. This may be an important consideration for residents looking for ways to reduce Pb exposure.

In Trail, residents can continue to access the ongoing programs of the THEP for information on soil testing and remediation, as well as other supports to reduce possible exposure to Pb in their home and yard.

5 Conclusions

The 2019 Garden Produce Sampling Program updated the range of lead (Pb) concentrations in garden produce in the Trail area. The updated results show that there has been a statistically significant decrease in mean Pb in fruit and leaf homegrown garden produce since previous studies. A similar comparison of mean Pb in root produce did not show a statistically significant decline when compared to the earlier samples. Average soil Pb levels have not changed significantly between the 2007-2013 and 2019 data sets, unless the garden has been remediated. If the garden soil has been replaced, the garden has significantly lower soil Pb levels than gardens that have not had remediation.

Previous studies did not evaluate the relative influence of Pb from ambient air (i.e., from dust) versus Pb in soil (from historical deposition of smelter emissions onto soils) on the produce Pb concentrations. The notably higher levels in leaf vegetables in previous studies raised the hypothesis that ambient air concentrations may be influencing produce concentrations. With ongoing improvements to air quality in Trail and the implementation of Teck's FDRP in 2012, there was an opportunity to obtain updated data to evaluate if Pb concentrations in garden produce have improved in recent years as a result of improved air quality. Based on the findings in the 2019 Garden Produce Sampling program, it appears that the significantly lower Pb concentrations in leaf and fruit produce are the result of substantial air quality improvements made by Teck through their FDRP.

While soil Pb concentrations were found to be correlated to garden produce Pb concentrations, this relationship only explains a small amount (1 to 14%) of the variation seen in the produce Pb concentrations. When produce Pb is considered with soil phosphorus (P), P helped explain 32% of produce Pb in root crops, but was less so for fruit and no relationship was found for leaf crops. As such, air quality appears to have a stronger influence on produce Pb concentrations than the soil Pb concentrations or P amendments. SNC-Lavalin interprets the lower concentrations in leaf and fruit produce Pb to be the result of substantial air quality improvements made by Teck through the FDRP.

Overall, the available data are not sufficient draw firm conclusions on whether garden produce is a key contributor to blood Pb concentrations in Trail, BC; however, the Pb concentrations in the garden produce tested do exceed the MLs recommended by the World Health Organization (FAO/WHO, 2015) and the European Community (EC, 2006). Preliminary risk calculations based on the existing data and produce consumption rates representative of the general Canadian population indicate the potential for the measured produce Pb concentrations to contribute to blood Pb where children are consuming garden produce on an ongoing basis, particularly root crops. To better understand the relative importance of the homegrown produce on Blood Lead Levels (BLLs), produce consumption should be further considered when evaluating potential exposure pathways. It is understood that Teck and the THEP will continue with ongoing programs and communications with the community, vegetable gardeners and families with young children.

6 References

ATSDR. 2019. Toxicological Profile for Lead (Draft for Public Comment). Agency for Toxic Substances and Disease Registry, Atlanta, GA. Available at: https://www.atsdr.cdc.gov/ToxProfiles/tp.asp?id=96&tid=22

Brown, SL, Chaney, RL and Hettiarachchi, GM. 2016. Lead in urban soils: a real or perceived concern for urban agriculture? J Environ Qual 45(1):26-36.

CCME. 2006. A Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines. Canadian Council of Ministers of the Environment, Winnipeg, MB. Available at: http://ceqg-rcqe.ccme.ca/download/en/351

EC. 2006. Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs. European Community. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02006R1881-20150521&from=EN

EFSA (European Food Safety Authority). 2013. Scientific Opinion on Lead in Food: EFSA Panel on Contaminants in the Food Chain (CONTAM). Parma, Italy. EFSA J 8:1570. doi:10.2903/j.efsa.2010.1570.

FAO/WHO. 2015. CODEX Alimentarus, International Food Standards: General Standard for Contaminants and Toxins in Food and Feed (CODEX STAN 193-1995) Adopted in 1995, Revised in 1997, 2006, 2008, 2009, Amended in 2010, 2012, 2013, 2014, 2015. Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO).

Fu, J and Cui, Y. 2013. In-vitro digestion/Caco-2 cell model to estimate cadmium and lead bioaccessibility/bioavailability in two vegetables: the influence of cooking and additives. Food and Chemical Toxicology (59): 215-221.

Health Canada. 2012. Federal Contaminated Site Risk Assessment in Canada, Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA). Contaminated Sites Division, Safe Environments Programme, Health Canada, Ottawa, ON.

Hilts, SR, Pan, UW, White, ER and Yates, CL. 1995. Trail Lead Program, Exposure Pathways Investigations, Final Report.

Interior Health. 2020. Children's Blood Lead Clinic Results , Fall 2020. Presentation by Interior Health Medical Health Officer to the Trail Area Health and Environment Committee. Trail, BC.

Mushak, P. 2011. Chapter 8 - Lead Exposure in Human Populations: Lead Toxicokinetics and Biomarkers of Lead Exposure. In: Trace Metals and other Contaminants in the Environment, Volume 10, 2011, Pages 243-316.

Paltseva, A., Cheng, Z., Deeb, M., Groffman, P.M., Shaw, R.K. and Maddaloni, M. 2018. Accumulation of arsenic and lead in garden-grown vegetables: Factors and mitigation strategies. Sci Total Environ. 640-641:273-283.

US EPA. 2014. Technical Review Workgroup Recommendations Regarding Gardening and Reducing Exposures to Lead-Contaminated Soils. Office of Solid Waste and Emergency Response, US EPA, Washington, DC. OSWER 9200.2-142.

7 Notice to Reader

This report has been prepared and the work referred to in this report have been undertaken by SNC-Lavalin Inc. (SNC-Lavalin) for the exclusive use of Teck Metals Ltd. (Teck), who has been party to the development of the scope of work and understands its limitations. The methodology, findings, conclusions and recommendations in this report are based solely upon the scope of work and subject to the time and budgetary considerations described in the proposal and/or contract pursuant to which this report was issued. Any use, reliance on, or decision made by a third party based on this report is the sole responsibility of such third party. SNC-Lavalin accepts no liability or responsibility for any damages that may be suffered or incurred by any third party as a result of the use of, reliance on, or any decision made based on this report.

The findings, conclusions and recommendations in this report (i) have been developed in a manner consistent with the level of skill normally exercised by professionals currently practicing under similar conditions in the area, and (ii) reflect SNC-Lavalin's best judgment based on information available at the time of preparation of this report. No other warranties, either expressed or implied, are made as to the professional services provided under the terms of our original contract and included in this report. The findings and conclusions contained in this report are valid only as of the date of this report and may be based, in part, upon information provided by others. If any of the information is inaccurate, new information is discovered, site conditions change or standards are amended, modifications to this report may be necessary. The results of this assessment should in no way be construed as a warranty that the subject site is free from any and all environmental impact.

Any soil and rock descriptions in this report and associated logs have been made with the intent of providing general information on the subsurface conditions of the site. This information should not be used as geotechnical data for any purpose unless specifically addressed in the text of this report. Groundwater conditions described in this report refer only to those observed at the location and time of observation noted in the report.

This report must be read as a whole, as sections taken out of context may be misleading. If discrepancies occur between the preliminary (draft) and final version of this report, it is the final version that takes precedence. Nothing in this report is intended to constitute or provide a legal opinion.

The contents of this report are confidential and proprietary. Other than by Teck, copying or distribution of this report or use of or reliance on the information contained herein, in whole or in part, is not permitted without the express written permission of Teck and SNC-Lavalin.

Appendix I

Produce Sample Collection Methodology

Appendix I – Produce Sampling Procedures

Garden produce samples will be collected from each garden depending on what is being grown and is available in the garden at the time of sampling. Produce must be ripe and ready to eat.

Sample containers will be labelled with the Property Identification (PID) and the produce codes. A focus will be on collecting the most common produce types as listed below:

Leafy Greens:

KAL	KALE
LET	Lettuce

Fruiting Crops:

PEA	Pea
STW	Strawberry
RAS	Raspberry
TOM	Tomato

Root Crops:

POT	Potato
CAR	Carrot

Samples will be collected as follows:

- The portion of the plant that is regularly eaten (fruit, leaves, and/or root) will be harvested by either picking the fruit or cutting with clippers.
- Produce will be weighed prior to leaving the site to ensure enough sample size (generally 100 g).
- Place samples in a Ziploc® bag, retaining air, to avoid damaging plant tissue in transit.
- Store samples in ice filled coolers while transporting samples from the property sites to the office. Care will be taken to prevent any damage to soft tissue, particularly for leafy produce.
- Samples will be washed offsite.
- At the office, wash vegetables by:
  - Rinse all vegetables to remove all visible dirt. Rinsing may be done with distilled, de-ionized water or tap water, since it has been tested in Trail, was determined to not be a source of lead and would represent what is typically done in a home;
  - Scrub root vegetables lightly with a root brush (a soft bristled brush) attempting to not remove the skin (record percent of skin removed if some comes off);
  - Place vegetable in a salad spinner and spin a minimum of 20 times or pat dry with paper towel;
  - Repeat, if dirt is still present (decontaminating any equipment between uses); and
  - Spin/pat until dry.

- Samples will be shipped to the lab within the same day as sample collection whenever possible or will be refrigerated until shipping within a day or two.
- Root crops will be peeled at the laboratory. Note on COC which samples need to be peeled.

Produce samples will be prepared as outlined and shipped in ice filled coolers to CARO and analyzed for metals in plant tissue for total metals by ICP-MS. Request that dry and wet weight also be reported.

The standard operating procedures from the lab are as follows:

Samples Obtained in the Field or Prior to Packaging:

Because produce is normally washed before being sold, it is permissible to remove visible soil particles by gentle washing with water, if necessary. Root crops sampled in the field, for example, are normally expected to require some washing. Celery stalks sampled in the field or spinach sampled prior to packaging may also require rinsing to remove sand and silt.

Removal of Inedible Portions:

All inedible portions of sample must be removed as per the guidelines set out by Health Canada, below. However, care must be taken to remove only the inedible portion, e.g. only the stem and core of the fruit, and not any of the surrounding flesh. If skin or peel can be consumed, it must be included in the sample to be analyzed. Root crops are peeled upon request.

Sample Homogenization:

The edible portion is blended using a robot coupe or food processor prior to analysis.

Operating Procedure – Composite Soil Assessment

Composite soil assessment sample collection and handling procedures for heavy metals in residential gardens

Scope:

This procedure describes the collection and handling of composite soil samples in residential flower and vegetable gardens. For the purposes of this procedure, general inorganic compounds, heavy metals in particular, are screened using an x-ray fluorescence analyzer (XRF) and submitted for laboratory analysis. For collection and handling of samples for other parameters, refer to the appropriate Preferred Operating Procedures.

Safety Precautions:

Potential contaminants of concern in residential soils include lead and other heavy metals, which can be harmful if ingested or inhaled. Physical contact with potential contaminants of concern should be avoided by wearing appropriate gloves while collecting and handling soil. Good hygiene and cleanliness should also be practiced to minimize exposure to heavy metals and transfer of contaminants to other sites.

Additional precautions must be followed to minimize radiation exposure while operating an XRF. Training and certification may be required for the specific XRF unit being used and are outlined in the OP: Shielded XRF operation and handling procedures.

Safety precautions associated with other onsite activities (i.e. remediation) may also apply. Refer to SNC-Lavalin Corporate Environmental Health & Safety Program for further information.

Quality Control:

Quality control is provided by careful documentation of field information, decontamination of sampling equipment between samples, homogenization of soil samples and documenting sample locations. Quality assurance is provided by submitting an appropriate number of blind field duplicate samples for laboratory analysis, generally one blind field duplicate for every ten samples submitted. Field duplicates and field samples are collected using exactly the same sample procedure, as described below. Sample naming is done such that the laboratory is unaware of which samples are duplicates. Refer to POP 4202 for QA procedures.

Materials, Equipment Required:

1. Personal Protective Equipment (PPE) and Safety Equipment (as applicable):
    - high visibility safety vest;
    - Nitrile gloves (or appropriate to potential contaminants of concern);

- designated footwear;
- appropriate eyewear;
- First Aid Kit (OFA Level 1);
- Eye wash station; and
- Fire Extinguisher.

2. Field Equipment:

   - pen and/or pencil;
   - Indelible felt marker;
   - field forms and/or field book (garden soil log);
   - site map, property information;
   - soil auger;
   - hand trowel;
   - sealable sample bags;
   - DI Water and spray bottle;
   - replacement soil and grass seed, as needed; and
   - camera.

Procedure

1. Confirm property ID (PID) and information in database prior to completing field sampling. Ensure property and contact information is current and complete and appropriate access consent has been obtained.
2. Inform property residents of sampling activities prior to commencing.
3. Prepare sample bags with appropriate sample nomenclature for sampling objectives: 1 composite surface soil (SS) sample per discrete vegetable garden (VG) or flower garden (FG) area:

   - Sample ID: SS*yy*-0PID-*VG#-yymmdd or* SS*yy*-0PID-*FG#-yymmdd*

   Note: Blind duplicates follow the same nomenclature as the sample being duplicated; however, garden sample duplicates are given a number; VG1, VG2 and a PID of 0001, 0002, respectively. Ensure that 2 duplicate samples of any variety, which are collected on the same date, do not have the same number or letter.

4. Using a soil auger and/or hand trowel collect soil from 10 discrete locations to form the aliquot within each of the discrete garden area. Collect samples to a depth of 15 cm. Exclude vegetation (i.e., grass and rootlets) and place soil from all 10 locations directly into the single labeled sample bag. Approximately 50 g of soil is needed for each sample including an additional 50 g for duplicates. Carefully homogenize soil and remove air space before sealing bag. (Direct bag away from you to avoid inhaling fine dust particles).
5. Complete the garden sampling soil log, or where yard soil assessment has also been completed, include garden sampling details on the property condition checklist (including the garden location on the property sketch) and property soil log. Refer to OP: Discrete soil assessment sampling procedures.
6. Enter sample locations into the survey 123 app on your smartphone and ensure accuracy is sufficient.
7. Photograph the garden, and any interesting points in the yard including access constraints.

8. Collect sample bags and dispose of all waste materials. Leave the property in a tidy condition, as found. Fill sample locations with clean bagged replacement soil as needed and top with grass seed as needed (generally not applicable for garden sampling)
9. All samples are screened using an XRF. XRF screening on soil assessment samples should take place in the Trail office XRF lab, utilizing the protective shield and therefore minimizing radiation exposure risks as much as possible. Refer to OP: Shielded XRF operation and handling procedures.
10. All vegetable garden samples are submitted for laboratory analysis. Flower garden samples are submitted for analysis on a case by case basis (i.e. is a maximum XRF screening result for the property) Generally; XRF screening results for flower gardens are sufficient.

    Special Considerations:

    - VG samples exceeding 1000 ppm for lead and/or 30 ppm for cadmium (or any other applicable UCC) will be offered remediation and thus, should be analyzed for Toxicity Characteristic Leaching Procedure (TCLP) for soil disposal purposes, requiring an additional 100 g of sample. Refer to OP: Preparation for Remediation and Yard Improvement Projects for additional information on soil disposal requirements.

11. Soil samples selected for analysis are submitted to the laboratory in the sealable plastic bag and labeled appropriately. Where, duplicate samples are analyzed, care should be taken that the soil is homogeneous between the two sample bags.
12. Prepare individual COCs for each property and assign a COC number (0PID-yymmdd) using the sample date. Vegetable garden composite samples are submitted with yard assessment samples from the same property, on the same COC. (Note: the COC number for remediation samples at the same property will differ by the sample date, as is the case for annual LTS sampling events). Ensure that the appropriate project number and Trail Health and Environment Program Pricing is indicated on the COC. DO NOT select any applicable regulatory limits. Digital copies of COCs are stored under a file name using the COC number followed by the date relinquished (e.g. 0PID-130509_130602). Once analytical results have been received and reviewed, remaining soil samples can be placed in long-term soil storage.
13. Provide an accurate completion date in the database for each task as it has been completed. Ensure all field documents, photographs and location data points have been electronically filed appropriately and all hard copies are filed by PID. Refer to OP: Data Management Procedures.

Technical Notes

Studies completed on sample preparation show that for the purposes of this program it is not necessary to dry and sieve the soil prior to XRF soil screening and it may be screened directly through the soil bag.

XRF results can be skewed if the soil is excessively moist or wet. Sample collection during heavy rain events should be avoided where possible.

A trial of composite procedures was completed in 2009. The trial indicated that composite sampling methods provided a good understanding of garden soil, where soil is often mixed and turned over at least annually. Statistical analysis of the composite indicated a co-efficient of variation within acceptable range for the gardens tested.

References

Appendix II

Participant Questionnaire

SNC·LAVALIN
Environment

Home Garden Survey

Project No:	Address:	Individual:
PID:	Location:	Date:
		Weather:

General Garden Information

Garden Size:	Condition:

What types of produce are currently growing in the garden?

What other produce types have been grown in this garden this year but are not currently growing?

What other produce types, if any, are planned for this garden this year?

What produce types have been grown in previous years that were not grown this year?

How many people in the family eat home-grown produce?

Is any produce given away or sold? **YES** **NO**
If YES, what type and how much?

Do you peel home-grown produce prior to consumption? **YES** **NO**
If YES, which produce is peeled?

Do you can, dry, or freeze home-grown produce for consumption later in the year? **YES** **NO**

Produce	Preservation Method (Canned, Dried, Preserved)	Approximate Quantity

SNC•LAVALIN Environment

Address: ____________________

Home Garden Survey (Cont'd)

Is there produce grown for uses other than human consumption (e.g., medicinal uses)? **If YES, what type or uses?**		**YES**	**NO**
How many years has this garden been present?			
Was there a garden here when the current homeowner moved in?	**YES**	**NO**	**UNKNOWN**
Is the garden in a raised bed?	**YES**	**NO**	**UNKNOWN**
Have other soils, compost, manure, or other amendments ever been added to the garden soil? **If YES, what/when/how?**		**YES**	**NO**
Has the garden been rototilled or plowed? **If YES, how recently and how often?**	**YES**	**NO**	**UNKNOWN**
Is the garden plot burned at the end of the growing season or prior to planting?	**YES**	**NO**	**UNKNOWN**
Is there now, or has there been a burn barrel, burn pile, or fire pit on the property or adjacent property near the garden? **If YES, where and proximate distance?**	**YES**	**NO**	**UNKNOWN**
Is there machinery, automobiles or other motorized equipment stored on the property or adjacent property near the garden? **If YES, where and proximate distance?**	**YES**	**NO**	**UNKNOWN**

Appendix III

Laboratory Analytical Reports

and

Appendix IV

Statistical Summaries

Data available upon request at:
programs@thep.ca

SNC•LAVALIN

SNC-Lavalin Inc.
8648 Commerce Court
Burnaby, British Columbia, Canada V5A 4N6
604.515.5151   604.515.5150
www.snclavalin.com