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October 20, 2023

AJ Downie
Regional Director – Southeast Coal Mining
Ministry of Environment and Climate Change Strategy (ENV)
3726 Alfred Avenue
Smithers, BC V0J 2N0

Reference: Second Revised Final Human Health Risk Assessment Report

Dear AJ

Please accept the attached as Teck's final submission of the Human Health Risk Assessment (HHRA) report. This submission is intended to satisfy Section 8.10 of Permit 107517 and ENV's letter dated December 21, 2018, and to address the comments received from the Ktunaxa Nation Council (KNC) following their review of the revised final report that was submitted on June 7, 2023.

This second revised final report represents the culmination of nearly five years of engagement and collaboration with members of the Human Health Workgroup (HHWG). The HHWG was established to make sure all necessary representatives and subject matter experts were present and engaged on all aspects of the project. The HHWG is a subject-matter subgroup of the Environmental Monitoring Committee (EMC) that includes representatives and subject-matter experts for the KNC, BC Interior Health, First Nations Health Authority, ENV, and Teck. This second revised final report reflects the significant efforts and contributions made by this group since its first meeting in December 2018.

The HHWG met each month and worked on increasing their collective understanding of the technical aspects of human health risk assessments in general and the unique aspects of this risk assessment in particular. Members shared knowledge, expertise, and resources, and discussed all decisions regarding the inputs and assumptions for this assessment. The assessment steps were completed in 2021 and a draft report was submitted to the HHWG for review in October that year. A final report was submitted to ENV on July 1, 2022. Following their review of the final report, KNC and IH provided additional comments that led to the revised final report submitted on June 7, 2023. Discussions following the June submission resulted in additional comments from KNC, which led to this second revised final report. The technical consultant team that conducted the HHRA and prepared the draft and final report(s) considered all review comments and incorporated into each report all those that could, in their professional opinion, be technically supported.

The results of this HHRA, which used data obtained from 2015 to 2020, are consistent with the results from the 2016 HHRA, which used data obtained between 2010 and 2016. This suggests that risks associated with water quality and food quality in the Elk Valley have not changed significantly over the past decade. Both HHRAs identified selenium and nitrate as the primary drivers of risk, and both constituents are addressed in the Elk Valley Water Quality Plan (EVWQP) and Permit 107517. The HHRA results confirm that Teck's mitigation strategy to reduce concentrations of selenium and nitrate in the Elk Valley (as outlined in the most recent Implementation Plan Adjustment) is focused on the right constituents of concern.

The outcomes of this HHRA and the uncertainties it identified will be addressed by Teck through its Adaptive Management Plan and continued collaboration with the HHWG. Teck understands the complex nature of the HHRA and is committed to working with the HHWG to develop communication materials and messages that will translate the findings in a way that has meaning for the general public and the Ktunaxa people.

If you have any questions regarding this submission, please do not hesitate to contact me at (250) 425-8247 or colleen.mooney@teck.com

Sincerely,

Colleen Mooney
Lead, Regional Water Monitoring
Sustainable Development
Teck Coal Limited

Prepared for
Teck Coal Limited

Prepared by
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Date
October 2023

SECOND REVISED FINAL HUMAN HEALTH RISK ASSESSMENT SUPPORTING THE ELK VALLEY WATER QUALITY PLAN

Bright ideas. Sustainable change.

ACRONYMS AND ABBREVIATIONS

95 UCLM	ninety-five percent upper confidence limit of the mean
µg	microgram(s)
µg/kg ww	microgram(s) per kilogram, wet weight
µg/kg-day	microgram(s) per kilogram per day
µg/L	microgram(s) per litre
ABS	absorption fraction
ABS_{derm}	dermal absorption fraction
ABS_{GI}	gastrointestinal tract absorption fraction
AF	adherence factor
AGM	Ktunaxa Nation Council Annual General Meeting
AP	averaging period
ATSDR	Agency for Toxic Substances and Disease Registry
AWTF	Active Water Treatment Facility
BC	British Columbia
berry	berry/rose hip
BW	body weight
C2C	Classrooms to Community
CCME	Canadian Council of Ministers of the Environment
CF	unit conversion factor
cm	centimetre(s)
cm/hr	centimetre(s) per hour
cm^2	square centimetre(s)
CNS	central nervous system
COC	constituent(s) of concern
COPC	constituent(s) of potential concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon(s)
CSM	conceptual site model
CSR	British Columbia Contaminated Sites Regulation
DA	designated area
DAD	dermally absorbed dose
derm	dermal
DL	detection limit(s)
DNEL	derived no effect level(s)
DQO	data quality objectives
EA	environmental assessment
ED	exposure duration
EF	exposure frequency
EMA	Environmental Management Act
EMC	Environmental Monitoring Committee
ENV	British Columbia Ministry of Environment and Climate Change Strategy

EPC	exposure point concentration
EPC_{berry}	berry/rose hip exposure point concentration
EPC_{DW}	drinking water exposure point concentration
EPC_{game}	game tissue exposure point concentration
EPC_{sed}	sediment exposure point concentration
EPC_{SW}	surface water exposure point concentration
ET	exposure time
EV	event frequency
EVM	Expert Group on Vitamins and Minerals
EVWQP	Elk Valley Water Quality Plan
Firelight	The Firelight Group (formerly known as The Firelight Group Research Cooperative
g	gram(s)
g/day	gram(s) per day
g/day ww	gram(s) per day, wet weight
GI	gastrointestinal
Golder	Golder Associates Ltd.
GSI	gonado-somatic index
ha	hectare(s)
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
hr/event	hour(s) per event
IH	Interior Health
IMBA	Impact Management and Benefit Agreement
INORG	inorganic
IOM	Institute of Medicine
IR	ingestion rate
IR_{berry}	berry/rose hip consumption rate
IR_{DW}	drinking water ingestion rate
IR_{fish}	consumption rate for fish tissue
IR_{game}	consumption rate for game muscle, or for game organ meat
IRIS	Integrated Risk Information System
IR_{sed}	sediment incidental ingestion rate
IR_{SW}	surface water incidental ingestion rate
K	coefficient or constant
KBLUP	Kootenay/Boundary Land Use Plan
kg	kilogram(s)
kg/mg	kilogram(s) per milligram
KNC	Ktunaxa Nation Council
K_p	dermal permeability coefficient
L	litre(s)

L/cm^3	litre(s) per cubic centimetre
L/hr	litre(s) per hour
LOAEL	lowest observable adverse effect level
L_{SW}/hour	litre(s) of surface water per hour
MAC	maximum acceptable concentrations
MFLNRORD	British Columbia Ministry of Forest, Lands and Natural Resource Operations and Rural Development
mg	milligram(s)
mg/cm^2	milligram(s) per square centimetre
mg/cm^2-event	milligram(s) per square centimetre per event
mg/day	milligram(s) per day
mg/kg	milligram(s) per kilogram
mg/kg ww	milligram(s) per kilogram, wet weight
mg/kg-day	milligram(s) per kilogram per day
mg/L	milligram(s) per litre
mg/visit	milligram(s) per visit
mg_{sed}/cm^2-event	milligram(s) soil per square centimetre skin per soil contact event
Minnow	Minnow Environmental Inc.
mmol/L	millimole(s) per litre
MU	management unit
NA	not applicable
NE	not evaluated
NHANES	National Health and Nutrition Examination Survey
NIOSH	National Institute of Occupational Safety and Health
NOAEL	no observable adverse effect level
p	permeability
PAH	polycyclic aromatic hydrocarbon(s)
PPRTV	Provisional Peer Reviewed Toxicity Values for Superfund
p-RfD	provisional reference dose
QA/QC	quality assurance and quality control
RAEMP	Regional Aquatic Effects Monitoring Program
RAF_{derm}	relative absorption fraction, dermal pathway
RBSL	risk-based screening level
RDWMP	Regional Drinking Water Monitoring Program
REACH	Registration, Evaluation, Authorization and Restriction of Chemicals
Reg	Consolidated Regulation
RfD	reference dose
RIVM	Dutch National Institute of Public Health and the Environment
RPD	relative percent difference
sed	sediment or soil
SF	cancer slope factor
SSA	skin surface area

SSA_{sed}	sediment skin surface area
SSA_{SW}	surface water skin surface area
SVOC	semi-volatile organic compound
SW	surface water
Synopsis	Freshwater Fishing Regulations Synopsis
Teck	Teck Coal Limited
TRV	toxicity reference value(s)
UCL	upper confidence limit
UCLM	upper confidence limit of the mean concentration
UF	uncertainty factor
ug/L	microgram(s) per litre
UL	upper intake level
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
Valley	Elk Valley
WHO	World Health Organization
Windward	Windward Environmental
WOE	weight-of-evidence
WQG	water quality guidelines
ww	wet weight

KTUNAXA TERMINOLOGY AND ACRONYMS USED

Ktunaxa ʔaqǂsmakniḱ	Ktunaxa human beings; Ktunaxa people
Ktunaxanintik	Term currently used to imply citizenship according to the Ktunaxa Citizenship Code. Not all Ktunaxa ʔaqǂsmakniḱ are formally/legally Ktunaxanintik at this time.
Ktunaxa Nation	Refers to the collective Ktunaxa Peoples and identity more broadly, not limited to bands, reserves, the Indian Act and related policies and organizations.
ʔaqǂsmakniḱmu	Ktunaxa Culture -what helps us to live
ʔa·knumuȼtiǂiǂ	Ktunaxa Natural Law
ʔa·kuḱpukam	Belonging and responsibility – roots
ʔa·kxamis q̓api qapsin	all living things
ʔamakʔis Ktunaxa	Land of the Ktunaxa
qukin ʔamakʔis	Raven's Land; Elk Valley
ȼamna ʔamakis	Land of the Wood Tick
Access Management Plan	A Plan defined under the Ktunaxa Nation Council (KNC) and Teck Coal Limited (Teck) Impact Management and Benefit Agreement (IMBA) focused on Ktunaxa access to Teck Properties for cultural and rights-based activities.
Ktunaxa Nation Council (KNC)	A governance organization comprised of the 4 Indian Act Bands, whose programming and services are provided through 5 Sectors, guided by the Ktunaxa Nation Vision Statement.
ʔakisq̓nuk	A Ktunaxa First Nation, formerly known as the Columbia Lake Indian Band and reserve
ʔaq̓am	A Ktunaxa First Nation, formerly known as the St Mary Indian Band and reserve
Yaqan nuʔkiy	A Ktunaxa First Nation, formerly known as Lower Kootenay Band and reserve
Yaq̓it ʔa·knuqǂi 'it	A Ktunaxa First Nation, formerly known as Tobacco Plains Band and reserve
ʔa·kisḱaqǂiʔit	Cranbrook area
Wild Foods Initiative (Program)	A Program defined under the KNC and Teck IMBA focused on the consumption and safety of "wild foods."
ʔa·kpiȼis	"favorite food"—replaces western concept of "wild food" and "traditional food". According to the principle of ʔa·kxamis q̓api qapsin, favorite food is Species-specific and is used here to mean the favorite food of the Ktunaxa ʔaqǂsmakniḱ--this would then also be more specific by person following the principle of 'take what you need' referred to below
sukiǂ ʔiknaǂa	Eating good, —replaces western concept of "preferred", "high consumers" and "heavy harvesters". Relative term--one person eating good is not necessarily the same amount for another person. Eating good is interconnected to 'take what you need'. This is the same principle for food relationships with 'all living things'
Hermeneutic	From the Greek philosophers meaning to interpret. Includes the theory and methodology of interpretation of knowledge stemming from sacred, philosophical and literary texts considered to be wisdom. Usually includes communications, understanding, and comprehension as well as language usage
Hermeneutic Phenomenology	An approach to making meaning of ones' lived experiences in order to recover world view, as a result of a purposeful interpretative process.
IMBA	Impact Management and Benefit Agreement – a confidential agreement between KNC and Teck

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EXECUTIVE SUMMARY

Background: A human health risk assessment (HHRA) was conducted on Teck Coal Limited's ("Teck") behalf for the Elk Valley to evaluate *potential* risks of chemical constituents in water from coal mining activities on human health. Although the constituents evaluated in the HHRA are naturally occurring, some can also be enriched through mining activities. This assessment is required under Environmental Management Act (EMA) Permit 107517, Section 8.10.[1]

The purpose of the HHRA is to evaluate whether any changes are needed in water quality management to address potential human health risks.

The HHRA was developed in consultation with members of the Environmental Monitoring Committee (EMC), which includes representatives of the British Columbia Ministry of Environment and Climate Change Strategy (ENV), Interior Health (IH), Ktunaxa Nation Council (KNC)–Lands and Resources Sector, Teck, and others. Members of the EMC advising on this HHRA are referred to as the 'HHRA Workgroup' throughout this report.

What is human health risk assessment (HHRA)?

Human health risk assessment (HHRA) is a process to evaluate the potential for adverse health risks under certain exposure conditions. In this assessment, potential health risks were evaluated using approved methodologies and risk management thresholds defined in the British Columbia (BC) Contaminated Sites Regulation (CSR) and Health Canada's Human Health Risk assessment guides. Health Canada and BC HHRA methodology was established to identify and assess risks at contaminated properties, and guide risk management. However, HHRA is not an exact science and cannot be used to predict actual health risks in a community. HHRA does not include an assessment of incidence or prevalence of disease in a community and should not be used to guide medical or public health interventions. Typically, the results of an HHRA are used to guide cleanup efforts, site use restrictions, and the need for continued monitoring or risk management. Under Permit 107517, the HHRA was performed to determine if changes are needed in managing water quality. An overview of this HHRA completed under Permit 107517 is presented in Table ES-1.

Risk estimates are ranked in the HHRA consistent with guidance from Health Canada (2010a, 2019) and ENV (2023). This risk ranking, or prioritization of risks, can be used to prioritize data gathering and risk management activities to better understand and reduce risks. As indicated in Table ES-1, hazard quotients (HQs) equal to or less than 0.2 are considered negligible; HQs equal to or less than 1, or consistent with reference areas are considered to have acceptable risks; and HQs greater than 1 and background, require further evaluation and may require risk management. Cancer risks were similarly ranked, by comparison with the ENV risk management threshold. Cancer risks equal to or less than 1 additional cancer case in 100,000 are considered negligible; cancer risks consistent with reference areas are considered to have negligible risks; and cancer risks greater than 1 in 100,000 and risks in reference areas require further evaluation and risk management.

Although risk estimates cannot be directly linked to specific health effects, we assume as risk estimates increase the potential for health risk increases. For this reason, exposure pathways and receptors with the highest risk estimates will be the highest priority for data gathering and risk management, as needed.

[1] Refers to current version of Permit 107517, dated May 18, 2023, which specifies the HHRA requirement in Section 8.10. The original Permit 107517 specified the HHRA requirement in Section 9.9.

Table ES-1. Overview of Risks Evaluated in the HHRA

<table>
<tr><td colspan="2">Risks were calculated for the local Ktunaxa People and other people in the Elk Valley who may come in contact with water and sediments within the Elk River watershed and Koocanusa Reservoir, use groundwater for drinking water, and/or consume locally harvested fish, deer, elk, berries, and rose hips. Risks also were calculated for consumption of surface water as drinking water.</td></tr>
<tr><th>Cancer Risks</th><th>Non-Cancer Risks</th></tr>
<tr><td>❖ Calculated as the incremental increase in probability of cancer associated with exposure to a chemical in surface water, sediment, groundwater, and/or food (e.g., game, fish, berries)
• Cancer risks are the estimated exposure dose multiplied by the chemical-specific cancer potency value.
• Cancer risk less than or equal to 1 additional cancer case in 100,000 people is considered ‘essentially negligible’. Cancer risk equivalent to background is considered acceptable (ENV 2023 and Health Canada 2010).
• If the cancer risk is greater than 1 in 100,000 and greater than background, additional assessment and risk management may be needed.</td><td>❖ Calculated the potential for non-cancer hazard associated with exposure to a chemical in surface water, sediment, groundwater, and/or food (e.g., game, fish, berries)
• Non-cancer hazards are assessed using the ratio of an estimated exposure dose to an acceptable dose of a chemical constituent. This ratio is referred to as a HQ.
• Initial screening was conducted based on a HQ of 0.2 to identify constituents and pathways of most importance. HQ values less than 0.2 have negligible risks. In risk calculations including consideration of background, where the HQ is less than or equal to the ENV risk management threshold of 1, no adverse health effects are expected (i.e., acceptable risk). If an HQ is greater than 1 and greater than background, additional assessment and risk management may be needed (ENV 2023).
• HQs are summed across chemicals to calculate a target organ HI. Chemical HQs are only summed if they have an adverse health effect on the same target organ or system.
• HQs can also be summed across exposure pathways to estimate cumulative risk for a specific chemical. This was done for selenium in the HHRA (see Figures ES-4 to ES-8).</td></tr>
<tr><td colspan="2">Notes:
ENV = British Columbia Ministry of Environment and Climate Change Strategy; HHRA = human health risk assessment; HI = hazard index; HQ = hazard quotient</td></tr>
</table>

What Was Evaluated in the HHRA?

This HHRA is focused on the water-related exposures (i.e., surface water, groundwater, sediment, fish) to humans that may be influenced by current and historical mining practices within the Elk Valley. In addition, because the diet is an important source of exposure to minerals, including selenium, the HHRA evaluated consumption of elk, deer, berries, and rose hips harvested in the Elk Valley. Risks associated with selenium in the background diet (i.e., foods from the grocery store) are also considered. This risk assessment is not predictive of risks that might be associated with any future mining projects. Dust emissions from mining operations were not the subject of this HHRA and were not directly characterized. However, potential influences associated with the deposition of dust emissions on environmental media evaluated in the HHRA, such as berries and on forage consumed by game, are inherently accounted for in this HHRA.

The HHRA evaluated a full range of constituents that could be influenced by mining operations. However, at the outset, selenium was known to be present in surface water at concentrations greater than the BC drinking water guideline of 10 µg/L in numerous locations, and selenium is a particular focus of this assessment (See Figure C-1, Appendix C).

The ways by which people can be exposed to chemical constituents in the environment can be described, or depicted, in a conceptual site model (CSM) that identifies the source(s) of chemical constituents, the pathways by which they are transported within the environment, environmental media in which they may be found (e.g., groundwater, surface water, fish), and possible routes by which people may contact the constituents (e.g., ingestion, skin contact).

Two example CSMs are provided as Figure ES-1 and Figure ES-2, with Figure ES-2 specific to Ktunaxa lifeways. Although human health and well-being are influenced by many things, the focus here is on water-influenced pathways to determine what further water quality management adjustments may be needed and on the consumption of several food items commonly harvested in the Elk Valley – deer, elk, berries, and rose hips.

Figure ES-1. Conceptual Site Model for the Elk Valley

The HHRA evaluated potential risks for Ktunaxa People and other people who may contact chemical constituents in surface water, sediment, groundwater, fish, berries, rose hips, and game in the Elk Valley and Koocanusa Reservoir. Mine workers and other workplace exposures were not evaluated because worker safety is regulated by both provincial and federal regulations. It is, however, recognized that workers who also live in the Elk Valley, may also have additional exposures from working as well as recreating, or eating locally harvested foods.

Exposures vary depending on the age of the person due to differences in body weight and media contact rates. For this reason, exposures for a range of life stages (i.e., infants, toddlers, young children, teens, and adults) were evaluated. The HHRA relied on a combination of federal and provincial guidance, studies provided by the KNC, and literature sources for numerical values representing how often people may contact environmental media or foods, and other factors that influence how much of a particular chemical constituent an individual may be exposed to during each life stage.

Figure ES-2. Conceptual Site Model for Ktunaxa Lifeways

Note: The narrative in Section 2.3 of the HHRA (Conceptual Site Model--"Ktunaxa Lifeways within qukin ʔamakʔis") should be reviewed with this figure.

What Data Were Used?

The HHRA used surface water, sediment, and fish tissue data collected through the following sources: Teck's Regional Aquatic Effects Monitoring Program (RAEMP); groundwater data collected through Teck's Regional Drinking Water Monitoring Program (RDWMP); data collected from other studies; and volunteer-provided samples as relevant. This included game and berry samples collected through the Wild Foods Sampling Program and additional samples donated by Teck, KNC, and Ktunaxa People.

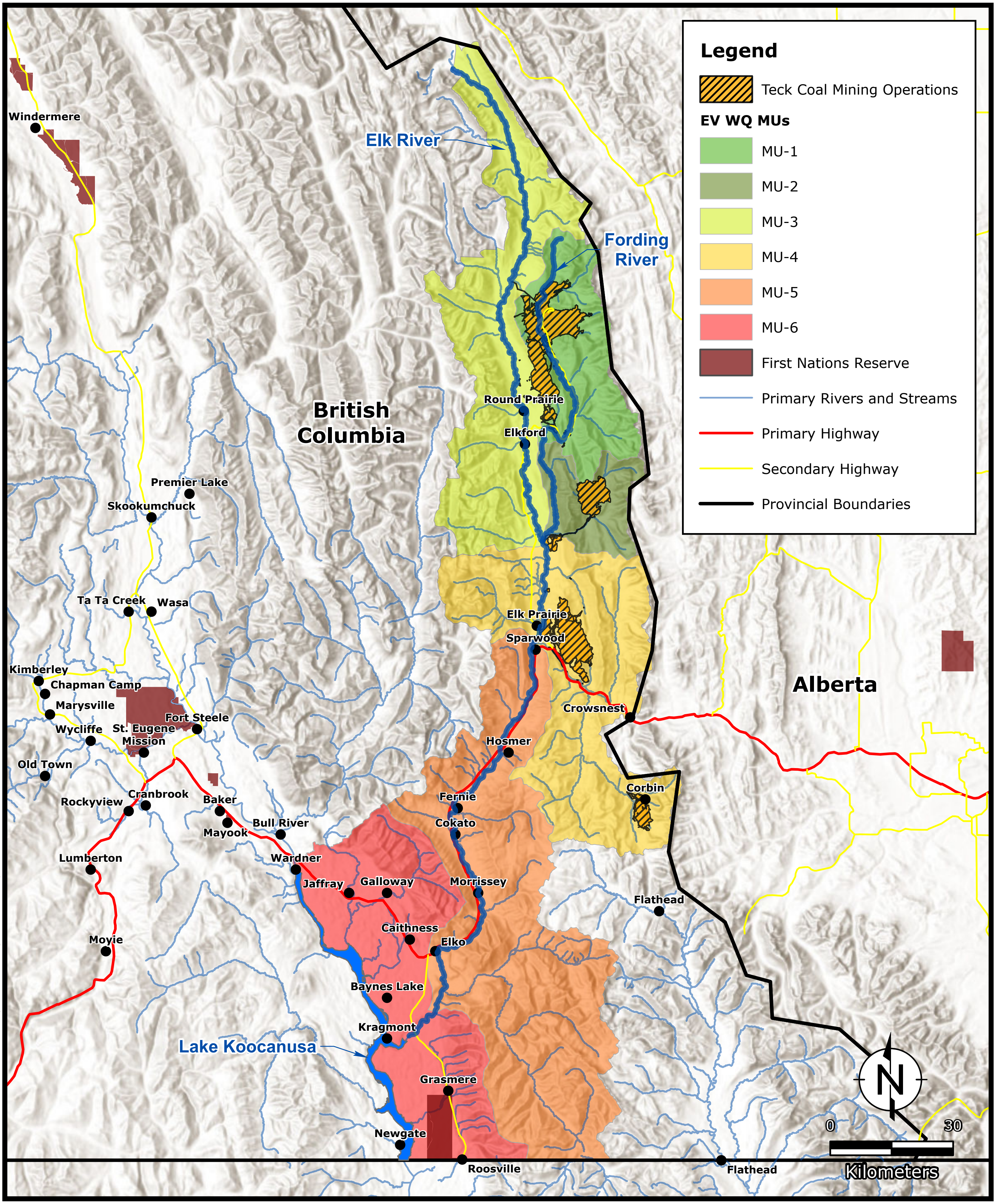
This HHRA assessed current conditions using environmental monitoring or tissue data collected from 2015 to 2020. Samples in all media were analyzed for metals, including selenium. A class of organic chemicals, referred to as polycyclic aromatic hydrocarbons (PAHs) were also analyzed in sediment, surface water, and some berry and game samples. General water quality parameters (e.g., nitrate, sulphate) were also analyzed in groundwater and surface water. In the HHRA, sample counts are shown on Tables 3-1 through 3-4 for fish and wild foods. For groundwater, surface water and sediment, sample counts by area and constituent are shown in the Appendix C screening tables. The sample locations for each medium are shown on Figures 3-1 through 3-6 of the HHRA.

Fish sampled include brook trout, bull trout, kokanee, largescale sucker, longnose sucker, mountain whitefish, northern pikeminnow, peamouth chub, rainbow trout, redside shiner, and westslope cutthroat trout, but all species were not available at all locations (see HHRA Section 6.3.3 and Figure 6-3 for more information). The fish samples used in the HHRA are from a sampling program that focuses on ecological effects rather than potential human health risks, and as a result, some fish species or sample locations may not reflect fish species people prefer to eat or areas where people prefer to fish.

What Areas Do the Data Represent?

The HHRA study area was defined in the Elk Valley Water Quality Plan (EVWQP) from 2014, and encompasses all the Teck mining operations in the Elk Valley and extends along the Elk River and into Koocanusa Reservoir to the Canada-U.S. border. The area, referred to as the Designated Area (DA), is divided into six management units (MUs), shown in Figure ES-3. The primary waterways evaluated were the Elk River (spanning MU-1 through MU-5) and Koocanusa Reservoir (MU-6). Risks were calculated for each MU as well as "valley-wide;" these risks were based on data from MU-1 through MU-5.[2]

[2] Valley-wide risks for game, berries, and rose hips incorporated data from MU-1 through MU-6 due to smaller sample size for these media.



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RAMBOLL

Elk Valley Water Quality Management Units

British Columbia, Canada

FIGURE

ES-3

DRAFTED BY: CKROHE | DATE: 4/25/2023 | PROJECT: 1690011690

How Were Exposures Calculated?

Concentrations of chemical constituents in aquatic media (i.e., water, sediment, and fish) and in additional media (i.e., game, berries, and rose hips) were first compared to screening levels which are conservative, numerical health-based values generally derived by provincial and federal government agencies used to identify constituents of potential concern (COPCs). COPCs are chemical constituents with concentrations in a medium that are greater than their respective screening level, regardless of whether they are related to mining practices or natural conditions.

Next, exposure was calculated for each COPC in each exposure medium by consumer group and life stage, which represented the amount of chemical constituent a person could contact or be exposed to on a daily basis. Each exposure dose was estimated by combining information about how much of a COPC is present in an environmental medium, how often someone contacts the medium, and other factors related to duration of contact, body weight, and life stage of the population. These contact rates, including consumption rates for food and water ingestion rates, are discussed in Section 4.2 of the HHRA. It is particularly important to note that five different consumption levels were used to evaluate exposure to COPCs in foods (e.g., fish, game, berries) sourced from the Elk Valley, as shown in Table ES-2. Table ES-3 provides a summary of all exposures evaluated in the HHRA.

The *preferred diet consumer* is unique to the Ktunaxa People, representing *sukiɬ ʔiknaɬa* (*eating good)* that is consistent with Ktunaxa cultural practices and preferences. [3] The consumption rates for the Ktunaxa *upper percentile consumer* are the 95th percentile values selected from a distribution of data obtained from dietary surveys completed with Ktunaxa adults in 2012 and 2013. The Ktunaxa *average consumer* is the mean consumption rate calculated from these dietary survey data. The consumption rate for the upper percentile recreator is the Canadian high fish consumer value from the Bureau of Constituent Safety. Consumption rates for younger age groups (toddlers, young children, teens) were derived from adult consumption rates.

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[3] sukiɬ ʔiknaɬa is the Ktunaxa phrase for "eating good" and replaces the western concept of “preferred,” “high consumers,” and “heavy harvesters.” sukiɬ ʔiknaɬa is a relative term; one person eating good is not necessarily the same amount for another person. This is the same for ‘all living things.’ Ktunaxa preferred rates are premised upon two key Ktunaxa principles:

a. Take what you need, according to your context including, cultural, spiritual, family size etc. as well as recognition of the food needs shared with other species and options for other foods in times of scarcity.
b. ʔa•kpiȼis is the Ktunaxa concept that refers to the favourite and regular foods eaten for both animals, birds, fish, and humans, according to inherent and interdependent relationships of ʔa̓kxam̓is q̓api qapsin—all living things—and so governed by Ktunaxa natural law—ʔa•knumuȼtiɬiɬ.

Table ES-2. Food Consumption Rates for Adults Evaluated in the HHRA

Population	Fish[a]	Fish Eggs	Game Meat[a]	Game Organs	Berries	Rose Hips
Preferred Diet Consumer - sukiɬ ʔiknaɬa (eating good)						
Ktunaxa	245 g/day 365 meals/yr	0.7 g/day	628 g/day 935 meals/yr	27 g/day 40 meals/yr	208 g/day	5 g/day
Upper Percentile Consumer						
Ktunaxa	43 g/day 64 meals/yr	Not evaluated	324 g/day 482 meals/yr	54 g/day 80 meals/yr	206 g/day	31 g/day
Recreator (not Ktunaxa)	40 g/day 60 meals/yr	Not evaluated	324 g/day 482 meals/yr	54 g/day 80 meals/yr	206 g/day	Not evaluated
Average Consumer						
Ktunaxa	10 g/day 15 meals/yr	Not evaluated	83 g/day 123 meals/yr	10 g/day 14 meals/yr	85 g/day	4.5 g/day
Recreator	10 g/day 15 meals/yr	Not evaluated	83 g/day 123 meals/yr	10 g/day 14 meals/yr	85 g/day	Not evaluated

Notes:

[a] Meal sizes are assumed to be 245 g/meal for adults consuming fish and game meat.

HHRA = human health risk assessment; g = grams; yr = year

Are Exposures Not Related to Mining Considered in HHRA?

All the chemical constituents identified as COPCs and evaluated in the HHRA are present in the environment from natural sources as well as from human-related activities, including mining. For example, PAHs are released during the combustion of organic matter such as from wildfires, grilling food over a flame, or automobiles, and naturally occurring metals are found in soil and water, and can be taken up into plants and animals that we eat. Exposure to these non-mining-related sources of COPCs are referred to as *background exposures*. Background exposures were evaluated in multiple ways in the HHRA, in addition to the mining-related exposures. Specifically, risk estimates were calculated for foods collected from areas other than the study area for comparison with risk estimates for fish, game, and berries collected in the Elk Valley and Koocanusa Reservoir.

What Health Risks Were Evaluated?

Each COPC is associated with one or more specific health effects. In setting chemical-specific toxicity reference values (TRVs), data from animal studies and human populations are considered and the lowest concentration that can cause an adverse health effect, or the highest test concentration that did not result in an adverse health effect, is selected. This concentration then is modified by uncertainty factors (UFs) to account for various forms of uncertainty in the toxicity database associated with the COPC. The resulting TRVs represent a conservative estimate of chemical toxicity and are more likely to overestimate than underestimate toxicity (Health Canada 2021b).

TRVs used in the HHRA may be based on cancer risks, or noncancer-related effects, and are obtained from environmental health regulatory agencies recommended by ENV and used by the HHRA Workgroup. For example, the TRV for selenium is from Health Canada, and has a value of

0.0057 milligrams of selenium per kilogram body weight per day (mg/kg-day). Exposures up to this concentration will not result in an adverse health effect.

What Are the Results of the HHRA?

The HHRA presents results in terms of cancer and noncancer risks for people in the Elk Valley who may contact COPCs in surface water, sediment, groundwater, fish, berries, rose hips, and game. The HHRA presents health risks for 1) Ktunaxa who have land and water-based relationships in the Elk Valley HHRA study area; 2) residents in the Elk Valley study area and visitors; and 3) full-time or seasonal residents and visitors who consume groundwater as drinking water.

Among the many COPCs evaluated in the HHRA, selenium contributed to higher risks than other COPCs across all exposure media and populations. Some amount of selenium is essential to life but chronic overexposure to selenium at exposures higher than the TRV (e.g., over 0.8 milligrams per day [mg/day]) may cause a health condition called selenosis. Symptoms observed in individuals exposed to chronically high levels of dietary selenium include loss of hair and nails, skin lesions, tooth decay, and abnormalities of the nervous system (ENV 2014). These effects typically resolve themselves once the exposure route is eliminated. Selenium is not known to cause cancer. However, arsenic and PAHs are considered carcinogens and were evaluated as such in the HHRA.

To understand the key contributors to elevated risks, the results for each exposure medium were reviewed; these exposure media-specific risks are summarized in Table ES-3. Risks presented in Table ES-3 are shown as having negligible risk if the results were lower than an HQ equal to or less than 0.2 or a cancer risk equal to or less than 1 in 100,000. Due to the multiple health protective assumptions that underlie HHRA methodology, HHRAs are more likely to overestimate rather than underestimate risks. This means that an HQ of 1 or less is a strong indicator that no adverse health effects are likely.

Table ES-3 also provides information about which exposures are the same whether someone is exposed to COPCs in a particular environmental medium within the study area, Elk Valley or Koocanusa Reservoir, or outside of the study area. In these cases, risks are considered consistent with background risks and are typically not evaluated further unless exposure conditions in the study area change.

Potential elevated health risks, identified here as HQs greater than 1, also are presented in Table ES-3 for each exposure medium. Because there are many health protective assumptions in HHRA methodology, an HQ greater than 1 is not a predictor of an actual health risk. Instead, an HQ greater than 1 indicates a need for further refinement of the HHRA assumptions or additional data collection. If study refinements or data gaps are addressed and HQs remain elevated, then risk management actions may be warranted. Section 7 of this HHRA provides a summary and conclusions of the HHRA, describes recommendations for next steps, and presents a summary of how the HHRA will be used in Teck’s Adaptive Management Plan.

Table ES-3. Summary of Risk Estimates for Mining-Related COPCs in Surface Water, Sediments, and Groundwater, Fish, Berries, Rose Hips, and Game Meat and Organs

		Negligible Risks	Acceptable Potential Risks [a]		Elevated Potential Risks [a]	Uncertainties
		HQ≤0.2	**HQ >0.2 and less than 1**	**Risks Consistent with Background**	**HQ>1 and Background**	
Decreasing Influence of Surface Water on Exposure	**Surface Water And Sediments**	• Negligible direct contact (ingestion or dermal contact) risk for recreational and cultural activities (e.g., swimming, wading, foraging) in Elk River, tributaries, and Koocanusa Reservoir water and sediment for all CoPCs except for sediment ingestion for cobalt in MU-4 • Surface water can contain microbiological contaminants (bacteria, viruses, and parasites) and industry-related substances. IH recommends testing and treating surface water (from rivers, streams, or lakes) anywhere in the province before drinking it	Selenium is present in surface water at concentrations greater than the BC screening value of 10 µg/L (see Appendix C, Figure C-1 for locations) Sediment ingestion: • Cobalt: MU-4 HHRA results for surface waters as drinking water: • Nitrate: MU-1, MU-2, MU-3, and MU-4 • Lithium: MU-1 MU-2, MU-3, MU-4, Valley-wide (MU-1 through MU-5 combined) • Selenium: MU-1, MU-3, Valley-wide • Uranium: MU-3 See also Tables 6-1 and 6-4	• Background risks are not evaluated	• Surface water in MU-1 and MU-3 would have elevated risks if used as drinking water for infants due to nitrates	• Agricultural uses of surface water are only evaluated in the uncertainty assessment; not expected to result in elevated risk
	Fish	• Negligible risk for all COPCs for average consumers in all MUs except MU-4 (selenium) and MU-6 (mercury) • Consumption of fish eggs has negligible risk in all MUs	Selenium: • Average consumers (15 meals/yr) MU-4 • Upper percentile consumers (60-64 meals/yr): MU-1, 2, 3, 4,-5 (separate), and Valley-wide • Preferred consumers (365 meals/yr) all MUs, and Valley-wide, and reference Mercury: • Average consumers: MU-6 • Upper percentile consumers: MU-2, MU-3, MU-5 and, MU-6, Valley-wide and reference • Preferred: All MUs, Valley-wide and reference Cobalt: • Preferred: MU-1, -MU-5 and Valley-wide Lead: • Preferred: MU-6 Thallium: • Preferred: All MUs, Valley-wide and reference See also Table 6-1	• For COPCs other than selenium, risks are generally consistent with background or below an HQ of 1 in MUs 1 through 5 • Selenium risks are consistent with background in MU-6 • HQs are greater than 1 for mercury in Koocanusa Reservoir for upper percentile and preferred consumers. However, concentrations are comparable to concentrations in regional lakes	• Preferred consumers: Elevated risks for selenium in MUs 1 through 5 • HQs are greater than 1 for mercury in Koocanusa Reservoir for upper percentile and preferred consumers. However, concentrations are comparable to concentrations in regional lakes	• We do not have data on which species people prefer for consumption and risks vary by species with Longnose Sucker being highest • Fish data are obtained from a sampling program that focuses on aquatic effects of mining rather than targeting locations and species that are regularly eaten by people. Thus, some data are not representative of exposure (e.g., Longnose Sucker from MU-4 mine sedimentation pond) • 'Valley-wide' risks are calculated using data for MUs 1-5. For people who consume fish from all MUs (MUs 1-6), risks will slightly differ (e.g., selenium risks will decrease by about 30% but generally remain in same risk category).

Table ES-3. Summary of Risk Estimates for Mining-Related COPCs in Surface Water, Sediments, and Groundwater, Fish, Berries, Rose Hips, and Game Meat and Organs

		Negligible Risks	Acceptable Potential Risks [a]		Elevated Potential Risks [a]	
		HQ≤0.2	**HQ >0.2 and less than 1**	**Risks Consistent with Background**	**HQ>1 and Background**	**Uncertainties**
Decreasing Influence of Surface Water on Exposure ↓	**Groundwater**	• Negligible risk for consumption of groundwater as drinking water for all COPCs except lithium in MU-4 when evaluated by MU	• Lithium and manganese >0.2 in individual wells in MU-4, MU-5 and by MU in MU-4 and MU-5 • Iron in individual well in MU-4 See also Table 6-1	• Background risks are not evaluated	• Two wells in MU-5 had elevated risk, one for lithium and one for manganese	• Not all wells were sampled • Groundwater was sampled for mining-related COPCs only; not all water quality parameters that can adversely affect human health were considered. Moreover, water quality can change over time • Agricultural uses of groundwater are only evaluated in the uncertainty assessment, but are not expected to result in elevated risk
	Wild Game Meat and Organ	• Game meat: Negligible risk for all COPCs for average consumers	Game Meat: • Upper percentile: aluminum, cobalt, iron, lead, lithium, and selenium exceeded in at least one MU • Preferred: aluminum, cobalt, iron, lead, lithium, nickel, and selenium exceeded in at least one MU Game Organ: • Average: cadmium and lead in at least one MU • Upper percentile: cadmium, iron, lead and selenium exceeded in at least one MU. Preferred: cadmium, iron, and lead exceeded in at least one MU See Also Table 6-7	• Risks for many metals are generally consistent with the reference dataset except for selenium • Game organ: HQs are greater than 1 in several MUs for the upper percentile consumer for lead and cadmium, but these are consistent with reference	• Game meat: Preferred consumption by toddlers in MU-5 (lead) results in elevated risk. • Game organ: See the column *Risks Consistent with Background*	• Data are not available for all species in all locations
	Berry and Rose Hip	• Rose hips: Negligible risk for average consumers	Berries: • Average, upper percentile, and preferred: aluminum, barium, cobalt, iron, lead, manganese, selenium, and vanadium exceed in at least one MU • Upper percentile and preferred: cadmium also exceeded in at least one MU Rose Hips: • Upper percentile: Manganese in some MUs See also Table 6-6	• Risks for many metals are consistent with reference • Manganese HQs for berries are equal to 1 for preferred and upper percentile consumers in reference areas	• Upper percentile and preferred consumers: Manganese HQs are elevated for toddlers consuming berries in MU-4	• Data are not available for all locations

Notes:
[a] Risks are categorized as acceptable or unacceptable (elevated potential risk) in accordance with ENV (2023) and BC Contaminated Site Regulation (BC 2021).
Valley-wide is defined as MUs 1-5 for aquatic media, MUs 1-6 for game meat, organ, berries, and rose hips. For individuals who consume fish or recreate in MUs 1-6, risks will slightly differ.
BC = British Columbia; COPC = constituent(s) of potential concern; HQ = hazard quotient; IH = Interior Health; MU = management unit; ug/L = microgram(s) per litre; yr = year

What Is the Contribution of Risk from Each Food Item and What Are the Cumulative Risks from All Foods Evaluated in the HHRA?

Risks from exposure to selenium in the Elk Valley were also considered in combination with risks from other dietary items not harvested within the Elk Valley or Koocanusa Reservoir, shown in Figures ES-4 through ES-8. Selenium was a primary focus of the HHRA because it is known to be mine-related, risks were greatest for selenium compared to other COPCs, and concentrations in fish and other foods are elevated compared to background (reference) locations.

Toddlers who only consume foods from the grocery store (referred to here as the market basket), were estimated to have an HI of 1.2 for selenium intake. An HI of 1.9 was calculated for toddlers with exposure to environmental media throughout the Elk Valley (i.e., MU-1 through MU-5)[4] who also consume market basket food together with fish, game, and berries at average consumption levels, and the HI was 6.6 when this toddler was assumed to consume foods at Ktunaxa preferred consumption rates. For comparison, toddlers consuming these foods and exposed to these media from reference locations were estimated to have an HI of 1.2 at average consumption levels and HI of 2.3 at preferred consumption levels.

Adults were estimated to have an HI of 0.4 based on selenium intake from a market basket diet. An HI of 0.8 was estimated for adults consuming fish, game, and berries at average consumption levels and who also are exposed to other environmental media in the Elk Valley (MU-1 through MU-5). This adult was estimated to have an HI of 3.6 when consuming foods in Elk Valley at Ktunaxa preferred consumption levels. For comparison, adults consuming foods from reference areas at average levels had an HI of 0.4 for average consumption levels and an HI of 1.4 for Ktunaxa preferred levels (Figures ES-4 through ES-8 provide more detail).[5]

The cumulative risk results indicate that Elk Valley foods are higher in selenium than market basket and reference area foods, with the exception of selenium in fish in Koocanusa Reservoir (MU-6). Consumption of Elk Valley foods contributes to total risk differently by consumer: the impact of locally harvested foods on average consumers is relatively minor. For example, the average consumer (toddler) has an HI estimate that is 0.7 higher than the background diet (i.e., market basket foods only); the preferred diet consumer (toddler) has a HI estimate that is 5.4 higher than the background diet. People who eat more have higher exposures and thus higher potential risks. Risks also increase with decreasing body mass, meaning toddlers generally have higher risks than adults. There were differences among the MUs and consuming locally harvested food in MU-4 had the highest increase in potential risk. These differences in cumulative selenium risk across MUs are mainly due to differences in fish HQs, which are likely attributable to differences in selenium concentration by MU and/or species sampled by MU.

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[4] If exposures are evaluated for MUs 1-6, risks associated with selenium in fish tissue decrease by about 30% for all ages and consumer groups. See section 6.11.3.2.

[5] Stacked bar charts are shown to one significant figure, so bars may have the same number but look slightly different due to rounding.

Figure ES-4. Cumulative Selenium Hazard Index for Average Recreators

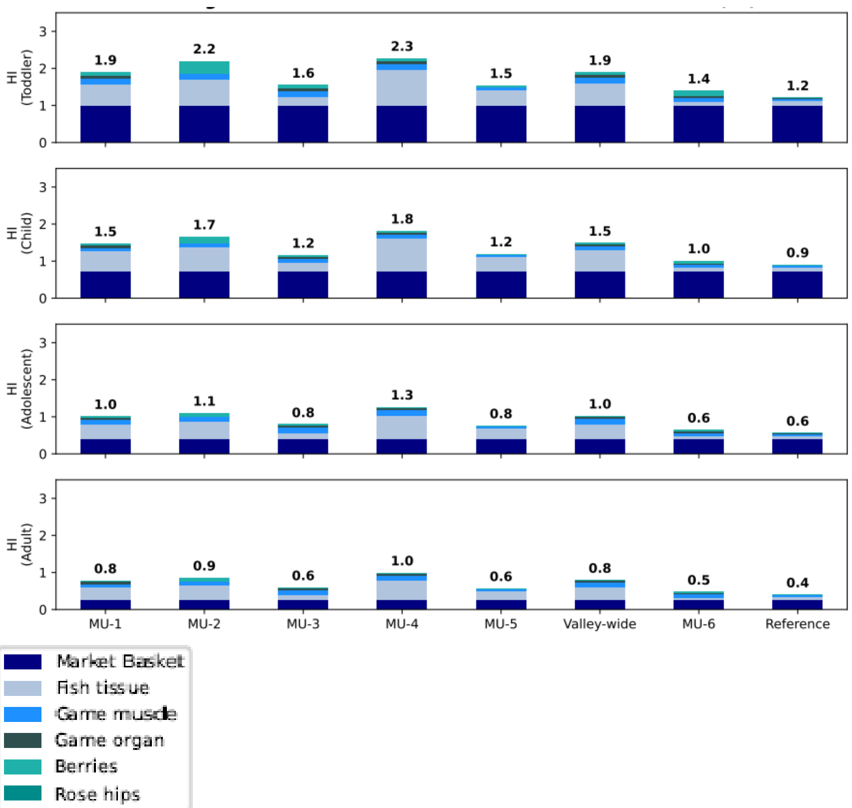
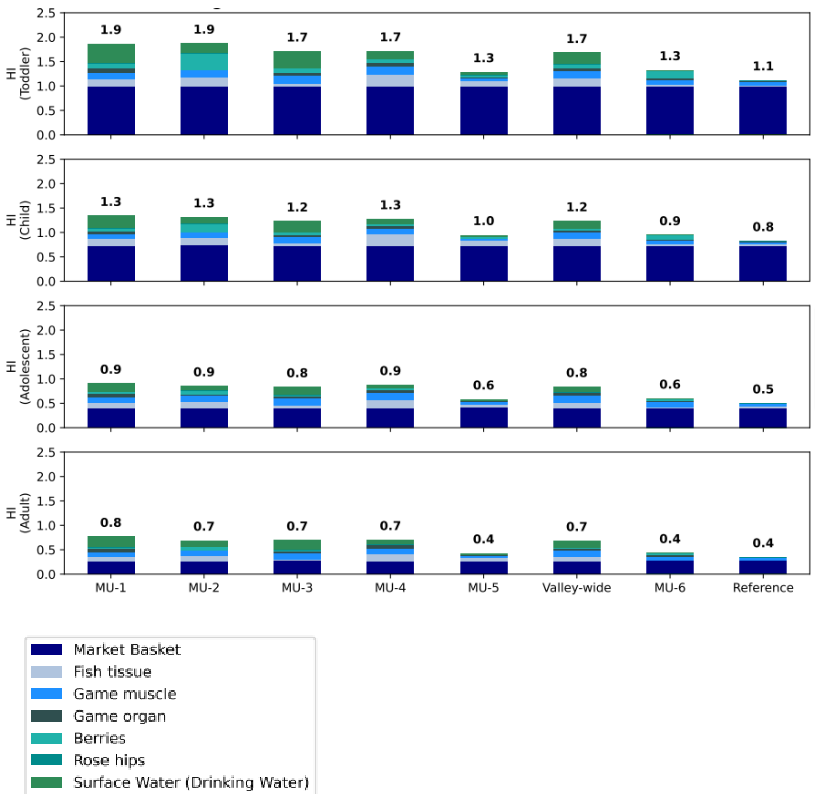


Figure ES-5. Cumulative Selenium Hazard Index for Average Ktunaxa



1. Risk estimates for MU-4 fish tissue are biased high due to sample composition. A significant proportion of the fish tissue samples collected in MU-4 are longnose sucker in Goddard Marsh, a mine sedimentation pond. Longnose sucker sampled in this location had elevated selenium concentrations, but do not represent a typical source of fish consumption.
2. Game meat and organ were not sampled in MU-3. The valley-wide HIs for game meat and organ are used to approximate exposures in MU-3.
3. Rose hips were not sampled in MU-6. The valley-wide HI for rose hips is used to approximate exposures in MU-6.
4. Valley-wide estimates incorporate all data from MUs 1-5 for fish fillet and fish eggs, and all data from MUs 1-6 for game muscle, game organ, berries, and rose hips, as available.

Figure ES-6. Cumulative Selenium Hazard Index for Upper Percentile Recreators

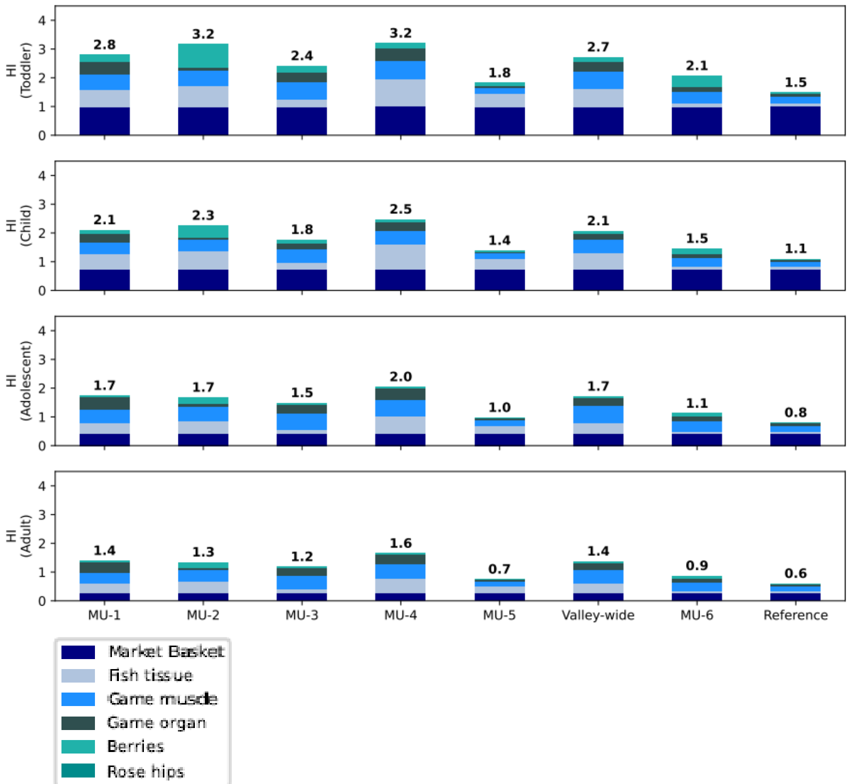
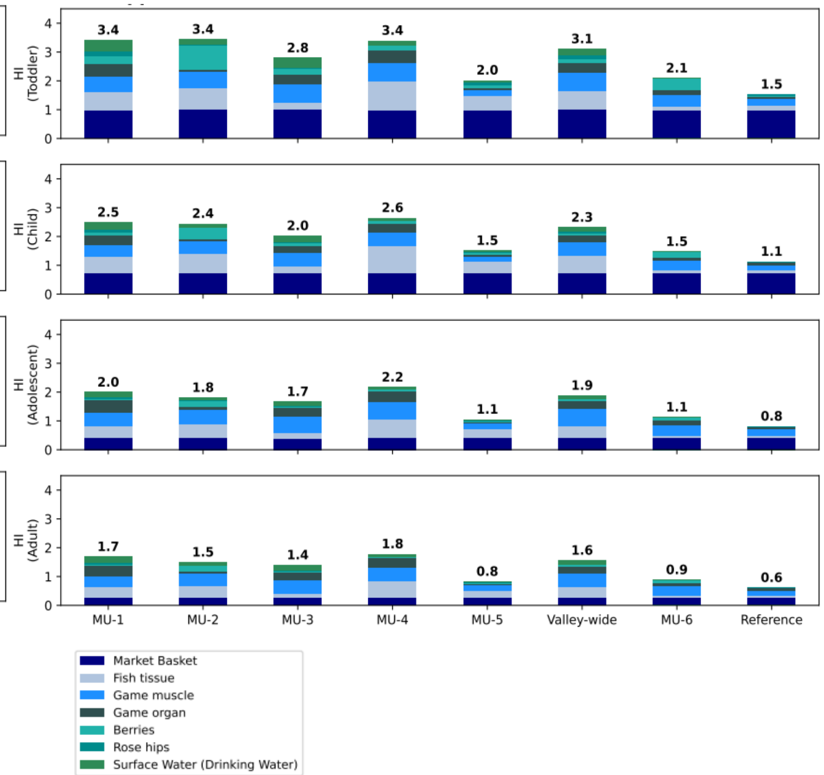
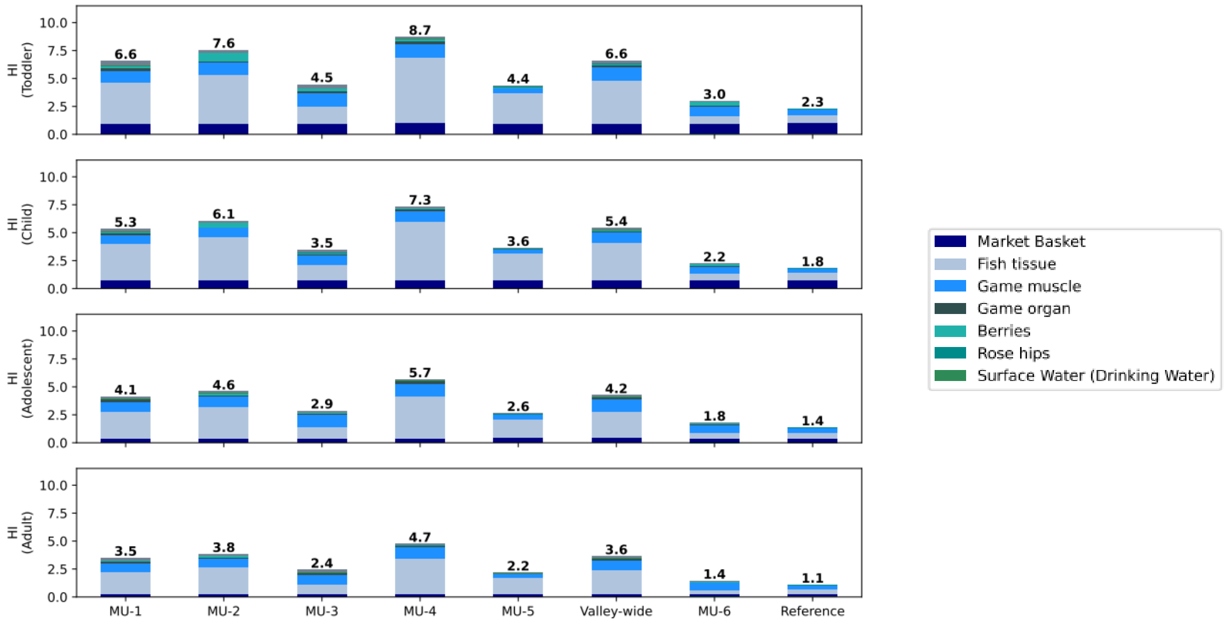


Figure ES-7. Cumulative Selenium Hazard Index for Upper Percentile Ktunaxa



1. Risk estimates for MU-4 fish tissue are biased high due to sample composition. A significant proportion of the fish tissue samples collected in MU-4 are longnose sucker in Goddard Marsh, a mine sedimentation pond. Longnose sucker sampled in this location had elevated selenium concentrations, but do not represent a typical source of fish consumption.
2. Game meat and organ were not sampled in MU-3. The valley-wide HIs for game meat and organ are used to approximate exposures in MU-3.
3. Rose hips were not sampled in MU-6. The valley-wide HI for rose hips is used to approximate exposures in MU-6.
4. Valley-wide estimates incorporate all data from MUs 1-5 for fish fillet and fish eggs, and all data from MUs 1-6 for game muscle, game organ, berries, and rose hips, as available

Figure ES-8. Cumulative Selenium Hazard Index for Preferred Ktunaxa



1. Risk estimates for MU-4 fish tissue are biased high due to sample composition. A significant proportion of the fish tissue samples collected in MU-4 are longnose sucker in Goddard Marsh, a mine sedimentation pond. Longnose sucker sampled in this location had elevated selenium concentrations, but do not represent a typical source of fish consumption.
2. Game meat and organ were not sampled in MU-3. The valley-wide HIs for game meat and organ are used to approximate exposures in MU-3.
3. Rose hips were not sampled in MU-6. The valley-wide HI for rose hips is used to approximate exposures in MU-6.
4. Valley-wide estimates incorporate all data from MUs 1-5 for fish fillet and fish eggs, and all data from Mus 1-6 for game muscle, game organ, berries, and rose hips, as available

Do Elevated Selenium Risks Translate to Health Effects?

As mentioned above, chronic overexposure to selenium at exposures higher than the TRV may cause selenosis. However, it cannot be concluded that a specific selenium intake or risk will result in observable health effects. Specific selenium intakes associated with health effects vary within a population and potentially even within an individual due to factors like genetics, past selenium intake, environmental stressors and nutrition. The selenium HIs and associated intakes estimated in this HHRA are intended to be conservative. It is likely that actual selenium intakes, if measured through biomonitoring, would differ. The HHRA is not a health study and is not able to predict levels of selenosis in the Elk Valley community or for a specific individual. Studies evaluating specific health effects typically include biomonitoring to directly measure exposure, collection of personal health histories and health effect data, and careful analysis of potential alternative cause for observed effects (i.e., confounding effects). In contrast, the HHRA methodology is an empirical model. However, the HHRA is useful in identifying environmental media that have unacceptable levels of selenium and informing managers on where further monitoring and potential risk management is needed. The elevated selenium risks (HIs above ENV's risk management threshold of 1) indicate the need for ongoing monitoring and adaptive management.

In interpreting the cumulative risk estimates for selenium, it is helpful to consider that the toxicity assessment for selenium (see Section 5.1.1) is based on a selenium intake with no associated health effects. The approach is protective of children and adults. Section 6.11.5.1 provides additional context regarding selenium intakes potentially associated with adverse health effects.

Are the Fish Safe to Eat?

Due to the health protective HHRA methodology and assumptions, the HHRA results can be used to identify where and for whom fish consumption risks from evaluation of COPCs are neglible. As listed in Table ES-3, risks are negligible for fish consumed throughout the study area, MUs 1 through 6, at average and upper percentile consumption rates (see consumption rates in Table ES-2). However, the HHRA methodology is not appropriate for identifying specifically where fish should not be harvested or which species should or should not be consumed except in cases where risks are sufficiently elevated that a precautionary approach to risk management is warranted. Based on the results of this HHRA, consumption of longnose sucker from Goddard Marsh (MU-4) due to elevated metals concentrations and risk estimates[6] is discouraged.

Fish consumption risks for all COPCs except cobalt, lead, selenium, mercury, and thallium were below the ENV preliminary risk threshold (HQ=0.2). Figure ES-9 shows HQs for the consumption of cobalt, lead, selenium, and thallium in fish, all of which had risks greater than the preliminary risk threshold. For the preferred consumer, the risks attributable to selenium in fish tissue are greater than risks for other COPCs, particularly in MUs 1 through 5 where HQs are greater than the ENV threshold of 1. Selenium HQs were not elevated for fish from MU-6 (Koocanusa Reservoir); however, mercury was a contributor to elevated risks in MU-6. Detailed risk estimates for all COPCs and all MUs are provided in Appendix H.

Figure ES-9. Elk Valley Fish HQs Comparison by Consumer and Location - Cobalt, Lead, Selenium, and Thallium

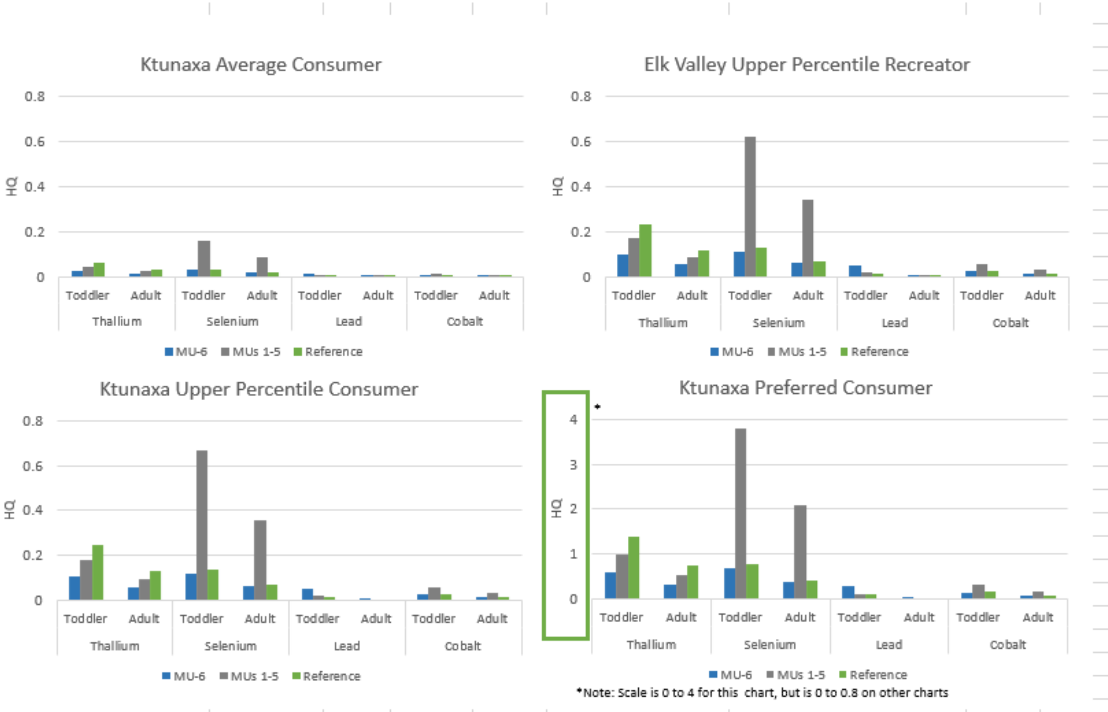
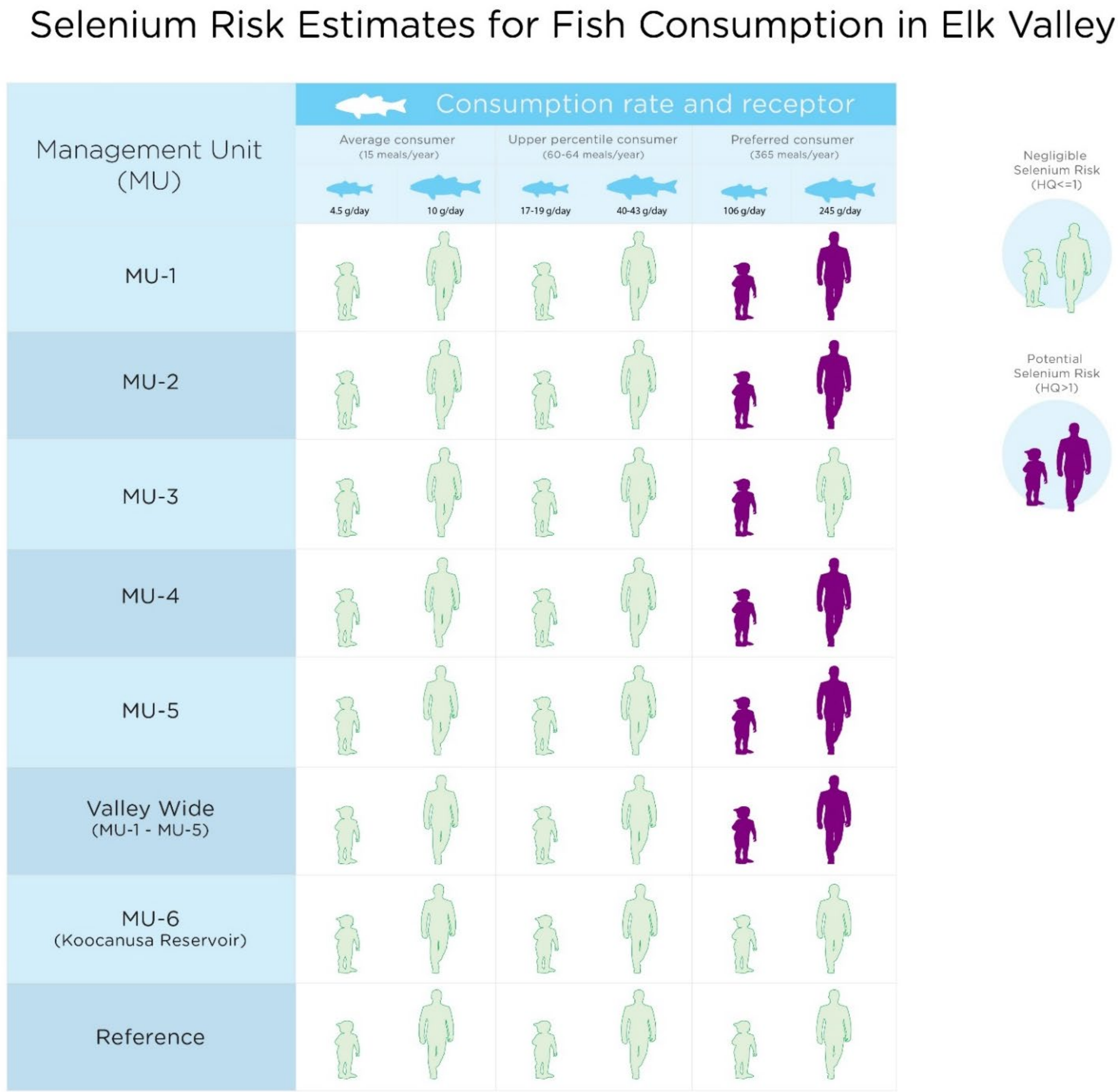


Figure ES-10 is an overview of the potential risks associated with selenium for those who consume fish at various levels within the Elk River (MU-1 through MU-5) or Koocanusa Reservoir (MU-6). As seen in Figure ES-10, consumption of up to 43 grams per day (g/day) of fish is below risk

[6] One-third of the longnose sucker samples in MU-4 come from one station, RG_GO13 (Goddard Marsh), which is an area known to be resident to longnose suckers. This location is not actively used by people for fishing and is directly downstream of sediment ponds just outside of the Elkview Mine permit boundary. The selenium concentrations in Goddard Marsh longnose sucker range from 7 to 30 milligrams per kilogram wet weight (mg/kg ww), with an average concentration of 18 mg/kg ww, which is substantially higher than for other fish in Goddard Marsh as well as for other fish and longnose sucker sampled at other stations in the Elk Valley.

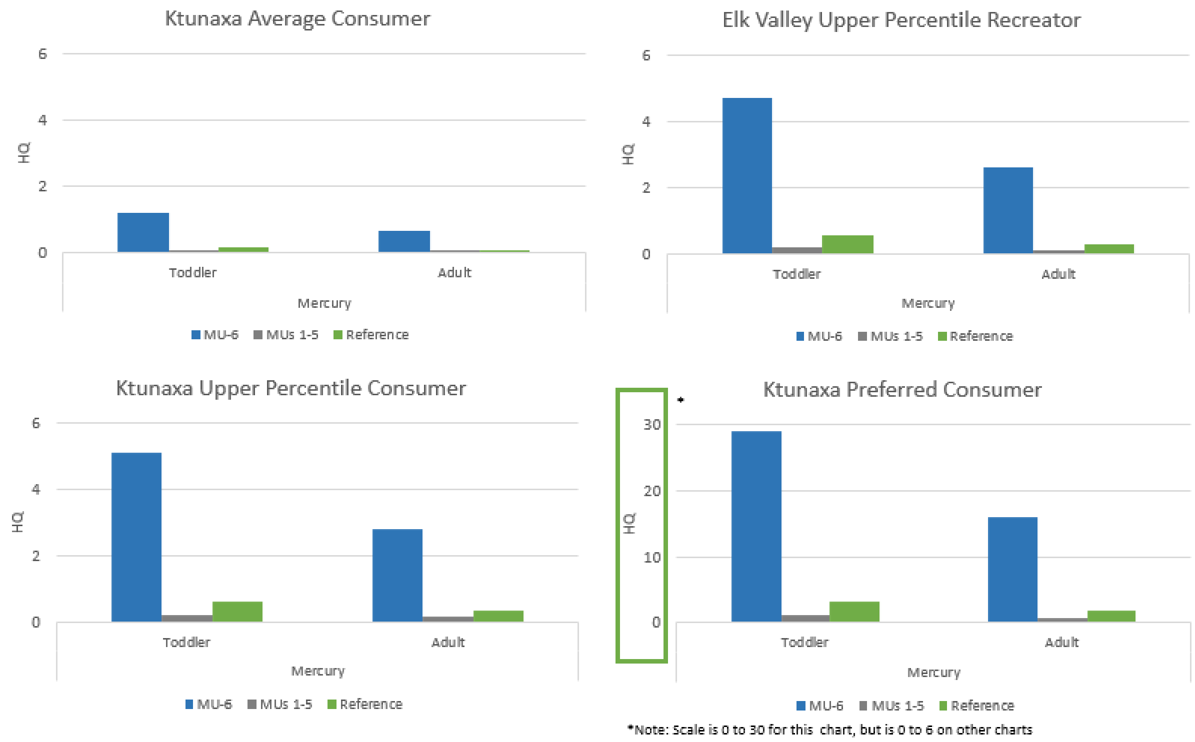
management levels of concern for the average and upper percentile adult consumer, based on the assessment of selenium risks. At the Ktunaxa preferred consumption rate of 245 g/day, or more, there is generally an elevated risk of overexposure to selenium within MU-1 through MU-5, particularly for younger children or those with a smaller body mass. There are no elevated risks related to selenium for consumption of fish from the Koocanusa Reservoir.

Figure ES-10. Selenium Risk Estimates for Fish Consumption in the Elk Valley



Mercury HQs for fish consumption are shown in Figure ES-11, which shows that risks are elevated for mercury for those who consume at upper percentile (Elk Valley recreator or Ktunaxa) or Ktunaxa preferred rates (i.e., 60 to 365 meals per year) from MU-6 (Koocanusa Reservoir). However, the mercury is not related to mining operations in the Elk Valley, and concentrations of mercury in Koocanusa Reservoir fish are comparable to concentrations in regional lakes (See Section 6.11.3.1, COPC Concentrations in Fish Tissue). Mercury risks are negligible for consumption of fish in MUs 1 through 5, at any consumption level.

Figure ES-11. Elk Valley Fish HQs Comparison by Consumer and Location – Mercury



As mentioned under 'Uncertainties' in Table ES-3, fish samples used in the HHRA are from a sampling program that focuses on ecological effects rather than collecting fish species regularly eaten by people and targeting locations where people prefer to fish. Specifically, some fish samples used in the HHRA were from locations near mine operations that are inaccessible to the public. In at least one case, this resulted in substantial increases in exposure point concentrations (EPCs) relative to other portions of the MU, (e.g., station, RG_GO13 in Goddard Marsh). Thus, some fish data used in the HHRA may not be representative of exposure but are unlikely to underestimate risk. Additional data on the fish species that people prefer to consume and common fish harvesting locations would improve risk estimates.

Is it Safe to Contact Surface Water and Sediment?

Surface water and **sediment** risks are negligible for all COPCs for ingestion or dermal contact during recreational or cultural activities except consuming fish (e.g., swimming, wading, foraging) in MUs 1 through 6. However, surface water can contain microbiological contaminants (bacteria, viruses, and parasites) and industry-related substances. IH recommends testing and treating surface water from rivers, streams, or lakes anywhere in the province before use as drinking water.

Is it Safe to Consume Local Water, Game, Berries, and Rose Hips?

Surface water in MU-1 and MU-3 would have elevated risks for infants, if used as drinking water, due to nitrates. Surface water can contain microbiological contaminants (bacteria, viruses, and parasites) and industry-related substances. Interior Health recommends testing and treating surface water from rivers, streams, or lakes anywhere in the province before use as drinking water. In the Elk Valley, the surface water at many locations has selenium concentrations above the BC water quality guideline of 10 µg/L. Some of these locations are elevated only during winter months, but some locations (such as tributaries close to mine operations) are elevated year-round (see Appendix C. Figure C-1 for map showing areas with elevated selenium). Drinking water systems in the Elk Valley predominately depend on groundwater wells. Agricultural uses of surface water are only evaluated in the uncertainty assessment but are not expected to result in elevated risk.

Groundwater use as drinking water has negligible risks for all COPCs when evaluated by MU and by individual well in all but two wells. In well-by-well analysis two wells in MU-5 had elevated risk, one for lithium and one for manganese. However, data were not available for all wells in the Elk Valley. Private well owners in the Elk Valley are encouraged to have their water tested either through Teck or privately.[7] The groundwater dataset included municipal wells in Elkford, Sparwood, and Fernie, the community well in Elko, and 49 private wells. On a population basis, the groundwater data in the HHRA represent more than 80 percent of the population of the Elk Valley (See Section 2.1.4). Agricultural uses of groundwater are only evaluated in the uncertainty assessment but are not expected to result in elevated risk.

Game meat consumption had HQs less than 1 for all COPCs and consumer groups except preferred consumers in MU-5, where toddlers had elevated risk for lead (HQ of 1.6), which is discussed further in the uncertainty assessment. The source of lead in meat in MU-5 is unknown but could be related to use of lead ammunition or industrial sources. **Game organs** had HQs less than 1 or were consistent with reference risks for all COPCs at all consumption levels. Game meat and organ meat risks for many metals are generally consistent with those for the reference dataset.

Berry and rose hip consumption had HQs less than 1 for all COPCs except for an elevated risk for manganese for toddlers consuming berries in MU-4 at preferred and upper percentile levels. Elevated risks associated with manganese in berries are discussed further in the uncertainty assessment and as indicated there, one consideration is that risks are below the ENV risk management threshold of 1 when berries are consumed from a variety of locations throughout the Elk Valley. Risks for many metals are consistent with reference.

For game meat, organ, berries, and rose hips, data are not available for all MUs, and sample sizes can be small within individual MUs, so we recommend focusing on valley-wide risks. Ktunaxa and other people may also consume additional foods from the land not evaluated in the HHRA see Section 6.12.1 in the main report).

Conclusions

This HHRA focused on water-related exposures influenced by mining practices in the Elk Valley. Concentration data for metals in surface water, groundwater, sediments, fish, game, berries, and rose hips were evaluated using health protective methods that were designed to not underestimate risks, and these methods likely overestimated risks. Areas that were unlikely to be influenced by mining activities were also considered (i.e., reference areas).

- Because the diet is a significant background source of exposure for many minerals, this HHRA evaluated the contribution from locally harvested foods (fish, elk, deer, berries) and from purchased food and beverages (market basket foods).
- Cumulative risk results indicate that Elk Valley foods are higher in selenium than market basket and reference area foods. In particular, higher levels of selenium were found in longnose sucker in MU-4 including Goddard Marsh.

[7] For municipal drinking water quality questions, reach out to your local health authority or refer to the public notice at this link: https://www.teck.com/media/ADV-010.2022_potable_water_public_notice.pdf.

- People who eat more have higher exposures and thus higher potential risks. Risks also increase with decreasing body mass, meaning toddlers generally have higher risks than adults. There were differences in cumulative risks between the MUs and consuming locally harvested food (especially fish) in MU-4 had the highest increase in potential risk.
- People who eat fish and other traditional foods at the Ktunaxa preferred rate from across MU-1 through MU-5 have risks that are 2.8 times higher than those for eating fish from reference locations (i.e., toddler valley-wide (MU-1 to MU-5) HQ was 6.6 versus HQ of 2.3 for reference locations; see Figure ES-8).
- Differences in cumulative selenium risk across MUs are mainly due to differences in fish HQs.
- The elevated risks related to selenium indicate that additional risk management measures should be considered for selenium in MU-1 through MU-5.
- There are no elevated risks related to selenium for consumption of fish from the Koocanusa Reservoir (MU-6).

- Recreational and cultural activities other than fish consumption that are associated with surface water and sediment contact were identified as negligible risk (e.g., swimming, wading and foraging).
- Consumption of fish, game, and berries at average consumer levels was identified as negligible risk.
- Consumption of game and berries at upper percentile or preferred rates results in some elevated risks, but these are consistent with reference areas except in three cases where HQs were modestly greater than the threshold of 1:
  - Preferred consumption of game by toddlers in MU-5 (due to lead).
  - Upper percentile and preferred consumption of berries by toddlers in MU-4 (due to manganese).
- Consumption of fish at preferred levels results in elevated risks for selenium for one or more age groups for MUs 1 through 5. Additional information regarding species-specific consumption preferences would be helpful in refining risk estimates.
  - Target organ HIs indicate selenium is the primary driver of risk in fish, other COPCs contribute negligibly to overall risk except mercury in MU-6 (Koocanusa Reservoir).
- Risks are elevated for mercury in fish from Koocanusa Reservoir, but concentrations of mercury in fish there are comparable to concentrations in regional lakes for which data are available.
- Consumption of groundwater as drinking water is below the ENV risk management threshold of 1 in wells evaluated in the HHRA except in two wells in MU-5 for which lithium and managenese concentrations resulted in slightly elevated risks. Participation in the RDWMP should be encouraged to continue monitoring drinking water supplies.
- Surface water in MU-1 and MU-3 should not be consumed as a daily drinking water source, particularly by infants who should avoid exposure to nitrates. In addition, all surface water should be treated to avoid potential exosure to microbiological contaminants that may be present.
- All cancer risks related to exposure to arsenic in all media are within levels identified as acceptable by Health Canada, i.e., 1 in 100,000, or are consistent with reference area risks.

What Are the Next Steps - How Will the HHRA Be Used?

The HHRA helps us understand what activities result in negligible or elevated risks in the Elk River watershed and whether water quality is being managed to be protective of human health. Risk estimates are ranked in the HHRA consistent with guidance from Health Canada (2010a, 2019) and ENV (2023). This risk ranking or prioritization of risks can be used to prioritize data gathering and risk management activities to better understand and reduce risks. Exposure pathways for receptors that result in noncancer risk estimates (i.e., HQs) equal to or less than 0.2 are considered negligible; HQs equal to or less than 1, or consistent with reference areas are considered to have acceptable risks; and HQs greater than 1 and background require further evaluation and may require risk management. Cancer risks were similarly ranked, by comparison with the ENV risk management threshold. Cancer risks equal to or less than 1 additional cancer case in 100,000 are considered negligible; cancer risks consistent with reference areas are considered to have acceptable risks; and cancer risks greater than 1 in 100,000 and background require further evaluation and risk management.

No cancer risks were identified that were greater than 1 in 100,000 and reference, but some HQs were greater than 1 and reference. Although risk estimates cannot be directly linked to specific health effects, we assume that as risk estimates increase the potential for health risk increases. For this reason, exposure pathways and receptors with the highest risk estimates (e.g., fish consumption by toddlers consuming at preferred levels) will be prioritized for data gathering and risk management, as needed.

Continued monitoring of environmental media and locally harvested foods is important to help us understand potential risks as mine operations continue. Ongoing efforts to address releases to surface water are expected to reduce selenium concentrations. Continued implementation of the Elk Valley Water Quality Plan (which includes water treatment and source control measures) is expected to improve selenium and nitrate concentrations in the Elk River watershed. Ongoing monitoring of selenium in surface water and fish tissue will inform our understanding of selenium uptake in fish and the potential for exposure to people consuming fish.

Looking ahead, a review and possible revision of components of environmental monitoring programs relevant to human exposures will help Teck respond to specific questions such as which specific fish species, game, or berries most influence health risks, and help us identify potential risks associated with specific harvest locations. In addition, continued monitoring and reporting in association with the environmental monitoring programs and inputs to the adaptive management process will serve as mechanisms for identification of increasing or decreasing chemical constituent concentrations that may affect potential health risks.

Teck will continue working with the HHRA Workgroup to respond to questions about human health risk within the Elk Valley (MUs 1 through 5) and Koocanusa Reservoir (MU-6) and will support the collection of data used to answer the question “Is water quality being managed to be protective of human health” as operations change into the future.

1. INTRODUCTION

Teck Coal Limited ("Teck") is required to perform a human health risk assessment (HHRA) for the Elk Valley focused on examination of the potential effects of mine-related water quality constituents on human health and to include an analysis of both current and preferred consumption of foods harvested within the Elk Valley (e.g., berries, game, fish). This HHRA was completed to satisfy this requirement, which is specified under Environmental Management Act (EMA) Permit 107517, Section 8.10. [8] As stated in Section 8.10, the HHRA must follow the British Columbia (BC) Contaminated Sites Regulation (CSR) approved methodologies and acceptable risk levels, and must be developed in consultation with the Environmental Monitoring Committee (EMC), which includes representatives of the Ktunaxa Nation Council (KNC)–Lands and Resources Sector, Interior Health (IH), Ministry of Environment and Climate Change Strategy (ENV), and others. Members of the EMC collaborating in development of this HHRA are referred to as the 'HHRA Workgroup' throughout this report. The Section 8.10 Permit language and associated concordance of the HHRA process is outlined in Table 1-1, and described in the sections below.

This introduction provides an overview of the regulatory driver for this HHRA and explanation of how this HHRA varies from other HHRAs performed under the Environmental Assessment Act, a review of the HHRA scope, a summary of how the methodology and HHRA report were developed, an overview of the previous HHRAs performed to support the Elk Valley Water Quality Plan (EVWQP), and finally, an outline of this report.

1.1 Regulatory Context

On November 18, 2014, ENV approved the area-based EVWQP (Teck 2014), which was developed under Section 89 of the EMA. The EVWQP outlines an initial implementation plan for water quality management, a calcite management plan, historical and ongoing aquatic effects monitoring and other monitoring, a comprehensive research and development program, and an approach for adaptively managing implementation of the EVWQP. The EVWQP also establishes targets for selenium, nitrate, sulphate, and cadmium within the Fording and Elk Rivers.

ENV subsequently issued an Area-based Effluent Permit (referred to as Permit 107517) under Section 14 of the EMA. Permit 107517 authorizes the release of constituents and calcite in the Elk Valley Designated Area (DA) consistent with the EVWQP conditions. Authorized discharges specified in Permit 107517 are assessed via Order Stations (i.e., compliance monitoring points) in rivers throughout the Elk Valley. Among the permit conditions is a requirement for conducting an HHRA, under Section 8.10, as noted above. The purpose of the HHRA is to identify any needed adaptive management actions to address unacceptable human health risks. An HHRA was completed in September 2016 under Permit 107517. The 2016 HHRA included an evaluation of berries and game based on a 2015 Ktunaxa Nation Dietary Study Report for the KNC (Fediuk and Firelight Group Research Cooperative[9] [Firelight] 2015) in addition to an evaluation of contact with surface water and consumption of fish by Elk Valley residents. A supplemental technical memorandum was prepared in September 2016 that evaluated health risks due to consumption of fish, berries, and game at Ktunaxa preferred consumption rates. This 2021 HHRA is an update to the 2016 HHRA and technical memorandum, relying on more recently collected environmental monitoring data (2015-2020), additional information on Ktunaxa preferred food consumption rates, and revised exposure scenarios developed in consultation with the HHRA Workgroup.

In addition to the requirement for an HHRA, Permit 107517 included the requirement to develop and maintain an Adaptive Management Plan (AMP) under Section 10. The AMP supports implementation of the EVWQP and confirms that human health and the environment are protected throughout the lifecycle of Teck's projects in the Elk Valley. Key questions and uncertainties

[8] Refers to current version of Permit 107517, dated May 18, 2023, which specifies HHRA requirement in Section 8.10. The original Permit 107517 specified the HHRA requirement in Section 9.9.

[9] Firelight Group Research Cooperative is now known as The Firelight Group.

specific to protection of human health are identified in the AMP, which draws on information from multiple Teck programs to resolve uncertainties and meet water quality permit requirements. The AMP also identifies actions needed, such as performing research and monitoring and making recommendations for adjustment of management actions, as warranted. Teck prepares annual AMP summary reports documenting activities and updates the AMP every three years. This HHRA, prepared to satisfy Permit 107517 Condition 8.10, will be considered within the AMP to inform responses to questions specific to the protection of human health.

Apart from managing water quality under the EVWQP and EMA Permit 107517, other permitting processes under the EMA are performed that also include evaluation of potential human health risks. HHRAs performed to satisfy other permitting requirements under the EMA are described here to provide additional context for the EVWQP Permit 107517 HHRA detailed herein, and describe how the overall objectives and methods differ for these various HHRAs. Prior to development of a new or expansion of an existing project, Teck must prepare an environmental assessment (EA) and EA application for an EA certificate, i.e., an approval, to proceed with the proposed project. An EA considers potential environmental, economic, social, heritage, and potential human health risks of the proposed project(s). An HHRA prepared as part of the EA application is comprehensive in evaluating potential health risks associated with multi-media exposures to mining-related constituents. The HHRAs consider a base case and predicted (i.e., modeled) future case(s) that account for emissions of particulates, and subsequent fate and transport of particulates to soil, surface water, and sediment, effluent inputs to surface water, and surface water-groundwater interactions. Exposures occurring through contact with soil, surface water, sediment, biota, and air are considered.

Two key differences between an HHRA completed to support an EA and the EVWQP are: 1) the EA HHRAs focus on predicted *future* risks related to a proposed mining project whereas this EVWQP HHRA focuses on risks associated with the current condition only; and 2) the EA HHRAs focus on predicted contributions from both aquatic pathways and the aerial deposition of particulates to environmental media and subsequent fate, transport, and uptake by biota whereas the EVWQP HHRA focuses primarily on risks associated with water quality (i.e., surface water and other pathways that may be influenced by surface water).

The HHRAs and other health-focused activities performed to support an EA sometimes overlap, but are rarely duplicative in that environmental media and methodology often differ in response to different questions being asked to satisfy varied permit needs.

Table 1-1. Concordance of HHRA Process with Permit 107517 Section 8.10 Requirements

Permit Condition	Response
The Permittee must conduct a HHRA, in consultation with the EMC to examine the potential effects of mine-related parameters of concern including selenium, mercury cadmium, chromium, copper, manganese, nickel, vanadium and zinc for the designated area. The Permittee is responsible for developing the HHRA design and addressing any concerns raised by the IH.	The HHRA evaluates potential human health risks for the listed mine-related parameters of concern. The HHRA also evaluates additional metals in all media, nitrate in groundwater in surface water, and PAHs and quinoline in surface water and sediments. Teck developed the HHRA methodology and report with regular engagement with the HHRA Workgroup. Teck engaged with IH on concerns raised throughout the process, as well as with other members of the HHRA Workgroup.
A draft terms of reference and a work plan for the HHRA must be discussed at the EMC. A final terms of reference and work plan for the HHRA shall be submitted by May 31, 2015 and be of a quality acceptable to the Director.	**December 2018 – June 2023**: The HHRA Workgroup met regularly by web-based conferencing to collaboratively work through a technical approach for the HHRA Methodology which followed an agreed-upon outline prepared at the Workgroup members' request. The Workgroup continued to meet regularly throughout development of the draft, final, and revised final HHRA to discuss technical questions, provide updates on risk calculations, and address Workgroup advice. **April 2020**: A draft methodology document was provided to the HHRA Workgroup for review, with placeholders for sections specific to the Ktunaxa CSM and updated Ktunaxa food consumption rates. The Ktunaxa CSM and diet study update were not included in the April 2020 methodology document because release of these items by the Ktunaxa Lands and Resources Sector was delayed due to the global coronavirus disease (COVID-19) pandemic. **May 2020**: Advice for revision of the draft methodology was provided to Teck by the HHRA Workgroup. **June 2020**: Written responses to advice were provided to the Workgroup. During discussions of Workgroup advice and Workgroup members expressing a desire to compress the HHRA schedule and compensate for lost time due to the pandemic, the Workgroup decided it would be acceptable to incorporate recommended methodology changes into the draft HHRA Report in lieu of preparing a final methodology document. **August 2020**: A technical memorandum providing preferred consumption rates for the Ktunaxa was provided to Teck for use in the HHRA.
The HHRA must follow the BC Contaminated Sites Regulation approved methodologies and levels of acceptable risk for Human Health Risk Assessment.	The HHRA is consistent with CSR and Health Canada guidance for performing a HHRA, specifically, *Part V: Guidance on Human Health Detailed Quantitative Risk Assessment for Chemicals (DQRA$_{Chem}$)* (2010a).
The Permittee must provide the results of the HHRA by March 31, 2016 to the EMC. The Permittee must	**March 31, 2016**: A draft HHRA was submitted to the EMC.

Permit Condition	Response
provide the results of the HHRA to the Director by March 31, 2016. The risk assessment must be to the satisfaction of the Director.	**September 2016**: The March 2016 HHRA was updated following receipt of additional advice from the EMC, and an additional memorandum was submitted that focused on calculating risks for Ktunaxa consuming foods at preferred consumption rates. **June 19, 2017**: According to a letter from Douglas Hill (Director, ENV) to Carla Fraser (Teck)), the HHRA was submitted as required by PE-107517, Section 9.9. However, due to knowledge gaps identified during EMC review, a revised HHRA report was requested that includes a complete analysis of current and preferred consumption rates. According to the letter, "*The final submission must be to the satisfaction of the director and include the EMC comments and Teck's responses to these comments identifying how these comments were considered in the final updated Report.*" **October 2021**: A revised draft HHRA was submitted to the EMC. The revised draft HHRA included a complete analysis of current and preferred consumption rates, using updated information on preferred consumption provided by KNC to Teck in August of 2020. **December 2021 – February 2022**: Advice was provided by the HHRA Workgroup to Teck. **July 2022**: A final HHRA Report was submitted to the HHRA Workgroup after revision of the draft HHRA based on Workgroup advice. **June 2023**: Revised Final HHRA submitted to the HHRA Workgroup reflecting additional advice received from the HHRA Workgroup in August 2022 and November 2022 to January 2023.
The assessment must determine the exposure pathways and potential human health risks from selenium and other mine-related parameters of concern which may be present in vegetation, fish and wildlife that are potentially used for food or medicinal sources, or present in currently known potable water sources. The assessment must take into consideration First Nations consumption patterns and risk sensitivities.	**Section 2.2** identifies relevant exposure pathways for selenium and other mine-related parameters of concern. In addition to the CSM developed following BC CSR and Health Canada Guidance, a Ktunaxa-specific CSM was provided by KNC and is included in **Section 2.3** of the HHRA. The relevant exposure pathways include exposure to mine-related parameters of concern which may be present in fish, vegetation, wildlife, currently known potable water sources (i.e., groundwater), sediments, and surface water. **Section 6** presents the potential human health risk results. The HHRA takes into consideration First Nations consumption patterns and risk sensitivities.
The study must incorporate information available from a variety of sources such as: traditional use studies, consultation records, consumption surveys, and baseline and monitoring data for mine-related parameters of concern.	The HHRA incorporates information from the 2015 Ktunaxa First Nation Diet Study (The Firelight Group 2015), the Ktunaxa Preferred Rates Memo (KNC 2020), and Health Canada, ENV, and United States Environmental Protection Agency risk assessment guidance to determine exposure rates. Baseline and monitoring data from Teck programs are used in the assessment, including data from

Permit Condition	Response
	Teck's RAEMP, RDWMP, and wild game and berry samples collected by Teck staff and Ktunaxa through the Wild Foods Sampling Program. Exposure quantification, including a description of the KNC diet studies, are described in **Section 4.2** Baseline and monitoring data are described in **Section 3.1**
Wherever possible, the assessment must incorporate data obtained from established monitoring programs. If required for the assessment, additional sampling programs must be implemented to ensure data gaps are addressed.	Data from existing Teck monitoring programs (i.e., RAEMP, RDWMP) are used in the assessment. The Wild Foods Sampling Program was implemented to address data gaps identified in the 2016 HHRA for wild game and vegetation samples. The data collected through the program are used in the 2023 Permit 107517 HHRA.
The conclusions and findings of the HHRA shall be risk ranked and prioritized and include recommended risk management controls and other mitigation actions to address human health risks identified in the HHRA for inclusion in the Adaptive Management Plan for the area.	**Section 6** ranks and prioritizes site risks consistent with Health Canada (2010a, 2019) and ENV (2023) guidance (i.e., HQs less than 0.2 and cancer risks equal to or less than 1 additional cancer case in 100,000 are negligible, HQs equal to or less than 1, and HQs and cancer risks consistent with reference areas are considered to have acceptable risks; and HQs greater than 1 and background, and cancer risks greater than 1 in 100,000 and background require further evaluation and may require risk management). Although risk estimates cannot be directly linked to specific health effects, we assume as risk estimates increase the potential for health risk increases and consequently, pathways and receptors with the highest risk estimates (e.g., fish consumption by toddlers consuming at preferred levels) are identified as highest priority for data gathering and risk management, as needed. **Section 7** of the HHRA includes a summary of risk results and recommendations, including a list of adaptive management actions to address human health risks reflecting the prioritized health risks.
Notes: BC = British Columbia; CSM = conceptual site model; CSR = British Columbia Contaminated Sites Regulation; EMC = Environmental Monitoring Committee; ENV = British Columbia Ministry of Environment and Climate Change Strategy; HHRA = human health risk assessment; IH = Interior Health; PAH = polycyclic aromatic hydrocarbon(s); RAEMP = Regional Aquatic Effects Monitoring Program; RDWMP = Regional Drinking Water Monitoring Program; Teck = Teck Coal Limited	

1.2 Scope of the Human Health Risk Assessment

The scope of the HHRA is outlined in Permit 107517 Condition 8.10, and includes consideration of the following:

- Exposure pathways and potential human health risks from selenium and other, mine-related parameters of concern which may be present in vegetation, fish, and wildlife that are potentially used for food or medicinal sources, or present in currently known potable water sources.
- Ktunaxa ʔaqⱡsmaknik̓[10] consumption patterns and risk sensitivities.
- Incorporation of information from a variety of sources such as: traditional use studies, consultation records, consumption surveys, and monitoring data for mine-related chemicals, as well as data obtained from established monitoring programs.
- Identification of additional sampling programs to address data gaps.
- Ranking and prioritization of risks, and recommendation of risk management controls and actions to address health risks for inclusion in the AMP.

The HHRA focuses on non-worker populations who may contact constituents in surface water, sediment, groundwater, fish, berries, rose hips, and game, and relies on exposure assumptions derived from a combination of federal and provincial guidance, studies provided by the KNC, and literature sources, as discussed later in this report. The focus here is not on worker populations because worker safety is regulated by provincial and national regulations. It is acknowledged that workers may also have exposure during mining activities and exposures to the media evaluated in this assessment. Non-chemical stressors or influences, such as climate change, barriers to access the outdoors or health care services, and other cultural, social, and structural determinants of health are not evaluated in this HHRA. While many other factors have important influences on health and well-being, this assessment is being conducted to evaluate the mining-related influences on surface water to assist in determining what, if any, further actions are needed to address mining impacts on surface water. It also is recognized that this approach cannot provide a comprehensive evaluation of well-being. In addition, climate change may introduce complex stresses into all regions and ecosystems, including Elk Valley. Climate change may potentially impact land use, resource availability, habitats, chemical transport, and chemical concentrations. The magnitude of such potential impacts are unknown. Also, exposures to constituents in soil and dust, and inhalation of particulates released to air are not included in this HHRA because these exposure media are not directly linked to water quality, which is the subject of Permit 107517 for which this HHRA is being completed.

To meet the conditions of Permit 107517, this HHRA relies on environmental monitoring data reflecting current mining operations. As mining operations expand or are curtailed, changes to the environment may be reflected by changes in monitoring data. Prediction of future changes in environmental conditions is beyond the scope of this HHRA.

1.3 HHRA Methodology Development

During a meeting in Kelowna, BC on December 13, 2018, the HHRA Workgroup discussed the path forward for addressing data gaps for an Elk Valley-wide HHRA. The HHRA Workgroup met regularly from December 2018 through submittal of the final HHRA in July 2022 by web-based conferencing to collaboratively work through a technical approach for the HHRA Methodology which followed an agreed-upon outline prepared at the Workgroup members' request and is consistent with CSR and Health Canada guidance for performing a HHRA, specifically, *Part V: Guidance on Human Health Detailed Quantitative Risk Assessment for Chemicals (DQRA$_{Chem}$)* (Health Canada 2010a).

[10] The United Nations Declaration on the Rights of Indigenous Peoples recognizes ʔaqⱡsmaknik under international law.

A draft methodology document was provided to the HHRA Workgroup in April 2020 for review, with placeholders for sections specific to the Ktunaxa conceptual site model (CSM) and updated Ktunaxa food consumption rates. The Ktunaxa CSM and diet study update were not included because release of these items by the Ktunaxa Lands and Resources Sector was delayed due to the global coronavirus disease (COVID-19) pandemic. Advice for revision of the draft methodology was provided in May 2020, and written responses to advice were provided to the Workgroup in June 2020. During discussions of Workgroup advice and Workgroup members expressing a desire to compress the HHRA schedule and compensate for lost time due to the pandemic, the Workgroup decided it would be acceptable to incorporate recommended methodology changes into the draft HHRA report in lieu of preparing a final methodology report. The advice received on the draft methodology was related to clarifying the process for selection of chemicals for evaluation in the HHRA and calculation of the exposure concentrations; removal of Sparwood drinking water well #3 and addition of well #4; updating the life stage age groups evaluated in the exposure assessment; clarification of selected fish consumption rates; revisions to DA names and labels; clarification of risk assessment terminology; and other requests for clarification (table containing HHRA Workgroup advice and Teck responses provided on the project SharePoint site).

This HHRA report is based on the methodology and additional advice received during report development and on the draft HHRA report submitted in October 2021. Advice was incorporated to the extent possible given the varied needs of Workgroup members and availability of data and exposure parameters while also maintaining alignment with HHRA guidance. A request from some members of the HHRA Workgroup for food consumption advisories was not addressed in this HHRA because HHRA methodology, as prescribed in provincial and federal guidance, is not consistent with the methods used to establish food consumption advisories. Also, additional information needed to complete an advisory (e.g., fish length by species, specific game harvest locations) is not available for the current dataset because the tissue monitoring data were not collected with the intent of establishing consumption advisories. However, food consumption advisories can be a recommendation based on the results of an HHRA, thereby guiding future data collection efforts and analyses. During finalization of this HHRA, Teck initiated discussions with the Workgroup to develop a roadmap leading to future changes in data collection, risk communication, and adaptive management for protection of human health in Elk Valley.

Following the revision of the draft HHRA report, a final report was prepared and submitted to the HHRA Workgroup in July 2022. HHRA Workgroup members performed additional review of the final HHRA Report, providing advice during the fall and winter 2022, largely focused on providing greater detail and clarity in the Executive Summary, Risk Characterization, and Uncertainty Assessment discussions. The current revised final HHRA Report is submitted in June 2023 following updates in response to this advice.

1.4 Summary of Previous Health Risk Assessment Studies

A summary of previous HHRAs performed to comply with the EVWQP and Permit 107517 is presented here, to provide context for the current HHRA.

In 2014, a screening level HHRA was completed to support development of the EVWQP (Teck 2014). The 2014 assessment focused on identifying exposure pathways potentially impacted by mining activity in the Elk Valley. The EVWQP HHRA evaluated protection of human health and groundwater within the watershed. The evaluation of constituents in water, sediment, and fish indicated that ingestion of fish or water and contact with sediment did not present unacceptable human health risks to Elk Valley residents or recreational users of the rivers or Koocanusa Reservoir. Results of the HHRA were used to inform the EVWQP and conditions of EMA Permit 107517.

In 2015, a health risk evaluation was completed for consumption of Koocanusa Reservoir burbot (Ramboll Environ 2015). The burbot health evaluation was completed as part of the *Lake Koocanusa Burbot Baseline Study* required under Permit 107517 Condition 9.7. The health evaluation compared concentrations of metals in burbot tissue to relevant ENV and United States

Environmental Protection Agency (USEPA) guidelines and utilized a burbot species-specific consumption rate and all species consumption rate provided in the 2012/*13 Ktunaxa Nation Diet Study Final Report* (Fediuk and Firelight 2015). These consumption rates were combined with other exposure parameters from Health Canada guidance to calculate risks associated with consumption of burbot tissue harvested from Koocanusa Reservoir. The health risk results were below risk management thresholds of concern indicating no adverse health effects would be expected for high fish consuming Ktunaxa or other fish consumers who consume burbot from Koocanusa Reservoir.

EMA Permit 107517 includes Section 8.10, which requires that a detailed HHRA be completed by March 2016. As directed by ENV, the HHRA utilized consumption rates provided in the 2015 *Ktunaxa Nation Diet Study Final Report* (Fediuk and Firelight 2015) combined with other exposure parameters from Health Canada guidance to calculate risks associated with consumption of wild foods harvested in the Elk Valley as well as risks related to surface water, sediment, and groundwater exposures.

The March 2016 HHRA was updated in September 2016 following receipt of additional advice from the EMC, and an additional memorandum was drafted that focused on calculating risks for Ktunaxa Peoples' consuming foods at their preferred consumption rates (discussed below). The 2016 HHRA results were consistent with the 2014 evaluation, which found that recreating in Koocanusa Reservoir and the Elk River and its tributaries did not result in risks or hazards in excess of ENV risk management thresholds. Because the risk management thresholds are protective of human health, no adverse effects would be expected. The HHRA identified nitrate and selenium as potential constituents of concern (COCs) in surface water if ingested as drinking water, and selenium in fish tissue if all fish consumed are harvested from the Elk River or its tributaries. Risks from consumption of game and berries were difficult to interpret in the absence of data from reference areas.

In 2018, ENV directed Teck to complete an updated HHRA using additional game and berry tissue data harvested from non-mine-influenced areas and also to incorporate additional information on Ktunaxa preferred consumption rates for berries, fish, and game that were not available at the time the 2016 HHRA was prepared. The current HHRA is presented in response to this direction and incorporates new information from the Ktunaxa Lands and Resources Sector and Firelight with a specific focus on preferred rates. *To support a more fulsome understanding of the preferred consumption levels and better reflect Ktunaxa knowledge relationships, the 2019 Diet Study Expansion was launched with the goal of engaging with Ktunaxa members from across all Ktunaxa bands in confirming the preferred Ktunaxa food consumption levels among the most 'sensitive' Ktunaxa receptors, Ktunaxa ʔaqⱡsmaknik, who are most reliant on Ktunaxa lands and waters for their health and well-being and have an implied objective of sukiⱡ ʔiknaⱡa ('eating good'). A technical memorandum providing preliminary results of this update was shared with the HHRA Workgroup in August 2020 for use in this HHRA.*

The information provided for use in the HHRA focuses specifically on preferred consumption rates or food required to enable 'sukiⱡ ʔiknaⱡa' (eating good), that is, the amount of harvested foods, consumed by Ktunaxa People reflecting their place-based food system including values, knowledge, and food culture, recognizing colonial development has impacted Ktunaxa tangible and intangible cultural resources and practices including the access to food systems, where these Indigenous foods exist and are harvested from and how they are processed for human consumption including ethics of use. ʔa·kpiȼ̓is is an important concept in this work, as it specifically refers to favorite food which is known to be species-specific.[11] Additional discussion of consumption rates is provided in Section 4.2.

[11] Italicized text denotes text provided by KNC, here and in subsequent sections of report.

1.5 Overview of the HHRA Report

The HHRA includes the following elements, including additional text drafted by representatives of the KNC included in other sections, as noted and cited herein.

- Section 1 Introduction
- Section 2 Problem Formulation: Describes the site, land use, surface and groundwater use, fishing, and provides a CSM including the DA populations and exposure pathways.
- Section 3 Data Characterization & Hazard Identification: Presents the data used in the HHRA and identifies which chemical constituents are a potential concern.
- Section 4 Exposure Assessment: Describes how exposure estimates are calculated for exposure pathways and populations identified in the CSM, as applicable for each management unit (MU)
- Section 5 Toxicity Assessment: Identifies the sources for toxicity values used in the risk assessment.
- Section 6 Risk Characterization: Describes how cancer and noncancer risks are calculated, compares risk results to risk management levels, and describes key uncertainties.
- Section 7 Summary and Recommendations
- Section 8 References

Detailed information supporting the HHRA is provided in the following appendices:

A: Distribution Plots for Elk Valley Fish, Game, Berry, and Rose Hip Samples

B: Guidelines Related to Human Health

C: Screening Appendix

D: Estimation of Berry Consumption Rates Using National Health and Nutrition Examination Survey (NHANES) Data

E: Health Evaluation of Lake Koocanusa Burbot

F: Selection of Market Basket Data for Selenium

G: Exposure Point Concentrations

H: Intakes and Risk Results (digital)

I: Cumulative Risk Stacked Bar Charts, All Life Stages

J: Consideration of Non-Water Quality Pathways Not Evaluated in Permit 107517 HHRA

K: EMC Advice and Teck Response Table

2. PROBLEM FORMULATION

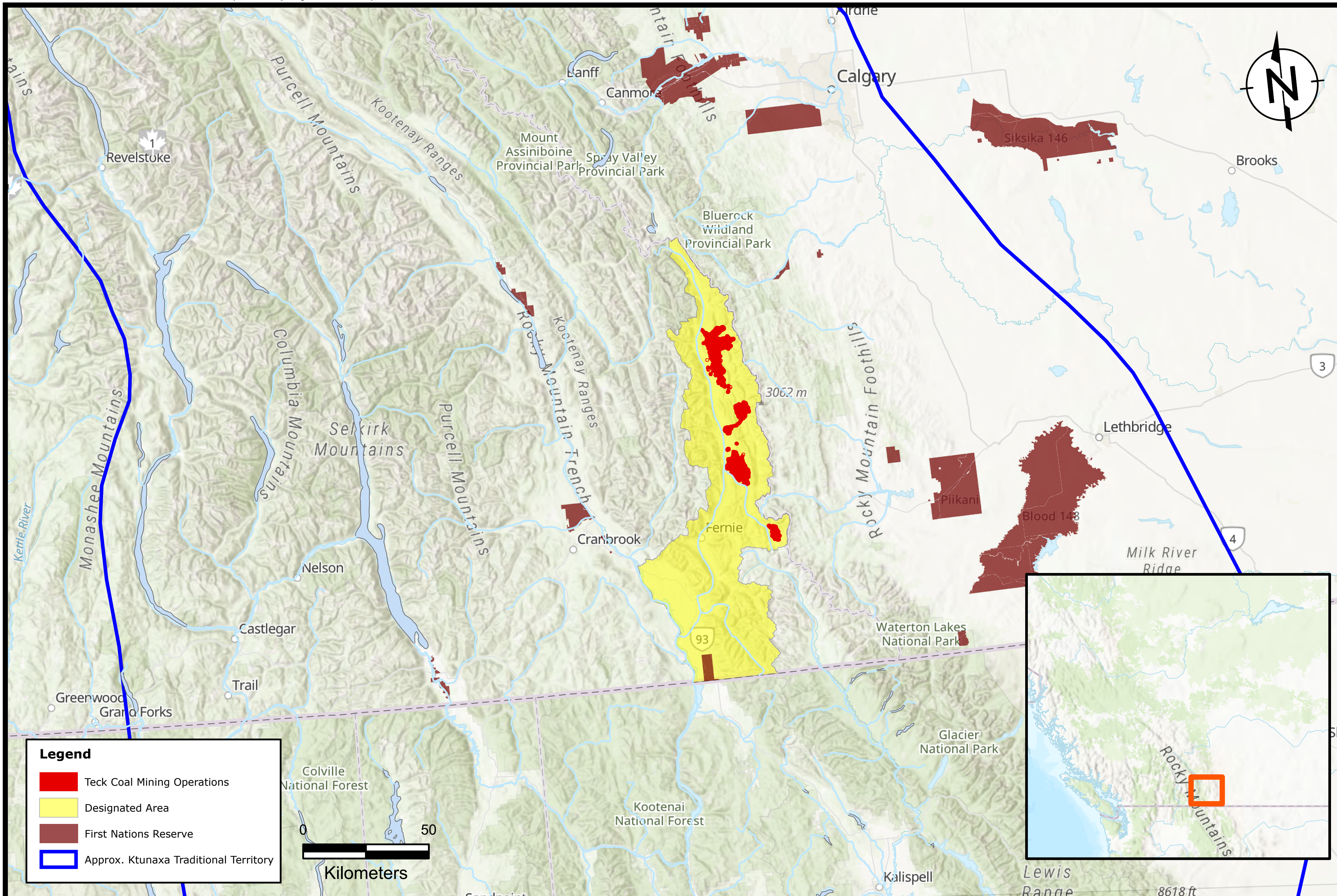
This problem formulation provides a description of the study area, including designated MUs, land uses, surface water use and fishing, and two CSMs characterizing how populations in and around Elk Valley may contact environmental media.

2.1 Description of the Study Area

The DA is geographically defined by Ministerial Order M113, and lies within ʔamakʔis Ktunaxa –the homelands and traditional territory of the Ktunaxa People. It is known specifically as qukin ʔamakʔis—Raven's land, and ₵am̓na ʔamakʔis—Land of the Wood Tick, so named as land districts according to Ktunaxa stories of creation and emergence.

Indigenous Peoples' such as the Ktunaxa, have a constitutional right to gather, harvest, and hunt for food, social, and ceremonial purposes in their homelands. This right is not limited to the reserve lands, and includes the waterways within the DA. Sec 35 of the Canadian Constitution defines and protects these Aboriginal Rights. The DA is described in general terms in this section and shown in Figure 2-1. There are several residential communities in the Elk Valley, including the District of Elkford, District of Sparwood, Hosmer, City of Fernie, Elko, and Jaffray. The economy that supports these communities depends in part on the mining industry as well as the timber and tourism industries. Teck owns open-pit steelmaking coal mines in the Elk Valley; from the north to south they are the Fording River, Greenhills, Line Creek, and Elkview Operations (Figure 2-1). Coal Mountain Mine operated until 2018 and is now in care and maintenance. Ktunaxa traditional land districts are shown in Figure 2-2.

C:\Users\censlin\OneDrive - Ramboll\GIS\Elk Valley\2019 WQP\Figures 1 and 2.aprx



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Elk Valley Water Quality Designated Area and Vicinity

British Columbia, Canada

FIGURE **2-1**

DRAFTED BY :CENSLIN | DATE: 5/13/2020 | PROJECT: 1690011690

Ktunaxa Traditional Land Districts
From Ktunaxa.org

FIGURE 2-2

Date Provided: June 22nd 2022

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2.1.1 Designated Management Units

The DA is divided into six MUs within the Elk River watershed (Figure 2-3). The EVWQP (Teck 2014) delineated the MUs based on the location of water quality monitoring compliance locations (i.e., Order Stations) and considers geographic features and hydrodynamic characteristics. The HHRA relies on the MUs as a spatial basis for defining exposure areas, and are listed here:

Management Unit 1 (MU-1): This MU is bisected by the Fording River upstream of Josephine Falls, drains an area of approximately 42,500 hectares (ha), and represents 9 percent of the total Elk River watershed. Numerous tributaries (e.g., Henretta Creek, Swift Creek, Kilmarnock Creek, Cataract Creek, Porter Creek, Line Creek) drain into the Fording River within this MU. Located just downstream of Greenhills Creek at the southern edge of MU-1 is Order Station FR4. It provides a synopsis of upstream water quality conditions. Active bituminous coal mines within MU-1 include Fording River Operations and Greenhills Operations. Developed areas (e.g., population centers, farming, transportation corridors, or recreational areas) are limited to the Rod and Gun organization located within this MU.

Management Unit 2 (MU-2): The Fording River downstream of Josephine Falls runs along the western limit of MU-2, drains an area of approximately 19,800 ha, and represents 4 percent of the total Elk River watershed. Tributaries that drain into the Fording River within this MU include Grace Creek and Line Creek. Located downstream of Line Creek and just before the confluence of the Fording and Elk Rivers is Order Station FR5. With the exception of the Line Creek Operations and the Grave Lake Recreation Site, there are no major developments (e.g., urbanization, farming, and transportation corridors) or recreational activities within this MU.

Management Unit 3 (MU-3): The Elk River runs along the eastern edge of this MU, which drains an area of approximately 88,400 ha, and represents 18 percent of the total Elk River watershed. Numerous tributaries (e.g., Wolf Creek, Willow South Creek, Cougar Creek, Wolfram Creek, Thompson Creek) drain into the Elk River within this MU. Located downstream of Thompson Creek and before the District of Elkford is Order Station ER1. Portions of Greenhills Operations are associated with this MU. There is some development in MU-3 and opportunity for recreation. Elkford, with adjacent acreage, is the only population centre within this MU.

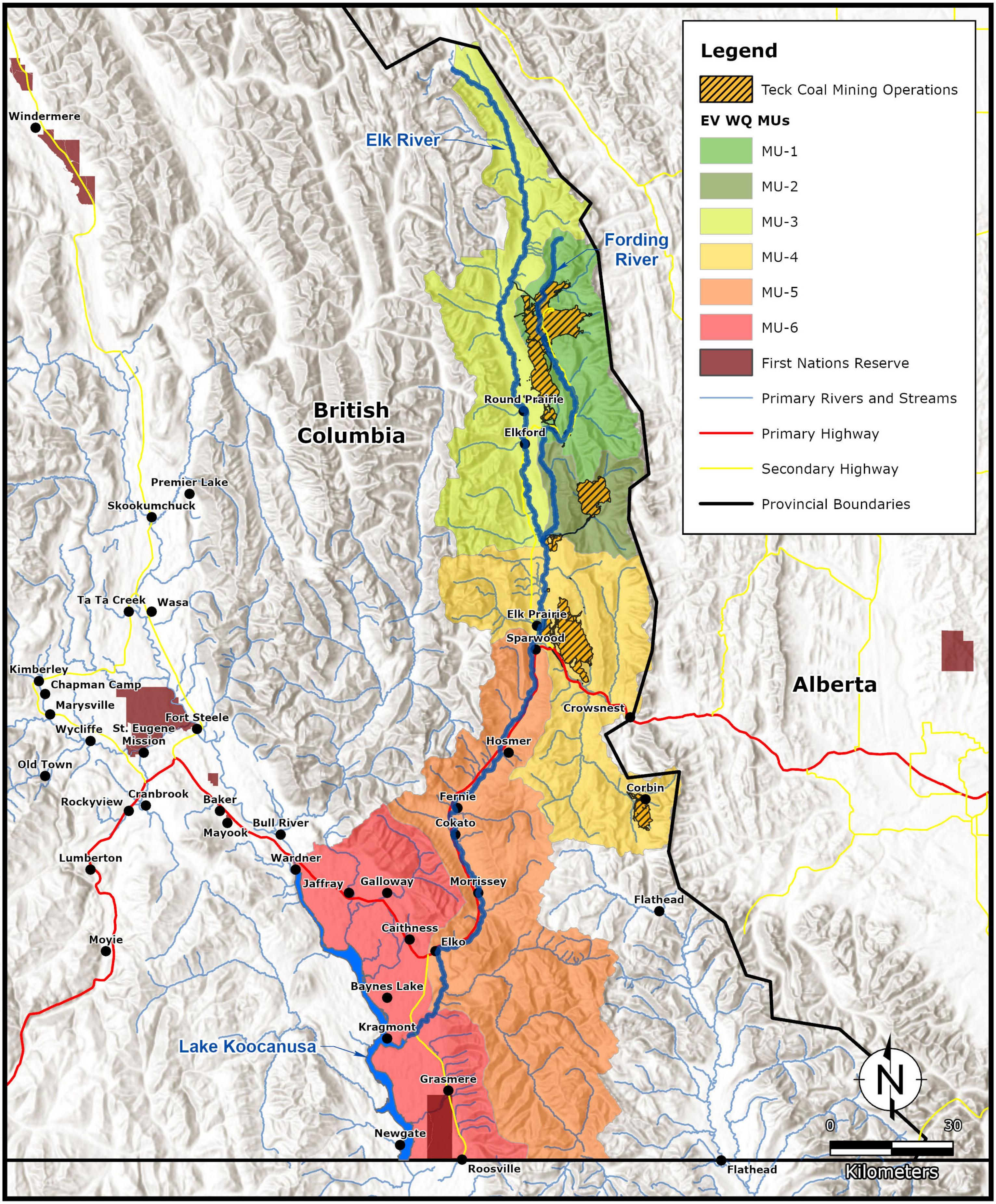
Management Unit 4 (MU-4): This MU drains an area of approximately 96,900 ha and represents 20 percent of the total Elk River watershed. The northern portion of MU-4 is bisected by the Elk River, with Michel Creek joining in at the southern limits of the MU. Elkview Operations is an active coal mine within MU-4. Coal Mountain Mine was formerly active and has been in care and maintenance since 2018. There is a small amount of development within MU-4, with some farming occurring east of the Elk River situated at the southern extent of MU-4, just north of the District of Sparwood.

Management Unit 5 (MU-5): MU-5 drains an area of approximately 148,000 ha and represents 30 percent of the total Elk River watershed. The Elk River meanders along the valley-bottom of MU-5 for approximately 78 km. The highest level of development (e.g., urbanization, farming, and transportation) is located within MU-5, which includes the City of Fernie, the District of Sparwood, and Elko Dam. Other settlements include Hosmer, Elko, Morrissey, and Cokato. MU-5 also supports a wide range of recreation-based activities (e.g., Sparwood Fish & Wildlife Association Gun Range, Fernie Rod & Gun Club Range, Fernie Alpine Resort, wilderness area hiking, camping, biking, snowmobiling, and skiing). No active bituminous coal mines are located within MU-5.

Management Unit 6 (MU-6): This MU drains an area of approximately 95,000 ha, represents 19 percent of the total Elk River watershed, and contains the Canadian portion of Koocanusa Reservoir. Rural settlements in MU-6, from north to south, include Wardner, Jaffray, Galloway, Caithness, Baynes Lake, and Kragmont. Also included in MU-6 are Grasmere, Yaq̓it ʔa•knuqⱡiʔit—known also as the Tobacco Plains Indian Band reserve, and the Canada-U.S. border crossing town of Roosville. MU-6 supports recreational activities, including activities on Koocanusa Reservoir as well as in undeveloped public wilderness areas. No active coal mines are located within MU-6.

In addition to evaluating risk on an individual MU-basis, data for aquatic media from MUs 1 through 5 were combined to understand "valley-wide" exposures. The valley-wide scenario was added to account for people who contact environmental media throughout the Elk River watershed, not just in one MU. Valley-wide was defined as MUs 1-5 and not MUs 1-6 because inputs to the watershed are predominantly mine-influenced in MUs 1-5, while inputs to MU-6 (Koocanusa Reservoir) include non-mining sources as well as mining influences from the Elk River. Additionally, MU-6 is a lentic environment and MUs 1-5 are primarily lotic.

Although people may consume fish or recreate in MUs 1-6, MU-6 is not included in the valley-wide assessment because MU-6 exposures reflect sources beyond mining. Focusing the valley-wide assessment on MUs 1-5 provides a more conservative approach. Potential uncertainties associated with the definition of valley-wide and the interpretation of the risk results is discussed in Section 6.11.3.2.



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RAMBOLL

Elk Valley Water Quality Management Units
British Columbia, Canada

FIGURE
2-3

DRAFTED BY: CKROHE | DATE: 9/29/2022

PROJECT: 1690011690

2.1.2 Land Use

Zoning information for the DA is under the Regional District of East Kootenay Elk Valley Zoning Bylaw No. 829, which provides the zoning in the Upper and Lower Elk Valley, covering most of the DA. A significant amount of land in the area is zoned as Rural Residential and Rural Resource. There are large areas designated as Watershed Protection Zones and as parks and recreation areas. In addition to recreation and cultural activities on the undeveloped land in Elk Valley, including hunting, harvesting edibles, motorized recreation (all-terrain vehicles), camping, horseback riding, hiking, and skiing, Rural Resource areas may provide the public unrestricted access to water for recreation. Teck-owned properties typically require permission for entry, though undeveloped lands may not have access restrictions and Greenhills Operations has a pipeline right-of-way used by ATVs. Generally, recreation areas are concentrated in MU-5 and MU-6, and residential areas are concentrated in MU-5.

The Kootenay/Boundary Land Use Plan (KBLUP) Implementation Strategy provides regional land and resource management guidelines and applies to all public lands and waters in the Kootenay/Boundary regional planning area, which includes the Elk Valley. The KBLUP Implementation Strategy designates Crown land portions of the DA as enhanced resource development zones, indicating that these areas are suitable for resource development activities and provide long-term access for coal mining. In addition to integrated, special, and enhanced resource development zones designated under the KBLUP Implementation Strategy, Crown land designations within the DA include an Indian Act reserve (Yaq̓it ʔa•knuqⱡiʔit — known also as the Tobacco Plains Indian Band reserve) and provincial parks protected areas. Big Springs Campground, RV Park, Ayes Ranch Campground and RV Park, Dorr Road Campground and Edwards Lake are all owned and operated by the Tobacco Plains Development Corporation and located on Koocanusa Reservoir as multipurpose sites for Recreation and Ktunaxa cultural practices.

2.1.3 Surface Water Use

Surface water within the DA is not currently used as a municipal potable source of drinking water. It is acknowledged that some private individuals may divert surface water for potable use; however, little information is publicly available describing specific draw volumes and uses. Surface water uses are dominated by recreational activities, although permits for surface water diversion have been granted for the Elk River, Fording River, Michel Creek, and Koocanusa Reservoir for irrigation and industrial uses. It is possible that some people may use surface water as a drinking water source while exercising Indigenous rights or while camping.

2.1.3.1 Surface Water Recreational Access

Waters within the DA are used for fishing, swimming, and non-motorized watercraft such as kayaking, canoeing, and inner-tubing/floating, and Koocanusa Reservoir is open to motorized boating. Access may be obtained through both official access points and informal ones, such as through private property and boat-in only access. A number of informal access points on the Elk River between Sparwood, Hosmer, and Fernie, for example, are used by both fishing guides and inner-tubers/floaters. Official access points are provided by city and provincial parks. BC Parks is responsible for the designation, management, and conservation of a system of ecological reserves, provincial parks, and recreation areas throughout the province. There are four access points along the Elk River managed by BC Parks, two of which (Mount Fernie and Elk Valley provincial parks) provide access for fishing. Morrissey and Elko provincial parks are protected areas. A private access point on the Elk River, the Elkford Lions Municipal Campground, also provides access for fishing. There are five access points in BC for Koocanusa Reservoir. All sites provide access for fishing, boating, and swimming. There are no identified official access points along the Fording River. Informal access points to the Elk River are found along Highway 3, including entry and exit points for small, non-motorized watercraft.

2.1.3.2 Recreational Angling

Waters within the DA are open to fishing except the segment of Fording River above Josephine Falls and Line Creek, its tributaries, and the Grave Creek watershed including Harmer Creek. All waters within the DA are considered Classified Waters, which are highly productive trout streams in BC. BC anglers must obtain a fishing license, which may include a requirement for a Classified Water license for productive trout habitat. During much of the fishing season, the trout fisheries upstream of the Elko Dam are catch-and-release only for recreational anglers.

The BC Ministry of Forest, Lands and Natural Resource Operations and Rural Development (MFLNRORD) provides the Freshwater Fishing Regulations Synopsis (Synopsis) (MFLNRORD 2021), which is updated every two years. The Synopsis provides regional regulations and restrictions on freshwater fishing in BC, as well as water-specific regulations and any exceptions to the regional regulations. Fishing season in the Kootenay region is from June 15th through March 31st (MFLNRORD 2021). Regional access restrictions to freshwater fishing in the Kootenay region (Region 4 of BC) include the following, which will limit the amount of fish that may be consumed from this area:

- No fishing in any stream in Region 4 from April 1 to June 14.
- Trout/char release in streams from November 1 to March 31.

For all game fish, the MFLNRORD regulates the daily catch quota and size limits on the fish an angler may keep. Daily catch quotas are the maximum number of fish of a given species, group of species, or size class that an angler may keep in one calendar day. Any fish caught that exceeds the daily catch quota must be returned to the body of water in which it was caught. In addition to catch quotas, the MFLNRORD also imposes size limits. Size limits enable fish to spawn at least once before they are harvested, thereby supporting future fishing opportunities. Table 2-1 summarizes daily catch quotas and size limits in the Kootenay region. Several sport fish are closed to fishing, except where noted in specific bodies of water in the Kootenay region. These fish include bass, perch, pike, and walleye, which are invasive species that disrupt natural ecosystems and threaten native fish species. To provide a strong disincentive to their illegal introduction, the MFLNRORD imposes closures on these species and, in some cases, entire bodies of water where non-native fish species occur (MFLNRORD 2021). The trout quota in the DA Class II Waters is one, compared with the region-specific daily trout catch quota of five. These quotas and limits, combined with catch-and-release restrictions, result in few opportunities for high levels of fish consumption in many portions of the DA and underscore the potential for higher harvest rates outside of the DA. The implications of the quotas and limits on fish consumption rates for recreational anglers is discussed in the Uncertainty Assessment, Section 6.11.3.1.

Table 2-1. Regional Daily Catch Quotas, Region 4 – Kootenay (MFLNRORD 2021)

Fish Species	Regional Daily Catch Quotas
Trout/char	5 daily, but not more than 1 rainbow trout or cutthroat trout over 50 centimetres daily; 2 from streams daily; 1 bull trout of any size daily
Bass	Closed to fishing
Burbot	2 daily
Crayfish	25 daily
Kokanee	15 daily, no more than 5 over 30 cm
Northern pike	Closed to fishing
Walleye	Closed to fishing
Whitefish	15 daily

Fish Species	Regional Daily Catch Quotas
Yellow perch	Closed to fishing
Notes: cm = centimetre(s); MFLNRORD = British Columbia Ministry of Forest, Lands and Natural Resource Operations and Rural Development	

2.1.3.3 Aboriginal Rights

Indigenous Peoples' such as the Ktunaxa, have a constitutional right to harvest fish from waters for food, social, and ceremonial purposes in their homelands, not limited to the reserve lands, which includes water within the DA. Sec 35 of the Canadian Constitution defines this Aboriginal Right. Based on the Ktunaxa Nation Diet Study, popular fish species consumed are trout (bull, lake, rainbow, and cutthroat), kokanee, and burbot (Firelight 2014), which also may be consumed by recreational anglers in the Elk Valley.

2.1.4 Groundwater Use

Groundwater is the primary source of drinking water for the communities in the area. For residents within incorporated areas, municipal water systems provide potable groundwater, while residents outside municipal distribution areas rely on private or community wells. Groundwater also may be used for irrigation. Forty-nine private wells are included in the HHRA dataset. Available drinking water well data were limited to those with owners who participated in the RDWMP at any point from first quarter 2015 – second quarter 2020. While 49 wells are a small subset of the total domestic private and municipal wells in Elk Valley, the HHRA dataset provides reasonable spatial coverage of the Elk Valley.

Fernie municipal water comes from the Fairy Creek Spring in the Three Sisters watershed, where water is collected from an underground aquifer then conveyed to a wet well and chlorination facility (City of Fernie 2019). Drinking water from the Fairy Creek Spring source becomes excessively turbid during freshet, during which time drinking water is obtained from wells in James White Park to maintain a consistent source of drinking water until turbidity levels subside. In 2019, the City of Fernie reports that approximately 7,816 residents (including 5,400 full-time residents) are served under the city's water distribution system (City of Fernie 2019) and Statistics Canada identifies 6,320 residents in Fernie in the 2021 census (Statistics Canada 2023). The municipal drinking water quality is monitored and managed by the city. The James White Park wells in Fernie were included in Teck's (RDWMP beginning in first quarter 2021. These are the only municipal drinking water data evaluated in the HHRA for Fernie.

The District of Sparwood owns three wells, two of which are on the west bank of the Elk River (Franz Environmental Inc 2013). The wells numbers 1 and 2, located adjacent to the Elk River, are presently not influenced by surface water under current pumping conditions. The third well (number 3) is influenced by surface waters from the Elk River or Michel Creek as indicated by increasing selenium concentrations; however, it is no longer used for drinking water (SNC-Lavalin). A fourth well near Cummings Creek serving the District of Sparwood came online in March 2020. Well 3 and the newly added Well 4 are included in the HHRA dataset. The population of Sparwood district municipality was 4,148 in the 2021 census (Statistics Canada 2023).

The District of Elkford (population 2,749 in 2021 census [Statistics Canada 2023]) operates four groundwater wells for potable water (District of Elkford 2017). Elkford also operates two wells for non-potable use, for irrigation of a golf course and cemetery, and owns a surface water intake on Boivin Creek that has not been in operation since 1980. One well operated by the District of Elkford is included in the HHRA dataset. A municipal well from the town of Elko is also included in the HHRA groundwater dataset.

In summary, groundwater data for six municipal wells (two James White Park wells in Fernie, Sparwood wells 3 and 4, one Elkford well, and one Elko well) and 49 private wells are included in the HHRA. Some of these wells may not have a connection between surface water and groundwater but are included to provide a comprehensive estimate of risk-based on the assumption that any potential risks identified in the HHRA are associated with wells influenced by surface water-groundwater interactions. Additional detail regarding the groundwater dataset used in the HHRA is provided in Section 3.1.1. The groundwater wells evaluated in the HHRA represent data for over 80% of Elk Valley residents. The total population of the Elk Valley is approximately 15,000 (Penfold Meyer 2015, Elk Valley Free Press 2022) and the combined population of Fernie, Sparwood and Elkford is 13,217; therefore, an estimated 88% of Elk Valley residents would be consuming municipal water. Although data were not available for all wells in the Elk Valley, the groundwater dataset used in this HHRA did include municipal wells in Elkford, Sparwood, and Fernie, the community well in Elko and 49 private wells. Taken together, it is likely that more than 80 percent of the population’s drinking water is represented in these data.

2.1.5 Populations of Interest

There are three populations of interest in the context of understanding potential interactions with surface water and groundwater within the DA. These populations are: people who recreate in surface waters, which includes both residents and non-residents and are referred to as recreational users; Ktunaxa ʔaqⱡsmaknik who continue to have land- and water-based relationships to the area that have been established since time immemorial; and groundwater consumers who may be full-time or seasonal residents and visitors.

People in Elk Valley who rely on or enjoy the watershed reside primarily in the population centers mentioned previously: the District of Elkford (population 2,600), District of Sparwood (population 3,900), City of Fernie (population 5,100)[12], unincorporated Jaffray (population 554), and unincorporated Hosmer (population 115). The small town of Elko has an unofficially reported population of 163 residents (BritishColumbia.com 2020). These cities and districts are all located within the East Kootenay Regional District (population of 60,500; which also includes district areas outside Elk Valley). In 1887, official ”Indian” reserves were established by the Canadian government according to the Indian Act, within East Kootenay Regional District. According to Statistics Canada an approximate population of Indigenous Peoples within the area is 2,030 (Statistics Canada 2021) . However, population data for Indigenous Peoples does not discern Ktunaxa-specific individuals and are imprecise by linking ethnicity and identity. A reliable source of census information for the Ktunaxa is currently unavailable.

Residents in the Valley include both full-time permanent residents and seasonal residents who are present primarily during the winter ski and snowmobile season. Residents and non-residents alike depend on surface water (e.g., Elk River, Koocanusa Reservoir) for recreation, accessing the waterways during the portion of the year when the rivers and reservoir are not frozen and/or snow-covered. The primary water-based recreational activity is fishing, though boating, tubing, and swimming also are reported.

Ktunaxa ʔaqⱡsmaknik̓ have occupied and used lands and waterways that encompass the DA for more than 10,000 years. Ktunaxa homelands are divided into land districts identified within the Ktunaxa Creation Story according to key land- and water-based relationships in keeping with ʔa·kxamis q̓api qapsin--principles of interrelatedness with and stewardship for all living things, and specific place-based resources. These traditional land districts are also associated with particular authority and responsibilities in those areas (Robertson 2010). The DA, as defined in the EVWQP, falls within two Ktunaxa traditional land districts, the Qukin ʔamakʔis (Land of the Raven) and

[12] Statistics Canada notes: “Use with caution. After the release of the 2016 or 2011 Census population and dwelling counts, issues affecting the data are occasionally uncovered. It is not possible to make changes to the 2016 or 2011 Census data presented in release tables.”; Revised count of total population of Fernie: 5,136.

Ȼamna ʔamakʔis (Land of the Wood Tick). Ktunaxa concerns are of great importance in this HHRA. Their traditional lands include the Kootenay and Columbia Rivers and the Arrow Lakes of BC (KNC 2005). Rivers and streams of the region provide sources of fish, including various trout species, and plants. Additional discussion of Ktunaxa lands and their relationship to the land is provided in Section 2.3.

Workers may have contact with mine-related constituents within the operations area; however, mine workers are not evaluated separately in this HHRA. The health and safety of mine operations workers is governed by WorkSafe BC regulations and managed through Teck's corporate health and safety program. The Teck health and safety program provides for use of personal protective equipment to minimize exposures and in some cases, medical and/or personal monitoring to verify that exposures are not exceeding occupational guidelines.

2.2 Conceptual Site Model

A CSM is a written description or image that conveys or depicts the ways by which people can be exposed to chemical constituents in the environment. A CSM identifies the source(s) of chemical constituents, the pathways by which they are transported within the environment, environmental media in which they may be found (e.g., ground water, surface water, fish), and possible routes by which people may contact the constituents found in environmental media (e.g., ingestion, skin contact). The following subsections describe how mine-related chemical constituents released to water may be transported to environmental media that are contacted by human populations of interest within the DA. Figure 2-3 is a linear schematic CSM representing the chemical sources, transport pathways, environmental media, exposure routes, and groups of people who may be exposed, often referred to as receptor populations. In this HHRA, the receptor populations are recreational users and the Ktunaxa. Note that the term 'recreational user' refers to people who are not Ktunaxa and includes both residents and non-residents of Elk Valley. All recreational users and Ktunaxa are assumed to consume groundwater. Figure 2-3 was developed in consultation with the HHRA Workgroup during development of the HHRA methodology document. An additional CSM figure and accompanying discussion specific to Ktunaxa are provided as Figure 2-4 and Section 2.3, respectively, and were informed directly by the Ktunaxa People in collaboration with the KNC.

2.2.1 Chemical Sources and Chemical Transport

Chemical constituents sourced from Teck's bituminous coal mines that may migrate within the environment are naturally occurring minerals and nitrate that are suspended in air as dust during blasting and earth-moving activities and deposited on soils. Enrichment of some minerals occurs via the unearthing, grinding, and transport of ore, though dust suppression practices focus on minimizing the transport of dust. When referencing the movement of 'minerals' in the context of mining activities, Permit 107517 specifies that the HHRA consider selenium, mercury, cadmium, chromium, copper, manganese, nickel, vanadium, and zinc, as well as nitrate, though Teck's monitoring program also includes additional minerals and some organic compounds. This is discussed further in Section 3.

Overland transport of minerals in storm water is controlled on the mine sites and discharged following settling out of sediments under permits granted by ENV. In addition, a water treatment facility at Line Creek is treating water from mine-impacted tributaries and the Elkview Saturated Rockfill effectively removes selenium and nitrate from water; additional water treatment facilities at Fording River and Elkview Operations and Greenhills Mine are or will be under construction to provide further reductions in selenium and nitrate in the Elk River watershed. Nevertheless, some water from precipitation and runoff flows through waste rock piles at the mines and can mobilize constituents of interest through the watershed.

Particulates emitted from combustion engines operating at the mine sites also may be released, which include organic hydrocarbons as byproducts of the combustion process. These particulates are deposited on surfaces and then may be transported through the environment via precipitation and overland runoff. In addition to engines at the mines and mine-associated roadways, all automobiles and other engines operating in the Elk Valley contribute to particulate emissions that are transported through the watershed. Runoff from surface streets and highways, in particular, is likely to contribute organic hydrocarbons to the watershed.

Once released to surface water, constituents (e.g., minerals, nitrate, and hydrocarbons) may be dissolved, or, adsorb to suspended sediment that may ultimately settle to the river bottom or be transported down-gradient. Sediment settled on riverbanks and beaches may become exposed to air during periods of low-flow or reservoir draw-down. In the case of sediment exposed on Koocanusa Reservoir beaches during draw-down, this sediment may become entrained by wind and suspended in air. In surface water and sediment, the distribution of constituents between the dissolved and particulate phases is relevant in characterizing exposures to people and aquatic biota. Chemical reactions may occur that lead to the formation of a variety of chemical species, particularly for metals/metalloids, which have important implications for assessing their bioavailability to fish and toxicity to people.

Constituents in surface water may influence groundwater when a hydraulic connection is present. In some cases, this gradient may be present only seasonally. Surface water transport of constituents resulting from anthropogenic activities may also occur to some extent, where surface water is conveyed for irrigation (e.g., watering gardens, yard soil, and green spaces).

2.2.2 Potential for Human Contact

A human health exposure pathway includes a receptor population (e.g., recreational user), an exposure medium (e.g., surface water), an exposure route (e.g., ingestion of water), and a point of contact (e.g., James White Park swimming area). If any of these elements are absent, the exposure pathway is incomplete. Exposure pathway completeness varies depending on people's access to and activities within each MU, which may be affected by factors such as season, water level, and administrative controls. Only complete or potentially complete exposure pathways are evaluated in this HHRA.

Constituents may be contacted by people in a variety of exposure media that are directly or indirectly affected by water quality within the DA: surface water, sediment, fish, riparian plants, groundwater that is hydraulically connected to the Elk River or its tributaries, and crops and livestock irrigated by surface water or groundwater. Skin contact with surface water and sediment is an exposure pathway for people who use water bodies within the DA for swimming, fishing, boating, harvesting and preparing riparian vegetation, and other recreational or cultural activities. Incidental ingestion of surface water and sediment also may occur during these activities. People also may contact constituents indirectly through consumption of aquatic and terrestrial biota that consume or reside in surface water within the DA. Examples of these aquatic and terrestrial biota are fish and berries.

In some cases, exposures may occur for people who convey surface water for use as a field irrigation source. Irrigation of garden produce, agricultural crops, and livestock may contribute to indirect chemical exposures through consumption of locally raised foods. Similarly, people may be directly exposed to constituents when impacted groundwater or surface water is used as a drinking water source and may be indirectly exposed when consuming food products grown using groundwater for irrigation.

Some exposure pathways are only affected by constituents in surface water (e.g., drinking surface water or consuming fish), while other pathways may be affected by constituents present in soil or air as well as surface water (e.g., pathways related to consumption of terrestrial plants or animals). To satisfy Permit 107517 Section 8.10 and inform the AMP while also addressing questions raised by the HHRA Workgroup, the HHRA will distinguish risks directly associated with exposures to surface waters that may receive inputs from the mines and risks indirectly associated with exposures to mine-impacted surface water.

Complete or potentially complete exposure pathways affected only by constituents in or derived from surface water include:

- Incidental ingestion of and dermal contact with surface water during recreation and cultural activities
- Incidental ingestion of and dermal contact with sediment, and inhalation of sediment as suspended dust during recreational and cultural activities
- Fish and shellfish ingestion
- Surface water as drinking water or irrigation water
- Groundwater as drinking water or irrigation water

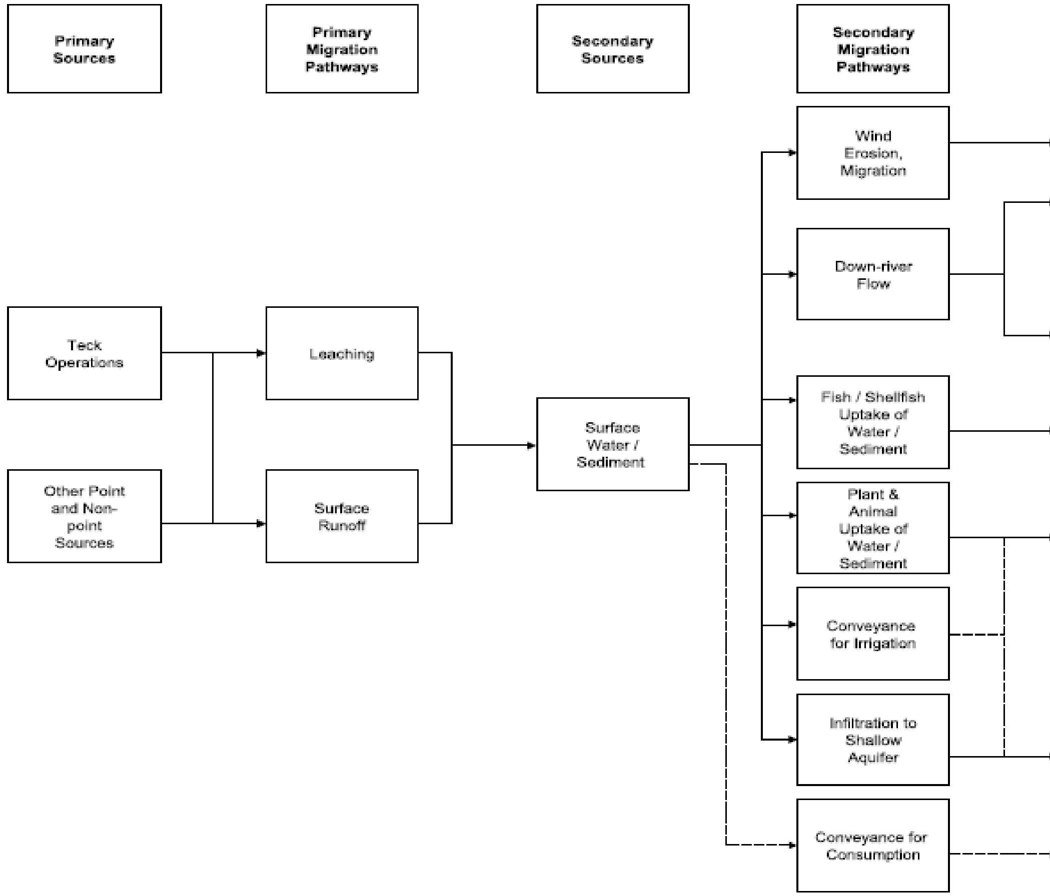
Additional pathways that may have more limited influence from constituents in surface water include:

- Ingestion of riparian vegetation and irrigated crops
- Ingestion of game and watered livestock

The pathways listed here were evaluated quantitatively in this HHRA with few exceptions. Exposures related to consumption of shellfish, irrigated crops, and livestock were not quantified in the HHRA, but are evaluated in the Uncertainty Assessment in Sections 6.11.3.4 and 6.11.2.4, respectively. The completeness or significance of the pathways listed above vary by season, location, availability, or other factors. In the case of surface water, it is not currently a municipal potable source of drinking water, though some private individuals may divert surface water for potable use. In this HHRA surface water is evaluated as a possible future drinking water source to inform water resource managers and is presented apart from other exposure pathways. The evaluation of chemical risks associated with consuming surface water as drinking water is not a full assessment of this resource as other factors, such as biological contamination, also must be considered prior to use. Nevertheless, these results may provide useful information for surface water management or for those who choose to periodically or seasonally consume surface water while spending time in Elk Valley. Additionally, this HHRA evaluated groundwater as a drinking water source but it is possible that there are no discernable surface water and groundwater interactions at each well included in the HHRA dataset, or, those interactions may be only seasonal. Finally, the HHRA focused on ingestion of wild-growing terrestrial foods as opposed to farmed crops or livestock irrigated with surface water. The evaluation of wild foods focused on plants and animals that are assumed to grow along or drink from the surface water bodies within the DA. When data representing riparian plants were not available for use, other plants of importance to the populations of interest were used as surrogates, though the linkage between the plants evaluated in this HHRA and surface water may not be present. Similarly, the contribution of surface water ingestion to total intake of mine-related constituents for upland game may be negligible, particularly relative to dietary intakes.

Some exposure pathways evaluated in the Environmental Assessment Certificate Applications supporting proposed mine facility development are not influenced by surface water and were not evaluated in this HHRA, so it is recommended that questions related to non-surface water-influenced pathways be addressed via the EA Certificate Application studies which are completed for all proposed projects and include a base case and a future case that anticipates potential future risks associated with operating mine conditions. An important pathway associated with the EA HHRAs is the inhalation of dust released to ambient air from mining activities. The EA HHRAs also consider the incidental ingestion of and dermal contact with dust once it has been deposited to land and incorporated into residential yard soil and household dust, as well as the subsequent inhalation of soil and dust particulates that are resuspended by wind that travels across bare soil.

In summary, the HHRA quantified potential exposures to surface water, sediment, fish, wild plants and game, and groundwater by the pathways shown in Figure 2-4.



Exposure Media	Exposure Pathways	Populations of Interest: Recreational User[1]	Populations of Interest: Ktunaxa
Wind-Blown Sediment[2]	Inhalation of airborne particulates	◉	◉
Surface Water / Sediment	Incidental ingestion of water	●	●
	Dermal contact with water	●	●
	Incidental sediment ingestion	●	●
	Dermal contact with sediment	●	●
Fish / Shellfish	Ingestion of fish fillet	●	●
	Ingestion of fish eggs	◉	●
	Ingestion of shellfish	◉	◉
Wild Plants / Crops[3]	Ingestion of riparian plants	●	●
	Ingestion of crops / homegrown produce	◉	◉
Game / Livestock / Plants[3]	Ingestion of game	●	●
	Ingestion of livestock	◉	◉
Groundwater[4]	Water ingestion	●	●
	Dermal contact with water	◉	◉
Surface Water[5]	Drinking water ingestion	●	●
	Dermal contact with drinking water	◉	◉

LEGEND

- ● Complete exposure pathway, evaluated in HHRA
- ◉ Complete exposure pathway, not evaluated in HHRA
- ○ Potential future exposure pathway, not current

Notes

1. The term recreational user refers to people who are not Ktunaxa and includes both residents and nonresidents of Elk Valley. All recreational users are assumed to consume groundwater.
2. Exposed sediment in Lake Koocanusa during low-water periods may be subject to wind erosion and subsequent inhalation by recreational visitors to the reservoir but this pathway is considered minor relative to direct sediment contact while swimming; Inhalation of particulates, while a potentially complete exposure pathway, is not evaluated in the HHRA.
3. Plant and animal uptake of surface water/sediment may occur but exposure via tissue ingestion is considered a minor pathway relative to fish ingestion.
4. Surface water infiltration to shallow aquifer is limited to areas where wells are located within Elk River floodplain.
5. Surface water within the Designated Area is not currently used as a municipal potable source of drinking water, although it is acknowledged that some private individuals may divert surface water for potable use. Surface water is also evaluated for populations wishing to understand lifetime exposures if, in the future, surface water is relied on as an exclusive drinking water source.

Conceptual Site Model for Residents

FIGURE 2-4

RAMBOLL US CORPORATION
A RAMBOLL COMPANY

Elk Valley
British Columbia, Canada

2.3 Conceptual Site Model-"Ktunaxa Lifeways within qukin ʔamakʔis" (Prepared by KNC)

The HHRA requirement within Teck's EVWQP Permit 107517 provided an opportunity to explore and document perceptions of qukin ʔamakʔis from two different standpoints. Within HHRA research generally, a CSM is utilized to demonstrate exposure pathways (direct and indirect) to contaminants through a visual representation to aid in the "problem formulation" stage of a risk assessment (i.e., determining which exposure routes and contaminants are of concern). CSMs are also very useful communication tools to support understanding of risk assessment study methodology and subsequent results. The CSM can act as a starting point for dialogue with non-researchers and those without a technical grasp upon which both frequency and dose of exposures can begin to be identified and articulated.

A CSM of the Elk Valley was developed by Teck in 2012 for their HHRA permitting requirements. The Ktunaxa were not expressly visible within the original CSM utilized—they were enveloped within the larger human population, defined as "First Nations."[13] What was missing through such an 'inclusion' is the appreciation of what makes Ktunaxa people, Ktunaxa ʔaqłsmaknik̓. Most notably, Ktunaxa ʔaqłsmaknik̓ roles, responsibilities and relationships within Ktunaxa ʔamakʔis and inherent waterways are documented according to their sacred covenant, that pre-date said industrial development, and related colonial experiences of reserves, residential schools, research and child welfare removals and other impacts enabled through the Indian Act and its related ideologies including the aggregation of distinct peoplehoods into "First Nations."

Ktunaxa identities are expressed as interdependent relationships with subsequent activities upon the landscape and within the waterways that can be best described as a culture and its practices, including stewardship. The term for this is ʔaqłsmaknik̓mu and refers to what helps us live as Ktunaxa. This is also referred to as Intangible Cultural Resource. In particular, ʔaqłsmaknik̓mu is unique to the Ktunaxa and while there is acknowledgment of past impacts aimed at removing this aspect of identity development, the Ktunaxa are looking to the future, and a continuance of being Ktunaxa ʔaqłsmaknik̓ within ʔamakʔis Ktunaxa. Active participation by the Ktunaxa within qukin ʔamakʔis, one of the seven Ktunaxa 'districts' or regions[14] requires deep understanding of both Ktunaxa knowledge relationships which are complex due to impacts over time from colonial impacts, and ought be approached with rigor.

Although impacts from coal mining originate in qukin ʔamakʔis, the impacts are more far reaching. Impacted water from the mines flows downstream into ȼam̓ na ʔamakis (Land of the Wood tick) adjacent to the First Nation of Yaq̓it ʔa·knuqⱡi̓ it and continues to flow through what is known as the Province of British Columbia before crossing the (colonially imposed) international boundary, into what is known as present day Montana. The Kootenai River then flows through the Ktunaxa territories of k̓ upawi¢q̓nuk (Ksanka Band, Confederated Salish and Kootenay Tribes of the Flathead Indian Reservation, near Elmo, Montana) and ʔaq̓ anqmi (Kootenai Tribe of Idaho near Bonners Ferry, Idaho) before turning north, and returning to B.C. in ʔaqyam‡up (Land of the Wolverine) flowing into Kootenay Lake and adjacent to the First Nation of Yaqan Nuʔkiy. The Kootenay/Kootenai River is woven into the heart of Ktunaxa homelands, is central to the Ktunaxa Creation Story, and has always supported and sustained Ktunaxa ʔakłsmaknik spiritually, culturally, socially, and economically.

Teck's permitting requirements for an updated HHRA provided an opportunity to do things differently (Draft Elk Valley Water Quality Plan HHRA Methodology, Ramboll 2020). An HHRA working group was formed which included representation of the KNC. In the early stages the idea of an updated CSM was discussed. At that point it was again recognized that the previous CSM did

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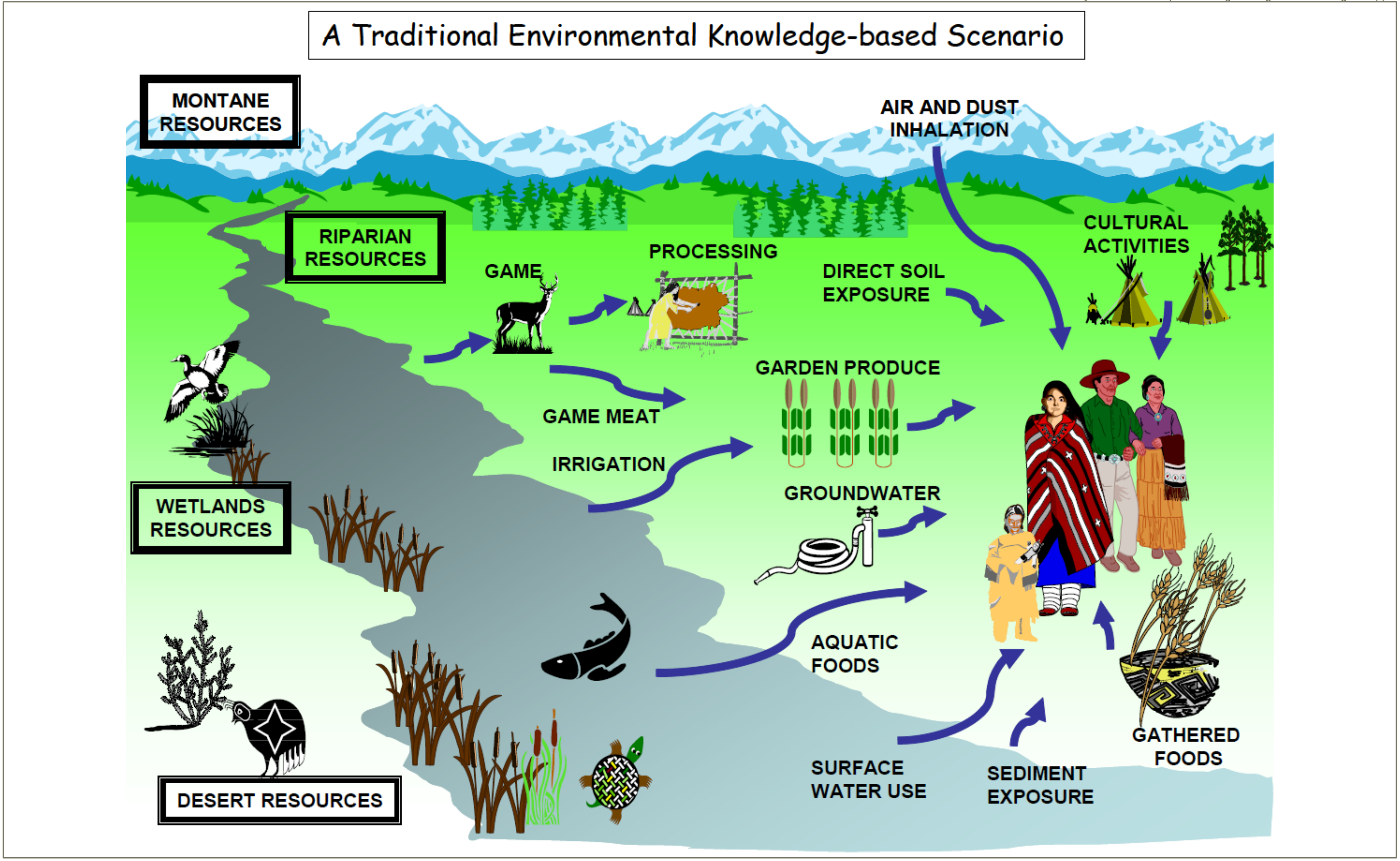
[13] A common misnomer is to reference Indigenous Peoples as First Nations, as defined within the Indian Act.

[14] The Seven regions are: kyawaȼ ʔamakʔis, qukin ʔamakʔis, ȼamna ʔamakʔis, ʔaknuqⱡuⱡam ʔamakʔis, miȼqaqas ʔamakʔis, skinkuȼ ʔamakʔis, and ʔaȼpu ʔamakʔis

not capture the unique relationship Ktunaxa have within ʔamakʔis Ktunaxa and that Ktunaxa ʔaqǂsmaknikʼ should have their own CSM.

Karen Fediuk, Senior Researcher with Firelight, provided the HHRA group the "Traditional Tribal Subsistence Exposure Scenario and Risk Assessment Guidance Manual" by Harper et al (2007). A key limitation inherent to the Harper et al. document is that it focused specifically within the context of the United States, whose relationship with Indigenous Peoples is quite different legally and politically and thus phenomenologically and culturally as well. This is a consideration since the Ktunaxa Nation has been divided as a result of the colonially imposed international border with two bands located within each Montana and Idaho.

What was of value from the Harper et al. document, was the process undertaken in developing a concept map of Indigenous Peoples use of lands and waterways which make visible contaminant pathways and the activities of those pathways. This document was extremely influential for conceiving how Ktunaxa interests and relationships could be understood and translatable not only to the HHRA process but also in support internally to Ktunaxa knowledge relationships inherent to Intangible Cultural Resources, and ʔaqǂsmaknikʼmu as related to the expression of Indigenous rights. This continues to be a key aspect as research is not "completed" at data analyses, interpretations, results and reporting but continues to impact/influence Ktunaxa lived experiences of place and stewardship responsibilities.



Tribal Exposure Pathways Based on a Subsistence Lifestyle
From Harper et al. 2007

FIGURE 2-5

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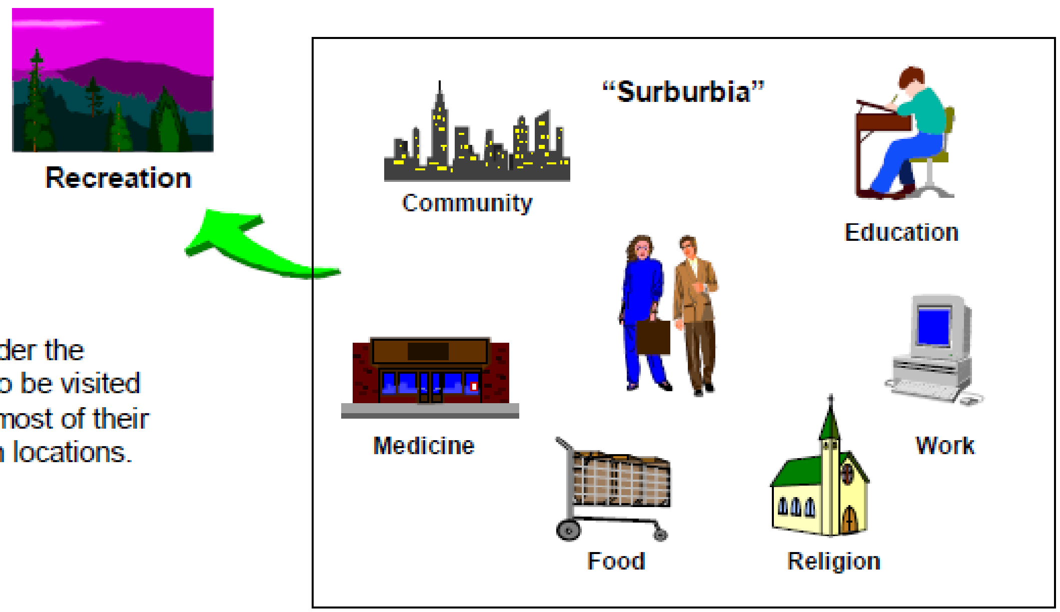
The recognition of how the environment has been purposefully reframed from a lifeways to an objectified relationship of "recreation" which was apparent in the original Teck CSM, is of absolute use and relevant to Ktunaxa self-development. In particular this perspective had to be corrected according to Ktunaxa principles of ʔa·kxamis q̓api qapsin and understood internal to the Ktunaxa to do so. The reframing of intangible cultural heritage, intangible cultural resource, and the reframing of cultural practice, as "cultural practice" rather than accepting normative Ktunaxa language according to relationships and attachments of peoples to place—waterways and landscapes, is captured in the development process of the Ktunaxa lifeways Conceptual Site Model. The illustration below found in Harper et al, visually represents the colonial shifts that have occurred that reframe, in this instance, Ktunaxa place-based relationships with landscapes and waterways.

Indigenous people live embedded within the environment and derive many services from it. They may leave it only to visit "suburbia" to obtain money.



Suburban dwellers consider the "environment" as something to be visited during recreation, and derive most of their services from other suburban locations.

Where People Go to Fulfill Elements of their Lifestyles

From Harper et al. 2007

FIGURE 2-6

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2.3.1 Process

KNC, Lands and Resources, determined that a self-reflective conceptual site model was a necessary step and would require Ktunaxa citizen input to ensure authenticity and validity of the product.

An initial CSM was compiled by a Senior Lands staff, which provided a visual cue for considering the interconnectedness of pictures of food and ways of living to the Ktunaxa people. This initial compilation was intended to elicit thought toward what a Ktunaxa Conceptual Site Model would look like, and how such a tool could be created, and if it was important to consider. This version was shared during a KNC engagement on the overall 2019 Diet Study Expansion project, with directors and senior staff in early June 2019. During this particular meeting one Ktunaxa director recognized their Ktunaxa name, and pointed out the connections of people to place to culture. This dialogue, then enabled other participants in the meeting to reframe the importance of cultural practice to Teck initiatives including the Diet Study itself.

Stemming from a Community Based Participatory Approach (Israel et al. 2005), utilizing aspects of the Photovoice research method (Nykiforuk et al. 2011), and the PostCard research method (Millman 2013), a Ktunaxa method to document Ktunaxa ʔaqⱡsmaknik̓ input into what a Ktunaxa conceptual site model of qukin ʔamakʔis, would entail, which in turn would enable the HHRA to proceed with modeling potential risk for Ktunaxa ʔaqⱡsmaknik̓ was suggested.

It was agreed that to create a Ktunaxa conceptual model would require community engagement and artists. A contract was entered into with two local Ktunaxa artists both of whom have ties to the Tobacco Plains band, Yaqīt ʔa·knuqⱡiʔit, who are related as well as were willing to work together on this project and collaborate toward a conceptual site model. Both also had previously worked on projects related to the visualization and recognition of place (a visual of a local watershed that was reflective of the Purcell mountain range and aspects of local geography as a tool for use with youth in appreciating 'place' in generic talk of watershed health and a re-creation of the C2C (Classrooms to Community) logo for gifting at an Environmental Education Network conference in which local place was visually represented).

A first step, was to meet with both artists together and invest in their understanding of the broader project thus building and sharing knowledge about the HHRA process, the conceptual site models so far proposed, as well as reviewing the learning undertaken by Harper et al. All of this investment would enable the facilitation of input into the Ktunaxa CSM itself in an interdependent way, enabling the artists to render as primary source interpretation with participants in the moment. From that point, the process was turned over to the artists to plan their engagement.

During the KNC Annual General Meeting (AGM), held in July 2019 at ʔaq̓am, Ktunaxa ʔaqⱡsmaknik̓ in attendance, provided input into a conceptual site model that reflects current Ktunaxa cultural practices and relationships with lands and waterways.

The artists were strategically placed at the entrance of the AGM and they were rendering in the moment, and posted for all to see as ideas were emerging from interactions, and quick chats with individuals across the lifespan and experience. Each person approached, was provided a 3"x3" post it note upon which they could write, in point form, or just a word or two, to answer the questions. Over 100 people provided answers to two key questions:

- "How does your family live on and use Ktunaxa Lands and Waters?"
  - There were 139 answers. The numbers reflect that some people had a lot of great answers and needed more than 1 post It note/response
- "What are your environmental concerns regarding Ktunaxa Lands and Waters?"
  - There were 84 answers.

The "post it note" completed was then posted upon the wall where the artists were working. Ktunaxa ʔaqⱡsmaknik̓ were encouraged to talk through the questions and to take a moment and think about all the ways in which they could either remember, or have been doing, on the lands and waters to get a better sense of the many ways in which Ktunaxa are in relationship to our homelands and waterways. They were also encouraged to read what others had written and review the many post it notes already up on the wall. On average people took a minute or two to complete the input.

2.3.2 Results

Each artist was rendering input in real time, according to their own ways and styles. The "Ktunaxa Lifeways within qukin ʔamak̓ʔis" is the direct collaboration of both artists capturing of the input garnered. The following paragraphs are the artists explanations, of the visual as they were the data interpreters for the CSM and were asked for their interpretations given they had context and conversation with those whose knowledge was contributed.

The importance of Ktunaxa language as first words with English below—this is in keeping with the recognition of impacts to Intangible Cultural Resources as well as centering Ktunaxa within Ktunaxa lifeways. Ktunaxa language is endangered and so increasing the visibility of Ktunaxa language is paramount to the language relearning efforts across generations.

The water cycle includes different uses of water—while water rights have not been approached in the same ways as Indigenous Rights, water is now re-emerging as a topic of importance. Water has a deep and equal cultural role for Ktunaxa, as evidenced within the Ktunaxa creation story. However, because the Canadian nation state did not and does not treat water the same as lands, Ktunaxa relationships with and to water and its uses are disconnected and thus limited to essential uses. This is not to say that Indigenous Peoples laws regarding water usage is gone, but that this application and recognition of water in use by Ktunaxa people in particular, reiterates the relationship is NOT ONLY to lands, but also waterways.

The family as more than nuclear and includes generations all of whose needs are unique to the individual and contribute to the collective. Within the family, is also the support for traditional ways of raising children, including breast feeding, and inclusion of various roles and responsibilities for overall familial well-being.

The mountain range includes the dust from mining at the left side. This is new and impact Ktunaxa lifeways currently in terms of being able to be in the waterways and landscapes safely.

The naming of certain plants and foods, and those of 'medicinal' significance speaks to the depth of Ktunaxa knowledge—that which is shared, and that which is not. Recognition of deep Ktunaxa knowledge and use, was paramount but also required some cultural safety and this seemed a good way to express the difference.

The fishing methods reflect the uptake by Ktunaxa ʔaqⱡsmaknik̓ of technologies, including old and new ways to harvest fish. Both the fish trap shown and rods, speaks to the importance of fish in diets when fish were plentiful and accessible. People have re-learned the fish trap from culture camps.

The spiritual groundedness is included here, representing the covenant between Ktunaxa peoples and place, through naⱡmuɣin, the land giant, as well as the overall guidance, or overview according to Ktunaxa ʔaqⱡsmaknik̓mu.

The challenges of a 'snapshot' approach: this graphic does not capture Ktunaxa seasonal rounds AND the frequency and dose, or the differences between regions inhabited and used by the Ktunaxa. Additionally, the time of year when input is sought, is a consideration for use of this CSM. Identification of and classification of specific information and application to qukin ʔamak̓ʔis.

The artists (both of whom have familial ties to the Elk Valley more broadly) noted that this work is limited due to the sample size as well as the sample population (those who attended the AGM) and *there is an inherent challenge to distilling a complex relationship with limited visuals. There were other inputs but due to the limitation of space on the page, artists determined to use the most frequent answers.*

In addition, certain images may represent other species or activities more generally. For example, huckleberries can also more generally represent the consumption of all berries. It was also important to ensure that different "exposure routes" were captured – for example, dermal exposure to water is captured by including a Ktunaxa person swimming.

Once completed, the Ktunaxa Lifeways within qukin ʔamakʔis was then presented for input and review by the Diet Study verification focus group. The verification focus group expressed some concerns about how the image may be misinterpreted by external organizations and non-Ktunaxa people. It was emphasized that it was important to provide a narrative with the CSM so it is not taken out of context. For example, the image is a simplification and is not inclusive of ALL the foods and lifeways of Ktunaxa in qukin ʔamakʔis.

Conceptual Site Model for Ktunaxa Lifeways within qukin ʔamakʔis

British Columbia, Canada

FIGURE 2-7

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The narrative in Section 2.3 of the HHRA (Conceptual Site Model--"Ktunaxa Lifeways within qukin ʔamak̓ʔis") should be reviewed with this figure.

Provided by Ktuxana Nation Council
Date Provided: March 17, 2021

3. DATA CHARACTERIZATION & HAZARD IDENTIFICATION

Permit 107517 specifies that the HHRA examine potential risks associated with mine-related parameters of concern, specifically selenium, mercury[15], cadmium, chromium, copper, manganese, nickel, vanadium, and zinc, in addition to nitrates that may be found in surface water-influenced environmental media. Aquatic environmental monitoring performed by Teck has included a broad range of parameters, including many that are not, or not wholly, mine-related and some that are rarely detected. To focus the HHRA on those constituents that may potentially present a risk to human health-based on their concentration in site media, frequency or magnitude of exposure and toxicity, a preliminary screening level risk assessment was completed by comparing environmental monitoring data to conservative risk-based guideline values. This process is common practice in HHRA and is described in Health Canada risk assessment guidance documents as the process for identifying constituents of potential concern (COPCs) (Health Canada 2019). Once this preliminary screening is complete, the COPCs then are further evaluated in the detailed quantitative assessment of exposure and risk.

This section lists the risk-based screening levels (RBSLs) used in identifying COPCs. This iteration of the HHRA updates the prior identification of COPCs in the 2016 HHRA by incorporating data collected since the previous HHRA, and by updating guideline values as needed. [16] A comparison of data collected within the DA to data collected from reference areas is also performed where possible. Constituents present at concentrations below the reference area concentrations or RBSLs are excluded from further evaluation in the HHRA. Innocuous, naturally occurring substances and analytes detected infrequently also were not retained as COPCs for further evaluation in the HHRA.

3.1 Overview of Chemical Data for HHRA

The HHRA utilizes relevant data for surface water, sediment, fish tissue, and groundwater collected through Teck's Regional Aquatic Effects Monitoring Program (RAEMP) and RDWMP. Samples collected for the RAEMP (i.e., fish, surface water, sediment) are focused on aquatic effects monitoring in areas known or expected to be mine-influenced (e.g., settling ponds, depositional areas) and are not necessarily representative of all locations where Elk Valley residents and visitors recreate or harvest foods, or where Ktunaxa People are "on the land." Use of these samples often represents a worst-case exposure scenario and is unlikely to underestimate exposure, but may overestimate exposure. This theme is discussed further in Section 6.11.3.1. The HHRA also considers data collected from other studies, including wild game and berry samples collected by Teck staff and Ktunaxa harvesters and hunters and KNC staff through the Wild Foods Sampling Program under the KNC/Teck Impact Management and Benefit Agreement (IMBA).

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[15] Although mercury is identified as potential mine-related parameter of concern in Permit 107517 and is evaluated in this HHRA, several evaluations have concluded that mercury concentrations observed in Elk Valley are not due to mining activities (Azimuth 2018, Azimuth 2019, Windward Environmental [Windward] et al. 2014). Background data collected on the Elk River, Michel Creek, and the Kootenay River indicate that elevated levels of mercury occur naturally during periods of high flow and turbidity and are not the result of mining activity. This is consistent with the evaluation conducted to develop the surface water quality early warning triggers, which did not identify mercury as a parameter for which early warning triggers were warranted (Azimuth 2018).

[16] Use of the term "guideline values" is different from the discussion of relevant guidance in Section 1 or in later sections of this report. In this case, use of the term guideline value is intended to represent a chemical-specific and medium-specific numerical criterion published by a ministerial or other government body that represents a chemical concentration below which no adverse health effects are anticipated in an exposed population. Mention of guidance or guidance documents in other portions of this report represent documents published by government agencies that provide instructions or methodologies for complying with regulations or policies, such as guidance or instructions on how to conduct an HHRA under Health Canada policy.

This HHRA assesses current conditions, using monitoring data reflecting existing operations.[17] Monitoring data obtained between the years 2015 and 2020 are evaluated in this HHRA dataset, as discussed with the Working Group in developing the HHRA Methodology. A general review of data quality and usability for all media was performed and refined as described in Section 3.2. Detailed information about the data used in the HHRA is provided in in this section and data are summarized in Appendix C in comparison with screening values.

3.1.1 Groundwater

Groundwater data collected under the RDWMP are evaluated in the HHRA and represent six municipal wells and 49 private wells. Of the municipal wells, two serve the City of Fernie (James White Park wells), two serve(d) the District of Sparwood (the recently retired Well 3 and new Well 4), and the other two serve the Districts of Elko and Elkford, respectively. Well locations are displayed in Figure 3-1. Private well identification information is not included in the HHRA to protect the privacy of individual well owners. It is understood that 55 wells (49 private and 6 municipal) are a small subset of the total private and municipal wells in Elk Valley, which may also be used for non-potable purposes. However, it is also worth noting that the HHRA dataset provides reasonable spatial coverage of the Elk Valley. It is not possible to provide an accurate, comprehensive total number of private and municipal pumping wells installed in the Elk Valley as it is not a requirement that wells be registered. The available groundwater data includes general water quality parameters, such as pH and conductivity, metals, and nitrate. As directed in the HHRA Methodology, the dissolved fraction of analyte concentrations was evaluated in the HHRA.

All data collected from 2015 through second quarter 2020 are included in the HHRA, apart from the Fernie municipal wells, where RDWMP data were collected beginning in 2021. Therefore, wells that were active at some point during that period, including those that have subsequently gone offline are included in the HHRA dataset. The number of sampling events differs by well. The wells are sampled on a request basis because the low concentrations of mine-related constituents in wells does not warrant regular sampling. This sampling approach was presented to and accepted by the Groundwater Working Group in July 2019.

The number of times an individual well was sampled over the 2015-2020 time period ranges from one to over thirty. Under the RDWMP, residents are provided access to an alternate source of clean drinking water and discouraged from consuming well water as a drinking water source when selenium, nitrate, sulphate, and/or cadmium concentrations are greater than BC drinking water quality guidelines (WQG). Use of these wells resumes when selenium, nitrate, sulphate, and /or cadmium concentrations decrease to concentrations below guidelines. Therefore, the HHRA dataset may include monitoring data representing wells with selenium, nitrate, sulphate, and/or cadmium concentrations that are periodically above WQGs. However, these wells were not used as a drinking water source while concentrations were above guidelines. For private wells where Teck installed a reverse osmosis system in a residence and a filtered water sample was available, the untreated water results were used in the HHRA rather than the post-treatment water results.

Because the sample collection period differs for the Fernie municipal wells (2021) compared to the other wells evaluated in the HHRA (2015-2020), the Fernie data are evaluated separately from the other groundwater data in the HHRA. Risks and screening results for the Fernie municipal well are discussed separately from other groundwater results and not included in the summary tables.

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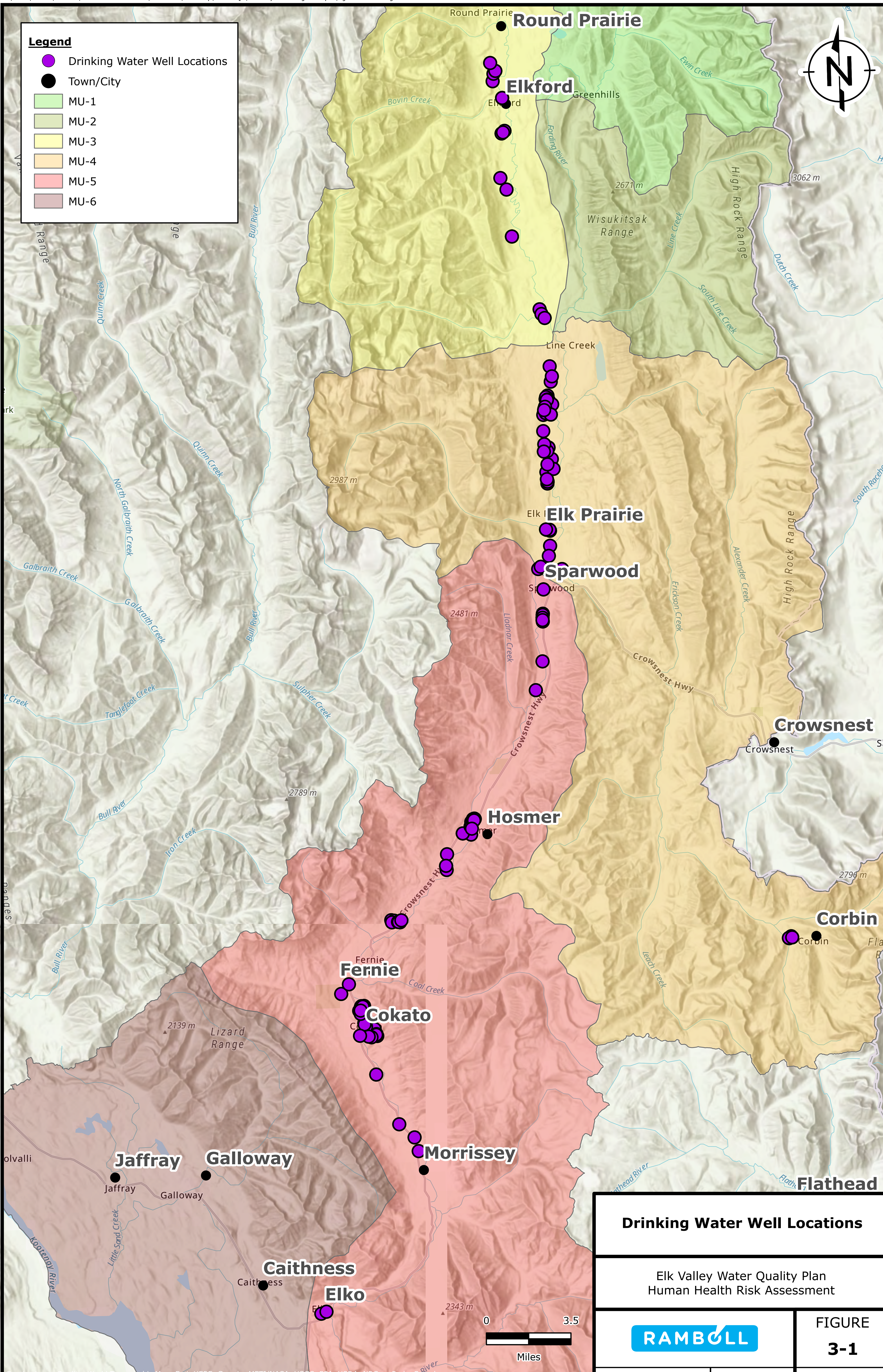
[17] The HHRA does not include trend analysis and focuses instead on current (i.e., last 5 years) data. Other programs (i.e., routine monitoring programs annual reports) evaluate trends in surface water, sediment, fish tissue, and groundwater concentrations. Work associated with the Adaptive Management Plan is one example where metals with increasing concentrations are being monitored and assessed for significance.

C:\Users\censlin\Ramboll\PNW GIS - Documents\PROJECTS\Elk Valley\2019 WQP\ElkValley - Drinking Well.aprx\Figure X - Drinking Water Well Locations - zoom



Drinking Water Well Locations

Elk Valley Water Quality Plan
Human Health Risk Assessment

RAMBOLL

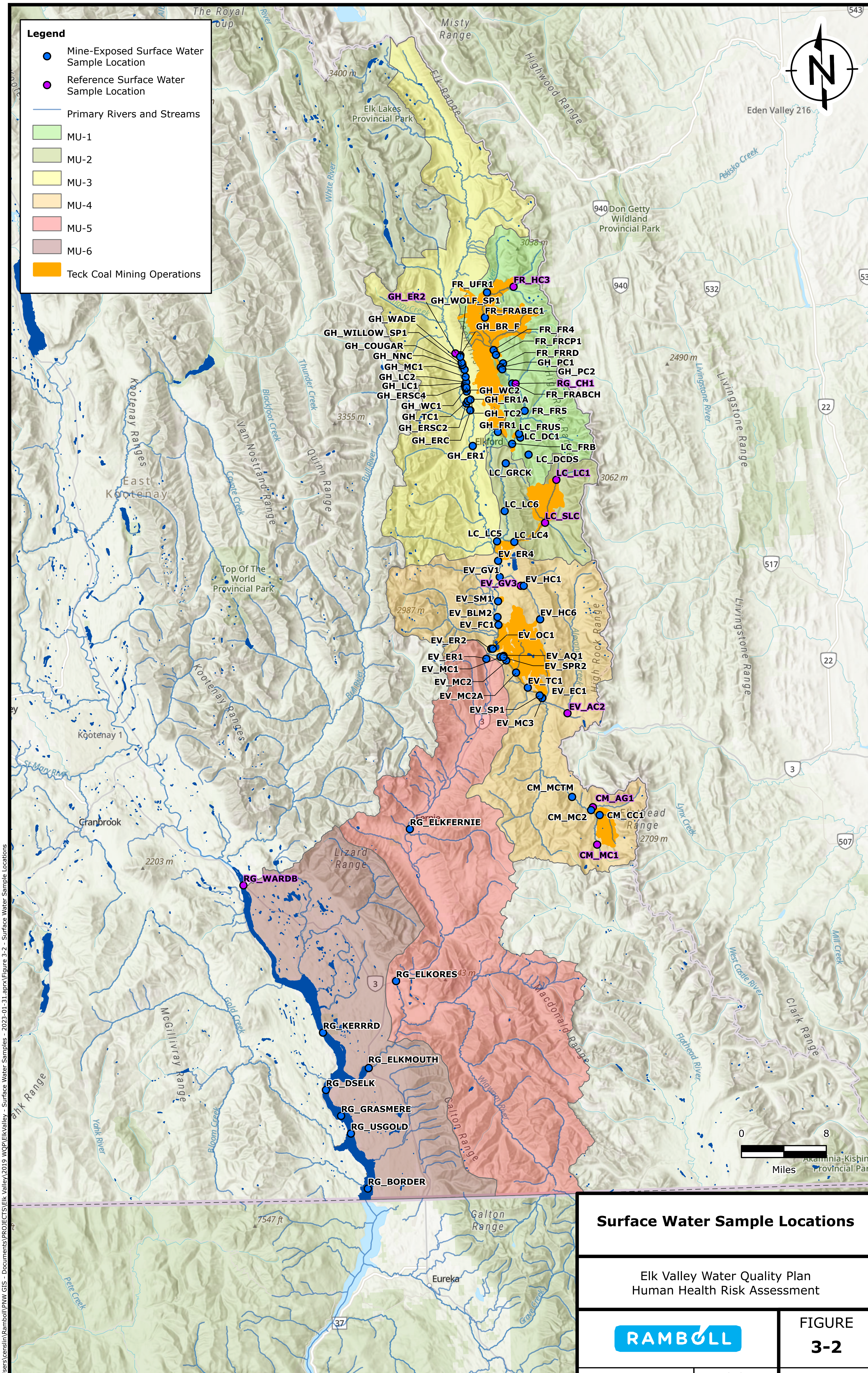
FIGURE
3-1

DRAFTED BY : CENSLIN | DATE: 7/28/2020 | PROJECT: 1690011690

3.1.2 Surface Water

Surface water data collected as part of Teck's routine water quality monitoring program, the RAEMP, and Koocanusa Reservoir studies were used in the HHRA. The locations of the surface water quality monitoring stations used in the HHRA are presented in Figure 3-2. Data collected from 2015 through July 2020 are included in the HHRA.

Surface water samples from lentic and lotic areas are included in the HHRA. As directed in the HHRA Methodology, both the total and dissolved fraction of analyte concentrations in surface water are screened in the HHRA, because surface water may or may not be filtered before it is ingested. The majority of surface water samples were analyzed for general water quality parameters, metals, and nitrate. Metals and nitrate are evaluated in the HHRA. A subset of samples were analyzed for selenium species, polycyclic aromatic hydrocarbons (PAHs), extractable petroleum hydrocarbons, and several other organics. The speciated selenium data are not included in the risk calculations but may be used in future evaluations where relevant. Of the organic compounds, the PAHs, acridine, and quinoline were analyzed most consistently and may be related to mining activities. However, acridine is not evaluated quantitatively in the HHRA because no screening or toxicity values are available. Extractable petroleum hydrocarbon data are not included because they were measured less frequently than PAHs, which represent the same class of constituents. Metals, nitrate, PAHs, and quinoline are the focus of the surface water evaluation.



Surface Water Sample Locations

Elk Valley Water Quality Plan
Human Health Risk Assessment

RAMBOLL

FIGURE 3-2

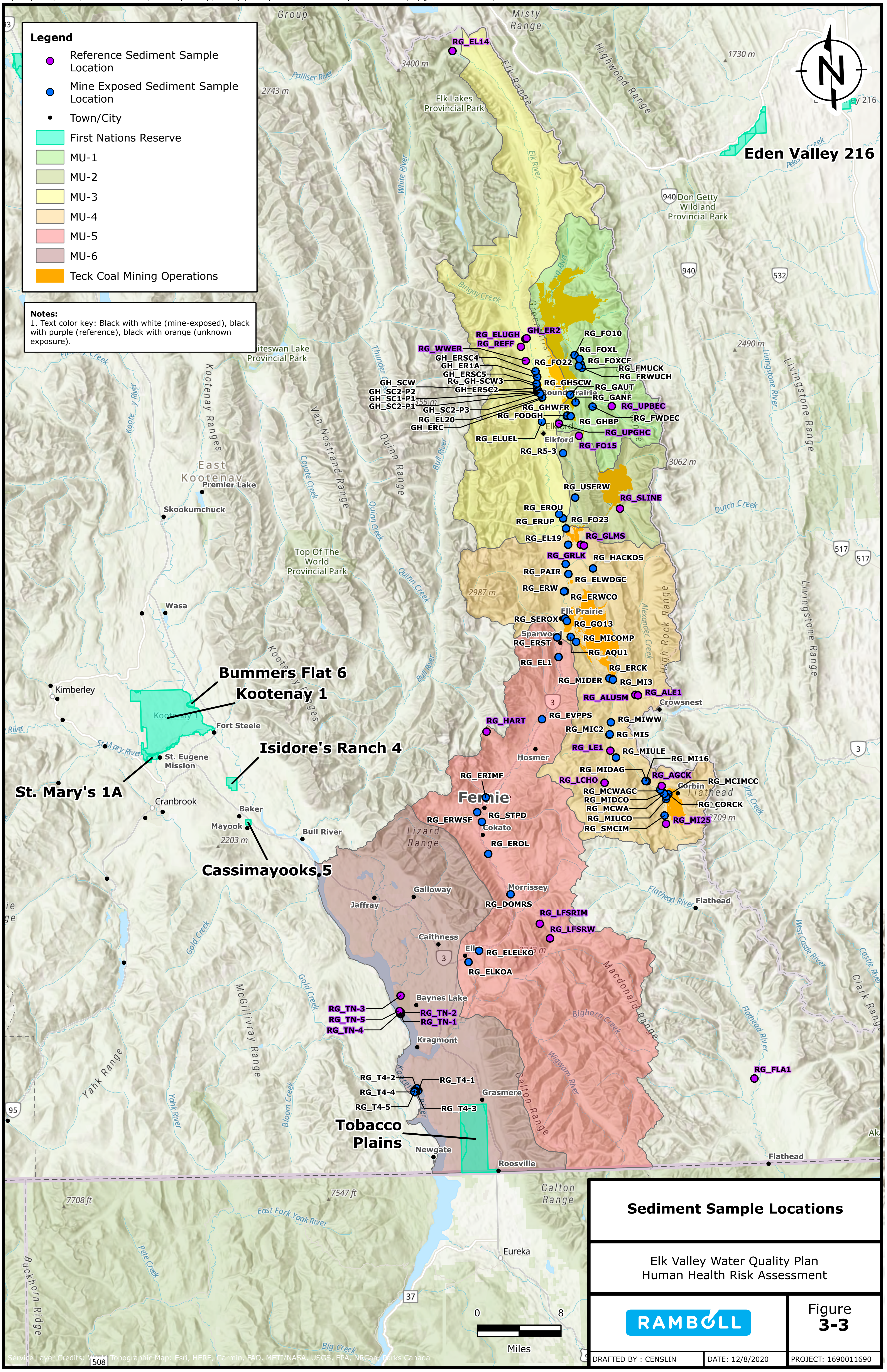
DRAFTED BY : CKROHE | DATE: 1/31/2023 | PROJECT:69001169

3.1.3 Sediment

Sediment data collected as part of the RAEMP and Koocanusa Reservoir studies were used in the HHRA. Sediment sampling stations represented in the HHRA are shown in Figure 3-3. Data collected from 2015 through fourth quarter 2019 are included in the HHRA for MUs 1-6. Data from third quarter 2020 are also included for MU-6.

Sediment samples from lentic and lotic areas are included in the HHRA. Sediment samples were collected from the top two or three centimetres (cm) of sediment for purposes of aquatic biota assessments but also represent a depth likely to be contacted by people recreating or performing other activities in surface water bodies within the DA so are appropriate for use in the HHRA. The sediment data include general sediment parameters (e.g., grain size, total organic carbon), metals, PAHs, acridine, and quinoline. Metals, PAHs, and quinoline are evaluated quantitatively in the HHRA, consistent with the surface water evaluation.

C:\Users\censlin\Ramboll\PNW GIS - Documents\PROJECTS\Elk Valley\2019 WQP\ElkValley - Fish and Sediment Samples - 2020-11-18.aprx\Figure X - Sediment Sample Locations

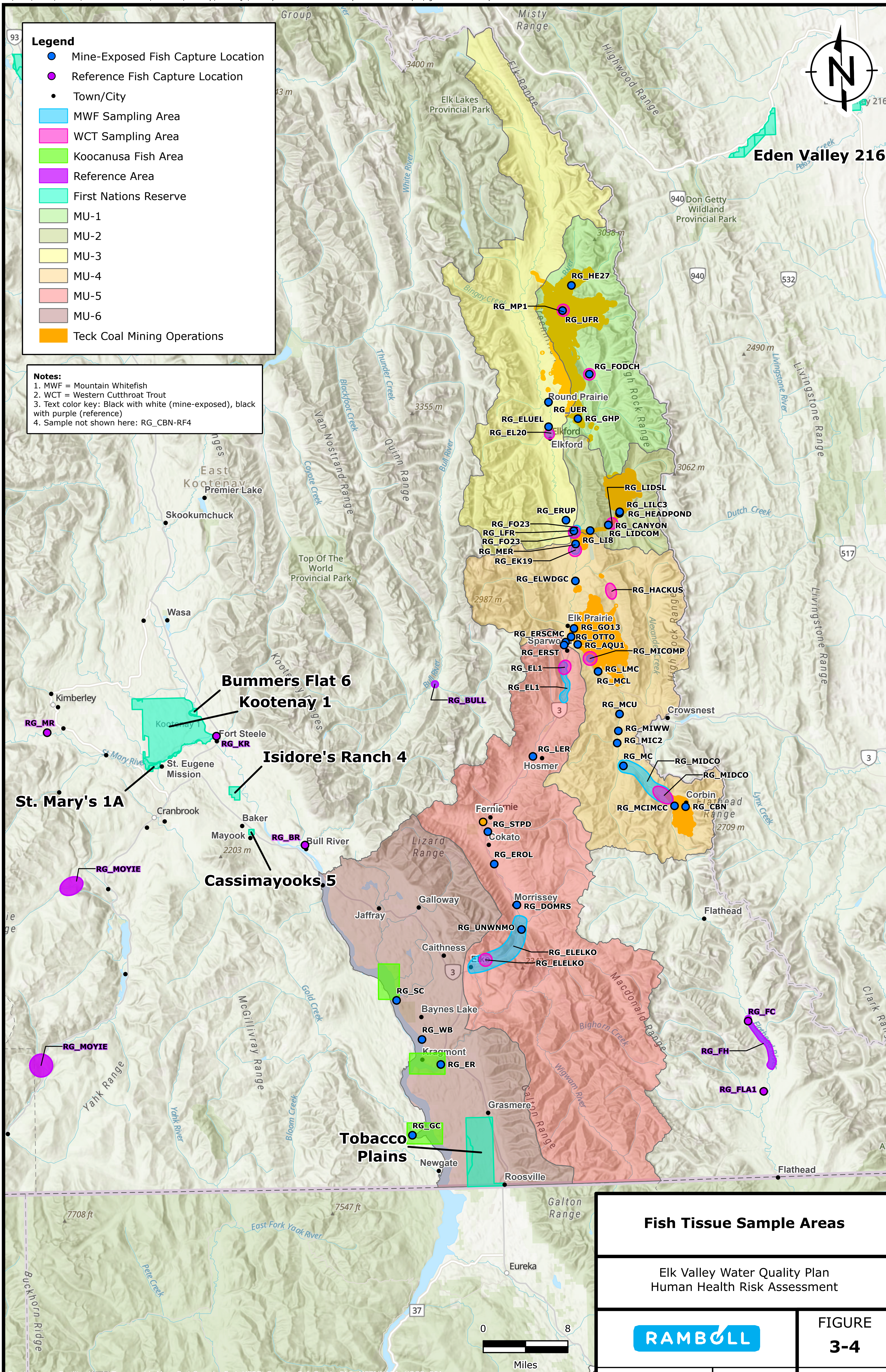


3.1.4 Fish

Fish tissue data collected as part of the RAEMP and Koocanusa Reservoir studies were evaluated for usability in the HHRA. The Ktunaxa Nation Diet Study conducted by Fediuk and Firelight (2015) identified bass, burbot, bull trout, brook trout, kokanee, lake trout, mountain whitefish, northern pikeminnow, rainbow trout, sturgeon, walleye, and westslope cutthroat trout as species consumed by Ktunaxa; not all species listed are present within the DA. Of the fish species identified in the Diet Study that are present within the Elk Valley or Koocanusa Reservoir, tissue data are available for bull trout, burbot, brook trout, kokanee, mountain whitefish, northern pikeminnow, rainbow trout, and westslope cutthroat trout. Additional fish species included in the HHRA but not discussed in the Diet Study are longnose sucker, peamouth chub, and redside shiner. Although bass, lake trout, walleye, and sturgeon were identified as consumed by Ktunaxa, these species are not present in the Elk River watershed or Koocanusa Reservoir (Windward et al. 2014; Minnow Environmental Inc. [Minnow] 2018), so they are not evaluated in the HHRA. Burbot data collected in 2014 (n=13) and 2015 (n=8) were previously evaluated for human health risks in *Health Evaluation for Consumption of Lake Koocanusa Burbot* (Ramboll Environ 2015; Appendix E) and are not evaluated in this HHRA. Shellfish are not quantitatively evaluated in the HHRA because no samples from potentially mine-influenced areas within the DA were available, and their presence and abundance within the DA was not confirmed by aquatic field biologists prior to completing this HHRA. A qualitative discussion of potential risks associated with shellfish consumption is in Section 6.11.3.4.

Fish sampling locations are displayed in Figure 3-4. Fish tissue data collected from 2015 through third quarter 2019 are included in the HHRA. The number of fish fillet (muscle) samples collected by species, lentic versus lotic areas, and MU in the DA and reference locations is summarized in Table 3-. Not all samples were analyzed for each analyte. For Table 3-1, sample counts for selenium are represented. Fish fillet tissue samples were evaluated for metals and percent moisture only, no organics were evaluated in fish tissue. Fish sampling was not conducted specifically for HHRA, so species and locations sampled may not be entirely reflective of what people consume. This is discussed further in Section 6.11.3.1.

C:\Users\censlin\Ramboll\PNW GIS - Documents\PROJECTS\Elk Valley\2019 WQP\ElkValley - Fish and Sediment Samples - 2023-01-31.aprx\Figure 3-4 - Fish Sample Locations



Fish Tissue Sample Areas

Elk Valley Water Quality Plan
Human Health Risk Assessment

RAMBOLL

FIGURE
3-4

DRAFTED BY : CENSLIN | DATE: 1/31/2023 | PROJECT: 1690011690

In addition to muscle tissue, fish ovary tissue data are available for most species. Fish ovary data are used in this HHRA as a surrogate tissue for fish eggs, a Ktunaxa food. Uncertainties regarding the use of ovary tissue as a surrogate for eggs and the influence of harvest time on concentrations are discussed in Uncertainty Section 6.11.3.4. The distribution of fish ovary data by species and MU is summarized in Table 3-2. Like fish fillet, only metals were analyzed in fish ovary tissue. For both fish fillet and ovary samples, counts are provided separately for lotic and lentic sample locations; however, the HHRA will not evaluate lotic and lentic locations as distinct sample types. This information is provided for additional characterization only and may inform interpretation of results.

Table 3-1. Fish Fillet Tissue Sample Summary (Selenium only)[18]

MU	Habitat	Fish Species	Sample Count Mine-Exposed	Sample Count Reference
1	Lentic	Westslope Cutthroat Trout	18	
	Lotic	Westslope Cutthroat Trout	35	
2	Lotic	Bull Trout	29	
		Mountain Whitefish	13	
		Westslope Cutthroat Trout	54	
3	Lentic	Longnose Sucker	12	
	Lotic	Mountain Whitefish	18	
		Westslope Cutthroat Trout	18	
4	Lentic	Longnose Sucker	53	
	Lotic	Brook Trout	1	
		Mountain Whitefish	22	
		Westslope Cutthroat Trout	64	
5	Lentic	Longnose Sucker	32	
	Lotic	Longnose Sucker	4	
		Mountain Whitefish	24	
		Westslope Cutthroat Trout	25	
6	Lentic	Bull Trout	5	
		Burbot[a]	21	
		Kokanee	29	
		Mountain Whitefish	23	
		Northern Pikeminnow	108	
		Peamouth Chub	30	
		Rainbow Trout	2	
		Redside Shiner	30	

[18] In this Revised Final HHRA, based on comments received in the July, 2022 HHRA, fish sampling stations RG_CBN and RG_MC moved from reference to MU-4 and station RG_FODCH moved from reference to MU-1.

MU	Habitat	Fish Species	Sample Count Mine-Exposed	Sample Count Reference
6	Lentic	Westslope Cutthroat Trout	6	
Outside of DA	Lentic	Longnose Sucker		13
	Lotic	Mountain Whitefish		38
		Westslope Cutthroat Trout		14

Notes:

[a] The burbot data were evaluated for human health risks in *Health Evaluation for Consumption of Lake Koocanusa Burbot* (Ramboll Environ 2015) and are not evaluated in this HHRA.

DA= designated area; HHRA = human health risk assessment; MU = management unit

Table 3-2. Fish Ovary Tissue Sample Summary

MU	Habitat	Fish Species	Sample Count
1	Lentic	Westslope Cutthroat Trout	1
2	Lotic	Bull Trout	5
		Mountain Whitefish	13
		Westslope Cutthroat Trout	1
3	Lentic	Longnose Sucker	11
	Lotic	Mountain Whitefish	13
4	Lentic	Longnose Sucker	48
	Lotic	Mountain Whitefish	16
5	Lentic	Longnose Sucker	19
	Lotic	Longnose Sucker	1
		Mountain Whitefish	22
6	Lentic	Northern Pikeminnow	86*
		Peamouth Chub	30
		Redside Shiner	30

Notes:

* Six samples from Northern Pikeminnow Selenium Toxicity Support Study, before fertilization.

MU = management unit

Sampled tissues are sent to the laboratory in their fresh, uncooked or 'wet' form, and then are processed and dried by the laboratory prior to analysis. Weight measurements prior to and after drying result in sample-specific moisture measurements that can be used convert the chemical concentrations analyzed from dry samples to concentrations based on a wet sample weight. Prior to performing any evaluation of the tissue data, all data were converted to a wet weight (ww) basis because in HHRA, the RBSLs and consumption rates are presented on a ww basis (consumption rates for dried foods are not available). Dry weight concentrations were converted to ww as shown in Equation 1:

Equation 1

$$Conc_{ww} = \frac{Conc_{dw}}{100} \times (100 - \%\ moisture)$$

When sample-specific moisture content was not available or the moisture content provided was outside the expected range for the tissue, a default moisture value was applied to obtain ww concentrations. For fish fillet tissue, the expected range is 70 to 80 percent, and a default value of 75 percent is applied, consistent with assumptions applied by ENV (2014). For fish ovary data, no default percent moisture value is available from ENV. Thus, the average percent moisture for fish ovaries from the 2015-2019 Elk Valley dataset was used (67 percent) as the default and applied to ovary samples where percent moisture was missing or outside the range of 60 to 75 percent.

A high proportion of samples had elevated detection limits (DLs) for many metals analyzed in fish tissue. Selenium and mercury results are not affected by this issue, but most other metals evaluated in the HHRA are affected. Specifically, about 25 percent of mine-exposed fish and 30 percent of reference fish samples had DLs that were consistently elevated in most metals. The majority were westslope cutthroat trout samples. The small sample mass of these samples impacted the sensitivity achieved by the laboratory, as described in the *Interlaboratory Tissue Analysis Validation Study* (Golder Associates Ltd. [Golder] 2020).

Cumulative distribution function plots that show the distribution of detected and non-detected results by metal for mine-exposed and reference fish are included in Appendix A1. As shown in the plots, non-detected results dominate the upper-end of the distribution for many metals. These elevated DLs have the potential to bias exposure point concentration (EPC) and 95th percentile reference concentration estimates high. Ninety-five percent upper confidence limit of the mean (95 UCLM) calculation methods (e.g., Kaplan Meier) included in USEPA's ProUCL software can account for non-detected results. The 95 UCLM estimates produced by ProUCL were reviewed and were not found to be biased by the elevated DLs. Because this statistic was not influenced by the elevated DLs, 95 UCLMs were calculated for reference fish instead of 95th percentile reference concentrations. The reference 95 UCLMs are directly compared with the mine-exposed 95 UCLMs for fish tissue in the Risk Characterization. This approach to comparing data representing mine-exposed and reference area fish was discussed with the HHRA Workgroup and agreed-upon prior to performing the evaluation.

3.1.5 Game, Berries, and Rose Hips

Analytical data representing game, berries, rose hips, and other wild plants compiled from the Wild Foods Sampling Program and additional, opportunistic samples collected by Teck and Ktunaxa staff and citizens are summarized in Table 3-3 and presented in Figure 3-5 and Figure 3-6. A total of 158 vegetation and 76 animal tissue samples were collected within the DA, and 69 vegetation and 53 animal tissue samples were collected outside the DA. Of the vegetation samples collected within the DA, 99 percent are berries and rose hips. Therefore, berries and rose hips are the only vegetation assessed quantitatively in the HHRA. The majority of animal tissue samples collected are from large game, specifically elk, mule deer, whitetail deer, bighorn sheep, and moose. Of the large game samples collected in the DA, about 70 percent are muscle tissue and 30 percent are organ tissue. Muscle and organ tissues are evaluated separately as described in Section 4.2.7 of the Exposure Assessment. Although several freshwater mussel, wild bird, and muskrat samples were submitted, the samples were predominantly collected outside the DA. Therefore, only large game is quantitatively evaluated in the HHRA. At the request of the HHRA Workgroup, box and whisker plots for selenium in game, berries and rose hips within the DA and in the reference area are included in Appendix A2.

An overview of game, berry, and rose hip sample counts by MU used in the HHRA is provided in Table 3-4.

The table also includes the sample count of these foods collected outside of the DA, which are used as a reference dataset in the HHRA. According to the Ktunaxa Nation diet study (Fediuk and Firelight 2015), 20 species of berry are traditionally consumed by the Ktunaxa including: blackcaps, blueberries, chokecherry, cranberry, dogwood berry, elderberries (blue and red), gooseberries, grouseberry/red alpine huckleberry, hawthorn, highbush cranberries, huckleberry (blue), kinnikinnick, oregon grape, raspberry, saskatoon berries, soapberry, sticky currant, strawberry, thimbleberry, and wild-rose hips. In the 2019 Ktunaxa Nation Diet Study Expansion, juniper berries were added to the list of berries consumed. Metals are the only analyte group measured in berries and game that are evaluated in the HHRA. PAHs were measured in a subset of these samples but were rarely (berries) or never (game) detected (Ramboll Environ 2016). Thus, only metals are evaluated in the HHRA. As with fish, dry weight concentrations provided by the laboratory were converted to ww concentrations for use in the HHRA (see Equation 1). Because of the variability in tissue and species types, default percent moisture values are not available and were not calculated. The sample-specific percent moisture values provided by the laboratory were always used to calculate the ww concentrations. Percent moisture data were not provided for two samples; fortunately, the reported concentrations were in ww units for these samples and the data were usable in the HHRA.

Table 3-3. Wild Foods Sampling Program Counts (as of February 2021)

Organism	Species	Tissue Type	Within DA	Outside DA
Plant	All	Berries	201	34
		Rose Hips	12	8
		Other	2	28
Animal	Mule Deer	Muscle	13	1
		Organ	1	2
	Whitetail Deer	Muscle	6	7
		Organ	6	6
	Elk	Muscle	36	9
		Organ	8	4
	Bighorn Sheep	Muscle	6	
		Organ	1	
	Freshwater Mussel	Muscle	2	12
	Grouse	Muscle		2
		Organ		1
	Muskrat	Muscle		1
	Moose	Muscle		2
		Organ	1	
	Osprey	Muscle		2
		Organ		1
	Woodpecker	Muscle		2
		Organ		1
	All Animal Muscle		63	38
	All Animal Organ		17	15

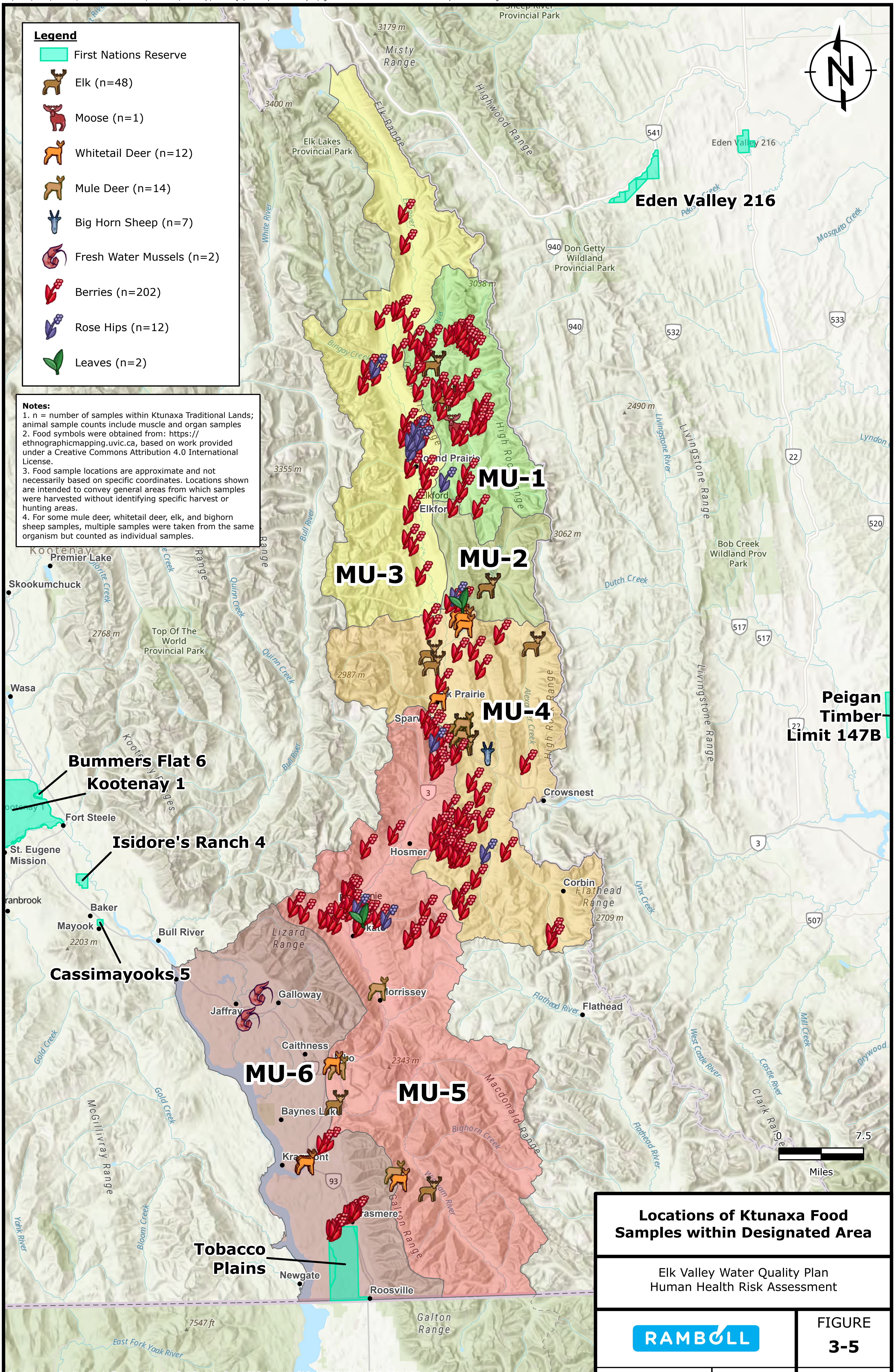
Notes:
DA = designated area

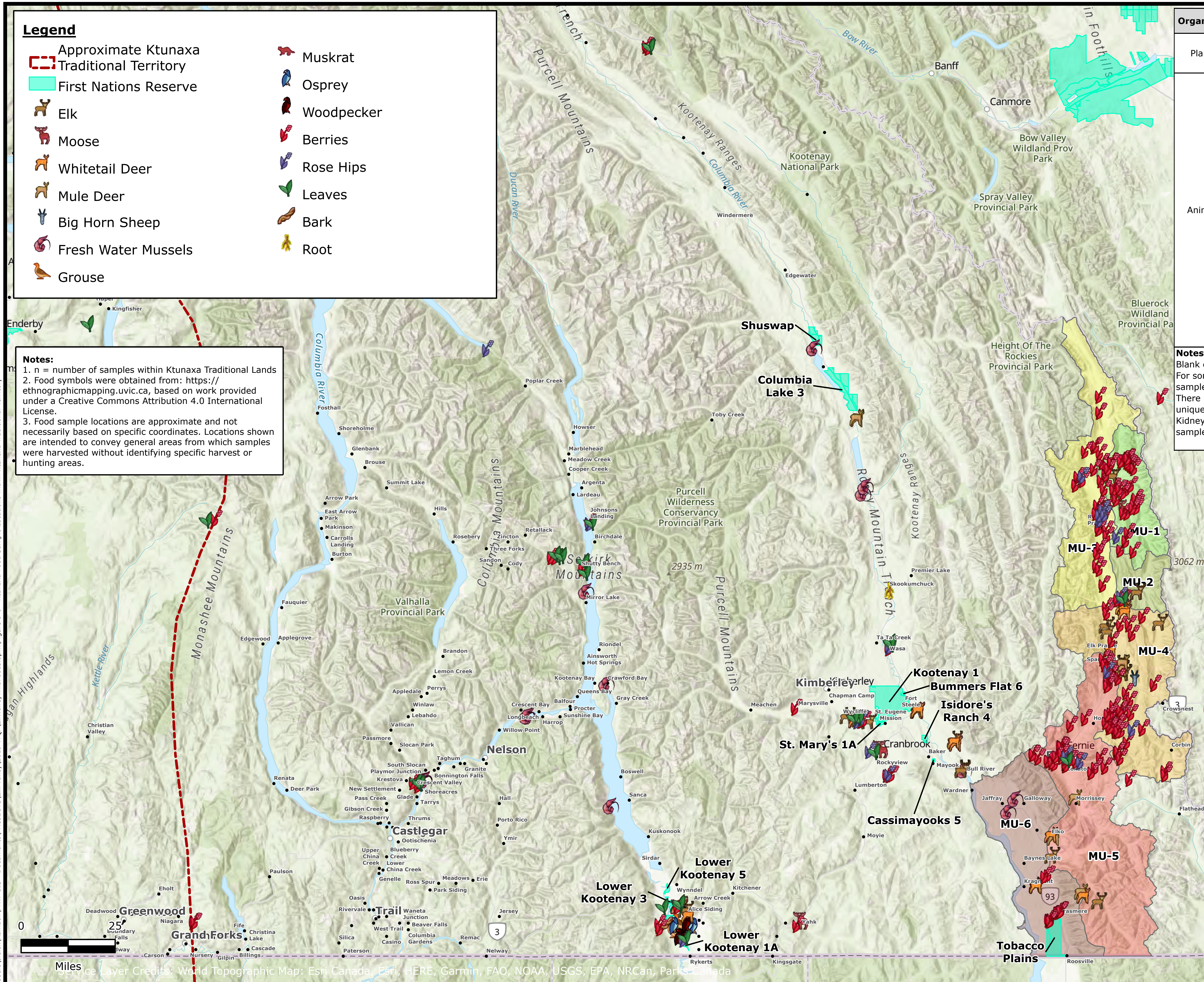
Table 3-4. Game, Berry, and Rose Hip Sample Counts by Management Unit and Outside Designated Area Used in the HHRA

MU	Sample Count			
	Berries	Rose Hips	Game Meat	Game Organ
1	43	1	8	3
2	4	1	4	1
3	35	6	0	0
4	52	1	41	10
5	52	3	6	1
6	15	0	2	2
Total sample count in DA	201	12	61	17
Sample count outside DA (Reference)	34	8	19	12

Notes:
Game includes elk, mule deer, whitetail deer, bighorn sheep, and moose samples.
Game meat includes game muscle and heart tissue samples.
Game organ includes liver and kidney samples.
DA = designated area; HHRA = human health risk assessment

C:\Users\sleick\Ramboll\PNW GIS - Documents\PROJECTS\Elk Valley\2019 WQP\ElkValleyWildFoods.aprx\Figure 3-5 - Locations of Ktunaxa Food Samples within Designated Area





Organism	Species	Tissue Type	Within Designated Area	Outside Designated Area
Plant	All	Berries	202	34
		Rose Hips	12	8
		Other	2	28
Animal	Mule Deer	Muscle	13	1
		Organ	1	2
	Whitetail Deer	Muscle	6	7
		Organ	6	6
	Elk	Muscle	36	9
		Organ	8	4
	Bighorn Sheep	Muscle	6	
		Organ	1	
	Freshwater Mussel	Muscle	2	12
	Grouse	Muscle		2
		Organ		1
	Muskrat	Muscle		1
	Moose	Muscle		2
		Organ	1	
	Osprey	Muscle		2
		Organ		1
	Woodpecker	Muscle		2
		Organ		1
	All Animal Muscle		63	38
	All Animal Organ		17	15

Notes:
Blank cells indicate no samples collected.
For some mule deer, whitetail deer, elk, and bighorn sheep samples, multiple samples were taken from the same organism but counted as individual samples. There are 106 mule deer, whitetail deer, elk and bighorn sheep samples from 56 unique locations.
Kidney and liver are grouped as organ samples; Heart is grouped with muscle sample data.

Ktunaxa Food Sample Locations within Ktunaxa Traditional Territory

Elk Valley Water Quality Plan
Human Health Risk Assessment

RAMBOLL

FIGURE 3-6

DRAFTED BY : SLEICK | DATE: 9/7/2021 | PROJECT: 1690011690

3.2 Data Usability Criteria

Data quality assurance and quality control (QA/QC) program process and evaluations were performed under the various environmental programs administered by Teck. A brief summary of QA/QC evaluations applicable to data used in this HHRA is provided here.

A data quality review was conducted on laboratory data reported in 2017, 2018, and 2019 for samples collected in support of the RAEMP. Reporting limits, data precision (based on field and laboratory duplicates), and data accuracy (based on matrix spike recoveries and/or analysis of standards or certified reference materials) were evaluated. Overall, the quality of the data was considered acceptable (Minnow 2020).

Golder (2020) completed an interlaboratory fish tissue data validation study which compared selenium analyses from four laboratories. Data were compared to data quality objectives (DQO) for accuracy, precision and sensitivity to evaluate how data quality varied as a function of tissue type and sample weight. The labs met the majority of the DQOs, with TrichAnalytics and ALS recommended as preferred labs.

Azimuth (2021) evaluated the precision (degree of reproducibility) of surface water quality measurements in the Elk Valley from 2012 to 2021. Relative percent difference (RPD) was calculated for each sample-duplicate pair and monthly mean RPDs for each constituent were reviewed over time. There were no clear increasing or decreasing trends over time. Despite occasional high magnitude RPDs, median and mean RPDs were typically <10 percent, demonstrating that concentrations were generally similar between the parent sample and its duplicate.

The 2021 Elk Valley Regional and Site-Specific Groundwater Monitoring Programs report provides a QA/QC assessment. SNC-Lavalin summarized RPDs for duplicate samples, summarized detections in field and trip blanks, and reviewed lab quality control reports for each groundwater monitoring program. Data were generally considered reliable (SNC-Lavalin 2022).

Ramboll (2020) prepared a data validation report to assess the validity and usability of analytical data generated from vegetation and animal tissue samples collected during 2017, 2019, and 2020 and determined the data to be usable (Ramboll 2020).

Several topics related to data quality and usability in HHRA are included here in the following subsections, specific to the use of non-detected results, duplicate and split samples, location considerations, and data representing innocuous substances.

3.2.1 Non-Detected Data

Non-detected results are reported as "<X" in the database where "X" is the DL. The DL is the lowest concentration that can be seen above the normal "noise" associated with the analytical method (USEPA 1989). Depending on the environmental media and lab performing the analysis, "X" may represent the minimum DL or reporting limit. As a conservative measure, non-detected results are represented as the full DL in the screening assessment (i.e., identification of COPCs) and risk calculations. Detected and non-detected results are evaluated separately in the screening. For non-detect results, DLs are compared to RBSLs to identify cases where the DL exceeds the value used in the screening. Analytes with DLs that exceed RBSLs are presented by environmental medium and MU in Appendix C. If an analyte was not detected in any samples within a medium, and the DL is lower than RBSLs, then it was assumed that the chemical was not present in that medium and the chemical was dropped from further consideration in the risk assessment.

3.2.2 Use of Duplicate and Split Samples

Field duplicates were collected with a subset of investigative samples in surface water, groundwater, sediment, and fish tissue, and evaluated as part of the QA/QC processes in the original monitoring program. Field duplicates also were collected during the Wild Foods Sampling Program. Duplicate samples were not included in the HHRA to avoid double-counting of results representing a single sample location. Split samples, which are a single sample divided in two parts and analyzed at separate laboratories, were also excluded from the HHRA database to avoid double-counting results. Only the sample result associated with the primary laboratory was retained and used in the HHRA.

3.2.3 Location Considerations

Each sample location was reviewed by Teck and the HHRA Workgroup to assess relevance for human exposure (i.e., accessibility of location) and whether the location represents a reference area or a mine-influenced location within the DA. Among mine-influenced locations, all those accessible to the public and without physical or administrative barriers preventing access are included in the HHRA dataset. Sampling locations representing areas within mine operations facility-controlled access areas are not included unless it is possible for the environmental medium to be contacted outside the facility-controlled area (e.g., fish moving downstream). Additionally, sample locations within facility-controlled access areas also were retained if the controlled location represents the closest approximation to a downstream location that is accessible but not represented by any other sample. In addition, fish sample locations include those where current regulations permit only catch-and-release by recreational anglers because they represent areas where Ktunaxa could harvest fish.

Reference locations upstream of or otherwise not influenced by mining operations are evaluated separately from mine-influenced sampling locations. Reference location data are collected under various environmental monitoring programs and are available for surface water, sediment, and fish tissue. Game, berry, and rose hip samples collected outside of the DA are considered representative of non-mine-influenced samples and are utilized in this HHRA as a reference dataset. Reference or background groundwater data were not available for use in the HHRA. Further discussion of reference data and reference concentrations is provided in Section 3.3.1.

3.2.4 Essential Nutrients and Other Innocuous Analytes

Constituents generally considered to be nontoxic or nutrients essential to life were excluded from the preliminary screening and risk calculations. Consistent with the 2016 HHRA, the essential nutrients calcium, magnesium, phosphorus, phosphate, potassium, and sodium were excluded from this HHRA. In addition, naturally occurring trace elements (bismuth, cesium, gallium, rhenium, rubidium, silicon, strontium, tellurium, thorium, titanium, tungsten, yttrium, and zirconium) were excluded from further evaluation. Regulatory agencies typically do not provide quantitative toxicity estimates for essential nutrients and trace elements; they are not frequently assessed and animal and human toxicity data are not available to develop quantitative estimates of toxicity. Lithium and fluoride were included due to potential influence from mining activities. In groundwater and surface water, innocuous water quality parameters (bromide, chloride, sulphate, sulfide, sulfur) were also excluded. Sulphate is an Order constituent, but generally poses low risk to human health and there is no applicable Canadian health-based water quality guideline or criterion. However, sulphate concentrations in groundwater and surface water are compared to Health Canada's aesthetic objective of less than or equal to 500 milligrams per litre (mg/L) sulphate in the Uncertainty Assessment, Section 6.11.2.5.

3.3 Hazard Identification

As briefly described in the introduction to Section 3, constituents measured in environmental media are compared to RBSLs representing a tolerable concentration for exposure. This preliminary screening level risk assessment identifies constituents that are present at concentrations below their respective RBSLs and need not be considered further in the HHRA, while those constituents with concentrations greater than the RBSLs are retained for further evaluation. In this HHRA, constituents in surface water and sediment with concentrations greater than RBSLs are also compared to reference area concentrations. Chemical concentrations greater than both RBSLs and reference levels are retained for additional analysis in the HHRA. This process is referred to as the Hazard Identification step in detailed, quantitative risk assessment.

For the preliminary screening level risk assessment, health protective RBSLs based on the most intensive possible contact or exposure pathway are used. For example, RBSLs for direct consumption of surface water as drinking water are lower and more health protective than guidelines based on recreational use of surface water. Thus, surface water and groundwater data are compared with RBSLs for drinking water and fish tissue data are compared with RBSLs for fish consumption. As described below, these RBSLs have been selected to be consistent with ENV risk management levels when screening one exposure pathway at a time (i.e., hazard quotient (HQ)=0.2 and cancer risk=1E-05). According to ENV and Health Canada guidance, these risk management levels are protective of human health, and risks below these levels are considered "essentially negligible." RBSLs have been compiled from various provincial and national regulatory agencies, including ENV, Health Canada, and USEPA and were considered acceptable for use by the HHRA Workgroup. Canadian guidelines are utilized preferentially. Constituents without RBSLs are screened using reference area concentrations only, when available.

For the preliminary screening level risk assessment process, the data representing mine-influenced areas within the DA were evaluated in whole. The maximum detected concentration of each analyte was compared to the appropriate constituent- and medium-specific RBSL. For surface water and sediment, if an analyte concentration exceeded the RBSL, that analyte was screened further using reference area concentrations. If the maximum chemical concentration was lower than the reference concentration, it was not evaluated further. If the maximum concentration was greater than the reference concentration, then the constituent was considered a COPC and was retained for further evaluation. This preliminary screening approach provides a health protective means to focus further risk assessment analyses, but the results are not used in risk management decision making. For example, all constituent concentrations measured over the previous five years are included in the screening, and use of the maximum concentration measured over the previous 5 years ensures that any constituent that may present a potential risk are evaluated in the detailed HHRA. This process was agreed-upon by the HHRA Workgroup during development of the HHRA methodology, as it was considered sufficiently protective.

3.3.1 Reference Concentrations

Reference areas are defined as locations that are up-gradient or otherwise not influenced by mining activities within Elk Valley or are above the confluence of the Elk River with Koocanusa Reservoir. For surface water, data for Elk River watershed reference areas were used to derive reference concentrations for MUs 1 through 5, while data from the Kootenay River and Koocanusa Reservoir reference areas were used to derive reference concentrations for MU 6. For sediment, all reference data were combined and used to derive reference concentrations for all MUs. Reference data are not yet available for groundwater.

Ninety-fifth percentiles were calculated for sediment and surface water data in reference areas as summarized in the Section 3.2.5 of the 2016 HHRA (Ramboll Environ 2016) and described in the Aquatic Environmental Synthesis Report (Windward et al. 2014) using data collected from 2015-2020. The 95th percentiles were compared to the maximum detected chemical concentrations representing mine-influenced locations. For surface water, the 95th percentile for the total and dissolved fractions were calculated and compared separately.

Fish, game, berry, and rose hip data representing non-mine-influenced areas are not used in the hazard identification process. Instead, these data are used to generate risk estimates for comparison with mine-influenced risks for the reasons discussed in Section 3.1.3, and the results of this comparison are discussed in the risk characterization (see Section 6).

3.3.2 Preliminary Risk-Based Screening for Surface Water and Groundwater

3.3.2.1 Drinking Water Guidelines

The RBSLs for surface water and groundwater are based on WQGs for residential drinking water. The ENV (2020) WQGs are generally consistent with those developed by Health Canada (Health Canada 2020) for drinking water. Health Canada works in partnership with the provinces and territories to develop the Guidelines for Canadian Drinking Water Quality (updated September 2020), which include guidelines for microbiological, chemical, nitrate, and radiological elements for which exposure could lead to adverse health effects in people (Health Canada 2020). The Guidelines for Canadian Drinking Water Quality typically provide maximum acceptable concentrations (MAC) for protection of human health for most contaminants, although the guidelines may also be based on aesthetic and operational considerations (Health Canada 2020). The approach for deriving MACs typically reduces the allowable concentration by a safety factor, accounting for the proportion of the daily intake allocated to drinking water in cases where more detailed data on relative contribution from other exposure pathways is absent.

ENV sets drinking water standards either by adopting a standard from another jurisdiction (e.g., most often Health Canada), or by conducting their own review of the available toxicological data and deriving their own standard (ENV 2021a). The ENV provides approved, working, or draft guidelines that can be used to evaluate safe levels of substances for the protection of a given water use. Health Canada drinking water guidelines were utilized for constituents when ENV guidelines have not yet been proposed or developed. BC Consolidated Regulation (Reg) 375/96 for the EMA CSR and USEPA guidelines were considered in cases where Canadian guidelines are unavailable. Although not used in this HHRA, the multiple barrier approach has proven to be an effective method in preventing or reducing contamination of drinking water sources. The results obtained in this HHRA may be used to further assess water quality using methods such as the multiple barrier approach (Health Canada 2002).

Additional numerical guidelines provided by ENV and Health Canada consider specific water and/or land uses, including recreation on surface water. Health Canada has developed guidelines for recreational uses of surface water, but they are principally based on the risk of infection from contact with pathogenic microorganisms, and not for chemical contaminants. Guidelines used to identify COPCs in groundwater and surface water are listed in Appendix B.

3.3.2.2 Surface Water Screening Results

Table 3-5 summarizes the inorganic constituents in surface water with maximum detected concentrations that are greater than drinking water RBSLs and reference concentrations. Analytical data for the dissolved and total fractions are presented separately. Monitored inorganic constituents present at concentrations below RBSLs and organic constituents are not shown in Table 3-5. An overview of the screening results for organic constituents in surface water is provided following the surface water COPC list. Detailed results listing sample count, percent of detected samples, maximum detected concentrations, maximum DLs for non-detect constituents, RBSLs used to identify COPCs, ratios of max detects to RBSLs, and the sample count exceeding RBSLs for all constituents are provided in Appendix C.

The constituents with maximum detected concentrations greater than RBSLs were retained as COPCs for surface water. The COPCs were identified using all mine-influenced data combined and will be evaluated in the detailed risk assessment within each MU. In addition to this area wide basis for identifying COPCs, Table 3-5 provides detailed results by MU for descriptive purposes that may later inform the risk characterization results.

Surface water COPCs are:

- Aluminum
- Antimony
- Arsenic
- Barium
- Cadmium
- Cobalt

- Iron
- Lead
- Lithium
- Manganese
- Nickel
- Nitrate Nitrogen (NO_3), as N
- Selenium
- Uranium
- Vanadium

As discussed in Section 3.2.4, sulphate was not retained as a surface water COPC due to the lack of an RBSL and because sulphate is an innocuous water quality parameter. Section 6.11.2.5 provides detail regarding the sulphate concentrations compared to Health Canada's aesthetic objective.

All PAH compounds in surface water were detected in less than 20 percent of sample results, with most PAH compounds never being detected. Several PAHs had DLs that consistently exceeded RBSLs; however, these compounds were never detected and were not retained as COPCs in surface water. Uncertainty regarding the exclusion of these PAHs is discussed in Section 6.11.2.3.

Concentrations of benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, chrysene, and indeno(1,2,3-c,d)pyrene exceeded the RBSLs in four surface water samples, but these constituents were not retained as COPCs. As noted in Appendix B, Table B-1, PAHs were screened individually, and the RBSLs for certain carcinogenic PAHs (cPAHs) were based on adjusting by benzo(a)pyrene potency equivalence factors. Per the ENV WQG guidance, individual cPAH concentrations can be adjusted and summed to represent total cPAHs as benzo(a)pyrene equivalent concentrations, and total cPAH concentrations are compared to the screening level of 0.00004 mg/L. For the four surface water samples where individual cPAH concentrations exceeded the respective screening levels, the cPAH concentrations were accordingly summed, and only one total cPAH concentration marginally exceeded the screening level (concentration of 0.000043 mg/L compared to 0.00004 mg/L), which is equivalent from a significant figure perspective. This result was inconsistent with the remaining cPAH surface water data as the concentrations were largely (97 to 100 percent) non-detect in surface water, and the few samples with detected concentrations had some elevated DLs, indicating the results may be unreliable. Therefore, further evaluation of cPAHs in surface water is not warranted.

Table 3-5. Constituents Identified as COPCs in Surface Water[19]

MUs with Results above RBSLs [a]	Constituents	Maximum Detected Concentration (µg/L)	Screening Guideline (µg/L)[b]	Reference Concentration (µg/L)[c]
Dissolved Fraction				
MU-3	Antimony	7.36	6	0.1
MU-1, 3, 4	Cobalt	25.5	1	1
MU-1, 2, 3, 4, 6	Iron	833	300	28.6
MU-1, 2, 3, 4, 5, 6	Lithium	290	8	5
MU-3, 4	Manganese	463	120	1.91
MU-3, 4	Nickel	190	80	0.62
MU-1, 2, 3, 4, 5	Selenium	798	10	2
MU-1,3	Uranium	23.1	20	1.7
Total Fraction				
MU-3, 6	Aluminum	26,500	9,500	309
MU-3	Antimony	7.03	6	0.11
MU-3	Arsenic	21.4	10	0.5
MU-3	Barium	1,620	1,000	68.5
MU-3	Cadmium	9.31	5	0.0433
MU-1, 2, 3, 4, 5, 6	Cobalt	61.5	1	0.332
MU-1, 2, 3, 4, 5, 6	Iron	54,800	300	282
MU-3, 4, 5, 6	Lead	33.9	5	0.267
MU-1, 2, 3, 4, 5, 6	Lithium	285	8	5.1
MU-1, 2, 3, 4, 5, 6	Manganese	1,670	120	13.4

[19] Based on comments in the July 2022 HHRA. surface water sampling location RG_KERRRD moved from reference to MU-6.

MUs with Results above RBSLs [a]	Constituents	Maximum Detected Concentration (µg/L)	Screening Guideline (µg/L)[b]	Reference Concentration (µg/L)[c]
MU-3, 4	Nickel	283	80	1.68
MU-1, 2, 3, 4, 5	Selenium	689	10	1.98
MU-1, 3	Uranium	24.5	20	1.71
MU-3, 4, 5, 6	Vanadium	72.7	20	2.42
MU-1, 2, 3 ,4	Nitrate Nitrogen (NO3), as N	112,000	10,000	278

Notes:

[a] Constituents were screened by MU (including MUs 1 – 6)

[b] Drinking water guidelines were used for screening of surface water data.

[c] Reference concentration data includes 95th percentile of samples collected between 2010 and 2015, from Elk River watershed, Kootenay River, and Koocanusa Reservoir. Separate reference concentrations were calculated for the Elk River watershed (MUs 1-5) and Koocanusa Reservoir (MU-6). Data from the Elk River watershed up-gradient of mining influence were used for MUs 1-5, and data from the Kootenay River and Koocanusa Reservoir upstream of the confluence with the Elk River were used for MU-6. Reference concentrations are the 95th percentile of samples collected in these locations from 2010-2015, as reported in the Aquatic Environmental Synthesis Report (Windward et al. 2014).

MU = management unit; RBSL = risk-based screening level; µg/L = microgram(s) per litre

3.3.2.3 Groundwater Screening Results

Groundwater screening results are summarized in Table 3-6. Monitored constituents present at concentrations below RBSLs are not shown (see Appendix C for complete screening results). The constituents in groundwater that are above drinking water RBSLs and identified as COPCs for groundwater are:

- Iron
- Lithium
- Manganese
- Selenium

Similar to surface water, sulphate was not retained as a COPC for groundwater. As previously noted, a comparison of the sulphate concentrations to an aesthetic objective (<500 mg/L) is provided in Section 6.11.2.5.

Analytical data for the Fernie municipal James White Park wells were screened separately from the other groundwater data as discussed in Section 3.1.1. All constituents were below drinking water RBSLs. Complete screening results for the Fernie municipal wells are presented in Appendix C-2b. Selenium data were obtained for Sparwood Wells 1 & 2 at a later date. Results for these wells are provided in Appendix C-2c. Because all constituents were below RBSLs and the sample collection dates do not align with sample collection dates for the rest of the groundwater dataset, the Fernie municipal wells are not evaluated further in the HHRA.

Table 3-6. Constituents Identified as COPCs in Groundwater

MUs with Results Above RBSLs a	Constituents	Maximum Detected Concentration (µg/L)	Screening Guideline (µg/L)
MU-4, 5	Iron	7,580	300
MU-4, 5	Lithium	115	8
MU-4, 5	Manganese	1,150	120
MU-4, 5	Selenium	15.8	10

Notes:

a Constituents were screened by MU (including MUs 1 – 6)

b All constituents listed in the table are Dissolved Fraction analytes.

c Drinking water guidelines were used for screening of surface water data.

COPC = constituent(s) of potential concern; MU = management unit; RBSL = risk-based screening level; µg/L=microgram(s) per litre; MU = management unit

3.3.3 Preliminary Risk-based Screening for Sediment

3.3.3.1 Sediment Guidelines

BC Reg 375/96 provides guidelines for acceptable concentrations of environmental substances (e.g. soil, surface water, groundwater, vapor, and sediment). These guidelines are intended to protect human health and the environment for specific types of land uses (e.g., agriculture, urban park, residential, commercial, or industrial). For this HHRA, residential numerical soil guidelines, protective of daily intake of contaminated yard soil have been selected to screen sediment data. BC Reg 375/96 Schedule 3.1 guidelines were utilized for all analytes, excluding thallium. [20] Guidelines reported as residential low-density were used. Where CSR Schedule 3.1 numerical soil guidelines were unavailable, a surrogate standard for a similar analyte was applied. Use of RBSLs for residential yard soil provides a highly conservative basis for identification of COPCs for sediment, which is contacted only during recreational or cultural activities as opposed to during daily activities in a residence.

3.3.3.2 Sediment Screening Results

A summary table of constituents which exceeded RBSLs for sediment screening and reference concentrations are provided in Table 3-7. Detailed screening results for all constituents monitored in sediment are listed in Appendix C. [21]

The COPCs retained for sediment include:

- Cobalt
- Lithium
- Iron
- Benzo(a)pyrene

Although selenium concentrations in sediment were below screening guidelines at all sampled locations, selenium was also evaluated in the risk assessment for sediment.

[20] The Thallium guideline is sourced from the Canadian Council of Ministers of the Environment (CCME 1999).

[21] Guidelines were not available for perylene and benzo(e)pyrene and are excluded from the screening. See Section 6.11.2.1 in Uncertainty Assessment for a discussion of potential risk.

Table 3-7. Constituents Identified as COPCs in Sediments

Chemical Group	MUs with Results above RBSLs [a]	Constituents	Maximum Detected Concentration (mg/kg)	Screening Guideline (mg/kg)
INORG	MU 4	Cobalt	434	25
	MU 4, 5	Lithium	32.6	30
	MU 5	Iron	36,700	35,000
	None	Selenium	85.5	200
SVOC	MU 5	Benzo(a)pyrene	8.43	5

Notes:

[a] Constituents were screened by MU (including MUs 1 – 6)

COPC = constituent(s) of potential concern; INORG = inorganic; mg/kg = milligram(s) per kilogram; MU = management unit; RBSL = risk-based screening level; SVOC = semi-volatile organic compound

3.3.4 Preliminary Risk-based Screening for Fish Tissue

3.3.4.1 Fish Tissue Guidelines

Fish consumption guidelines have been developed from Canadian and U.S. sources, with a preference given to Canadian sources. Health Canada provides a maximum standard value of 0.2 milligrams per kilogram wet weight (mg/kg ww) for total mercury in fish consumed by subsistence populations, assumed to be based on a fish consumption rate of 40 grams (g) per day (Health Canada 2007). The derivation of this standard accounts for intake via multiple media (i.e., air, drinking water, diet) such that total mercury intake is not expected to exceed the provisional tolerable daily intake level of 0.23 micrograms per kg per day (µg/kg-day) (Health Canada 2007). Generally, mercury in air and water are not significant sources of human exposure; the diet, particularly fish, is the primary route of mercury intake and is the focus of managing mercury exposures in the general population (Health Canada 2007).

ENV provides fish tissue guideline values only for selenium (ENV 2014) and uses a matrix of values based on three levels of fish consumption, i.e., "high" (220 grams per day [g/day]), "moderate" (110 g/day), and "average" (30 g/day) fish consumers. Guideline values are based on edible tissue and provided both in terms of ww and dry weight (with the conversion based on an assumed 75 percent moisture content). These values have been derived by using Health Canada's intake algorithm for fish ingestion and the dietary tolerable upper intake for selenium. Due to HHRA Workgroup member concerns about selenium exposures, selenium will not be screened to determine if it will be retained for further evaluation in the HHRA; selenium will be automatically retained regardless of concentrations reported in fish tissues.

Because ENV has not developed fish tissue guidelines for other constituents, a RBSL-computing tool was used to generate tissue RBSLs for all constituents. The tool enables risk assessors to calculate chemical RBSLs for edible fish tissue, with a user-defined fish consumption rate and target risk levels. The RBSL-calculating tool has been configured to be consistent with ENV and Health Canada risk management levels (i.e., HQ=0.2 and cancer risk=1E-05). For this screening, a consumption rate of 245 g/day is used, according to a memo from KNC on August 11, 2020 citing preferred intake rates for fish (KNC 2020). All RBSLs used to identify COPCs in fish tissue are provided in Appendix B.

Maximum constituent concentrations in fish fillet data were used to compare to fish tissue RBSLs and identify COPCs. Fish fillet is relied upon instead of whole-body fish sample data because fillet is typically assumed to represent the primary tissue consumed in HHRA; however, some populations may preferentially consume additional tissues such as the skin, head, and organs. At the request of the HHRA Workgroup, uncertainties associated with excluding whole body tissue data are discussed in Section 6.11.3.1. A separate screening was not completed for fish ovary tissue. Thus, COPCs identified for fish fillet were also considered COPCs in the fish ovary (egg) evaluation.

3.3.4.2 Fish Tissue Screening Results

Constituent concentrations in fish tissues that were greater than RBSLs are listed in Table 3-8. Monitored constituents present at concentrations below RBSLs are not shown (see Appendix C for complete screening results).

The following constituents had maximum detected concentrations that exceeded RBSLs in fish tissue, and were retained as COPCs for fish tissue and fish eggs:

- Aluminum
- Antimony
- Chromium
- Cobalt
- Iron
- Lead
- Mercury
- Nickel
- Selenium
- Thallium
- Uranium
- Vanadium
- Zinc

Additionally, because many constituents had elevated DLs in the fish tissue samples, as discussed in Section 3.1.3, there were several instances where the DL exceeded the RBSL for a particular constituent, but no detected results exceeded the RBSL. Constituents with elevated DLs but no detected results exceeding the RBSL include arsenic, beryllium, boron, cadmium, and lithium. A conservative approach was taken to retain the constituents as COPCs in fish tissue if they were identified as COPCs in other media. This approach excludes beryllium and boron as COPCs but retains the other constituents as COPCs. Therefore, the following constituents with DLs, but no detected results, exceeding RBSLs in fish tissue were retained as COPCs in fish tissue and fish eggs:

- Arsenic
- Cadmium
- Lithium

Table 3-8. Constituents Above Fish Guidelines (detected results only)

MUs with Results above RBSLs [a]	Constituents	Maximum Detected Concentration (µg/kg ww)	RBSL (µg/kg ww)
MU-3, 4, 5, 6	Aluminum	155,000	57,714
MU-5	Antimony	82	23
MU-1, 2, 3, 4, 5, 6	Chromium	10,900	58
MU-1, 2, 3, 4, 5, 6	Cobalt	71	17
MU-1, 2, 4, 5, 6	Iron	271,560	40,400
MU-1, 2, 3, 4, 5, 6	Lead	775	75
MU-1, 2, 3, 4, 5, 6	Mercury	2,200	12
MU-2	Nickel	1,546	635
MU-1, 2, 3, 4, 5, 6	Selenium	30,000	329
MU-1, 2, 3, 4, 5, 6	Thallium	52	4
MU-6	Uranium	171	35
MU-4, 5	Vanadium	406	289
MU-5, 6	Zinc	44,506	32,897

Notes:

[a] Constituents were screened by MU (including MUs 1 – 6)

MU = management unit; RBSL = risk-based screening level; µg/kg = microgram(s) per kilogram; ww = wet weight

3.3.5 Game, Berries, and Rose Hips

Game, berries, and rose hips were not compared to RBSLs because guidelines for these media are not available. COPCs in berry, rose hips, and game tissue potentially related to water quality originate from contact with surface water and sediment in the DA (i.e., through plant uptake from sediment or surface water or ingestion by animals). Therefore, the COPCs identified in the screening for surface water and sediment were used as the COPCs for game, berries, and rose hips. This approach was discussed with and accepted by the HHRA Workgroup during development of the HHRA methodology. The game, berry, and rose hip COPCs are:

- Aluminum
- Antimony
- Arsenic
- Barium
- Cadmium
- Cobalt
- Iron
- Lead
- Lithium
- Manganese

- Nickel
- Selenium
- Uranium
- Vanadium

As discussed in Section 3.1.4, only metals are evaluated in wild foods in the HHRA, and so organic COPCs identified in sediment were not evaluated in wild foods.

4. EXPOSURE ASSESSMENT

The exposure assessment provides quantitative estimates of dose for people contacting COPCs in surface water-associated exposure media in Elk Valley, shown in the CSM. In addition, exposures associated with consumption of game, berries, and rose hips that may have contact with COPCs in water-associated exposure media also are evaluated. Exposures are estimated by combining information about how much of a COPC is present in an environmental medium, how often someone contacts the medium, and other factors related to duration of contact, body weight, and life stage of the population. The specific values used in estimating exposure for each population of interest are presented in this section.

4.1 Exposure Point Concentrations

An EPC is the measured chemical concentration in an environmental medium to which a population is exposed, or potentially exposed. The EPC is typically represented by the (95 UCLM). The USEPA's ProUCL software version 5.1.002 was used to calculate UCLMs (USEPA 2016a). In this final revised HHRA some UCLMs were recalculated because several stations were reassigned as either "exposed" or "non-exposed" to mine influences. The updated UCLMs were calculated using ProUCL version 5.2 (USEPA 2022).[22] ProUCL provides parametric and nonparametric methods of calculation and accounts for analytical results below the sample DL. The ProUCL-recommended method for calculation of the UCLM was used as the basis of the EPC, unless this value exceeded the maximum detected concentration. If the recommended UCLM exceeded the maximum concentration, the maximum was selected to represent the EPC.

All relevant environmental data collected since the previous HHRA (see Section 3.1) were used to calculate the EPCs. Thus, the EPCs are based on data collected across multiple years (generally late 2015 through early 2020). Analyte- and medium- specific EPCs were calculated for each MU (MUs 1 through 6, mine-exposed locations only) and for reference data for fish fillet, game, berries, and rose hips. EPCs representing valley-wide exposure (generally MUs 1 through 5 unless otherwise specified) were also calculated. Sample sizes for some media (game, berries, and rose hips) in some MUs were small and thus may not represent long-term exposures. Consequently, estimates based on valley-wide EPCs may be more representative of site risks.

As described in Sections 3.1.3 and 3.1.4, analytical concentration data for fish, game, berry, and rose hip tissues provided in dry weight by the laboratory were converted to ww prior to calculating EPCs. Percent moisture data for fish fillet tissue were adjusted as needed to be consistent with ENV assumptions (ENV 2014). Game, berry, and rose hip data were converted to ww using the percent moisture values reported by the laboratory. As discussed further in the Uncertainty Assessment, fish were collected as part of an assessment of mine-related EA. Thus, the species collected within each MU do not necessarily represent species people prefer to eat or species that are abundant at that location.

Food concentrations and food consumption rates are both based on wet weights. However, changes in metal concentrations in foods related to food preparation methods, including drying or smoking foods, were considered in the Uncertainty Assessment (Section 6.11.3.2) at the request of the HHRA Workgroup.

Additional EPC considerations are presented in the remainder of this section.

4.1.1 Nitrate

One exception to calculation of a longer-term average concentration based on multiple years of data is for nitrate in surface water. In the previous HHRA, it was found that nitrate concentrations

[22] Fish sampling stations RG_CBN and RG_MC moved from reference to MU-4 and station RG_FODCH moved from reference to MU-1. EPCs were recalculated using the updated ProUCL version 5.2 for MU-1, MU-4, Valley wide, and reference areas. Surface water sampling location RG_KERRRD moved from reference to MU-6 and surface water UCLs were recalculated for MU-6 using updated ProUCL version 5.2.

trended upward and it was necessary to calculate mean concentrations on an annual basis. It was also determined that nitrate EPCs should be calculated on a quarterly basis: January through March, April through June, July through September, and October through December to account for shorter-term exposures, and potential seasonal peaks in concentration. This is discussed further in Section 6.5.1.

4.1.2 Inorganic Arsenic Fraction

The EPC for arsenic in fish tissue includes an adjustment for the assumption that on average less than 10 percent of the total arsenic measured in freshwater fish filets is inorganic arsenic. This adjustment, along with the adjustment applied to game, berries, and rose hips was determined to be acceptable to the HHRA Workgroup during development of the HHRA methodology, based on the rationale provided here.

Historically, total arsenic concentrations have been used to estimate arsenic intake from fish and seafood; however, it has long been known that the majority of arsenic in fish is relatively nontoxic organic arsenic (Schoof and Yager 2007). Organic arsenic is substantially less toxic than the inorganic form and is generally not considered a risk to human health (Schoof and Yager 2007). In deriving an estimate of inorganic arsenic in fish, Schoof and Yager (2007) compiled data from six studies which had a total of 42 samples from eight species of fish. The percent inorganic arsenic in fish tissue from these studies ranged from 0.18 to 26 percent with a mean of 6.8 percent and a 75th percentile of 10 percent. More recent studies beyond those summarized in Schoof and Yager (2007) support the finding that total inorganic arsenic in freshwater fish tissue comprises less than 10 percent of total arsenic (de Rosemond et al. 2008; Exponent and Parametrix 2013; Idaho Department of Environmental Quality 2008; Oregon Department of Environmental Quality 2011). Because the inorganic arsenic correction factor of 10 percent was the 75th percentile of the freshwater fish data compiled from eight studies by Schoof and Yager (2007), it is considered a conservative estimate of inorganic arsenic intake from fish. Another recent study by Tanamal et al. (2021) reported data on 180 samples of fish from nine lakes that were analyzed for total and inorganic arsenic in Yellowknife, Northwest Territories, Canada. The percent inorganic arsenic fraction ranged from 0.9 to 19.6 percent in these samples. These data show a similar range in inorganic arsenic percentages as those summarized by Schoof and Yager (2007).

Although inorganic arsenic is not specifically analyzed in Elk Valley fish tissue, there is sufficient evidence that an assumption of 10 percent of total arsenic is a conservative estimate for inorganic arsenic in fish tissue. In addition to published studies of arsenic speciation in fish, arsenic speciation data for fish collected from the Upper Columbia River provide regional support for this adjustment fraction (Exponent and Parametrix 2013). For Upper Columbia River fish, total and inorganic arsenic were analyzed separately in fish fillets. Inorganic arsenic was not detected in any of the 98 samples above the laboratory's limit of detection (0.004-0.005 mg/kg). Many of the fish species found in the Upper Columbia River also are found and consumed in the Elk Valley, including burbot, kokanee, rainbow trout, and mountain whitefish. To better understand uncertainties related to inorganic arsenic in fish, an analysis is included in the Uncertainty Assessment (Section 6.11.3.7) that assumes inorganic arsenic is present at 20 percent of total arsenic concentrations.

Arsenic concentrations in game, berries, and rose hips also are adjusted using media-specific inorganic arsenic fractions. Food-specific inorganic arsenic fractions were obtained from a market basket study by Schoof et al. (1999). In the study, total and inorganic forms of arsenic were measured in food items common to the North American diet including fruit, meat, vegetables, bread, and rice. Inorganic arsenic was found to comprise 46 percent of the total arsenic in fruit (e.g., apples, bananas, grapes, oranges, peaches, and watermelon) and 0.78 percent of the total arsenic in beef. The 46 percent adjustment fraction was applied to berries and rose hips, and the 0.78 adjustment was applied to wild game tissue. This approach has been adopted in other Elk Valley HHRAs, including the Baldy Ridge risk assessment which also assessed berry and game ingestion in Elk Valley (Golder 2015). USEPA has also documented a low fraction of inorganic arsenic in fruits and meats, suggesting fruits contribute 18 percent of the inorganic arsenic content in the average North American diet, and meats contribute 5 percent (Xue et al. 2010). Uncertainties regarding the assumed inorganic arsenic fractions are discussed in Section 6.11.3.7.

4.1.3 Total Mercury and Methylmercury

Total mercury analyzed in surface water and sediment is evaluated as total mercury in the COPC screening and exposure assessment processes. Total mercury analyzed in fish tissue is compared to a RBSL based on health effects of methylmercury and the exposure assessment assumes that 100 percent of total mercury analyzed in fish tissue is in the form of methylmercury. While some studies find that 90 to 100 percent of mercury in fish is methylmercury (Cabañero et al. 2004; Jewett et al. 2003; Shao et al. 2016; Wagemann et al. 1997), other studies report a lower percent of methylmercury.

4.2 Exposure Quantification

Evaluation of COPCs identified in the constituent screening process involves the calculation of pathway-specific exposure estimates that consider the characteristics of human activities. The exposure estimates were based on Health Canada (2010a, 2019, 2021a) and USEPA Risk Assessment Guidance for Superfund algorithms as recommended by ENV (2017a), exposure assumptions for the exposure pathways identified as complete in the CSM, and population- and MU-specific information. Exposure rates vary over a lifetime as body weight and behaviors change, so doses are calculated for each life stage relevant to the exposure pathway (i.e., toddler, child, adolescent, and adult).

Exposure assumptions presented in the following sections were discussed and agreed-upon during a series of HHRA Workgroup teleconference meetings held throughout 2019 and early 2020. While the final, selected exposure parameters are presented in the main body of this HHRA, a summary of the discussions leading to the selection of berry consumption rates and data for use in evaluating market basket consumption of selenium is presented in Appendix D. Quantification of Ktunaxa preferred consumption rates were developed by Firelight and the KNC and are presented in the August 11, 2020 memorandum from the KNC to Teck (KNC 2020).

4.2.1 Receptor Age Groups, Body Weights, Exposure Duration and Averaging Time

Certain exposure terms are common to all receptor populations, such as body weights, assumed duration of exposure, and the means to estimate averaging time for cancer and noncancer endpoints. These terms applied across all populations are described here and summarized in Table 4-.

Age Groups

Health Canada (2019) prescribes specific age groups for evaluation in HHRA. These groups include infants 0 to 6 months; toddlers aged 6 months to 4 years; children aged 5 to 11 years, adolescents ages 12 to 19 years, and adults (≥ 20 years). The age groups are defined in this way to characterize exposure and risk by age group to better reflect differing activity levels, consumption rates, and body weights so that risks are not under- or overestimated. An infant from 0-3 months old is not a standard life stage recommended by Health Canada but is included here to ensure that the risk to nitrate is adequately conservative for the life stage most sensitive to methemoglobinemia.

Body Weight

Body weights selected for this HHRA are consistent with those recommended by Health Canada (2019, 2021a), which are taken from Richardson (1997, Table 2.2). These values represent the arithmetic mean of body weights for males and females, as presented in the Health Canada reference documents. A more recent reference by Richardson and Stantec (Stantec Consulting Ltd.) (2013) provides higher body weights for all ages except toddlers; however, these estimates have not yet been adopted by Health Canada. Use of the lower body weights adopted by Health

Canada and presented in Table 4- will result in slightly more health protective exposure estimates because exposures are calculated on a body weight basis, i.e., a COPC concentration per kg body weight basis. Body weight for infants ages 0-3 months is not a standard age group addressed in Health Canada risk assessment guidance (2019) but is added here from data presented by USEPA (2008a). The Child-specific Exposure Factors Handbook lists mean body weights of 4.8 kg and 5.6 kg for age groups 0 to < 1 month and 1 to <3 months, respectively (USEPA 2008a). The weighted average of these two age ranges is representative of the infant (0-3) months age group, as shown in Table 4-.

It is noted that body weight data for Ktunaxa are also available in the Ktunaxa Nation Diet Study (Fediuk and Firelight 2015) which reports weights for 83 adults including an average weight of 73.6 kg for the 48 women and an average weight of 84.1 kg for the 35 men for whom data were reported. These body weights were higher than the body weights for adults of 70.7 kg used in the HHRA (Table 4-1) as identified in Health Canada (2019). The lower body weight for adults was applied because it is based on a larger more robust dataset and because use of a lower body weight is a health protective assumption as noted above.

Exposure Duration and Averaging Time

Exposure duration (ED) is the number of years an individual is assumed to be exposed to COPCs within the study area. In this assessment, each of the receptor groups are assumed to be exposed to COPCs in the DA for their full lifetimes. Cancer risks are considered over a lifetime, i.e., have an averaging time of 365 days for 80 years and noncancer effects have an averaging time of 365 days over the duration of years of exposure (Health Canada 2010a; 2010b; 2019; 2021a).

Table 4-1. Proposed General Exposure Terms: Body Weights, Exposure Duration and Averaging Times

Exposure Factors	Units	Receptors and Age Groups						Source
		Infant (0-3 months)[a]	Infant (0-6 months)[b]	Toddler 0.5-4 years	Child 5-11 years	Adolescent 12-19 years	Adult ≥ 20 years[c]	
Body Weight (BW)	kg	5.3	8.2	16.5	32.9	59.7	70.7	Health Canada (2019) (Based on Richardson 1997)
Exposure Duration (ED)	years	0.25	0.5	3.5	6	7	60	Health Canada (2019)
Averaging Period for Cancer	years	80	80	80	80	80	80	Health Canada (2019)
Averaging Period for Noncancer	years	0.25	0.5	3.5	6	7	60	Same as ED

Notes:
[a] BW for infant 0-3 months based on USEPA 2008a
[b] BW for infant 0-6 months based on Health Canada 2019.
[c] EDbased on an 80-year lifespan.
BW = body weight; ED = exposure duration; kg = kilogram(s); yr = year

4.2.2 Consumption of Drinking Water

Drinking water is included as a groundwater exposure pathway and is only evaluated in locations monitored under the RDWMP that are active, either currently or at some point over the 2015-2020 time period (see Section 3.1.1). The evaluation of groundwater as drinking water represents current exposures for many residents in the DA, where groundwater is the primary source of drinking water distributed by either municipal or private/community well.

Drinking water is also included as a primary exposure pathway for surface water; although, it is not a current complete pathway for most residents. In reality, residents within the DA rely almost exclusively on groundwater for drinking water. Consideration of exposures via ingestion of surface water is evaluated here in the event some populations, such as Ktunaxa or residents living outside the municipal water distribution system, are interested in understanding lifetime exposures should surface water be relied on exclusively as a drinking water source.

Ingestion rates (IR) for drinking water were calculated using the following Equation 2:

Equation 2:

$$Dose = \frac{EPC_{DW} \times IR_{DW} \times EF \quad \times ED}{BW \times AP \times CF_a}$$

Where:

Dose	average daily dose (lifetime for carcinogens only) (L/kg-day)
EPC_{DW}	drinking water exposure point concentration (mg/L)
IR_{DW}	drinking water ingestion rate (L/day)
EF	exposure frequency b (days/year)
ED	exposure duration (years)
BW	body weight (kg)
AP	averaging period for noncarcinogens or carcinogens (years)
CF_a	unit conversion factor (365 days/year)

Drinking water exposure parameter values for Equation 2 are provided in Table 4-2. Dissolved COPC concentrations are used to estimate intake for groundwater as drinking water, and total COPC concentrations are used to estimate intake for surface water ingestion as drinking water.

A typical resident is assumed to rely exclusively on water (surface or groundwater) from the DA, drinking between 0.3 to 1.5 litres (L) of water per day (IR_{DW}), for 7 days per week (EF_b), for 52 weeks per year (EF_c), for the duration of each life stage (ED) (Health Canada 2019; 2021a). Body weight values from Health Canada (2019, 2021a) are also incorporated, along with standard averaging periods (APs) for threshold constituents (i.e., noncarcinogens) and carcinogens.

An infant age 0 to 3 months old is not a standard life stage recommended by Health Canada but is included here solely for the evaluation of nitrate in surface water, should surface water be used to reconstitute dehydrated infant formula. This exposure scenario is included to ensure that the risk to nitrate is adequately characterized for the most sensitive life stage, i.e., a newborn infant, to nitrate-induced methemoglobinemia.

Table 4-2. Exposure Factors for Ingestion of Surface Water and Groundwater as Drinking Water

Exposure Factors	Units	Infant (0-3 months)[a]	Infant (0-6 months)	Toddler	Child	Adolescent	Adult	Source
Drinking Rate	L_{SW}/day	0.88	0.3	0.6	0.8	1	1.5	Infant 0-3 months: USEPA 2008a All other life stages: Health Canada 2019, 2021a
Drinking EF	days/yr	365	365	365	365	365	365	

Notes:

[a] Infant 0-3-month life stage is analyzed for nitrate exposure only. This life stage is the most sensitive to nitrate exposure.

EF = exposure frequency; L = litres; SW = surface water; yr = year

4.2.3 Surface Water and Sediment Direct Contact

Residents, Ktunaxa residents and visitors, and tourists to the Elk Valley may use surface waters within the DA for a variety of activities, such as swimming, tubing, wading, foraging, and harvesting aquatic biota. During such activities, dermal contact with and incidental ingestion of surface water and sediment may occur. Through conversations with the HHRA Workgroup, two main exposure scenarios were identified: swimming or tubing on the Elk River or Koocanusa Reservoir, and wading or foraging along the Elk River. Of the various aquatic activities reported for the Elk Valley, swimming was selected for exposure estimation as it represents the greatest potential contact with surface water and sediment, and the exposure estimates are expected to be protective for other activities. The tubing and swimming scenario is evaluated for both recreational residents and Ktunaxa. The wading and foraging scenario was also identified by the HHRA Workgroup as a protective means to evaluate Ktunaxa exposures during visits to the Elk River, its tributaries, and Koocanusa Reservoir.

The methods presented here for quantification of exposure via contact with sediment and surface water are based on Health Canada guidance (2017; 2019) available at the time the HHRA methodology was developed in consultation with the HHRA Workgroup. Subsequent to completing the risk assessment calculations, Health Canada (2021a) released an updated guidance document addressing subchronic exposures. We have updated citations to note where the methodology is consistent with the updated Health Canada guidance (2021a) and provide a discussion in Section 6.11.4.3 of where the current methodology differs from the recent guidance update.

To calculate exposure related to contact with surface water, separate doses are calculated for incidental ingestion and dermal contact with surface water. These doses are summed to create the scenario-specific exposure estimates for surface water. Equation 3 is used for the exposure dose calculation of incidental ingestion of surface water (either while tubing/swimming or during wading/foraging). Exposure parameters for incidental ingestion of surface water are provided in Table 4-3.

Equation 3:

$$Dose = \frac{EPC_{SW} \times IR_{SW} \times ET \times EF \times ED}{BW \times AP \times CF_a}$$

Where:

Dose	average daily dose (lifetime for carcinogens only) (mg/kg-day)
EPC_{sw}	surface water exposure point concentration (mg/L)
IR_{SW}	surface water incidental ingestion rate (L/hour)
ET	exposure time (hours/day)
EF	exposure frequency (days/year)
ED	exposure duration (years)
BW	body weight (kg)
AP	averaging period for noncarcinogens or carcinogens (years)
CF_a	unit conversion factor (365 days/year)

The dose for dermal contact with surface water is referred to as a "dermally absorbed dose" (DAD) and is calculated differently than the dose for the ingestion pathways. Exposure parameters for dermal contact with surface water are provided in Table 4-3. The dose for dermal contact with inorganic COPCs in surface water is calculated according to the following Equation 4:

Equation 4:

$$DAD = \frac{EPC_{SW} \times K_p \times t_{event} \times EV \times EF \times ED \times SSA_{SW} \times CF_b}{BW \times AP \times CF_a}$$

Where:

DAD	dermally absorbed dose for average daily (lifetime for carcinogens) exposures (mg/kg-day)
EPC_{SW}	surface water exposure point concentration (mg/L)
K_p	dermal permeability coefficient (cm/hr) [COPC-specific]
t_{event}	event time (hr/event)
EV	event frequency (events/day)
EF	exposure frequency (days/year)
ED	exposure duration (years)
SSA_{SW}	surface water skin surface area (cm^2)
CF_b	unit conversion factor (L/cm^3)
BW	body weight (kg)
AP	averaging period for noncarcinogens or carcinogens (years)
CF_a	unit conversion factor (365 days/year)

For sediment contact, the sediment samples used in this analysis are from depositional areas within waterways, which represent sediments that are transported downriver with the currents. These depositional areas may not be accessible and could have higher concentrations than more accessible bank but are considered to be a conservative approximation of sediments that would be contacted along the riverbanks.

EF assumptions for sediment contact are consistent with those applied in the surface water pathway-specific evaluation for tubing/swimming and wading/foraging activities. Equation 5 below is used for the exposure dose calculation of incidental ingestion of sediment:

Equation 5:

$$\text{Dose} = \frac{EPC_{sed} \times IR_{sed} \times EF \times ED \times CF_b}{BW \times AP \times CF_a}$$

Where:

Dose	average daily dose (lifetime for carcinogens only) (mg/kg-day)
EPC_{sed}	sediment exposure point concentration (mg/kg)
IR_{sed}	sediment incidental ingestion rate (mg/day)
EF	exposure frequency (days/year)
ED	exposure duration (years)
CF_b	unit conversion factor ($1E^{-06}$ kg/mg)
BW	body weight (kg)
AP	averaging period for noncarcinogens or carcinogens (years)
CF_a	unit conversion factor (365 days/year)

Exposure parameters for incidental ingestion of sediment are provided in Table 4-3. A DAD is calculated to evaluate dermal contact with COPCs in sediment. The DAD for contact with constituents in sediment is calculated using Equation 6:

Equation 6:

$$DAD = \frac{EPC_{sed} \times AF \times SSA_{sed} \times EF \times ED \times ABS_{derm}}{BW \times AP \times CF_a}$$

Where:

DAD	dermally absorbed dose for average daily (lifetime for carcinogens) exposures (mg/kg-day)
EPC_{sed}	sediment exposure point concentration (mg/kg)
AF	sediment-to-skin adherence factor (mg/cm^2-event)
SSA_{sed}	sediment skin surface area (cm^2)
EF	exposure frequency (days/year)
ED	exposure duration (years)
ABS_{derm}	dermal absorption fraction
BW	body weight (kg
AP	averaging period for noncarcinogens or carcinogens (years)
CF_a	unit conversion factor (365 days/year)

Exposure Parameters for Dermal Contact with Sediment are Provided in Table 4-3.

4.2.3.1 Exposure During Tubing or Swimming

Although the Elk River is quite cold and has hazards associated with quickly moving current and obstacles, it is a beautiful and popular destination for tubing when weather allows. Koocanusa Reservoir is warmer and is a popular swimming and boating destination. An EF for tubing and swimming of 52 visits per year was selected here by the HHRA Workgroup, which is approximately 4 times per week over a 3-month period. [23] This relatively high rate of swimming was purposely selected to provide a high-end estimate of exposure and risk and consequently, may be an overestimate for many people recreating in the Elk Valley and Koocanusa Reservoir.

For this assessment, it is also assumed that visitors might swim for up to an hour during each tubing outing on the Elk River and for up to four hours on each visit to Koocanusa Reservoir. Although it is recognized that some swim days may be longer or shorter, these exposure times (ETs) are based on long-term averages. In addition, it is recognized that some water is inadvertently ingested during swimming. IRs identified by USEPA (2011) for consideration of exposure during wading or swimming are 0.049 litres per hour (L/hr) for a toddler or child and 0.021 L/hr for adults.

The DAD for contact with water while swimming was derived using dermal permeability constants (Table 4-4) and methods from USEPA (2004), as recommended by ENV (2017a). The skin surface area (SSA) assumed for swimming contact is the whole body, with values provided by Health Canada (2019; 2021a). It is assumed that the event frequency (EV) is equal to one event per day. For dermal exposures in water, only the dissolved fraction of COPCs in the water column may be absorbed across the skin, however the total COPC concentrations in surface water are conservatively used to evaluate the dermal exposure pathway.

[23] It is noted that the 52 day exposure frequency (EF) is less than 90 days and can be considered subchronic (Health Canada 2021a). However, because there are no Health Canada, USEPA IRIS or WHO subchronic toxicity values available, risk estimates were calculated using the same methodology as applied to chronic exposure scenarios.

Table 4-3. Exposure Factors for Contact During Tubing or Swimming

Exposure Factors	Units	Toddler	Child	Adolescent	Adult	Source
Swimming/Tubing EF	days/yr	52	52	52	52	~Four times a week 3 months[a]
Swimming/Tubing ET	hours (or events)/day	4	4	4	4	Koocanusa Reservoir (MU-6)[a]
		1	1	1	1	Elk River (MUs 1-5)[a]
Skin Surface Area, Whole Body (SSA_{SW}) – surface water contact	cm^2	6,130	10,140	15,470	17,640	Health Canada (2019)
Skin Surface Area, Hands, Forearms, Feet, Lower Legs (SSA_{sed}) – sediment contact	cm^2	2,150	3,585	5,480	6,190	Health Canada (2019)
Incidental Ingestion of Surface Water (IRsw)	L_{SW}/hour	0.049	0.049	0.021	0.021	USEPA (2011) based on wading or swimming
Incidental Ingestion of Sediment (IRsed)	mg/visit	20	20	20	20	Health Canada (2019)
Sediment AF	mg_{sed}/cm^2-event	0.45	0.57	0.51	0.40	Weighted average sediment adherence factors derived using data from Health Canada (2017, 2019, 2021a)

Notes:

[a] Values shown for exposure frequency and exposure time were developed in consultation with the HHRA Workgroup and are based on local knowledge and informed by professional judgment.

cm^2 = square centimetres of skin; EF = exposure frequency; ET = exposure time; L_{SW}/hour = litres of water per hour; mg_{sed}/cm^2-event = milligrams soil per square centimetre skin per soil contact event; mg/visit = milligrams per visit; MU = management unit; SSA_{sed}=sediment skin surface area; SSA_{SW} = surface water skin surface area; yr = year

Table 4-4. Constituent-Specific Permeability Constants

Constituent	Kp (cm/hr)
Aluminum	0.001
Antimony	0.001
Arsenic	0.001
Barium	0.001
Cadmium	0.001
Cobalt	0.0004
Iron	0.001
Lead	0.0001
Lithium	0.001
Manganese	0.001
Nickel	0.0002
Selenium	0.001
Uranium	0.001
Vanadium	0.001
Notes: cm/hr = centimetres per hour; Kp = dermal permeability constant	

For sediment contact while tubing and swimming, no data are available on sediment IRs; therefore, for this assessment, soil IRs are assumed to represent sediment ingestion for recreational visitors. Specifically, a soil IR of 20 milligrams per day (mg/day) is assumed for adults and children per Health Canada guidance (2019, 2021a) but may represent an overestimate of exposure. The EF is assumed to be the same as those for surface water described above. The dermal exposure to sediment pathway incorporates a sediment-to-skin adherence factor (AF) for the hands, feet, forearms and lower legs that was derived based on SSAs and AF provided in Health Canada guidance (2017, 2019, 2021a). Specifically, the AFs for the hands were multiplied by the surface area of the hands and the AF for other skin areas was multiplied by the AF for other parts of the body (i.e., feet, forearms and lower legs), respectively. These two values are then summed and divided by the total surface area for these body parts to create a SSA-weighted AF for each life stage, as shown in Equation 7:

Equation 7:

$$\text{Weighted AF} = \frac{(SSA_{hands} \text{ x } AF_{hands}) + (SSA_{other} \text{ x } AF_{other})}{SSA_{hands} + SSA_{feet}}$$

Health Canada (2010b; 2010c; 2021a; 2021b) recommends using a relative absorption fraction (ABS) for the dermal pathway (RAF_{derm}) to account for the fraction of a substance that desorbs from the soil or sediment and is absorbed across the skin surface relative to the amount of the substance in soil or sediment. For inorganic substances in soil, very little absorption occurs via the dermal pathway. The only inorganic COPC with an assigned RAF_{derm} from Health Canada (2010c; 2021b) is selenium (0.01). Health Canada (2010c) recommends a default value of 0.01 be applied for inorganic constituents without an assigned RAF_{derm}, so a RAF_{derm} of 0.01 was also used to quantify dermal exposures to cobalt, iron, and lithium in sediment. Dermal absorption was quantified for the only organic COPC in sediment, benzo(a)pyrene, using the Health Canada (2010b; 2010c; 2021b) RAF_{derm} of 0.148.

4.2.3.2 Exposure During Wading and Foraging

Table 4-5 provides proposed exposure factors for ingestion or dermal contact with surface water and sediment during wading or foraging in the Elk River or Koocanusa Reservoir. An EF for wading and foraging for up to 138 visits per year is assumed. This EF is based on the assumption that visits might occur 46 weeks per year rather than 52 per year, because of the river banks being inaccessible due to water levels or ice. The EF assumes adults and older children might visit 3 times a week for 46 weeks (138 days) and toddlers would be brought along less frequently visiting up to 2 times a week (92 days). The proposed EF was purposely selected to provide a high-end estimate of exposure and risk and may be an overestimate for many individuals. The proposed ET for visits is half an hour.

SSAs proposed for this scenario are based on the assumption that people's hands, forearms, feet, and lower legs will contact water while wading. The estimated SSAs were derived using half the value for legs, half the value for arms, and values for hands and feet as listed in Richardson (1997), which was also used by Health Canada (2019; 2021a). In addition, incidental ingestion of water is proposed to occur at the same rate as described above for swimming and tubing and is based on USEPA (2011).

For sediment contact during Ktunaxa cultural activities, a higher sediment IR is assumed based on data from two studies evaluating soil ingestion in First Nations individuals living a cultural lifestyle. Doyle et al. (2012) reported on a mass balance tracer study in seven adults of First Nations decent in BC during 3 weeks of camping / fishing and identified a mean soil IR of 75 mg/day and a 90th percentile rate of 193 mg/day. A second mass balance study by Irvine et al. (2014) reported a mean soil IR of 32 mg/day and a 90th percentile rate of 153 mg/day in eight adult First Nations individuals during a 13-day camping trip. For this HHRA, a sediment IR of 200 mg/day was selected by the HHRA Workgroup to represent an upper-end IR for adults and children. The 200 mg/day is consistent with the standard default IR for young children applied by USEPA (2014) and is higher than that identified in updated soil analyses for children (von Lindern et al. 2016) and in studies evaluating First Nation's soil IRs. The SSA for sediment contact is assumed to be consistent with surface areas applied for wading and foraging, i.e., hands, feet, forearms and lower legs will be assumed to contact sediments. The sediment AFs are the same as described above for swimming and tubing.

Table 4-5. Exposure Factors for Contact During Wading and Foraging

Exposure Factors	Units	Toddler	Child	Adolescent	Adult	Source
Wading / Foraging EF	days/yr	92	138	138	138	Assumed 46 weeks
Wading / Foraging ET	Hours/visit	0.5	0.5	0.5	0.5	Average over time
Skin Surface Area, Hands, Forearms, Feet, Lower Legs	cm^2	2,150	3,585	5,480	6,190	Health Canada (2019)
Incidental Ingestion of Surface Water (IRsw)	L_{SW}/hour	0.049	0.049	0.021	0.021	USEPA (2011) based on wading or swimming
Incidental Ingestion of Sediments (IRsed)	mg/visit	200	200	200	200	Doyle et al. (2012); Irvine et al. (2014); USEPA (2014)
Sediment AF	mg_{sed}/cm^2-event	0.028	0.025	0.023	0.023	Weighted average sediment Afs derived using data from Health Canada (2017; 2019; 2021a)

Notes:

AF = exposure frequency; cm^2 = square centimetres of skin; EF = exposure factor; ET = exposure time; L_{SW}/hour = litres of surface water per hour; mg_{sed}/cm^2-event = milligrams soil per square centimetre skin per soil contact event; mg/visit = milligrams per visit; yr = year

4.2.4 ʔa·kpiǂis (Ktunaxa Food, Prepared by KNC)

4.2.4.1 Ktunaxa Consumption of ʔa·kpiǂis

While this study approached Ktunaxa food knowledge according to a normative methodology and ideology, certain Ktunaxa terms re-emerged as a result of following a Ktunaxa knowledge relationship. In meeting with Ktunaxa knowledge holders and language speakers in particular, about the Diet Study, the normative Diet Study terminologies were dissected for meaning. Given this was the third attempt to glean more accurate understanding of the role of place-based Indigenous foods, this was considered especially important, but an overlooked consideration that would also impact 'meaning making' and analyses. The two Ktunaxa concepts ʔa·kpiǂis and sukiɬ ʔiknaɬa are defined below.

ʔa·kpiǂis refers to "favorite food" and replaces the western concept of "wild food" and "traditional food." Throughout the focus groups, Ktunaxa ʔaqɬsmaknik̓ raised concerns for the food systems of 'all living things,' not just human centered food needs. When discussing food lists in focus groups, participants added their 'favorite food' to the study's generated list, despite the lack of calculated values because the Ktunaxa food system is varied and interdependent with ʔa·kxam̓is q̓api qapsin. sukiɬ ʔiknaɬa is the Ktunaxa phrase for "eating good" and replaces the western concept of "preferred," "high consumers," and "heavy harvesters." sukiɬ ʔiknaɬa is a relative term--one person eating good is not necessarily the same amount for another person. This is the same for 'all living things' ʔa·kxam̓is q̓api qapsin. sukiɬ ʔiknaɬa is also related to the Ktunaxa principle of 'taking only what you need, which again is relative to the individual and can be context specific to ʔa·kpiǂis.

4.2.4.2 Summary of Original Diet Study - Method and Summary

Ktunaxa ʔaqɬsmaknik̓ Ktunaxa have occupied and used lands and waterways that encompass the DA for more than 10,000 years, relying on the fish, land animals, shellfish and plants for all their subsistence needs. Colonialism, landscape changes and cumulative impacts have made it challenging for many families to continue their rights-based harvesting and dietary patterns. As a goal of the Ktunaxa Nation is to support a future where Ktunaxa ʔaqɬsmaknik̓ can confidently rely on qu̓kin ʔamakʔis (Raven's Land or Elk Valley) for Ktunaxa foods (ʔa·kpiȼis—favorite foods, not human centric), which grow wild, for some, or all, of their subsistence needs.

In 2012, KNC undertook the Ktunaxa Nation Diet Study to build a reasonable estimation of the current Ktunaxa "traditional food" consumption and harvesting patterns in order to inform and characterize the risk of chemical exposure to Ktunaxa ʔaqɬsmaknik̓. Additionally, Ktunaxa Nation wanted to answer the question: Is it safe for Ktunaxa citizens to eat the amount of traditional food that they report they would prefer to eat, if the levels of contaminants remain at current levels? Therefore, in addition to having an understanding of current risk for the Ktunaxa population (average and 95th percentile intake), it is critical to have a clear understanding of whether it is safe for Ktunaxa citizens to eat the amount of ʔa·kpiȼis that they report they would prefer to eat, if the levels of contaminants remain at current levels.

The Ktunaxa Nation diet study sought to have a representative cross-section of Ktunaxa living in ʔamakʔis Ktunaxa. Therefore, participants were randomly selected from the Ktunaxa Nation database which contained 319 mailing addresses in the South Eastern Kootenay Region (extending to the Slocan Valley in the west, Revelstoke in the North and to the borders with the U.S. and Alberta). In total 82% of contacted households participated with 98 individuals completing an in person interview during fall/winter 2012 and winter/spring 2013. Ktunaxa food consumption rates were estimated through use of a semi-quantitative food frequency questionnaire that asked about the seasonal use of 98 traditional foods. Three dimensional plastic models resembling food quantities were used to assist in determining usual portion sizes. Harvesting and sharing of traditional foods were found to be common practices. Most households had local game meat (93% reporting), berries (83% of households) and fish (68%), while almost half reported eating local plant roots/greens (48%). Overall, there was wide variation in reported use of traditional foods along with a relatively high rate of household food insecurity (44%), which further reinforced the critical importance of Ktunaxa foods to health and well-being. Current and 95th percentile consumption rates were shared with Teck in 2014 (Firelight 2014) in a technical memo.

In 2015, the Ktunaxa Nation diet study report was finalized and contained an additional section on recommended minimal preferred rates for future HHRAs to use to increase the certainty around the safety of eating traditional foods at the levels preferred. These intake levels were drawn from 95th percentile intake amounts from the 2012/2013 research and two focus groups in 2015.

2015 Focus Group Preliminary Preferred Rates Derivation

In May 2015, two gendered focus group meetings were held with Ktunaxa harvesters and elders to discuss past use and preferred minimal consumption levels to meet food and cultural needs. The results supported the use of the 95th percentile amounts from the 2013 diet study for an initial estimation of a preferred Ktunaxa diet. Concerns remained though, that the rates captured in the random survey did not adequately reflect the extent of Ktunaxa ʔaqɬsmaknik̓ whose diet composed primarily of favorite place-based Ktunaxa foods.

The information from the two focus groups in 2015 was considered good additional information but was limited in scope as well as the number of individuals interviewed. Therefore, there was interest in holding additional focus groups in all communities in order to develop a more fulsome understanding of the preferred consumption levels and better reflect Ktunaxa knowledge relationships. In order to develop a more fulsome understanding of the preferred consumption levels of Ktunaxa food, in a Ktunaxa Diet according to Ktunaxa knowledge, additional research and adequate research design is necessary.

In preparation for upcoming HHRAs in qu̓kin ʔamakʔis, there was an identified need to confirm the preferred Ktunaxa food consumption levels among the most sensitive Ktunaxa receptors. Those Ktunaxa ʔaqɬsmaknik who are most reliant on Ktunaxa lands and waters for their health and well-being have an implied objective of 'eating good' Ktunaxa "favorite foods."

Preferred amounts are also meant to establish a reasonable threshold for the full practice of an Indigenous right to hunt, trap, fish or harvest, as opposed to current consumption which may be impacted by scarcity, concerns about contamination, access difficulties, or other changes or concerns.

The 2015 Final Report recommended that future HHRAs consider the most sensitive Ktunaxa consumer as having a consumption level by total food category approaching:

- 43 -168 grams per day of fish
- 324-355 grams per day of game meat
- 69 grams of birds
- 10 grams per day of game organs, and
- 206 grams of berries.

Historic (circa 1960) consumption levels along with data from the focus groups strongly supported the use of the 95th percentile estimated daily intake and the preferred diet findings for any future HHRAs. Concerns remained after the release of the Ktunaxa Nation Diet Study Report in 2015 that intake levels were based on limited data and may not provide a conservative enough estimate. Preferred amounts are meant to reflect the intentions documented within the United Nations Declaration on the Rights of Indigenous Peoples to practice and perpetuate inherent rights including in Canada, according to Sec 35 Constitutional Rights, to hunt, trap, fish or harvest, food. Current consumption rates reflect colonial impacts, including physical, cultural, social and technical, that are exacerbated further, by scarcity and concerns about contamination, access difficulties, or other changes not yet documented in current Ktunaxa self-development research efforts.

4.2.4.3 2019 Ktunaxa Nation Diet Study Expansion

The 2019 Ktunaxa Nation Diet Study Expansion was designed to better describe quantitatively, for the purpose of HHRAs, the amounts of ʔa·kpiȼis needed by Ktunaxa ʔaqłsmaknik̓ to achieve sukił ʔiknała. The 2019 KNC Diet study expansion looked to quantify the upper level of amounts needed for a family to live off the land fully (no commercial meats available). As per the findings from the 2012/2013 study, Ktunaxa eating at the 95th percentile based would only obtain around 600 calories (459 calories from animal-based foods and 120 calories from berries). Assuming a caloric level of 2,500,[24] this represents about 24% of total calories, providing approximately 75 g of protein, 29 g of carbohydrate and 21 g of fat. Preferred amounts are meant to establish a reasonable threshold for the full practice of an Indigenous right to hunt, trap, fish or harvest, as opposed to current consumption which may be impacted by scarcity, concerns about contamination, access difficulties, or other changes or concerns. The method was adapted from the Rights-Based Harvest Estimation method developed by Candler et al. (2015).

The project team engaged with 5 Ktunaxa communities in the East Kootenay Region to quantify the preferred rates of Ktunaxa foods through 10 focus groups held during fall 2019. In total, there were:

- 2 sets of focus group results for ʔakisq'nuk - Oct 17 (5 citizens) and Dec 9 (10 citizens);
- 2 sets of focus group result for ʔakisq̓nuk and Yaqʼit ʔa·knuqǂiʽit - Nov 13 (7 citizens) and Dec 17 (6 citizens);
- 3 sets of focus group results for ʔa·kisqakǂiʼit - Nov 14 (7 citizens), Nov 19 (6 citizens) and Dec 7 (10 citizens);

[24] Chosen as an average daily caloric requirement, this level is well below the 95th percentile of total energy intake from the Canadian Community Health Survey (2004), which reported that the total energy intake among adults 19+ was 4,121 for males and 2,729 for females in BC and 3,736 for males and 2,651 for females across Canada. A reasonable total energy intake for active harvesters could be expected to approach 3,193 to 3,425 calories/day.

- 2 sets of focus group results for ʔaq̓am - Nov 20 (10 citizens) and Nov 21 (15 citizens); and;
- 1 set of focus group results for yaqan nuʔkiy - Dec 11 (13 citizens).

Each focus group took approximately 3.5 to 4 hours. Focus groups were facilitated by KNC Staff (Jim Clarricoates, Melissa Teneese, Vickie Thomas) and contractors Michele Sam (MAS Consulting) and Firelight (Karen Fediuk). The focus groups began with participants reviewing a pre-developed food list from the previous Ktunaxa Nation diet study. They would identify foods they were familiar with as well as add foods that were not already on the food list. This activity was integral to identifying all of the preferred animal and plant species required by Ktunaxa ʔaqǂsmaknik̓ for the full practice of Ktunaxa subsistence and cultural needs, included in Aboriginal Rights to hunt, trap, fish and harvest.

Each focus group then proceeded to estimate the amount of food, by species that would be harvested yearly assuming a healthy ecosystem and a set family size, to meet food and cultural needs. All estimates (e.g. pounds of fish, number of ungulates, gallons of berries, roots and plants) were recorded on posters and in notes and verified by the group. A variety of measuring devices (bags, buckets, cup and spoon) were used extensively, to help gauge the amounts suggested. There was considerable variation in the amounts of species estimated by each focus group and between focus groups, which would be expected given the Ktunaxa principles and terminologies noted above.

A verification focus group comprised of a subset of focus group participants verified in a Zoom meeting on May 7th, 2020 that the average amounts tallied, represented a reasonable level of what would be needed for a family to live largely off the land. Additionally, the verification focus group reviewed and discussed appropriate scaling of consumption rates for adult weights to other age groups.

Ktunaxa Preferred rates are premised upon two key Ktunaxa principles:

1. Take what you need, according to your context including, cultural, spiritual, family size etc. as well as recognition of the food needs shared with other species and options for other foods in times of scarcity.
2. ʔa•kpiȼ̓is is the Ktunaxa concept that refers to the favorite and regular foods eaten for both animals, birds, fish, and humans, according to inherent and interdependent relationships of ʔak̓xamis q̓api qapsin—all living things—and so governed by Ktunaxa natural law—ʔa•knumuȼtiǂiǂ.

Ktunaxa preferred rates are higher than the 95th percentile current rates for fish, large animals, and plant-based foods. Rates for birds were lower while berries were similar. There are additional rates for several foods which were not estimated previously, including fish eggs, shellfish, and several plants.

Based on the average across the groups, the preferred daily per capita intake from Ktunaxa foods is 3 lb or 1.36 kg. By food categories, this includes:

- 245 grams (8 oz) of fish, .7 grams of fish eggs, .6 grams of shellfish;
- 693 grams (24 oz) of land animals;
    - 649 grams muscle meat (628 grams large animal meat (159 grams of deer, 200 grams of elk, 111 grams of moose, 32 grams of bear meat), and 21 grams small animals);
    - 27 grams organ meats from deer, elk and moose;
    - 17 grams of marrow/fat from deer, elk and moose;
- 28 grams of birds and eggs (16 grams of birds, 12 grams of bird eggs);
- 208 grams (7 oz) of berries;

- 144 grams (5 oz) of plant roots;
- 25 grams (1 oz) of other plants; and
- 11 grams of lichen; and 6 grams of mushrooms.

The Ktunaxa preferred food estimates were evaluated for their reasonableness and the potential of the pattern to meet rights-based food, food security and nutrition needs. The nutrients provided by Ktunaxa foods were calculated by multiplying and summing daily preferred intakes for each species using available federal (Canadian Nutrient File at https://food-nutrition.canada.ca/cnf-fce/index-eng.jsp) and U.S. (Food Data Central at https://fdc.nal.usda.gov/) food composition information. The pattern was assumed to meet needs if:

- up to 75% of total energy (1,875 calories) is from animal-based foods;
- aquatic and terrestrial animal-based foods contribute a similar amount of calories (39% and 36%); and
- protein intake from traditional food provides up to 35% of total energy or 218 grams on a 2,500 caloric level.

On a per capita basis, assuming that an individual was an active adult and that their caloric needs were set to 2,500 calories, the preferred diet rates would meet 62% of total energy needs, 96% of protein needs, 48% of fat needs, 39% of carbohydrate needs, 370% of iron needs and 250% of vitamin D needs. Animal-based foods would provide 52% of the total energy needs (1,308 calories) and plant-based foods would provide 9% (228 calories).

Current rights-based harvest estimates and the limited relative proportion of fish to land animals, reflects changes in use due to large and cumulative impacts on the availability and confidence in the quality of foods from the water. If Ktunaxa were able to eat at the preferred levels that were estimated during this diet study expansion project, there would still be a significant caloric contribution (38%) from store-bought or locally cultivated foods. The limited proportion of fish reflects the serious decline in both the availability and confidence in the quality of fish and the ongoing impacts from the historic loss of salmon from the upper Columbia. This results in a higher than expected intake of land animals and reflects the Ktunaxa principles--"So to some it may seem not like a lot, but to others it is a lot" Chad Luke Jr (May 7, 2020).

4.2.5 Fish Fillet and Fish Egg

Recreational fishing and fish ingestion by Ktunaxa and recreational anglers is evaluated in this HHRA based on available fish tissue data. Fish egg ingestion is quantified using fish ovary data as a surrogate tissue because fish eggs were not available. Uncertainties regarding the representativeness of the fish tissue dataset and use of ovary tissue as a surrogate for eggs are discussed in Sections 6.11.3.1 and 6.11.3.4 respectively. Consumption rates for fish fillet and fish eggs are presented in Table 4-6 and are discussed in more detail below.

Doses for ingestion of fish tissue are proposed to be calculated using the following Equation 8:

Equation 8:

$$\text{Dose} = \frac{EPC \times IR_{fish} \times EF \times ED \times CF_d}{BW \times AP \times CF_a}$$

Where:

Dose	average daily dose (lifetime for carcinogens only) (mg/kg-day)
EPC	fish tissue exposure point concentration (mg/kg, wet weight)
IR_{fish}	consumption rate for fish tissue (fillet or eggs) (g/day, wet weight)
EF	exposure frequency (365 days/year)

ED	exposure duration (years)
CF_d	unit conversion factor ($1E^{-03}$kg/g)
BW	body weight (kg)
AP	averaging period for noncarcinogens or carcinogens (years)
CF_a	unit conversion factor (365 days/year)

Table 4-6. Consumption Rates for Fish Fillet and Fish Eggs

Population	Tissue	Units	Toddler	Child	Adolescent	Adult	Source
Preferred Diet Consumer							
Ktunaxa	Fillet	gfish/day ww	106	189	245	245	KNC (2020)
Ktunaxa	Egg	g/fish egg/day ww	0.3	0.5	0.7	0.7	KNC (2020)
Upper Percentile Consumer							
Ktunaxa	Fillet	gfish/day ww	19	33	43	43	Fediuk and Firelight (2015) consumers only 95th percentile
Recreator	Fillet	gfish/day ww	17	31	40	40	Health Canada (2007)
Average Consumer							
Ktunaxa	Fillet	gfish/day ww	4.5	8.0	10	10	Fediuk and Firelight (2015) consumers only average
Notes: g/day ww = grams of food item per day, measured in wet tissue weight							

The Bureau of Constituent Safety's Canadian adult high fish consumer value (40 g/day) is used for recreational anglers, described here as 'Recreator.' This consumption rate takes into account Coastal provinces, adult men, and recreational and subsistence fishers who are expected to eat more fish than the general population (Health Canada 2007). The same report cites that the general all-persons intake for Canadians is 21 g/day. An intake of 40 g/day is representative of Elk Valley residents who are assumed to represent higher fish consumers than the general population, and is protective of exposures to Elk Valley residents who consume less fish and whose fish consumption rates are reflective of a typical Canadian intake.

Three separate fish consumption rates are evaluated for Ktunaxa who consume fish in Elk Valley – average consumers, upper percentile consumers, and preferred diet consumers. Average and upper percentile consumption rates for Ktunaxa were reported in the 2012 Ktunaxa Nation Diet Study Final Report (Fediuk and Firelight 2015), which was based on participation information from 98 Ktunaxa individuals from 92 households. Preferred diet fish consumption rates for Ktunaxa were provided by the KNC in an August 11, 2020 memo to Teck (KNC 2020).

For the 2012 Ktunaxa Nation Diet Study Final Report, participants were asked where they lived, if they ate Ktunaxa foods that were harvested in the wild, and how often and where in the last 10 years the participant had harvested certain Ktunaxa foods. For food consumption frequency, participants were asked how often they had eaten particular foods in the past year. For consumers of a particular food, the portion size and season of use was also requested. The food consumption study also included questions about food avoidance and determined that fish was the food most commonly avoided due to chemical contamination concerns (by 19 of 89 Ktunaxa ʔaqⱡsmaknik participants). Twenty-three areas avoided were identified, including Koocanusa, Elk Valley, and Elk River, among others.

Preferred consumption rates were not included in the Ktunaxa Nation Diet Study technical memo (2014) or the Ktunaxa Diet Study Final Report (2015) (Firelight 2014; Fediuk and Firelight 2015). The 2012 Ktunaxa Nation Diet Study Final Report showed that for adult consumers of fish, the 95th percentile consumption rate for all freshwater fish was 43 g/day and the average was 10 g/day. Following additional consultation with their communities, the KNC (2020) reported a preferred consumption rate of 245 g/day[25] (8 oz/day) for adult consumers. In accordance with the KNC (2020) preferred diet memo, fish consumption rates for adults are also applied to adolescents, and consumption rates for other life stages (i.e., toddlers and children) are estimated based on the ratio across life stages from Richardson (1997), Table 6.2.

Fish egg consumption is also evaluated in the HHRA for Ktunaxa preferred diet consumers. Fish egg consumption rates were not available in the 2012 Ktunaxa Nation Diet Study, so fish eggs are evaluated at the preferred consumption rate only. Fish egg consumption is evaluated using the Ktunaxa preferred diet rate of 0.7 g/day for adults and scaled to the different life stages using the methodology described above for fish fillet.

Fish fillet meal sizes identified for Ktunaxa adult consumers in the 2012 Ktunaxa Nation Diet Study Final Report were 291 g for men and 199 g for women (average of 245 g meal size). Thus, the preferred consumption rate for adults of 245 g/day would represent 365 meals per year and the 95th upper percentile rate of 43 g/day represents 64 meals per year (or 1.25 times per week) assuming each meal is a 245 g serving size (Fediuk and Firelight 2015; Firelight 2020). Similarly, the 95th upper percentile consumption rate of 33 g/day for children also represents 64 meals per year assuming each meal is based on the preferred daily consumption value of a 189 g serving size.

4.2.6 Berries and Rose Hips

Uptake of COPCs into plants could occur via contact of crops with irrigation water, if and where surface water is used for irrigation, or, by uptake from surface water or sediment into native plants growing in riparian areas. It is expected that only a small fraction of consumed berries will be harvested in riparian areas. Use of surface water for irrigation of other green spaces, such as home gardens, parks, golf courses, etc., is possible. Only irrigation of consumable products, such as home gardens, orchards, and farms, are relevant for human health evaluation. This evaluation focuses on berries and rose hips, which are known to be harvested in the DA.

Berries and rose hips are an important component of the Ktunaxa diet, and ingestion may contribute to exposures to COPCs identified in surface water when harvested from riparian areas. Other residents and recreational users may also gather and consume berries growing in riparian areas whose rates of berry and rose hip harvesting within the study area are not known. For this HHRA, berry consumption estimates represent all berry types harvested in the DA, in aggregate and it is acknowledged that any amount, including none or all, berries or rose hips consumed may be harvested from areas with direct linkages to surface water. A species-specific evaluation is not performed, although rose hip consumption is evaluated separately from berries. The equation for the berry/ rose hip consumption exposure dose is as shown in Equation 9:

[25] The Canadian First Nations fish consumption rate of 220 g/day (Health Canada 2004) was used by ENV to derive a "high fish intake" selenium water quality screening value (ENV 2014).

Equation 9:

$$\text{Dose} = \frac{EPC_{berry} \times IR_{berry} \times EF \times ED \times CF_d}{BW \times AP \times CF_a}$$

Where:

Dose	average daily dose (lifetime for carcinogens only) (mg/kg-day)
EPC_{berry}	Berry/rose hip exposure point concentration (mg/kg, wet weight)
IR_{berry}	Berry/rose hip consumption rate (g/day, wet weight)
EF	exposure frequency (365 days/year)
ED	exposure duration (years)
CF_d	unit conversion factor ($1E^{-03}$ kg/g)
BW	body weight (kg)
AP	averaging period for noncarcinogens or carcinogens (years)
CF_a	unit conversion factor (365 days/year)

As with fish, separate consumption rates are applied for Ktunaxa average consumers, upper percentile consumers, and preferred diet consumers. The average and upper percentile consumption rates for berries are also assumed to apply to non-Ktunaxa who harvest berries in the area. Only Ktunaxa are expected to regularly consume rose hips. Consumption rates for berries and rose hips are shown in Table 4-7. The upper percentile and average consumption rates come from the 2012 Ktunaxa Nation Diet Study Final Report (Fediuk and Firelight 2015). The preferred diet value for berries is from the KNC 2020 memo, and the preferred diet rate for rose hips was provided in a later email from Karen Fediuk of Firelight to Julie Tu of Ramboll (Fediuk 2021). The preferred diet rate for berries (208 g/day) is very similar to the upper percentile rate (206 g/day). Berry consumption rates apply to total berry consumption, inclusive of all berry types consumed. For rose hips, the preferred rate (5 g/day) is similar to the average consumer rate (4.5 g/day), while the upper percentile rate (95^{th} percentile) is much higher (31 g/day). Of note, the 2012 Ktunaxa Nation Diet Study Final Report reports a 90^{th} percentile consumption rate for rose hips of 9 g/day, which suggests the 95^{th} percentile rate of 31 g/day is influenced by high rose hip consumption from a few consumers. Berry and rose hip consumption rates are applied to all age ranges in accordance with the KNC 2020 memo, meaning rates were not scaled across life stages.

The Canadian Total Diet Study reports much lower intake rates for berries (i.e., 3.8 g/day for toddlers and 9.8 g/day for adults for blueberries, raspberries, and strawberries combined) than those published by Firelight, and it appears that the underlying dietary information in Health Canada (2005) may not represent current berry consumption rates. Specifically, Appendix D shows analyses based on data collected on berry consumers in the United States during 2013-2016 within the National Health and Nutrition Examination Survey (NHANES). As indicated in Appendix D, consumption rates for berries were estimated from the NHANES data based on consumption of all berries for consumers only and identified a mean of 77 g/day and a 95^{th} percentile of 233 g/day. Thus, the NHANES consumption rates are similar to the rates for the Ktunaxa upper percentile and preferred consumer. Appendix D provides further detail on the analyses conducted using NHANES data.

Table 4-7. Berry Consumption Rates

Population	Media	Units	Toddler	Child	Adolescent	Adult	Source
Preferred Diet Consumers							
Ktunaxa	Berries	g/day ww	208	208	208	208	KNC (2020)
Ktunaxa	Rose hips	g/day ww	5	5	5	5	Email from Karen Fediuk (2021)
Upper Percentile Consumers							
Ktunaxa and Recreators	Berries	g/day ww	206	206	206	206	95^{th} percentile consumers only Fediuk and Firelight (2015)
Ktunaxa	Rose hips	g/day ww	31	31	31	31	
Average Consumers							
Ktunaxa and Recreators	Berries	g/day ww	85	85	85	85	Average consumers only Fediuk and Firelight (2015)
Ktunaxa	Rose hips	g/day ww	4.5	4.5	4.5	4.5	
Notes: All values are in grams per day, wet weight							

4.2.7 Wild Game

Surface water extraction for watering livestock and consumption of surface water by terrestrial mammals (e.g., elk and deer) is a possible exposure pathway if people subsequently consume the animals. Many game resources are consumed, and elk and deer are the predominant species consumed. As discussed in Section 3.1.4, large game tissues are available for elk, mule deer, whitetail deer, moose, and bighorn sheep. Available game data are combined as follows: muscle and heart tissue for all large game species are combined and evaluated as muscle meat, and liver and kidney tissue for all large game species are combined and evaluated as organ meat. As game may have different dietary patterns and people may have consumption preferences for particular game species, uncertainties associated with combining all available game data are discussed in Section 6.11.3.6.

Doses for ingestion of game muscle and for game organ meats are calculated using Equation 10:

Equation 10:

$$\text{Dose} = \frac{EPC_{game} \times IR_{game} \times EF \times ED \times CF_d}{BW \times AP \times CF_a}$$

Where:

Dose	average daily dose (lifetime for carcinogens only) (mg_{tissue}/kg-day)
EPC_{game}	game tissue exposure point concentration for muscle or for organ meat (mg/kg, wet weight)
IR_{game}	consumption rate for game muscle, or for game organ meat (mg_{tissue}/day, wet weight)
EF	exposure frequency (days/year)
ED	exposure duration (years)

CF_d	unit conversion factor ($1E^{-03}$ k/g)
BW	body weight (kg)
AP	averaging period for noncarcinogens or carcinogens (years)
CF_a	unit conversion factor (365 days/year)

Consistent with the evaluation for fish and berries, the 95th percentile rates from the 2012 Ktunaxa Nation Diet Study Final Report (Fediuk and Firelight 2015) are used for upper percentile Ktunaxa consumers and the 50th percentile rates are used for average Ktunaxa consumers. Fediuk and Firelight (2015) consumption estimates for all game meat combined (either muscle or organ meat depending on media evaluated) for consumers only are used in exposure estimates. The preferred diet rates for game muscle meat and organs are from the KNC 2020 memo. No data are currently available to estimate consumption rates for Elk Valley residential consumers who are not Ktunaxa. Thus, the average and upper percentile consumer rates published in the Ktunaxa study are also used for consumers of wild game that are not Ktunaxa. Table 4-8 provides consumption rates for game for all populations. Of note, the preferred diet rate for game meat muscle (628 g/day) is almost twice as much as the upper percentile rate (324 g/day). In contrast, for organ meat, the preferred rate (27 g/day) is half of the upper percentile rate (54 g/day).

In accordance with the KNC (2020) memo, game consumption rates for adults are also applied to adolescents, and consumption rates for other life stages (i.e., toddlers and children) are estimated based on the ratio across life stages from Richardson (1997), Table 6.2.

Table 4-8. Game Meat and Organ Consumption Rates

Population	Media	Units	Toddler	Child	Adolescent	Adult	Source
Preferred Diet Consumers							
Ktunaxa	Muscle	g/day ww	191	280	628	628	KNC (2020)
Ktunaxa	Organ	g/day ww	8.2	12.1	27	27	
Upper Percentile Consumers							
Ktunaxa and Recreators	Muscle	g/day ww	98.4	144	324	324	95th percentile consumers only Fediuk and Firelight (2015)
Ktunaxa and Recreators	Organ	g/day ww	16.4	24.1	54	54	
Average Consumers							
Ktunaxa and Recreators	Muscle	g/day ww	25.1	37.1	83	83	Average consumers only Fediuk and Firelight (2015)
Ktunaxa and Recreators	Organ	g/day ww	3.0	4.5	10	10	

Notes:
All values are in grams per day, wet weight

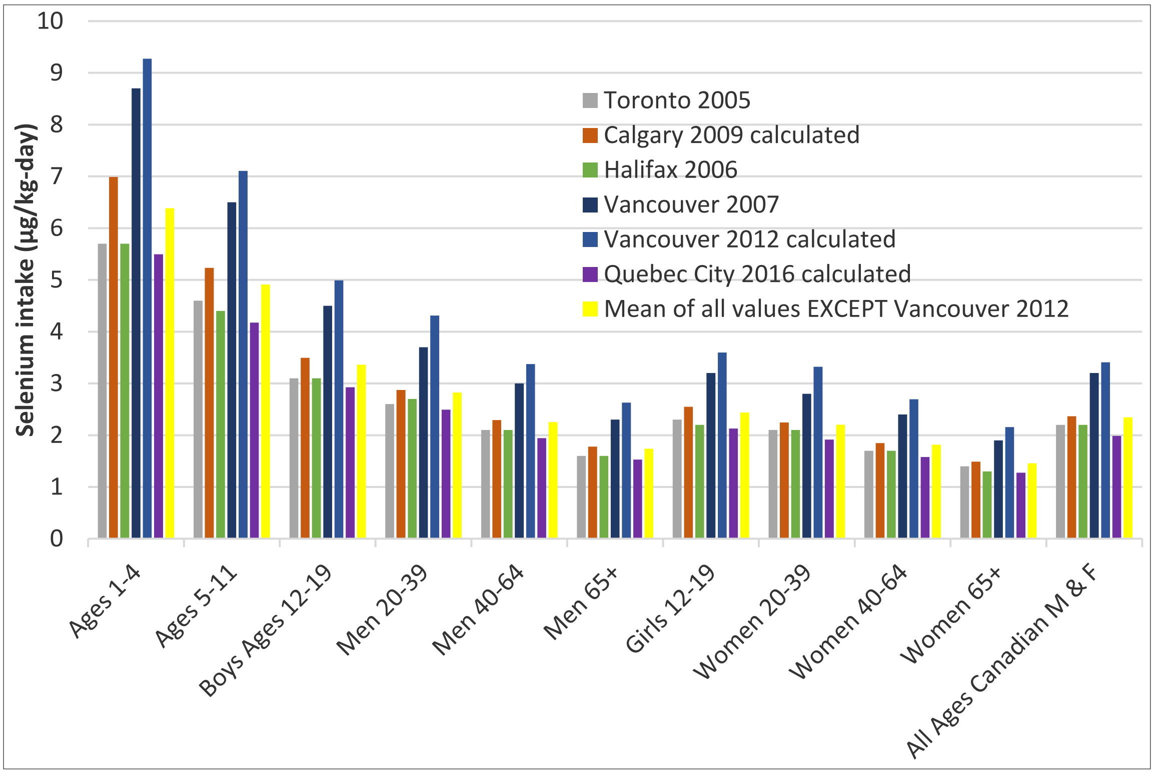
Meal sizes for all game meat identified for Ktunaxa adult consumers were 322 g for men and 170 g for women (average of 245 g meal size) (Fediuk and Firelight 2015). Meal sizes were not provided for preferred rate consumption. If meals are at the same 245 g size, the 628 g/day preferred consumption rate would equate to 936 meals per year or about 2.5 meals per day of meats. The preferred daily consumption rate for game meat muscle described here is 2.5 times greater than the daily consumption rate of fish. For the adult Ktunaxa preferred consumer, this results in a total daily intake of 873 g of meat and fish, 365 days per year.

4.3 Discussion of Background Exposure

Commercial foods and consumer products can contribute to exposures to COPCs in addition to those associated with mining activity. Quantifying background exposures is important to understanding the significance of and providing context for mine-related exposures. The 2016 HHRA (Ramboll Environ 2016) included consideration of market basket foods based on the average daily intakes for selenium as provided in the Canadian Total Diet Study (Health Canada 2005). The Canadian Total Diet Study provides dietary intakes of selenium and other metals for residents of various inland and coastal cities, by gender and age groupings. Available information for BC First Nations diets rely heavily on coastal populations which consume much higher quantities of marine fish and shellfish, which would not be relevant to interior populations. Therefore, the 2016 HHRA incorporated market basket intake data for Toronto, which was selected to reflect an inland diet rather than a coastal diet based on advice received from the EVWQP Technical Advisory Committee. The 2016 HHRA identified a hazard index (HI) of 1 associated with exposure to selenium in market basket foods. During development of the methodology for the current HHRA, the Workgroup expressed concerns regarding the representativeness of the Toronto dietary data to represent Elk Valley resident or Ktunaxa resident exposures.

Given the Workgroup concerns, market basket intake of selenium was further explored in discussions with the HHRA Workgroup during teleconferences in 2019. Through analyses and discussions described further in Appendix F, it was determined that use of all available data from Canadian cities except the 2012 data for Vancouver would be used to estimate selenium in market basket foods. Following consultations with Health Canada, the Vancouver 2012 data was not included because it was identified as potentially inaccurate. However, Vancouver analyses from 2007 were included in the overall estimate. The use of a nationwide estimate is representative of market basket foods because the food supply in Elk Valley comes from national and international food sources, as confirmed by consultation with local grocery store managers. Figure 4-1 shows total selenium intake by age group for Canadian cities with selenium market basket data and an average concentration for all Canadian cities excluding the Vancouver 2012 data. The dietary intake estimates are based on consumption rates of different types of foods by Canadians and these consumption rates have changed over time and may not be completely representative of current intake for a given food, which adds uncertainty to the market basket estimates. Newer dietary intake data are being analyzed by Health Canada and the market basket analyses can be updated when dietary intake data are received from Health Canada, if necessary.

Figure 4-1. Selenium Intake by Gender and Age in Canadian Cities (in µg/kg-day)



Market basket exposure estimates were calculated for selenium in the Canadian diet through use of all available data from Canadian cities except the 2012 data for Vancouver, which was excluded because it was identified as potentially unrepresentative. The Canadian Diet Study intake rates account for consumption of foods from all food categories, grains, dairy, meat products, processed foods, fruits, vegetables, and more. The intake of selenium was calculated based on market basket intake amounts for each food based on Health Canada food intake data and on concentrations of selenium from Canadian cities. The first estimate of intake considered all foods and a second estimate excluded foods that might be obtained from Elk Valley. Specifically, the contribution of selenium from meat and berry food items was subtracted out of our market basket analysis by setting the selenium intake values to zero within each study's results (Calgary 2009, Halifax 2006, Quebec City 2016, Toronto 2005, and Vancouver 2007) (Health Canada 2020b). Each study used the same food item categories in their surveys; therefore, a food category subtracted from one study's results was subtracted in all study datasets.

The animal meats and animal meat products identified for subtraction included beef (steak, roast/stew, and ground cuts), pork (fresh and cured), veal, and lamb. Poultry and poultry products were left in, including liver pate, lunch meats (cold cuts or canned), chicken burgers, chicken nuggets, eggs, and egg breakfast sandwiches. Dairy products such as milk, cheese, and yogurt were not subtracted out. General and/or composite meat items subtracted included hot dogs, weiners, organ meat, and meat soups. One dinner category comprising meat, cereal, and vegetables was subtracted out while the dinner category composed of meat or poultry with vegetables was left in. Other meat preparations subtracted included hamburgers, beef chow mein, and a general category for “meat, poultry, or eggs.” All seafood categories were subtracted out, which included all fresh or frozen shellfish and fish (both freshwater and marine species). Berry food items subtracted out included blueberries, cherries, grapes, raspberries, strawberries, bottled grape juice, and a category for “jams.” All other fruits and fruit products were left in, including pies (apple or other). Selenium in water was also not included in these estimates because selenium in water was evaluated based on site-specific data.

Market basket estimates are included in the risk characterization section of this HHRA to provide context for DA exposure estimates and to more fully evaluate cumulative selenium exposure.

5. TOXICITY ASSESSMENT

The purpose of the toxicity assessment is to characterize various adverse effects that may be associated with individual constituents and quantification of chemical toxicity. The quantification of toxicity can consist of the identification of a maximum tolerable dose, a threshold below which no adverse health effects are expected, or a measure of the relationship between dose and severity of adverse effect for which no threshold is assumed. The quantitative estimates of toxicity are referred to as toxicity reference values (TRVs).

ENV (2017, 2021a,b) guidance for performing risk assessment recommends USEPA's Integrated Risk Information System (IRIS) as the preferred source for TRVs, followed by use of Health Canada and World Health Organization (WHO) guidance. During the preparation of the final draft of this HHRA, Health Canada released updated TRV guidance (Health Canada 2021b) which included updated or reaffirmed values for several COPCs. Because ENV (2021a) guidance specifies USEPA IRIS as the preferred source for TRVs, IRIS values were preferentially used over Health Canada (2021b) values except for selenium and uranium. The Health Canada (2021b) value for lead was also used to evaluate lead toxicity for children because there is no IRIS value for lead. In instances where USEPA IRIS (2021), Health Canada (Health Canada 2010b, 2021b), and WHO lacked a TRV for a COPC, or in cases where TRVs have been withdrawn, values were obtained from additional sources listed in ENV guidance or from the literature as deemed appropriate.

IRIS and ENV (2017b) were relied upon for weight-of-evidence (WOE) classification of each COPC; WOE utilizes available data to determine if a substance is a human carcinogen. Human and animal studies and other relevant information are evaluated to assign a WOE category to each substance: carcinogenic to humans, likely to be carcinogenic to humans, suggestive evidence of carcinogenic potential, inadequate information to assess carcinogenic potential, and not likely to be carcinogenic to humans (USEPA 2005). Consideration of the WOE classification for each COPC is useful in understanding uncertainties underlying cancer risk estimates, particularly for COPCs for which evidence is only suggestive of carcinogenicity.

Threshold and non-threshold TRVs are discussed in Sections 5.1 and 5.2, respectively. Some constituents have both threshold and non-threshold TRVs reflecting different health endpoints. Those constituents were evaluated using both TRVs. Oral TRVs for all COPCs are listed in Table 5-9, which also provides the sources for each TRV, critical health effect, and other information needed to understand the use of and confidence in each TRV. Oral TRVs are also used to assess dermal exposures. Detailed profiles of several analytes are available on the USEPA IRIS website or other relevant sources.

5.1 Threshold, Non-Carcinogenic, COPCs

Threshold-response constituents may cause adverse health effects only once a specific dose, the threshold dose, has been exceeded. Doses below the threshold are not expected to result in adverse health effects. The threshold dose is never known with certainty but is represented by a conservative estimate called a TRV. TRVs represent average daily exposure levels at which no adverse effects are expected to occur during chronic exposures. TRVs are expressed as the amount of substance (mg) per unit body weight (kg) per unit time (day), or mg/kg-day, and are most often based on oral exposures.

TRVs are calculated based on review of results of toxicity studies in animals, and sometimes human epidemiological studies. The most representative studies are used to identify the highest threshold dose for health endpoints associated with the toxicity of a given substance. The results of individual studies are used to identify "no observable adverse effect levels" (NOAELs) or "lowest observable adverse effect levels" (LOAELs).

The TRVs incorporate uncertainty factors (UFs) and modifying factors to account for uncertainty in the NOAEL or LOAELs used to derive the TRV. The magnitude of the combined factors depends on the confidence in the study used to derive the NOAEL or LOAEL and accounts for: variation in the general populations and protection of sensitive populations, use of animal models instead of epidemiology studies in humans, duration of exposure, use of a LOAEL instead of a NOAEL, and overall data quality. Altogether, the factors can span several orders of magnitude. The use of these factors ensures there are no risks at or below the TRV. If a noncancer TRV is exceeded, further evaluation is needed to determine if there is a risk of adverse effects.

Health Canada (2021b) uses a distinct TRV for metals that are essential trace elements, called the tolerable upper intake level (UL). The UL is interpreted and applied as the tolerable daily intake for ingestion exposure. This method considers that some metals found at contaminated sites are essential in human nutrition. Toxicity is represented by a U-shaped dose response curve, which quantifies the safe range of intakes between deficiency and toxicity. The (UFs)used in the calculation of the UL tend to be much lower than those traditionally used to establish the tolerable daily intake while remaining fully protective.

TRVs used here are derived for chronic exposure consistent with values recommended in Health Canada (2021b), which indicates that, "At this time, HC does not prescribe TRVs for exposures of lesser duration (i.e., acute, subchronic)." Health Canada goes on to state that short duration TRVs from other regulatory agencies can be used with appropriate scientific rationale. However, no subchronic TRVs were identified in ENV guidance and exposure analyses conducted here used chronic exposure methodology. The USEPA IRIS files have very few subchronic toxicity values and none are for the COPCs identified here. If future analyses are conducted evaluating subchronic exposure, such analyses will rely on available subchronic TRV values. Uncertainties associated with reliance on chronic toxicity values are discussed in Section 6.11.5.5.

5.1.1 Selenium Toxicity

Selenium is an essential nutrient for humans, but may also cause adverse health effects if exposures are too high. The dose response curve is U-shaped, meaning there is a safe range of intakes between deficiency and toxicity. Selenium deficiency can compromise the immune system, increase the risk of miscarriage, and cause cardiovascular disease. Deficiency occurs when daily intake falls below 20 µg/day. Chronic exposures to selenium higher than the TRV (e.g., over 800 µg/day for adults) may cause a health condition called selenosis. Symptoms observed in individuals exposed to chronically high levels of dietary selenium include loss of hair and nails, skin lesions, tooth decay, and abnormalities of the nervous system (ENV 2014).

Figure 5-1. Health Canada Toxicity Reference Values (TRVs) for Selenium by Age Group

Age Group	TRV Value mg/kg$_{bw}$/day
0-6 mo	0.0055
6 mo to <5 yrs	0.006
5 to <12 yrs	0.0063
12-<20 yrs	0.0062
>20 yrs	0.0057

Notes:

mg/kg$_{bw}$/day = milligram(s) per kilogram of body weight per day; mo = month; TRV = toxicity reference value(s); yr = year

Health Canada has a range of TRVs for selenium which are based on the ULs for selenium derived by the Institute of Medicine ((IOM) 2000, ENV 2014; see Figure 5-1). In this risk assessment, the Health Canada TRV value of 0.0057 mg/kg-day for oral exposure to selenium (Health Canada (2021b) is used to estimate threshold effects regardless of age group because it is the most conservative for the relevant age ranges (i.e., 6 months to adult). The TRV is derived from a study by Yang and Zhou (1994), which followed five adult patients from a seleniferous region of China with overt clinical signs of selenosis over six years. The critical effect was hair and nail brittleness and loss, which are signs and symptoms of selenosis following chronic selenium exposure. Yang and Zhou identified a NOAEL of 800 µg/day and a LOAEL of 910 µg/day in the adult population studied. This can be interpreted to mean that the onset of selenosis occurs at or above daily selenium intakes of 910 µg/day, and that no adverse effects are expected below 800 µg/day. There is uncertainty in applying the Yang and Zhou findings to children because no children were included in the study. The 0.0057 mg/kg-day TRV is based on the NOAEL of 800 µg/day. A UF of 2 was applied to the NOAEL, resulting in a UL of 400 µg/day. The 400 µg/day UL was then divided by an adult body weight of 70.7 kg to yield the TRV of 0.0057 mg/kg-day (IOM 2000, Health Canada 2021b).

No clear NOAEL has been established for young children, and so the Health Canada TRVs for infants and children are based on background dietary intake (i.e., average selenium levels in human breast milk) rather than a NOAEL (IOM 2000, Health Canada 2021b). The resulting TRV for infants 0 to less than 6 months of age is 0.0055 mg/kg-day. For all other child and adolescent age ranges, the TRVs are slightly greater than 0.0057 mg/kg-day. Because the TRVs are so similar, the 0.0057 mg/kg-day TRV is applied to all ages in this assessment. IOM (2000) states, "...there is no evidence indicating increased sensitivity to selenium toxicity for any age group." Exposures greater than the TRV are considered unacceptable in this HHRA. Additional considerations regarding the TRVs for selenium and selenium intakes potentially associated with adverse health effects are discussed in Section 6.11.5.1.

5.2 Non-threshold, or Carcinogenic, COPCs

Genotoxic or carcinogenic constituents are assumed to have no threshold of safety, such that the only dose which causes no adverse effect is zero.[26] WOE categories for these constituents include "carcinogenic to humans," "likely to be carcinogenic to humans," and sometimes "suggestive evidence of carcinogenic potential." As with threshold substances, human epidemiological data often are not available and animal studies are used to quantify toxicity of carcinogens. Quantifying the low dose estimates of carcinogenic potential requires the use of mathematical models which assume a linear relationship in the extrapolation from the high doses applied in animal toxicity studies to low doses observed in the environment. The models calculate the 95 percent confidence limit of the slope of the curve that describes the dose-cancer potency relationship, called a cancer slope factor (SF). SFs describe the carcinogenic potency of the chemical and are used to provide an upper-bound estimate for the probability of cancer occurrence in a population. The SF is expressed as the inverse of a dose (i.e., $(\text{mg/kg-day})^{-1}$) and quantified the number of predicted cancers per unit dose. Thus, the dose multiplied by the SF equals the expected cancer risks.

5.3 Other Considerations

The majority of TRVs are based on studies in which animals were administered a substance via oral pathways (i.e., ingestion in food or feeding tube administration). Dermal TRVs are largely unavailable and so route-to-route extrapolation is applied for derivation of dermal TRVs. This extrapolation procedure adjusts oral TRVs, which are based on administered doses, to represent absorbed doses. The absorbed dose TRVs may be used to assess risks of dermal exposures that are calculated as absorbed doses. Such route-to-route extrapolation introduces some uncertainty because the distribution of absorbed constituents may differ between oral and dermal exposures; however, these differences are expected to be small for metals.

An absorption factor reflecting the percentage of a dose of a substance absorbed in the gastrointestinal tract (ABS_{GI}) is derived from the same study that forms the basis of the TRV. To calculate a dermal TRV, the oral TRV is modified by the ABS_{GI} as shown here:

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[26] Some carcinogens are not genotoxic and may have a threshold below which risks are negligible; however, no current TRVs for carcinogens are based on thresholds.

Equation 11:

$$\text{Noncancer } TRV_{derm} = TRV \times ABS_{GI}$$

$$\text{Cancer } TRV_{derm} = \frac{SF}{ABS_{GI}}$$

The magnitude of the toxicity factor adjustment is inversely proportional to the ABS_{GI}. For example, for a substance that is completely absorbed in the gastrointestinal tract (ABS_{GI}=1), the oral and dermal TRVs are the same. However, when oral absorption of the chemical is low (i.e., ABS_{GI}=0.1), the adjusted dermal TRV is one tenth of the original noncancer oral TRV or ten times higher than the original SF.

When assessing dermal exposures in this risk assessment, the oral TRVs will be adjusted to reflect absorbed dose. In general, organic constituents have relatively high oral absorption and are assumed to have an ABS_{GI} of 1. When oral absorption is more than 50 percent, it is also assumed to have a value of 1. This assumption may lead to a slight underestimation of risk. The extent of the underestimation is inversely proportional to the actual oral absorption. Antimony, barium, cadmium, manganese, nickel, and vanadium are known to have limited oral absorption and their oral TRVs were adjusted to reflect absorbed dose prior to assessing dermal exposures.

The HHRA considers the potential for interactions between constituents and determines whether those interactions increase or decrease potential risks. For example, it is known that the interaction of mercury and selenium is antagonistic, i.e., the toxicity is reduced when both metals are present (Zhang et al. 2014), and uncertainties are discussed in Section 6.11.6.1.

Table 5-1. Toxicity Reference Values for Constituents of Potential Concern

COPC	Chronic Oral RfD mg/kg-day		Oral Slope Factor $(mg/kg\text{-}day)^{-1}$	Target Organs/Health Effects	Source[a]	Confidence in TRV(s)	ABS_{Gi}[b]
Aluminum	1.0		--	Nervous / CNS effects	ATSDR 2008	Low	1
Antimony	0.0004		--	Hematologic / longevity, blood glucose, cholesterol	USEPA IRIS	Low	0.15
Arsenic	0.0003		1.5	Noncancer: Cardiovascular, Dermal / hyperpigmentation, keratosis, possible vascular complications Cancer: Bladder, lung, liver, skin cancer	USEPA IRIS	Noncancer: Medium Cancer: Human Carcinogen	0.95
Barium	0.2		--	Urinary / nephropathy	USEPA IRIS	Medium	0.07
Cadmium	Non-diet	0.0005	--	Urinary / significant proteinuria	USEPA IRIS	High	0.05
	Diet	0.001					0.025
Chromium (III)	1.5		--	Other / No effects observed	USEPA IRIS	Low	0.013
Cobalt	0.0003		--	Endocrine / decreased iodine uptake	USEPA PPRTV	Low	1
Iron	0.7		--	Gastrointestinal / Gastrointestinal effects	USEPA PPRTV	NA	1
Lead	Adults	0.0013	--	Developmental, Nervous, Cardiovascular / increase of no more than 1 mmHg in average adult systolic blood pressure (adults) and decrease of 1 IQ point (infants and children)	Wilson et al. (2013)	NA	1
	Children <11 yrs	0.0005			Health Canada 2021b		
Lithium	0.002		--	Urinary / Adverse renal effects	USEPA PPRTV	Low-to-Medium	1

COPC	Chronic Oral RfD mg/kg-day		Oral Slope Factor (mg/kg-day)$^{-1}$	Target Organs/Health Effects	Source[a]	Confidence in TRV(s)	ABS_{GI}[b]
Manganese[c]	Non-diet	0.024	--	Nervous / CNS effects	USEPA IRIS	Medium	0.04
	Diet	0.14					
Methylmercury	0.0001		--	Nervous / Neurobehavioral, developmental	USEPA IRIS	High	1
Nickel, soluble	0.02		--	Developmental / Decreased body and organ weights	USEPA IRIS	Medium	0.04
Nitrate (As N)	0-6 mo. infant:	0.37	--	Hematologic / methemoglobinemia	0-6 mo. infant: Calculated for 0-6 mo. age-range based on USEPA IRIS	NA	1
	0-3 mo. infant:	1.6			0-3 mo. infant: USEPA IRIS		
Selenium	0.0057		--	Nervous, Hematological, Dermal / Selenosis (skin discoloration, nail deformation)	Health Canada 2021b	High	1
Thallium[d]	0.00007		--	Dermal / Alopecia (hair loss)	USEPA PPRTV	Low	1
Uranium	0.0006		--	Urinary / nephrotoxicity	Health Canada 2021b	NA	1
Vanadium[e]	0.005		--	Urinary / kidney histopathology	USEPA IRIS	Low	0.026
Zinc	0.3		--	Immune, Hematologic / decreases in erythrocyte copper, zinc-superoxide dismutase activity	USEPA IRIS	Medium/High	1

COPC	Chronic Oral RfD mg/kg-day	Oral Slope Factor $(mg/kg\text{-}day)^{-1}$	Target Organs/Health Effects	Source[a]	Confidence in TRV(s)	ABS_{Gi}[b]
Benzo(a)pyrene	0.0003	1	Developmental, Immune, Reproductive / Gastrointestinal tumors, neurobehavioral changes	USEPA IRIS	Noncancer: Medium Cancer: Probable human carcinogen	1

Notes:

[a] USEPA sources derived from either IRIS or PPRTV databases.

[b] Gastrointestinal absorption factors were obtained from USEPA (2004).

[c] Manganese TRV of 0.14 mg/kg-day accounts for all sources of exposures, including the diet, and is applied only to food items. The TRV for non-food items is calculated by subtracting the dietary contributions from the RfD and applying a modifying factor of 3, resulting in an RfD for non-food items of 0.024 mg/kg-day.

[d] Thallium TRV derived from EPA's previous references doses for thallium sulphates, thallium chloride, and thallium acetate. To account for the mass of the compounds, reference doses were modified by dividing the thallium atomic weight by the respective compounds' molecular weight and calculating a mean of the adjusted values.

[e] Vanadium TRV derived from reference dose from vanadium pentoxide by factoring out atomic weight of the oxygen. Vanadium pentoxide (V2O5) has a molecular weight of 181.88, where the two atoms of vanadium contribute 56% of the molecular weight. Vanadium pentoxide's RfD of 0.009 mg/kg-day multiplied by 56% gives an RfD of 0.005 mg/kg-day

ABS_{Gi} = chemical absorption factor gastrointestinal; ATSDR = Agency for Toxic Substances and Disease Registry; CNS = central nervous system; COPC = constituent(s) of potential concern; IQ = intelligence quotient; IRIS = Integrated Risk Information System; mmHg = milligram(s) of mercury; mg/kg-day = milligram(s) per kilogram per day; mo = month; NA= not available; RfD = reference dose; PPRTV = Provisional Peer Reviewed Toxicity Values for Superfund; TRV = toxicity reference value

6. RISK CHARACTERIZATION

The objective of risk characterization is to quantify health risks from exposure to COPCs present in surface water-associated media in the DA. To characterize risks, quantitative estimates of exposure and toxicity are combined to yield numerical estimates of potential health risk for noncarcinogenic and carcinogenic COPCs. Risks, or the potential for adverse effects to occur, are assessed by combining exposure estimates with TRVs using algorithms provided in Health Canada (2019, 2021a) guidance. Risks for threshold and non-threshold COPCs are presented separately. The results discussions focus first on those current exposure pathways directly influenced by water quality in Elk Valley and Koocanusa Reservoir: ingestion of groundwater as drinking water, contact with surface water and sediment while recreating or wading/foraging, and consumption of fish from within the DA. Then, risk results for the potential future ingestion of surface water as drinking water pathway are presented. Following these pathway discussions are the risk estimates for game, berries, and rose hips and comparisons to reference media. Then, there is an analysis of the impact on total risk from exposures via all Elk Valley media and market basket intakes.

Additional discussions are presented that provide context for risks, including consideration of uncertainties.

6.1 Noncancer Risk Calculations

Health risks other than cancer are characterized as the increased likelihood that an individual will suffer adverse health effects as a result of chemical exposure. To evaluate noncancer risks, the ratio of the average daily intake to the TRV is calculated. This ratio is referred to as the HQ. If the calculated value of the HQ is less than or equal to 1, no adverse health effects are expected. If the calculated value of the HQ is greater than 1, then further risk evaluation is needed. A comparison to 0.2 on an exposure pathway basis is provided as a preliminary step prior to accounting for exposure from multiple media, background, and multiple chemical interactions (Health Canada 2010a; 2010b; 2021a). The HQ was calculated for the ingestion/dermal and inhalation pathways using Equations 12 and 13:

Equation 12:

$$HQ = \frac{\text{Intake}}{\text{TRV}}$$

Where:

HQ	Hazard quotient associated with exposure to the COPC via the specified exposure route (dimensionless)
Intake	Estimated average daily intake of the COPC via the specified exposure route (mg/kg-day)
TRV	Toxicity reference value for the COPC (mg/kg-day)

To evaluate the effect of exposure to multiple constituents that act on the body in a similar manner, the HQs for each exposure pathway for individual COPCs are typically summed to determine a noncancer HI using Equation 13:

Equation 13:

$$HI = HQ_1 + HQ_2 + \ldots + HQ_i + \ldots$$

Where:

HI	hazard index
HQ_i	hazard quotient for COPC *i*

Hazard indices (HIs) for multiple COPCs are generally not summed if the reference doses for the COPCs are based on effects on different target organs. This is because the noncancer health risks associated with COPCs that affect different target organs are unlikely to be additive.

HQs and HIs are provided in Appendix H (provided electronically), Tables HQ-1 through HQ-14 and HI-1 through HI-3.

6.1.1 Prioritization of Hazard Quotients – Risk Ranking

Hazard quotients are prioritized (ranked) based on their magnitude relative to risk management thresholds, and for fish, game, berries, and rose hips, in comparison with risks at reference locations. The ranking approach applied here is consistent with guidance from Health Canada (2019) which emphasizes the importance of baseline conditions (e.g., reference and background diet), the magnitude of risks, and the uncertainties in risk estimates. In this HHRA, HQs equal to or less than 0.2 are considered negligible; HQs equal to or less than 1, or consistent with reference areas, are considered to have acceptable risks; and HQs greater than 1 and background require further evaluation and may require risk management. Although HQs cannot be directly linked to specific health effects, we assume that as HQs increase the potential for health risk increases. For this reason, exposure pathways and receptors with the highest HQs will be prioritized for data gathering and risk management, as needed.

6.2 Cancer Risks Calculations

Risks for non-threshold constituents are calculated by multiplying the dose by the TRV. The dose is based on the cumulative exposures occurring during all life stages and are averaged over a lifetime. Cancer risk is calculated as follows:

Equation 14:

$$\text{Cancer Risk} = \text{Dose} \times \text{SF}$$

Where:

Cancer Risk	Incremental probability of cancer associated with exposure to a COPC via the specified exposure route (dimensionless)
Dose	Estimated lifetime dose of the COPC via the specified exposure route (mg/kg-day)
SF	Cancer slope factor (i.e., TRV) for the COPC $(\text{mg/kg-day})^{-1}$

ENV and Health Canada consider cancer risks equal to or less than 1 in 100,000 (also noted as 1E-05) to be “essentially negligible” (Health Canada 2010a, 2021a). This level represents an incremental cancer risk above the baseline risks experienced by the population. The cancer risks are upper-bound estimates of excess potential cancer risk for lifetime exposure to COPCs. A number of assumptions were applied in the calculation of these risks, many of which are likely to overestimate exposure and toxicity. The actual cancer incidence is likely lower than the estimates presented here.

Cancer risk was calculated for all non-threshold COPCs in each MU and for valley-wide exposures to recreators and Ktunaxa. Cancer risks were calculated starting with the 7-month life stage for most exposure pathways (i.e., incidental ingestion of sediment and surface water while swimming) because they are not considered to be relevant exposures that a 0 to 6-month-old infant may experience. One exception to this is ingestion of groundwater and surface water as drinking water, where cancer risks are estimated beginning with the 0- to 6-month-old life stage.

Because cancer risks are assumed to be additive, risks associated with simultaneous exposure to more than one carcinogen in a given medium or across media are typically combined to estimate the total cancer risk associated with each exposure pathway (USEPA 1989). Health Canada (2010a; 2010b) specifies that cancer risks should be added only if they elicit similar effects on the same target organ. Arsenic and benzo(a)pyrene are the only carcinogens evaluated in this HHRA. Although arsenic and benzo(a)pyrene affect different organ systems, they are conservatively added together in cumulative cancer risk estimates, where applicable. Individual COPCs with cancer risks greater than 1E-05 are identified as COCs and may warrant further evaluation. All cancer risk results are provided in Appendix H, Tables CR-1 through CR-12.

6.2.1 Prioritization of Cancer Risks- Risk Ranking

Cancer risks are prioritized (ranked) similar to the ranking described for noncancer risks in Section 6.1.1, based on their magnitude relative to risk management thresholds, and for fish, game, berries, and rose hips, in comparison with risks at reference locations. Cancer risks are compared with Health Canada (2010) and ENV (2023) risk management thresholds. Specifically, cancer risks equal to or less than 1 additional cancer case in 100,000 are considered negligible; cancer risks consistent with reference areas are considered to have negligible risks; and cancer risks greater than 1 in 100,000 and risks in reference areas require further evaluation and risk management.

6.3 Noncancer Risk Estimates for Pathways Directly Related to Water Quality

HQs for direct contact with media affected by water quality within the DA are presented first, inclusive of ingestion of groundwater as drinking water, contact with surface water while recreating or performing traditional activities, and consumption of fish. Risks for fish consumption are evaluated separately from consumption of game, berries, and rose hips because, unlike terrestrial foods, fish may be directly influenced by changes in water quality and because water quality is the focus of Permit 107517 and this HHRA. Table 6-1 presents an overview of the COPCs by media where the most sensitive life stage (generally the toddler except for groundwater) exceeded an HQ of 0.2 in any MU. Detailed noncancer risk results showing HQ results by media, MU, and receptor for these pathways are in Appendix H Tables HQ-1 through HQ-10.

To understand the implications of potential use of surface water as drinking water and support future water resource management decisions, noncancer risks were estimated for infant (0-6 months) consumers in addition to the default Health Canada life stages within each MU and this is described in Section 6.5. As indicated in Section 6.5, surface water in MU-1 and MU-3 would have elevated risks if used as drinking water for infants due to nitrates.

Noncancer risks for exposure to COPCs in groundwater, surface water, sediment, and fish eggs (ovary) are generally negligible, most yielding HQs less than 0.2 except as follows. Noncancer risks for exposure to nitrate in surface water, as described above and further in Section 6.5, were greater than 0.2. Noncancer risks for current consumption of groundwater as drinking water were equal to or below an HQ of 0.2 for all COPCs except for lithium in MU-4 for the infant and toddler, where HQs were just slightly above the 0.2 threshold (HQ=0.25 for the infant and toddler life stages). Note the groundwater risk results presented here are on an MU-wide basis, an additional evaluation on a well-by-well basis, prepared at the request of the HHRA Workgroup, is presented in Section 6.3. Another relevant consideration is that the HHRA focused only on COPCs thought to be related to mining activities: not all water quality parameters that can adversely affect human health were considered. Moreover, water quality can change over time.

For all COPCs in all MUs, exposures via recreational contact or while wading/foraging in surface water result in negligible risks (HQ $\leq$ 0.2). Specifically, contact with surface water resulted in HQs at or below 0.01. Contact with sediment during recreational and traditional uses generally resulted in HQs $\leq$ 0.2. The one exception was contact with cobalt in sediment in MU-4 while foraging/wading, which resulted in HQs of 0.6 for a toddler, 0.4 for a child, and 0.3 for an adolescent. As discussed in the Uncertainty Assessment, the TRVs for cobalt and lithium are highly uncertain and provide overly conservative risk estimates. If proposed alternate TRVs (Ramboll 2021) for cobalt and lithium are applied, risk estimates for these media would be below an HQ of 0.2 (see discussion of the TRVs used in this HHRA in Section 5.1, and discussion of alternative TRVs in uncertainty sections 6.11.5.2.1, and 6.11.5.2.2). These alternate TRVs were only explored and discussed in the Uncertainty Assessment, risks results presented here utilize the current TRVs for cobalt and lithium recommended by ENV guidance. Preferred consumption of fish eggs, which was evaluated using fish ovary tissue, has negligible risk; HQs are less than 0.04 in all MUs for all COPCs and receptors.

Table 6-1. COPCs with HQs > 0.2 for Pathways Directly Related to Water Quality (Toddlers, Infants Only)

Analyte	All scenarios[b]				Fish		
	Groundwater[a]	Surface Water (Recreation)[b]	Sediment	Fish Egg/Ovary	Preferred Ktunaxa	Upper Percentile Ktunaxa and Recreator	Average Ktunaxa
Aluminum	NA		NA				
Antimony	NA		NA				
Arsenic	NA		NA				
Barium	NA		NA	NA	NA	NA	NA
Cadmium	NA		NA				
Chromium	NA	NA	NA				
Cobalt	NA		**X** (MU-4)[c]		**X** (MU-1-5)		
Iron							
Lead	NA		NA		**X** (MU-6)		
Lithium	**X** (MU-4)						
Manganese			NA	NA	NA	NA	NA
Mercury	NA	NA	NA		**X** (MU-1-6)	**X** (MU-2,3,5,6)	**X** (MU-6)
Nickel	NA		NA				
Selenium					**X** (MU-1-6)	**X** (MU-1-5)	**X** (MU-4)
Thallium	NA	NA	NA		**X** (MU-1-6)		
Uranium	NA		NA				
Vanadium	NA		NA				
Zinc	NA	NA	NA				
Benzo(a)pyrene	--	NA		--	--	--	--

Notes:

'X' = COPC/media where most sensitive life stage exceeded HQ of 0.2 in any MU.

Blank = all receptors had HQ ≤0.2.

NA = Constituent not identified as a COPC in specified medium

'--' = No data for COPC in specified medium.

[a] Most sensitive receptor for groundwater is infant life stage, in all other media toddler is the most sensitive.

[b] For incidental ingestion of surface water while recreating. Risks for ingestion of surface water as drinking water presented in Table 6-4.

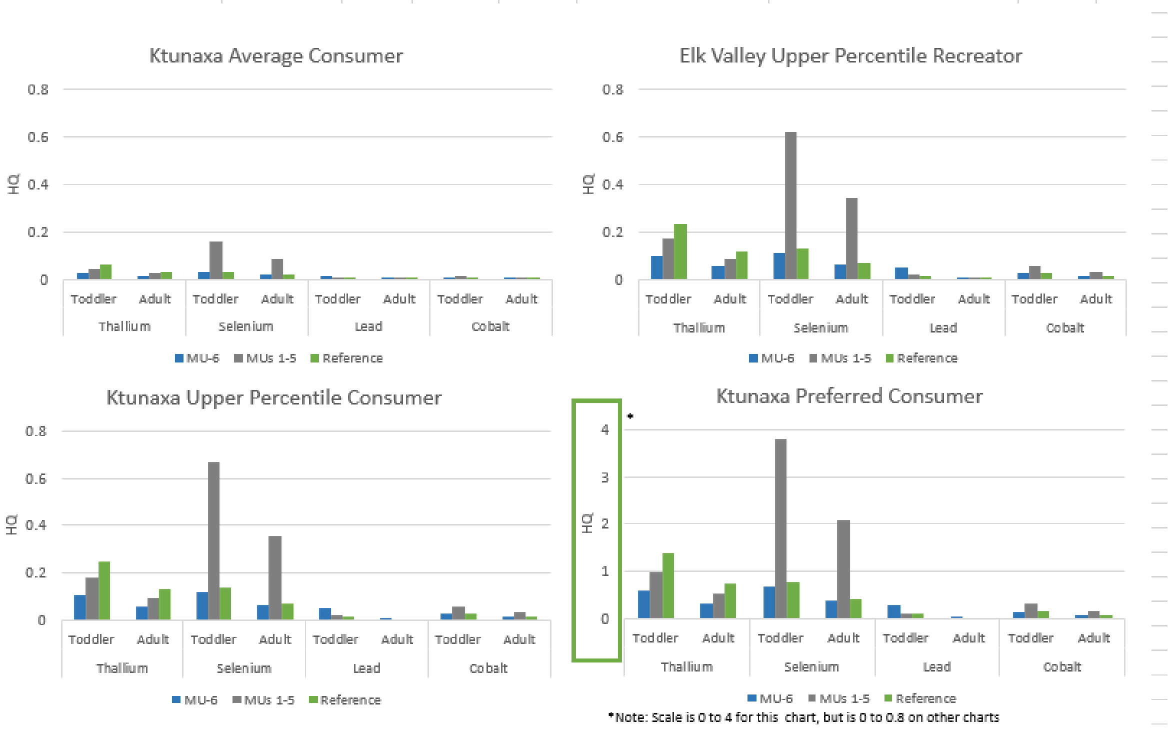
[c] HQ of 0.2 exceeded for cobalt in sediment only when wading/foraging exposure pathway is assessed, not swimming.

	All scenarios[b]	Fish
COPC = constituent(s) of potential concern; HQ = hazard quotient; MU = management unit		

6.3.1 Noncancer Risk Estimates for Fish

Consumption of fish (muscle tissue) yielded some HQs equal to or greater than 0.2 for cobalt, lead, mercury, selenium, and thallium in one or more MUs. Lead, cobalt, and thallium risks are above 0.2 only for the Ktunaxa preferred consumer. Figure 6-1 shows the range of cobalt, lead, selenium, and thallium. HQs for Ktunaxa toddlers and adults consuming fish at a range of consumption rates. Considering risks for preferred diet toddlers, hazards associated with lead are slightly above 0.2 (HQ=0.3) in MU-6 only; all other MUs are equal to or below an HQ of 0.2. HQs for cobalt range from 0.15 in MU-6 to 0.65 in MU-1 for the Ktunaxa preferred diet toddler. Thallium risks range from 0.6 in MU-6 to 1.3 in MU-3 and in MU-4 for the Ktunaxa preferred diet toddler. However, thallium risks are higher in reference fish than in any of the Elk Valley MUs for this receptor (HQ=1.4). Thus, although noncancer risks were above an HQ of 0.2 for lead, cobalt, and thallium, lead risks appear generally low, and cobalt and thallium risks are not unique to the Elk Valley. Figure 6-1 provides a visual representation of thallium, selenium, lead, and cobalt HQs for Ktunaxa preferred diet toddlers and adults consuming fish.

Figure 6-1. Elk Valley Fish HQs Comparison by Consumer (Toddler and Adult) and Location - Thallium, Selenium, Lead, Cobalt

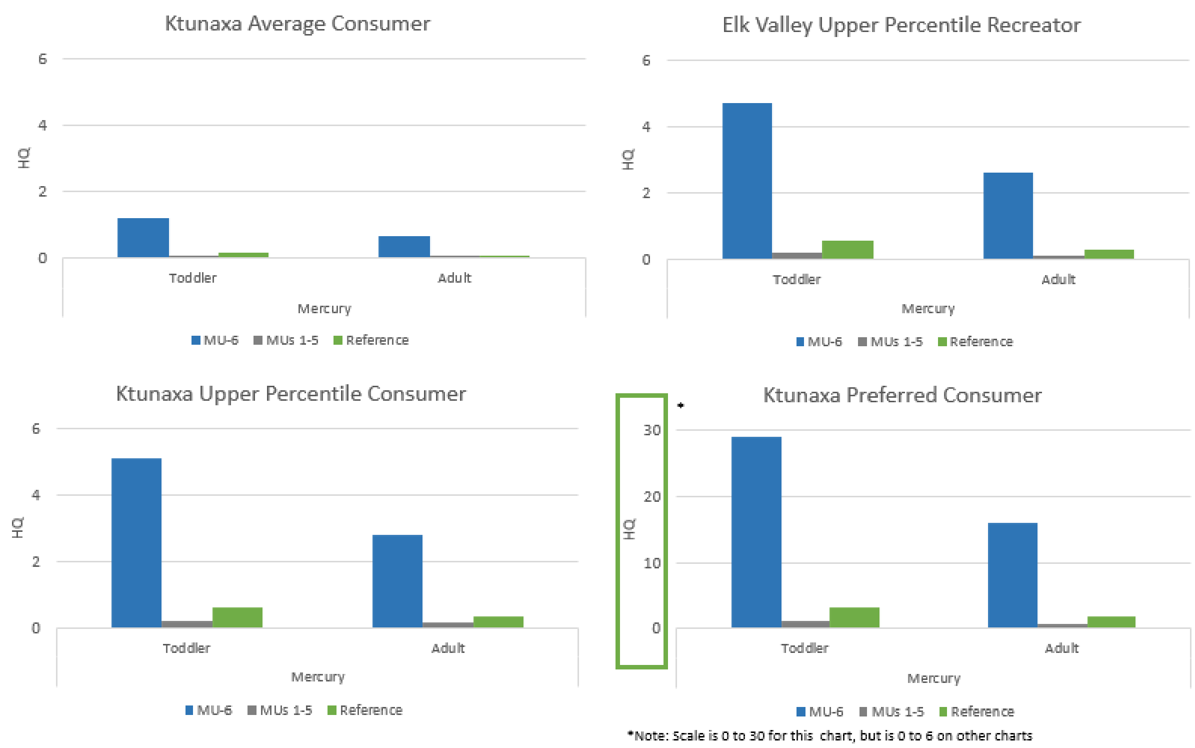


Risks calculated for consumption of selenium (MUs 1-5) and mercury (MU-6) in fish are above an HQ of 0.2 for all toddler receptors evaluated in at least one MU. Selenium HQs for toddlers range from 0.03 (average Ktunaxa consumer; MU-6) to 7.7 (preferred Ktunaxa consumer; MU-4). The majority of selenium HQs were below 0.2 for average Ktunaxa consumers but were greater than an HQ of 0.2 for Ktunaxa and recreator upper percentile consumers and preferred diet Ktunaxa consumers. Reference area selenium HQs also were greater than 0.2 for the Ktunaxa and recreator upper percentile consumers and preferred diet Ktunaxa consumers.

Mercury HQs for fish consumption were elevated in MU-6 compared to MUs 1-5 and Elk Valley reference fish. The Uncertainty Assessment provides more detail on mercury concentrations by fish species and compares mercury concentrations in MU-6 fish to fish in regional waterways (Section 6.11.3.1). Mercury HQs ranged from 1.2 (average toddler Ktunaxa consumer) to 29 (preferred diet

Ktunaxa consumer) in MU-6. HQs were sometimes above 0.2 in MUs 1-5, but were also above 0.2 in reference areas. Figure 6-2 shows the range of mercury HQs for consumption of fish by toddlers and adults.

Figure 6-2. Elk Valley Fish HQ Comparison by Consumer (Toddler and Adult) and Location - Mercury



6.3.2 Hazard Indices by Target Organ for Pathways Directly Related to Water Quality

To evaluate the effect of exposure to multiple constituents that act on the body in a similar manner, HQs for COPCs acting on the same target organ system were summed across exposure pathways. Target organ(s) of effect for the COPCs are shown in Table 5-9. Some COPCs such as selenium act on multiple organ systems, and thus risk estimates for those COPCs may be included in the sum under multiple target organ categories. When HQs are summed across multiple exposure pathways and media, the result is an HI which is compared to the risk management threshold of 1. Table 6-2 provides an overview of the target organ HIs that are above 1. Detailed target organ HIs are provided in Appendix H Table HI-3.

Table 6-2. HIs by Target Organ for Pathways Directly Related to Water Quality with HI>1 by MU

Target Organ (COPCs)	MU 1			MU 2			MU 3			MU 4			MU 5			MU 6		
	Pref	UP	Avg	Pref	UP	Avg	Pref	UP	Avg	Pref	UP	Avg	Pref	UP	Avg	Pref	UP	Avg
Dermal (Selenium, Thallium)	X			X			X			X	X		X					
Developmental (Mercury, Lead)																X	X	X
Endocrine (Cobalt)																		
Gastrointestinal (Iron)																		
Hematological (Selenium)	X			X			X			X	X		X					
Immune (Zinc)																		
Nervous (MUs 1-5: Selenium; MU 6: Mercury)				X	X					X	X		X			X	X	X
Urinary (Lithium)																		
Other (Chromium)																		

Notes:

'X' = most sensitive life stage (toddler) exceeded HI of 1 AND increment from reference >0.2.

Gray shading (only) = at least one receptor exceeded HI of 1, but risks are equal to (increment from ref <0.2) or less than background risks.

Blank = all receptors and life stages had target organ HI≤1.

Avg = average Ktunaxa consumer; COPC = constituent(s) of potential concern; HI = hazard index; MU = management unit; Pref = preferred diet Ktunaxa consumer; UP = upper percentile Ktunaxa and recreator consumer

Fish consumption contributes the most to total HIs. Where HIs exceed 1, the contribution from media other than fish is negligible. The driver for elevated HIs was either selenium or mercury. In most cases only the preferred diet resulted in HIs above 1, with the exception of the dermal and nervous system pathways in MU-4 (selenium) and the developmental and nervous system pathways in MU-6 (mercury), where the upper percentile Ktunaxa and recreator diets also yielded HIs above 1. HIs are equal to 1 (MU-6, rounded to one significant figure) or below 1 (MUs 1-5) for average Ktunaxa consumers. It is known that the interaction of mercury and selenium is antagonistic, i.e., the toxicity is reduced when both metals are present. Uncertainties are discussed in Section 6.11.6.1.

6.3.3 Consideration of Fish EPC Species Composition

In addition to the variation by diet, the fish selenium HQs vary by fish species and MU (Table 6-3, Figure 6-3). Note that the HQs in Table 6-3 and Figure 6-3 assume 100 percent of fish consumed is from the MU specified and for the species shown. Thus, the HQs may over- or underestimate risks depending on the species and location of fish consumed.

Despite this caveat, the species- and MU-specific HQs and EPCs provide insight into what species and locations have the highest selenium concentrations, what species and locations may pose the greatest potential risk to Elk Valley fish consumers if regularly consumed, and how species-specific risks compare to risks when all species are evaluated in aggregate. For example, the longnose sucker samples strongly influence the selenium EPC and HQ in MU-4 when combining the tissue data for all species, particularly since in MU-4, 40 percent of the fish samples are longnose sucker. The longnose sucker selenium EPC is 10.8 mg/kg ww in MU-4. The EPC for all fish combined in MU-4 is 5.3 mg/kg ww and the upper percentile HQ for toddlers is 1, but the EPC decreases to 1.7 mg/kg ww and the HQ to 0.3 when longnose sucker are excluded (Table 6-3, Figure 6-4). One-third of the longnose sucker samples in MU-4 come from one station, RG_GO13 (Goddard Marsh), which is an area known to be resident to longnose suckers that is not actively used by people for fishing and is directly downstream of sediment ponds just outside of the Elkview Mine permit boundary.

The selenium concentrations in Goddard Marsh longnose sucker range from 7 to 30 mg/kg ww, with an average concentration of 18 mg/kg ww, which is substantially higher than for other fish in Goddard Marsh as well as for other fish and longnose sucker sampled at other stations. Selenium concentrations in longnose sucker sampled in MUs 3 and 5 are somewhat elevated compared to other fish species in their respective MUs, but the EPCs are still in the range of other fish, suggesting localized effects for sucker in MU-4.

Teck's Active Water Treatment Facility (AWTF) at the Line Creek Operations released more bioavailable forms of selenium (e.g., selenite and organoselenium species) from 2016 through March 2018, which resulted in increased uptake of selenium in some fish located downstream of the AWTF during this time period. Local aquatic effects are documented in the Line Creek Local Aquatic Effects Monitoring Program Report, 2018 (Minnow 2019). The AWTF was fully shut down in March 2018 and recommissioned with an advanced oxidation process to remove the highly bioavailable selenium species, which commenced August 30, 2018. The AWTF release of bioavailable selenium species is likely responsible for the high-selenium concentrations observed in bull trout in MU-2 (selenium EPC = 6 mg/kg ww; Table 6-3) and is also believed to have led to enhanced selenium bioaccumulation in westslope cutthroat trout. Bull trout sampled in MU-2 in 2018 were located immediately downstream of the AWTF and were targeted for collection because they were primarily deceased (n=4). The average selenium concentration for bull trout sampled in MU-2 in 2018 was 9 mg/kg ww, which is significantly higher than the average selenium concentrations for bull trout sampled in 2017 (3 mg/kg ww) or 2019 (2 mg/kg ww). Because the advanced oxidation process installed at the AWTF has significantly shifted the selenium species discharged in effluent to a less bioavailable form (e.g., selenate), selenium concentrations in bull trout and westslope cutthroat trout are expected to decrease moving forward.

MFLNRORD regional fishing regulations such as access restrictions and daily catch quotas can reduce the potential for consumption of fish from the Elk Valley area by anglers. When these restrictions are considered, Elk Valley-sourced fish consumption is likely lower than the consumption rates used in this report, and as a result risks are also lower. Section 6.11.4.1 of the Uncertainty Assessment incudes an alternate analysis of selenium HQs by fish species that considers MFLNRORD restrictions.

Figure 6-3. Fish Consumption HQs for Selenium, Ktunaxa Preferred Diet (Toddler)

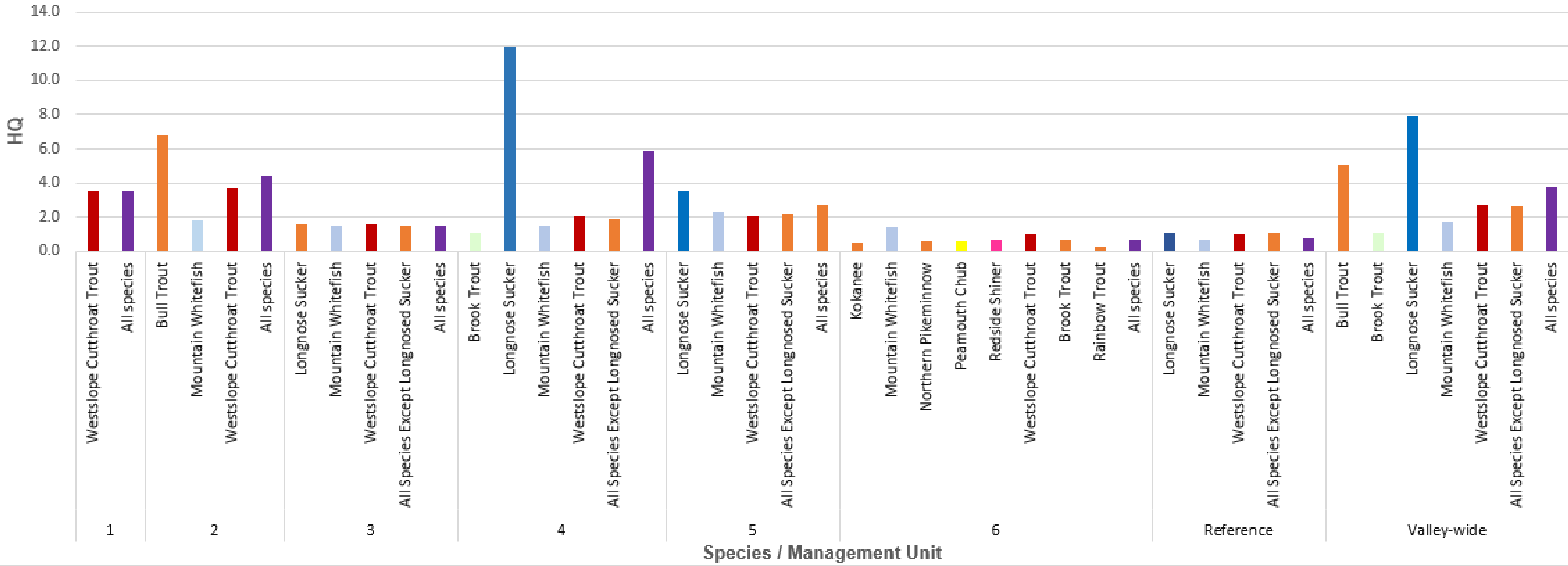


Figure 6-4. HQs for Selenium in Fish with and without Longnose Sucker (Ktunaxa Upper Percentile Consumer, Toddler and Adult)

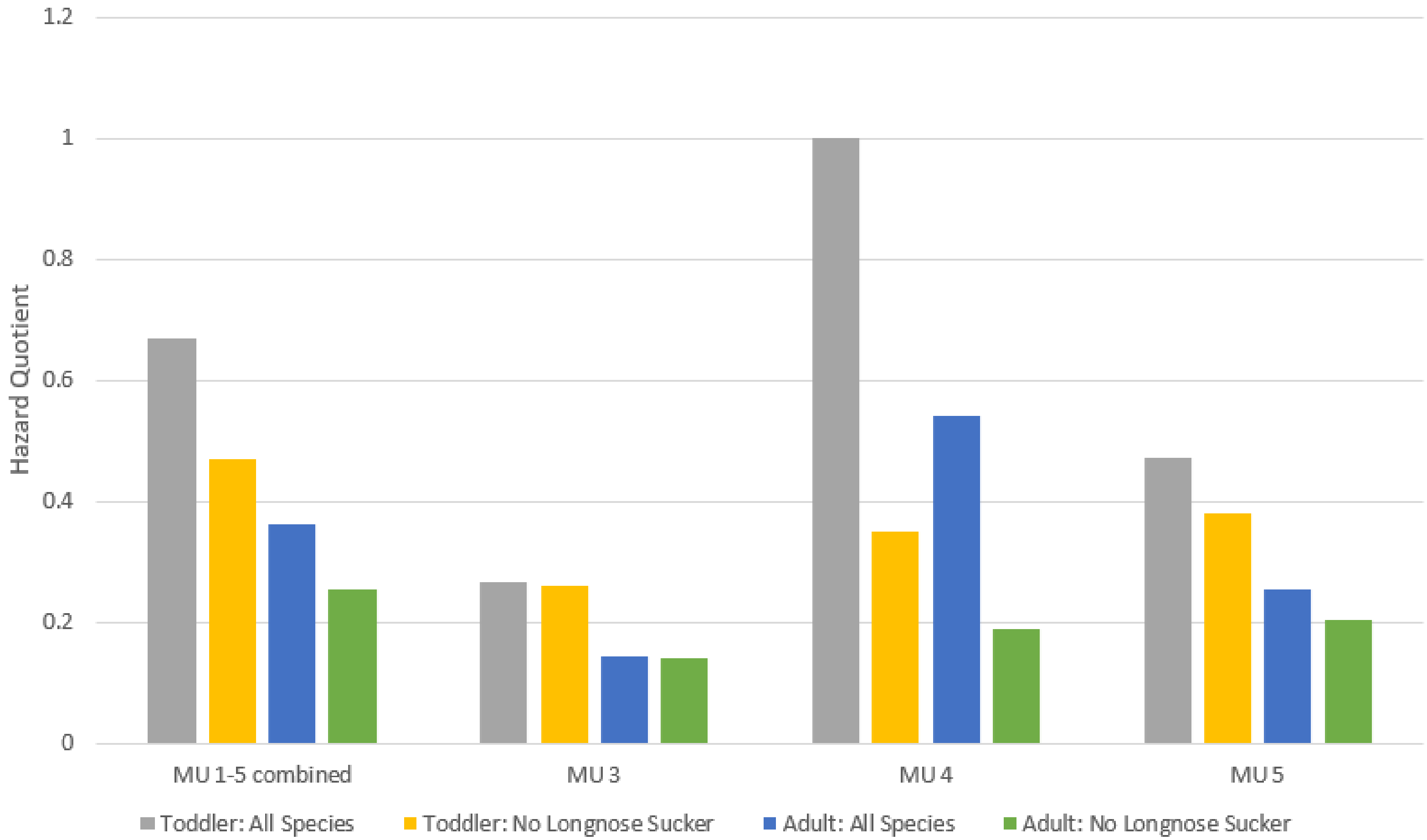


Table 6-3. EPCs and HQs for Selenium in Fish Tissue by Species and MU (Toddler and Adult)

MU	Species	Sample Count	Proportion of Fish Species in 'All Species EPC' [a]	EPCs (mg/kg ww)	HQ - Average Consumer - Ktunaxa		HQ - Upper Percentile Consumer - Ktunaxa		HQ - Upper Percentile Consumer - Recreator		HQ - Preferred Consumer - Ktunaxa	
					Toddler	Adult	Toddler	Adult	Toddler	Adult	Toddler	Adult
1	Westslope Cutthroat Trout	53	100%	3.14	0.2	0.08	0.6	0.3	0.6	0.3	3.5	1.9
	All Species	53	NA	3.14	0.2	0.08	0.6	0.3	0.6	0.3	3.5	1.9
2	Bull Trout	29	30%	6.03	0.3	0.2	1.2	0.6	1.1	0.6	6.8	3.7
	Mountain Whitefish	13	14%	1.61	0.08	0.04	0.3	0.2	0.3	0.2	1.8	1.0
	Westslope Cutthroat Trout	54	56%	3.29	0.2	0.08	0.6	0.4	0.6	0.3	3.7	2.0
	All Species	96	NA	3.90	0.2	0.1	0.8	0.4	0.7	0.4	4.4	2.4
3	Longnose Sucker	12	25%	1.46	0.07	0.04	0.3	0.2	0.3	0.1	1.6	0.9
	Mountain Whitefish	18	38%	1.30	0.06	0.03	0.3	0.1	0.2	0.1	1.5	0.8
	Westslope Cutthroat Trout	18	38%	1.41	0.07	0.04	0.3	0.2	0.3	0.1	1.6	0.9
	All Species	48	NA	1.34	0.06	0.03	0.3	0.1	0.2	0.1	1.5	0.8
	All Species (except Longnose Sucker)	36	75%	1.33	0.06	0.03	0.3	0.1	0.2	0.1	1.5	0.8
4	Brook Trout	1	<1%	0.96	0.05	0.03	0.2	0.1	0.2	0.1	1.1	0.6
	Longnose Sucker	53	38%	10.79	0.5	0.3	2.1	1.2	2.0	1.1	12.0	6.6
	Mountain Whitefish	22	16%	1.36	0.07	0.04	0.3	0.2	0.3	0.1	1.5	0.8
	Westslope Cutthroat Trout	64	46%	1.87	0.09	0.05	0.4	0.2	0.3	0.2	2.1	1.1
	All Species	140	NA	5.28	0.3	0.1	1.0	0.5	1.0	0.5	5.9	3.2
	All Species (except Longnose Sucker)	87	62%	1.78	0.08	0.04	0.3	0.2	0.3	0.2	1.9	1.0
5	Longnose Sucker	36	42%	3.11	0.15	0.08	0.6	0.3	0.6	0.3	3.5	1.9
	Mountain Whitefish	24	28%	2.04	0.10	0.05	0.4	0.2	0.4	0.2	2.3	1.2
	Westslope Cutthroat Trout	25	29%	1.88	0.09	0.05	0.4	0.2	0.3	0.2	2.1	1.1
	All Species	85	NA	2.39	0.11	0.06	0.5	0.3	0.4	0.2	2.7	1.4
	All Species (except Longnose Sucker)	49	58%	1.92	0.09	0.05	0.4	0.2	0.4	0.2	2.2	1.2
6	Kokanee	29	12%	0.49	0.02	0.01	0.1	0.05	0.09	0.05	0.6	0.3
	Mountain Whitefish	23	10%	1.25	0.06	0.03	0.3	0.1	0.2	0.1	1.4	0.8
	Northern Pikeminnow	108	46%	0.52	0.02	0.01	0.1	0.05	0.09	0.05	0.6	0.3
	Peamouth Chub	30	13%	0.53	0.03	0.01	0.1	0.05	0.1	0.05	0.6	0.3
	Redside Shiner	30	13%	0.58	0.03	0.01	0.1	0.06	0.1	0.06	0.7	0.4
	Westslope Cutthroat Trout	6	3%	0.91	0.04	0.02	0.2	0.10	0.2	0.09	1.0	0.6
	Bull Trout	5	2%	0.60	0.03	0.01	0.1	0.06	0.1	0.06	0.7	0.4
	Rainbow Trout	2	1%	0.26	0.01	0.01	0.05	0.03	0.05	0.03	0.3	0.2
	All Species	233	NA	0.62	0.03	0.02	0.1	0.07	0.1	0.06	0.7	0.4

MU	Species	Sample Count	Proportion of Fish Species in 'All Species EPC' [a]	EPCs (mg/kg ww)	HQ - Average Consumer - Ktunaxa		HQ - Upper Percentile Consumer - Ktunaxa		HQ - Upper Percentile Consumer - Recreator		HQ - Preferred Consumer - Ktunaxa	
					Toddler	Adult	Toddler	Adult	Toddler	Adult	Toddler	Adult
Reference	Longnose Sucker	13	20%	0.97	0.05	0.03	0.2	0.1	0.2	0.1	1.1	0.6
	Mountain Whitefish	38	58%	0.57	0.03	0.02	0.1	0.06	0.1	0.06	0.6	0.3
	Westslope Cutthroat Trout	14	22%	0.92	0.04	0.02	0.2	0.1	0.2	0.09	1.0	0.6
	All Species	65	NA	0.69	0.03	0.02	0.1	0.07	0.1	0.07	0.8	0.4
	All Species (except Longnose Sucker)	52	80%	0.63	0.03	0.02	0.1	0.1	0.1	0.06	0.7	0.4
MUs 1-5 combined	Brook Trout	1	0.2%	0.96	0.1	0.03	0.2	0.1	0.2	0.1	1.1	0.6
	Bull Trout	29	7%	4.25	0.2	0.1	0.9	0.5	0.8	0.5	5.1	2.7
	Longnose Sucker	101	24%	6.98	0.3	0.2	1.4	0.8	1.3	0.7	7.9	4.2
	Mountain Whitefish	77	18%	1.54	0.07	0.04	0.3	0.2	0.3	0.2	1.7	0.9
	Westslope Cutthroat Trout	214	51%	2.43	0.1	0.06	0.5	0.3	0.5	0.2	2.7	1.5
	All Species	422	NA	3.39	0.2	0.1	0.7	0.4	0.6	0.3	3.8	2.1
	All Species (except Longnose Sucker)	321	76%	2.33	0.1	0.06	0.5	0.2	0.4	0.2	2.6	1.4

Notes:

Reflects the proportion a fish species represents of the total fish sample only, not the proportion consumed or present in a MU. See Section 6.11.3.1.

[a] If it is assumed fish is consumed from all MUs (MUs 1-6), the selenium EPC for all species combined decreases to 2.4 mg/kg. HQs for the Ktunaxa preferred consumer become 2.7 for toddlers and 1.5 for adults. See Section 6.11.3.2 for additional discussion on risks associated with combining fish in MUs 1-5 vs MUs 1-6.

EPC = exposure point concentration; HQ = hazard quotient; MU = management unit; NA = not applicable

No shading in HQ columns indicates HQ ≤ 0.249

HQ > 0.249 (i.e., 0.2), but does not exceed 1.49 (i.e., 1)

HQ > 1

The following are some key findings shown in Table 6-3 regarding selenium:

- Fish represented in this dataset for the Elk Valley (MUs 1-5 combined) have selenium EPCs five times greater than in the reference samples (3.4 mg/kg ww for MU-1 through MU-5 combined in comparison with 0.69 mg/kg ww in reference).
- The highest selenium levels are found in fish collected in MU-4 (EPC of 5.3 mg/kg for all species combined), particularly Longnose Sucker (EPC of 10.8 mg/kg).
- Bull Trout in MU-2 (EPC of 6.03 mg/kg) and Longnose Sucker in MU-4 (EPC of 10.8 mg/kg) had the highest selenium concentrations.
- Risks associated with exposure to selenium through fish consumption are negligible (HQ=0.2 or less) for average fish consumers (4.5 g/day for toddlers and 10 g/day for an adult) in the Elk Valley (MUs 1-5 combined, all species combined).
- A higher risk of selenium exposure is identified for average consumers of Bull Trout in MU-2 (toddlers only) and Longnose Sucker in MU-4 (both toddlers and adults).
- Upper percentile fish consumers (43 g/day) catching fish from MU-1 through MU-5 have higher risks (HQ greater than 0.2) associated with selenium intake.
- The preferred rate of fish consumption for the Ktunaxa toddler will result in a higher risk of selenium exposure (HQ greater than 0.2) when consuming fish from the Elk Valley or from reference sites, but risk is 2-8 times greater when eating fish from the Elk Valley (i.e., all species combined HQs range from 1.5 in MU-3 to 5.9 in MU-4, and 0.7 in reference), with highest risks in MU-4.
- Risks for MU-6 for all consumption levels are the same as, or slightly lower than, risks for consuming fish from reference areas.

6.4 Cancer Risk Estimates for Pathways Directly Related to Water Quality

The following carcinogenic COPCs were evaluated in the HHRA for pathways directly related to water quality: arsenic in surface water, fish, and fish eggs, and benzo(a)pyrene in sediment. Detailed cancer risk estimates are presented in Appendix C, Tables CR-1 through CR-7. When cancer risks are summed across pathways (Appendix C, Table CR-12), risks are less than the ENV risk management threshold of 1E-05 for the Elk Valley recreator, average Ktunaxa, and upper percentile Ktunaxa consumers. Cancer risks are 2E-05 for preferred Ktunaxa consumers in most MUs (MU-1, 3, 4 and MU-6) and 1E-05 for MU-2, MU-5, and Valley Wide. Cancer risks are driven by fish consumption. When cancer risks for Elk Valley and reference fish are compared, cancer risks are the same or lower than reference (i.e., 2E-05 for Ktunaxa preferred consumers in reference, MU-1, 3, 4 and MU-6, less than 1E-05 for other consumers), indicating there is no additional cancer risk associated with consumption of Elk Valley fish.

6.5 Noncancer Risk Estimates for Ingestion of Surface Water as Drinking Water

Surface water within the DA is not a current municipal drinking water source, and concentrations of selenium in surface water frequently are greater than the WQC, as shown in Appendix C, Figure C-1. Additionally, surface water can contain microbiological contaminants (bacteria, viruses, and parasites) and industry-related substances and for this reason, IH recommends testing and treating surface water (from rivers, streams, or lakes) anywhere in the province before drinking it.

To understand the implications of potential use of surface water as drinking water and support future water resource management decisions, noncancer risks were estimated for infant (0-6 months) consumers in addition to the default Health Canada life stages within each MU. Although toddlers are typically the most sensitive life stage, infants who ingest formula reconstituted with surface water have similar or greater exposures to COPCs in surface water and thus are the most sensitive life stage.

As discussed in Section 4.2.2, an infant age 0 to 3 months old is also evaluated solely for the evaluation of nitrate in surface water. This exposure scenario is included to ensure that the risk to nitrate is adequately characterized for the most sensitive life stage, i.e., a newborn infant, to nitrate-induced methemoglobinemia. Risk results for the seasonal nitrate evaluation are presented in Section 6.5.1.

Table 6-4 provides an overview of the HQs for surface water COPCs other than nitrate that exceed 0.2 for the 0-6 month infant. Detailed noncancer risk results showing HQ results for all life stages are listed in Appendix H, Table HQ-2, and demonstrate that for surface water ingestion, the infant and toddler are the most sensitive life stages, and adults are the least sensitive to exposure. HQs for the 0-6 month infant were above 0.2 for lithium in MUs 1, 2, 3, and 4, for uranium in MU-3, and for selenium in MU-1 and MU-3. HQs were below 0.2 for all COPCs in MUs 5 and 6, indicating a low risk associated with exposure to COPCs in surface water in these MUs. HQs were below 1 in all MUs. HQs were less than 0.2 for adults for all COPCs except lithium in MU-3. Lithium TRV uncertainty is discussed in Section 6.11.5.2.2.

When HQs are summed across COPCs by target organ of effect for surface water as drinking water pathway, no target organ systems have an HI above 1. HI results for all target organ systems for this pathway are provided in Appendix H, Table HI-1.

Table 6-4. COPCs with HQs > 0.2 For Surface Water as Drinking Water Pathway (Toddler, Infant)

Analyte	MU-1	MU-2	MU-3	MU-4	MU-5	MU-6
Aluminum						
Antimony						
Arsenic						
Barium						
Cadmium						
Cobalt						
Iron						
Lead						
Lithium	X	X	X	X		
Manganese						
Nickel						
Selenium	X		X			
Uranium			X			
Vanadium						

Notes:
'X' = COPC where most sensitive life stage (0-6 month infant) exceeded HQ of 0.2.
Blank = all receptors and life stages had HQ ≤0.2.
COPC = constituent(s) of potential concern; HQ = hazard quotient; MU = management unit

6.5.1 Seasonal Nitrate Risk Characterization

Nitrate samples in surface water were collected multiple times throughout the year, allowing for analysis on a seasonal scale.[27] Seasons where nitrate concentrations are high may be of concern for infants at risk for blue baby syndrome (i.e., methemoglobinemia) if surface water is used to reconstitute formula. HQs were calculated for seasonal nitrate risk within each MU for 0 to 3 month and 0- to 6-month-old infants.

Seasonal nitrate EPCs were higher in MUs 1, 2, and 3 (range 7 to 26 mg/L) than in MUs 4, 5, and 6 (range 0.4 to 3 mg/L; see Appendix G for full EPC list). Because formula made with surface water would be the only source of nitrate exposure in an infant exposure scenario, an HQ of 1 is the appropriate indicator of risk for nitrate. HQs above 1 are identified in Table 6-5, detailed HQs are in Appendix H, Table HQ-3 including HQs greater than the screening level of 0.2. The HQs indicate nitrate exposure may sometimes be a risk (i.e., greater than an HQ of 1) for infants consuming surface water in MU-1 and MU-3. Risks peak during the January to March and October to December periods, and are lowest from April to June.

These results are consistent with the 2016 HHRA, which also identified potential risks from nitrate if infants were to regularly ingest surface water in MU-1 and MU-3. One additional season, July to September for MU-3, was found to have HQs greater than 1 when the 2021 HHRA dataset was

[27] Table C-1 provides a summary of nitrate samples by MU in comparison with screening values. A total of 7,318 nitrate samples were available with a range of samples per MU from 2,307 in MU-4 to 538 in MU-2.

used. When nitrate EPCs are compared between the 2016 and 2021 HHRA datasets[28], nitrate concentrations are generally consistent across years in MUs 1, 2, 5, and 6, but increased in MU-3 (2X increase) and decreased in MU-4 (3X decrease) in the 2021 dataset compared to the 2016 dataset. Also of note, nitrate EPCs increased about 6-fold in MU-3 and 2-fold in MU-1 in the January to March season in the 2021 dataset compared to the 2016 HHRA dataset. Other MUs also had increases in nitrate during January to March, indicating nitrate may be increasing during this season.

At present, residents of Elk Valley consume groundwater as their primary drinking water source and do not ingest surface water except incidentally through water recreation, or Ktunaxa may ingest surface water incidentally or intentionally. Consistent with the 2016 HHRA, our results indicate there would be potential health risk if infants were to regularly ingest surface water in MU-1 (January to March) and MU-3 (July to March).

Table 6-5. Seasonal HQs >1 for Nitrate in Surface Water as Drinking Water Pathway, 0 to Month and 0 to 6-Month Infants

MU	Season	HQ 0-3 month	HQ 0-6 month
MU-1	1: Jan-Mar	X	X
	2: April-June		
	3: July-Sept		
	4: Oct-Dec		
MU-2	1: Jan-Mar		
	2: April-June		
	3: July-Sept		
	4: Oct-Dec		
MU-3	1: Jan-Mar	X	X
	2: April-June		
	3: July-Sept	X	X
	4: Oct-Dec	X	X
MU-4	1: Jan-Mar		
	2: April-June		
	3: July-Sept		
	4: Oct-Dec		
MU 5	1: Jan-Mar		
	2: April-June		
	3: July-Sept		
	4: Oct-Dec		
MU 6	1: Jan-Mar		
MU 6	2: April-June		

[28] The 2016 HHRA dataset consists of surface water data collected from early 2014 through January 2016, and the 2021 dataset includes data collected from late 2015 through July 2020.

MU	Season	HQ 0-3 month	HQ 0-6 month
	3: July-Sept		
	4: Oct-Dec		
Notes: MU = management unit; HQ = hazard quotient			

6.6 Cancer Risk Estimates for Ingestion of Surface Water as Drinking Water

Arsenic in surface water was evaluated for potential cancer risk if regularly consumed as drinking water over a lifetime. Cancer risks were equal to or below the ENV risk management threshold of 1E-05 in all MUs except MU-6, which had a risk of 2E-05 (Appendix H, Table CR-1).

6.7 Contributions to Noncancer Risk Estimates from Game, Berries, and Rose Hips

This section summarizes risk estimates related to consumption of berries, rose hips, and game meat and organs. Although samples of game and berries were collected from most individual MUs, samples sizes were small in some areas making resulting risk estimates less reliable. Consequently, the focus of this summary is on area wide (MUs 1 through 6) risk estimates. Appendix H, Tables HQ-10 through HQ-14, provide detailed HQs for consumption of game, berries, and rose hips in each of the MUs, valley-wide, and in reference areas.

6.7.1 Contributions to Noncancer Risk Estimates from Berries and Rose Hips

As described in Section 4.2.6, risks associated with consumption of berries were estimated based on consumption of berries at the following consumption rates:[29] preferred (208 g/day), upper percentile (206 g/day) and average rates (85 g/day) and consumption of rose hips at the following rates: preferred (5 g/day), upper percentile (31 g/day) and average rates (4.5 g/day). Table 6-6 presents an overview of the COPCs by medium where the most sensitive life stage (toddler) exceeded an HQ of 0.2 in any MU and in reference areas. Appendix H, Tables HQ-11 and HQ-14, show HQs associated with consumption of berries and rose hips harvested from within each of the individual MUs, valley-wide, and at reference locations. EPCs for COPCs in MUs and reference areas are summarized in Appendix G, Table G-7, for berries and in Appendix G, Table G-8, for rose hips.

Table 6-6 summarizes COPCs where the HQs are greater than 0.2 for the most sensitive life stage for consumption of berries and rose hips. For consumption of berries, aluminum, barium, cobalt, iron, lead, manganese, nickel, selenium, and vanadium all have HQs greater than 0.2. Many COPCs have similar or higher HQs in reference areas, as discussed in Sections 6.7.3 and presented in Table 6-6 and in Appendix H tables HQ-11 and HQ-14. If an alternate TRV for cobalt is applied, the cobalt HQs would decrease to less than 0.2 (see the Uncertainty Assessment TRV discussion in Section 6.11.5.2.1). Consumption of rose hips at the upper percentile rate had an HQ greater than 0.2 for manganese, but not for any other COPC. There are no HQs greater than 1 for rose hips in any MU or in the area wide estimates.

No HQs are greater than 1 for consumption of berries in the valley-wide exposure estimates. As shown in Appendix H, Table HQ-11, manganese HQs were equal to 2 for toddlers consuming berries at the preferred and upper percentile rate in MU-4, which indicates a potential for adverse effects. Manganese is discussed further in Section 6.11.4.5. HQs were equal to or less than 1 for all other age groups and MUs. In summary, while HQs were greater than 0.2 for many COPCs for toddlers consuming berries at preferred or upper percentile levels, many of the COPCs were also

[29] As described in Section 4.2.6, the same consumption rate was applied to all life stages for berries and rose hips.

greater than 0.2 in reference areas and would not be expected to be associated with adverse effects.

Table 6-6. COPCs with HQs > 0.2 in Any MU for Consumption of Berries and Rose Hips (Toddler)

Analyte	Berry			Rose Hips		
	Preferred	Upper Percentile [a]	Average [a]	Preferred	Upper Percentile	Average
Aluminum	**X** (MU-2,4,5)	**X** (MU-2,4,5)	**X** (MU-4)			
Antimony[a,b,c]						
Arsenic[c]						
Barium	**X** (MU-2-6)	**X** (MU-2-6)	**X** (MU-5,6)			
Cadmium[a]	**X** (MU-3,4,5)	**X** (MU-3,4,5)				
Cobalt	**X** (MU-1-6)	**X** (MU-1-6)	**X** (MU-1,4)			
Iron	**X** (MU-2,4,5)	**X** (MU-2,4,5)	**X** (MU-4)			
Lead	**X** (MU-4,5)	**X** (MU-4,5)	**X** (MU-4)			
Lithium[a,b,c]						
Manganese	**X** (MU-1-6)	**X** (MU-1-6)	**X** (MU-1,3,4,5,6)		**X** (MU-2,4,5)	
Nickel	**X** (MU-1,2,4,5)	**X** (MU-1,2,4,5)				
Selenium	**X** (MU-2,6)	**X** (MU-2,6)	**X** (MU-2)			
Uranium[a]						
Vanadium	**X** (MU-4)	**X** (MU-4)	**X** (MU-4)			

Notes:
[a] Includes Ktunaxa and recreator consumers.
[b] No risk results for rose hips in reference areas
[c] No risk results for berries in reference areas
'X' = most sensitive life stage (toddler) exceeded HQ of 0.2 in any MU.
Blank = all receptors had HQ $\leq$ 0.2.
Shaded = Grey ( ) HQ > 0.2 in reference areas for toddlers
COPC = constituent(s) of potential concern; HQ = hazard quotient; MU = management unit

6.7.2 Contributions to Noncancer Risk Estimates from Game Meat and Organs

As described in Section 4.2.7, risks associated with consumption of game meat (muscle) were estimated based on consumption at the following rates for adults: preferred (628 g/day), upper percentile (324 g/day) and average rates (83 g/day) and consumption of game organs at the following rates: preferred (27 g/day), upper percentile (54 g/day) and average rates (10 g/day). Table 6-7 provides a summary of COPCs with HQs greater than 0.2 for consumption of game meat and organs in any MU. Appendix H, Tables HQ-12 and HQ-13, show HQs associated with consumption of game muscle and organ harvested from within each of the individual MUs, valley-wide, and at reference locations.

Table 6-7. COPCs with HQs > 0.2 in Any MU for Consumption of Game Meat and Organs (Toddler)

Analyte	Game Meat			Game Organ		
	Preferred	Upper Percentile [a]	Average [a]	Preferred	Upper Percentile [a]	Average [a]
Aluminum	**X** (MU-1,4)	**X** (MU-4)				
Antimony[b,c]						
Arsenic						
Barium						
Cadmium				**X** (MU-1,4,6)	**X** (MU-1,4,6)	**X** (MU-1,4,6)
Cobalt	**X** (MU-1,2,4,6)	**X** (MU-2,4,6)				
Iron	**X** (MU-1-6)	**X** (MU-1-6)		**X** (MU-1,2)	**X** (MU-1- 6)	
Lead	**X** (MU-1,4,5)	**X** (MU-1,4,5)		**X** (MU-4)	**X** (MU-4)	**X** (MU-4)
Lithium[b]	**X** (MU-1)	**X** (MU-1)				
Manganese						
Nickel[c]	**X** (MU-2)					
Selenium	**X** (MU-1-6)	**X** (MU-1,2,4,6)			**X** (MU-1,4)	
Uranium[b,c]						
Vanadium[c]						

Notes:

[a] Includes Ktunaxa and recreator consumers.

[b] No risk results for game meat in reference areas

[c] No risk results for game organ in reference areas

'X' = most sensitive life stage (toddler) exceeded HQ of 0.2 in any MU.

No game tissue samples were taken from MU-3.

Blank = all receptors had HQ $\leq$ 0.2.

Shaded = Grey (▢) HQ > 0.2 in reference areas for toddlers.

COPC = constituent(s) of potential concern; HQ = hazard quotient; MU = management unit

As shown in Table 6-7, there are no HQs greater than 0.2 associated with average consumption rates of game muscle. At the preferred and upper percentile consumption rates for game muscle, aluminum, cobalt, iron, lead, lithium, nickel, selenium, and vanadium all have HQs greater than 0.2. However, cobalt and lithium HQs would fall below 0.2 if alternate TRVs are used as described in Uncertainty Assessment Sections 6.11.5.2.1 and 6.11.5.2.2. Consumption of game organs is associated with HQs greater than 0.2 for cadmium and lead in the preferred, upper percentile and average consumption rates. Iron has a HQ greater than 0.2 for the preferred and upper percentile rate, and selenium has a HQ greater than 0.2 at the upper percentile consumption rate. Many

COPCs have similar or higher HQs in reference areas, as discussed in Section 6.7.3 and presented in Appendix H, Tables HQ-12 and HQ-13.

No HQs are greater than 1 for consumption of game muscle or organs in the valley-wide exposure estimates. The lead HQ for consumption of game muscle was equal to 2 in MU-5. While consumption of organ meat at the upper percentile level was associated with HQs equal to 2 for cadmium in MU-1, MU-4, and MU-6 and for lead in MU-4, HQs were also equal to 2 in the reference area. HQs were equal to or less than 1 for all other COPCs and MUs. As described above, HQs from individual MUs are less reliable than those from the valley-wide area due to small sample sizes in the MUs.

6.7.3 COPC-Specific Noncancer Risk Estimates from Combined Consumption of Berries, Game Meat, and Game Organs

COPC-specific HIs were calculated for the Ktunaxa toddler assuming that one individual could consume berries, rose hips, game organ, and game meat at the upper percentile consumption rates for each of these resources. Specifically, the toddler was assumed to consume 206 g/day of berries, 31 g/day of rose hips, 98.4 g/day of game muscle, and 16.4 g/day of game organ meat sourced valley-wide. To derive HIs, the HQs for each food item for a given COPC was combined. Table 6-8 shows COPC-specific HIs for the Ktunaxa toddler upper pecentile consumer for foods consumed valley-wide and in reference areas. HQs for many COPCs were greater than 0.2 for an individual food item, but the HIs based on all foods combined were equal to or less than one. Exceptions are cadmium and lead, which had HIs greater than one in reference areas.

Table 6-8. HIs for the Toddler Upper Percentile Consumer for Consumption of Berries, Rose Hips, Game Muscle, and Game Organs

Chemical	Elk Valley-wide	Reference
Aluminum	0.4	0.4
Barium	0.6	0.5
Cadmium	1	3
Cobalt	1	1
Iron	1	1
Lead	2	2
Lithium	0.3	NA
Manganese	1	1
Nickel	0.3	0.2
Selenium	1	0.4
Uranium	0.08	NA
Vanadium	0.3	0.2

Notes:

NA= could not be calculated because chemical either not analyzed or not detected in two or more reference media.

Antimony and arsenic not shown because results primarily (>50%) non-detect.

Lower hazard indices observed for average consumer, higher HIs observed for preferred consumer.

See Figure 3-6 and Table 3-4 for further detail on samples outside of the DA used as reference locations.

DA = designated area; HI = hazard index

6.7.4 Hazard Indices by Target Organ for Consumption of Berries, Game Meat and Game Organs

HIs also were generated by summing valley-wide HQs across food types for COPCs that act on the same target organ system. HIs were calculated assuming that one individual could consume berries, rose hips, game organ, and game meat from the same location at the preferred, upper percentile, or average consumption rates for each of these resources. This analysis included all COPCs; COPCs that contributed the most to each target organ system HI are listed in Table 6-9. For foods collected valley-wide, Table 6-9 indicates that berries, organ meat and rose hips can be consumed at any of the rates considered in the HHRA and all foods can safely be consumed at average consumption rates. Consumption rates are summarized in Table ES-2, Table 4-6, Table 4-7, and Table 4-8, and include the following average consumption rates: fish 10 g/day or 15 meals a year; game 82 g/day, or 123 meals per year; game organs 10 g/day or 14 meals per year; berries 85 g/day. Selenium is the greatest contributor to wild food HIs. Detailed results are shown in Appendix H, Table HI-2.

Table 6-9. HIs by Target Organ for Valley-wide Consumption of Berries, Rose Hips, Game Meat, and Game Organs

Target Organ (COPCs)	Berries			Game muscle			Game organ			Rose hips			Sum of Wild Foods		
	Pref	UP	Avg	Pref	UP	Avg	Pref	UP	Avg	Pref	UP	Avg	Pref	UP	Avg
Dermal (Selenium, Vanadium)				X									X	X	
Developmental (Lead, Nickel)															
Endocrine (Cobalt)															
Gastrointestinal (Iron)															
Hematological (Selenium)													X		
Nervous (Manganese, Selenium, Aluminum)													X	X	
Urinary (Barium, Cadmium, Lithium)															

Notes

'X' = most sensitive life stage (toddler) exceeded HI of 1 AND exceeded reference HI by increment of >0.2.

Gray shading (only) = at least one receptor exceeded HI of 1, but risks are equal to or less than background risks.

Blank = all receptors had HI $\leq$ 1.

Avg = average Ktunaxa or recreational consumer; COPC = constituent(s) of potential concern; HI = hazard index; Pref = preferred diet Ktunaxa consumer; UP = upper percentile Ktunaxa and recreator consumer

6.8 Contributions to Cancer Risk Estimates from Game, Berries, and Rose Hips

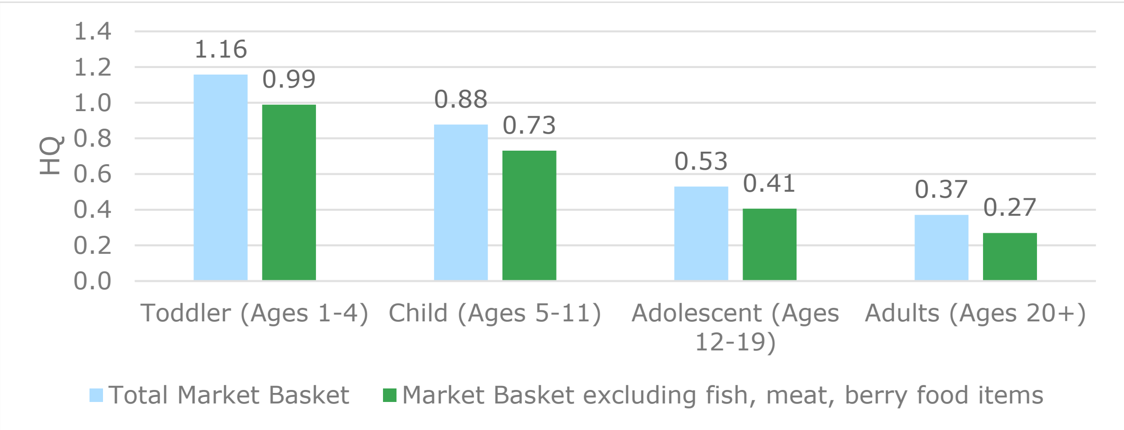
Cancer risk estimates for game, berries, and rose hips were based on exposures to arsenic, the only carcinogenic COPC identified. As shown in appendix H table CR-11, when cancer risks are summed across wild plant/game pathways, risks were less than or equal to 1E-05 for all consumers valley-wide and in all MUs. Cancer risks were driven by berry consumption, even though arsenic in berries was primarily non-detect (only detected in 14 percent of berry samples valley-wide). Because arsenic was only detected in one berry reference sample, reference risks were not calculated.

6.9 Selenium Market Basket Evaluation

As described in the exposure assessment section, selenium present in commercial foods and tap water (i.e., the market basket) contributes to selenium exposure. In addition to evaluation of selenium in foods harvested from Elk Valley, exposure to selenium in commercial dietary items also was evaluated to understand the relative contributions from mine-related and non-mine-related exposures to total selenium intake. Exposure estimates were calculated for selenium in the Canadian diet through use of all available data from Canadian cities except the 2012 data for Vancouver, which was excluded because it was identified as potentially unrepresentative (see explanation in Section 4.3). Market basket estimates were calculated for all foods and for the market basket intake after excluding foods similar to those evaluated in the HHRA (fish, animal meat, and berry food items).

HQs were calculated for intake of selenium in a conventional Canadian diet as the ratio of selenium dietary intake to the selenium TRV. Figure 6-5 shows HQs, by age group provided in the Canada Diet Study,[30] for both all market basket foods and the market basket excluding fish, animal meats, berries, and tap water. Cumulative exposure estimates including surface water intake for Ktunaxa receptors are shown in the next section. All HQs for selenium in market basket food estimates are greater than 0.2 and HQs round to 1 for many estimates. The finding that selenium is present in market basket foods at levels generating an HQ at or greater than the preliminary ENV and Health Canada risk management threshold of 0.2 provides helpful perspective in considering HQs for foods from Elk Valley. Although hazards related to selenium cannot be completely avoided because selenium occurs naturally in a wide range of dietary items, regardless of source, additional measures to reduce contributions of selenium to the environment from mining are likely to reduce total exposures.

Figure 6-5. HQs for Selenium Based on Canadian Market Basket Intake and Concentrations in Canadian Cities



6.10 Cumulative Noncancer Risks

Selenium HQs for all dietary items combined with HQs for foods harvested from Elk Valley provide an estimate of cumulative risks for Elk Valley residents. Cumulative risks across all pathways and

[30] HQs calculated based on Health Canada intake amounts for foods and the average of selenium concentrations in market basket foods from the following datasets: Calgary 2009, Halifax 2006, Quebec City 2016, Toronto 2005, and Vancouver 2007.

receptors[31] were generated for selenium only and include risks associated with market basket foods. Table 6-10 and Figure 6-6 present cumulative risks by consumer across all pathways for the toddler and adult life stage based on valley-wide[32] exposures. Cumulative risks for all life stages are shown in Appendix I. Cumulative HIs are 2 for the average recreator and average Ktunaxa consumers, 3 for upper percentile Ktunaxa and recreator consumers, and 7 (6.6) for preferred diet Ktunaxa consumers. As is apparent in Figure 6-6 and Table 6-10, HIs for cumulative exposures are largely attributable to consumption of fish, market basket foods, game, berries, and rose hips. While fish consumption is a primary contributor to risks, contributions from other water quality-related pathways are negligible including: groundwater as drinking water; surface water as drinking water; and ingestion of or dermal contact with sediment and surface water. To streamline results, subsequent figures exclude the non-food aquatic pathways and focus on market basket, fish, and other foods pathways. In addition, in response to comments from reviewers, the cumulative risk estimates also include surface water as drinking water for Ktunaxa receptors.[33,34] Figure 6-7, Figure 6-8, Figure 6-9, Figure 6-10, and Figure 6-11 compare selenium risks for average market basket, reference area foods,[35] and Elk Valley-sourced foods for average recreators, average Ktunaxa, upper percentile recreators, upper percentile Ktunaxa, and preferred diet Ktunaxa consumers, respectively.

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[31] In Figures 6-6 and 6-7, and Table 6-10, the average recreator uses Canadian high consumer fish consumption rate (40 g/day) and Ktunaxa average consumer rates for berries, game meat, and game organ.

[32] Valley-wide incorporates all data from MUs 1-5 for aquatic pathways (fish fillet, fish eggs, groundwater, sediment, surface water) and all data from MUs 1-6 for game muscle, game organ, berries, and rose hips, as available.

[33] Because fish eggs (ovary) were only evaluated for preferred consumers and were a minor contributor to total HI, they are also excluded from subsequent figures.

[34] Although it is noted that surface water should not be consumed prior to treatment due to the presence of biological contaminants, a surface water as drinking water pathway is provided here to evaluate selenium in surface water for Ktunaxa receptors at the request of commentors.

[35] See Figure 3-6 and Table 3-4 for further detail on samples outside of the DA which are used as reference locations.

Figure 6-6. Cumulative Selenium HI by Consumer, Valley-wide (Toddler and Adult)

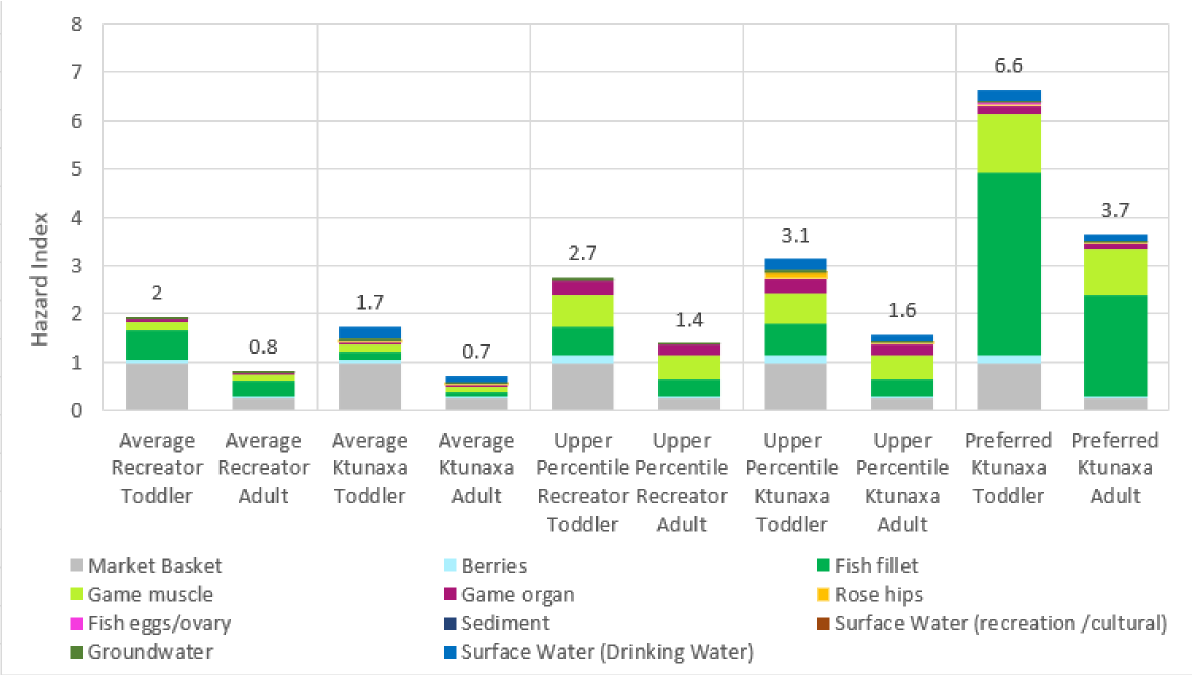


Table 6-10. Cumulative Selenium HI by Consumer, Valley-Wide [a] (Toddler and Adult Life Stage)

	HQs									
Media	**Average Recreator [b]**		**Average Ktunaxa**		**Upper Percentile Recreator [c]**		**Upper Percentile Ktunaxa**		**Preferred Ktunaxa**	
	Toddler	Adult	Toddler	Adult	Toddler	Adult	Toddler	Adult	Toddler	Adult
Market Basket [d]	1	0.3	1	0.3	1	0.3	1	0.3	1	0.3
Fish fillet	0.6	0.3	0.2	0.1	0.6	0.3	0.7	0.4	4	2
Game muscle	0.2	0.1	0.2	0.1	0.6	0.5	0.6	0.5	1	0.9
Game organ	0.06	0.04	0.06	0.04	0.3	0.2	0.3	0.2	0.2	0.1
Berries	0.06	0.01	0.06	0.01	0.1	0.03	0.1	0.03	0.1	0.03
Rose hips	NE	NE	0.02	0.004	NE	NE	0.1	0.03	0.02	0.004
Fish eggs/ovary	NE	NE	NE	NE	NE	NE	NE	NE	0.03	0.02
Groundwater [e]	0.05	0.03	0.05	0.03	0.05	0.03	0.05	0.03	0.05	0.03
Sediment [f]	0.004	0.001	0.004	0.001	0.004	0.001	0.004	0.001	0.004	0.001
Surface Water (Recreation / cultural) [g]	0.003	0.0003	0.003	0.0003	0.003	0.0003	0.003	0.0003	0.003	0.0003
Surface water / drinking water [h]	NA	NA	0.2	0.1	NA	NA	0.2	0.1	0.2	0.1
Cumulative HI	**2**	**0.8**	**2**	**0.7**	**3**	**1**	**3**	**2**	**6.6**	**3.6**

Notes:

[a] Valley-wide incorporates all data from MUs 1-5 for aquatic pathways (fish fillet, fish eggs, groundwater, sediment, surface water) and all data from MUs 1-6 for game muscle, game organ, berries, and rose hips, as available.

[b] Average recreator uses Canadian high consumer fish consumption rate (40 g/day) and Ktunaxa average consumer rates for berries, game meat, and game organ.

[c] Upper percentile recreator uses Canadian high consumer fish consumption rate (40 g/day) and Ktunaxa upper percentile consumer rates for berries, game meat, and game organ.

[d] Excludes fish, meat, and berry food items

[e] Assumes groundwater consumed as drinking water

[f] For wade/forage pathway

[g] For swimming in Elk River pathway

[h] Although it is noted that surface water should not be consumed prior to treatment due to the presence of biological contaminants, a surface water as drinking water pathway is provided here to evaluate selenium in surface water for Ktunaxa receptors at the request of commentors.

g/day = gram(s) per day; HI = hazard index; HQ = hazard quotient; MU = management unit; NA = not appliable; NE = not evaluated

Figure 6-7. Selenium Hazard Index for the Average Recreator Toddler and Adult: Reference vs Elk Valley[36]

[36] Stacked bar charts are shown to one significant figure, so bars may have the same number but look slightly different due to rounding.

Figure 6-8. Selenium Hazard Index for the Average Consumer Ktunaxa Toddler and Adult: Reference vs Elk Valley

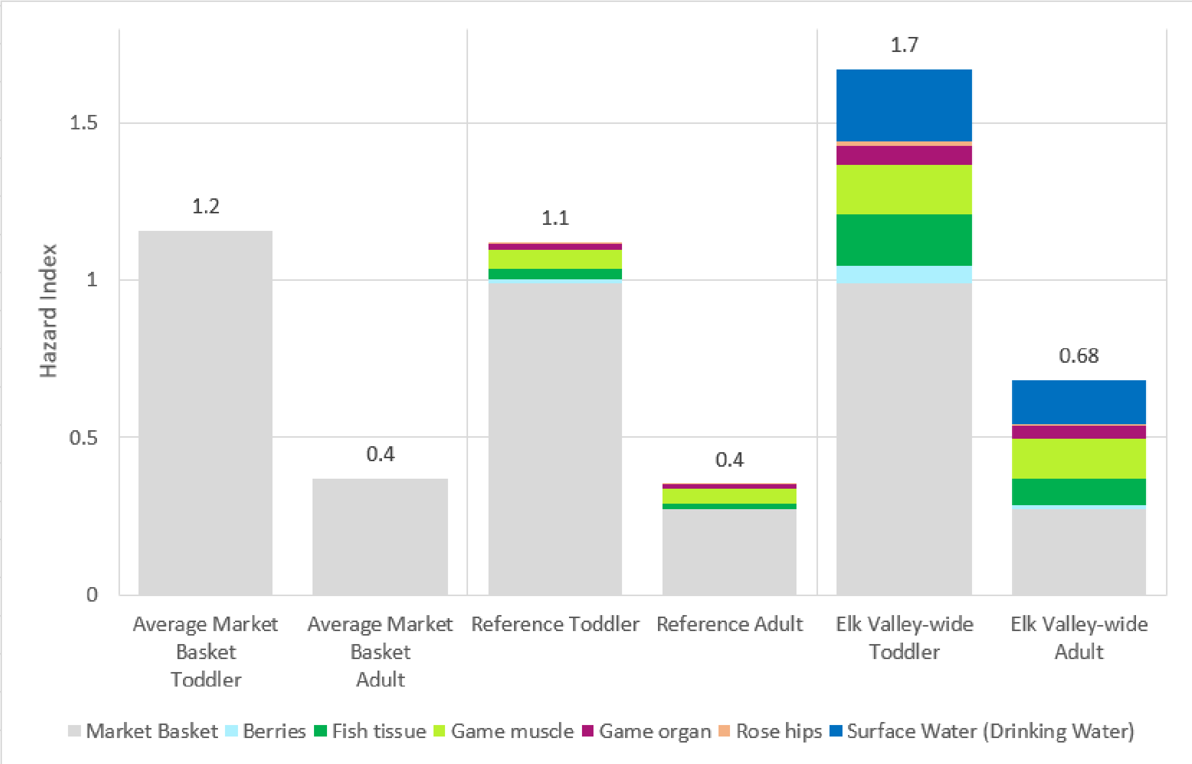


Figure 6-9. Selenium Hazard Index for the Upper Percentile Consumer Recreator Toddler and Adult: Reference vs Elk Valley

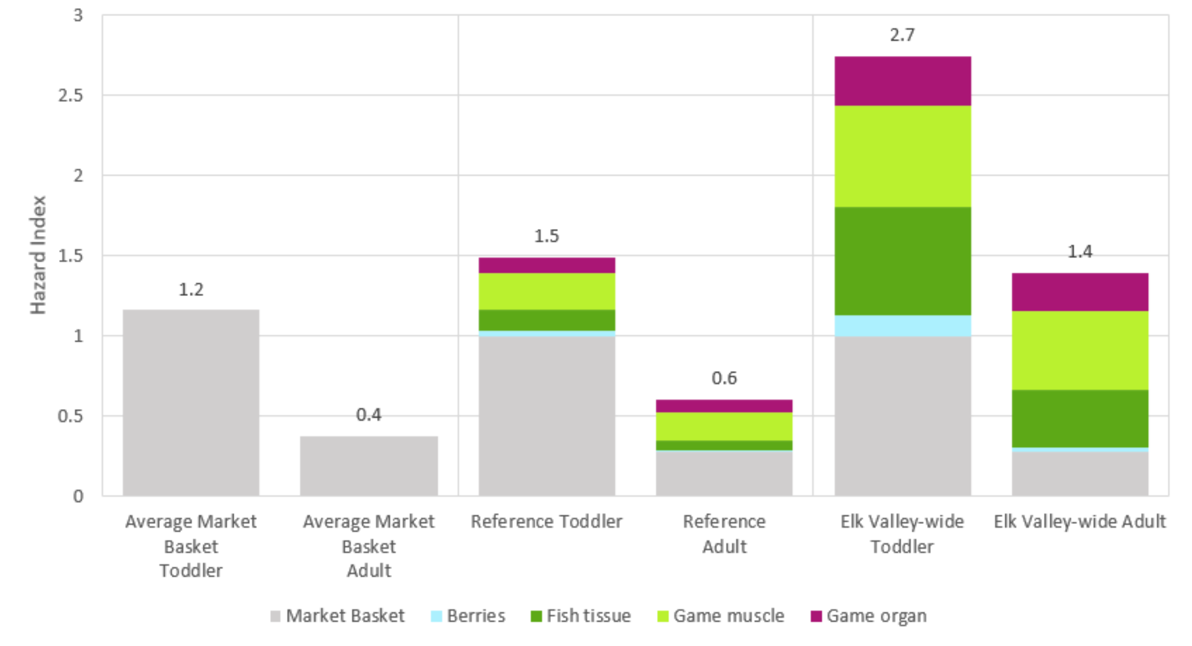


Figure 6-10. Selenium Hazard Index for the Upper Percentile Consumer Ktunaxa Toddler and Adult: Reference vs Elk Valley

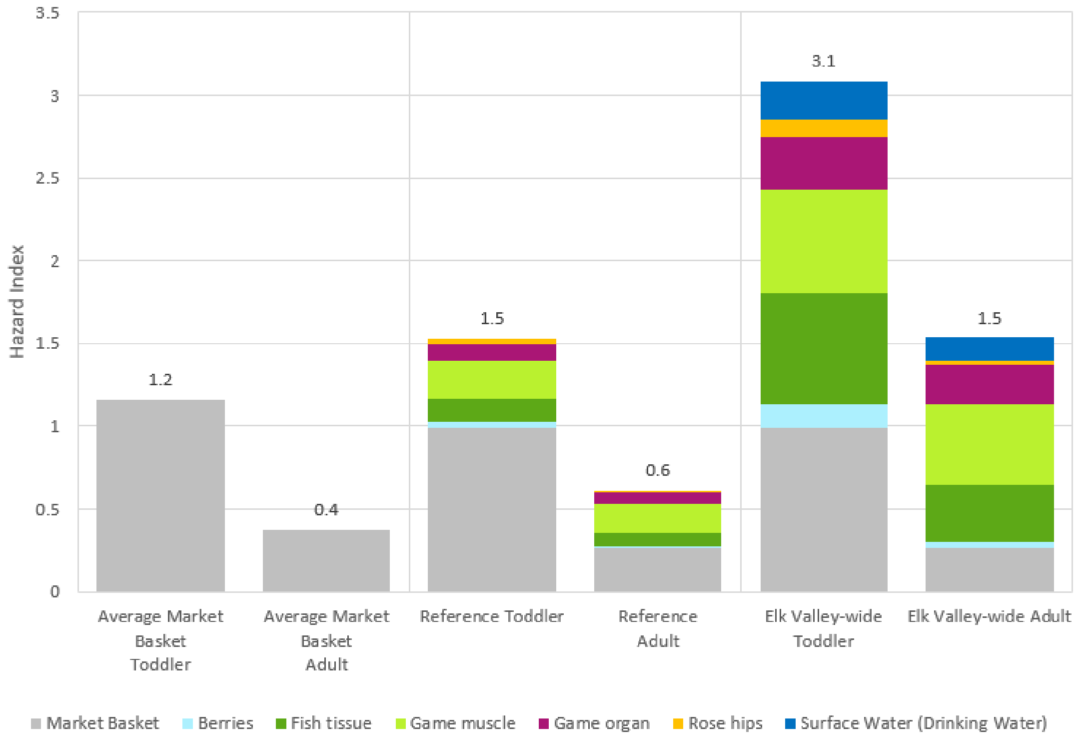
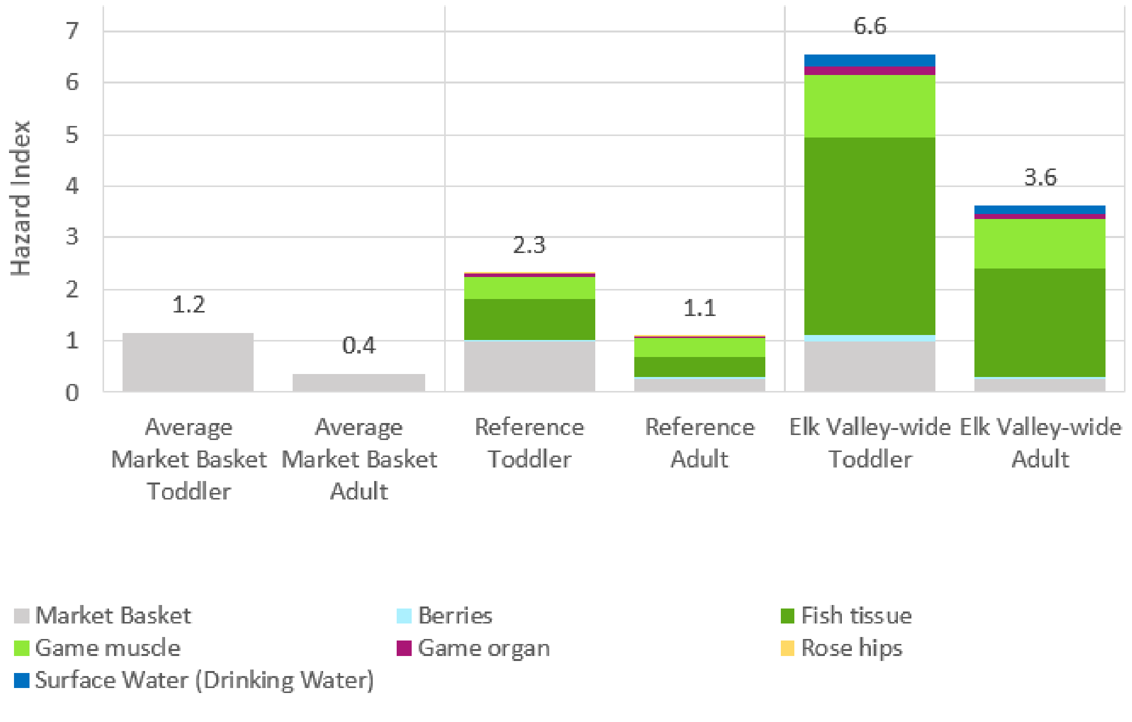


Figure 6-11. Hazard Index for the Preferred Consumer Ktunaxa Toddler and Adult: Reference vs Elk Valley

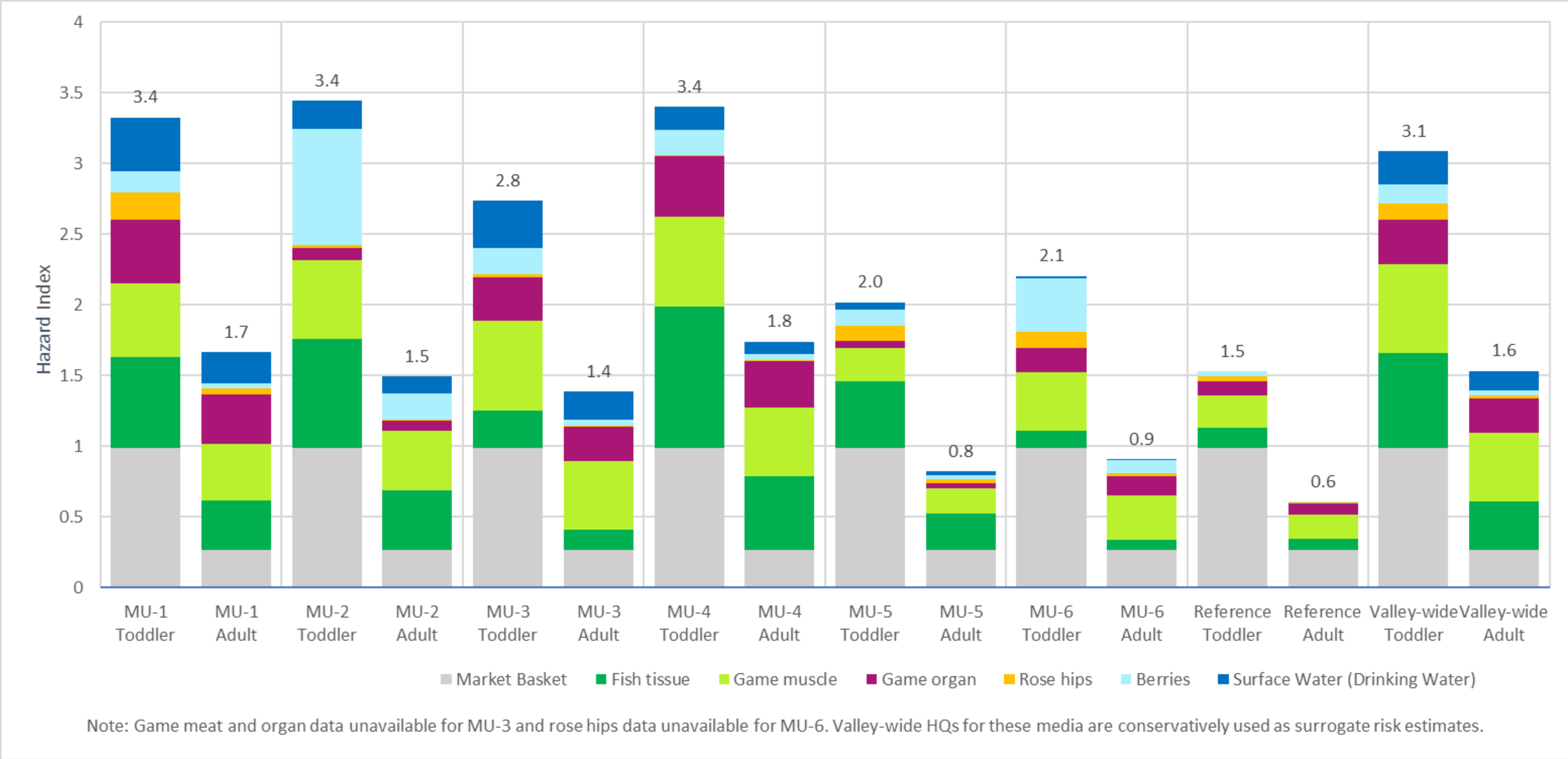


The cumulative HIs were calculated by summing the HQs associated with selenium intakes across media for a single consumer. However, it is likely that many Elk Valley resource users would consume the various food items at different rates, e.g., the preferred rate for berries and game muscle, the upper percentile rate for fish, and the average rate for game organ and rose hips. Thus the true cumulative HI for many Elk Valley consumers is likely a combination of the different consumer rates rather than one rate alone.

The greatest contributor to cumulative HI varies by consumer, but the three primary contributors are market basket, fish fillet, and game muscle. As described in Section 6.3, fish fillet HQs significantly decrease when longnose sucker is excluded from risk estimates, and decrease further when MFLNRORD fishing restrictions are considered. As described in Section 6.9, selenium intakes from market basket alone are approximately equivalent to an HQ of 1. For average and upper percentile Ktunaxa consumers and Elk Valley recreator consumers, market basket is the single largest contributor to selenium risks. For Ktunaxa preferred diet consumers, fish fillet is the largest contributor to the total HI, contributing over 4X that of market basket estimates. Game muscle consumption alone also contributes more to total HI than market basket. These results are driven by the consumption rates of these resources for preferred Ktunaxa consumers, which are higher than the average Canadian consumption rates for meat and fish used in the market basket estimate. The differences in market basket versus reference and Elk Valley selenium total diet intakes are shown in Figures 6-7 through 6-11. When considering 'background' selenium intakes, the reference HIs are a more accurate estimate of background for Ktunaxa and other people who harvest their own fish, game, and berries as opposed to purchasing foods from markets.

Figure 6-12 shows a comparison by MU of cumulative risks from Elk Valley foods and market basket for the Ktunaxa upper percentile consumer. Cumulative MU-specific risks are illustrated in the figure only because MU-specific HI values could not be calculated because some MUs had no data for certain food types (e.g., no game meat or organ sampled in MU-3), and because variability in sample size for game, berry, and rose hips by MU affected EPC calculations and thus limits comparability across MUs. Figure 6-12 shows that differences in cumulative selenium risk across MUs is mainly driven by differences in fish HQs. For example, MU-4 has a higher fish HQ than other MUs and thus has the highest cumulative selenium risk. As discussed in Section 6.3 and 6.11.2.3, variability in fish selenium EPCs and HQs by MU could be due to differences in fish species sampled by MU in addition to localized selenium impacts. Game muscle and organ meat are significant contributors to total selenium risks across MUs, but generally have lower HQs than fish. Exceptions are in MU-6, which had lower selenium fish HQs than other MUs, and MU-1, which had higher game organ HQs than other MUs. Berries were a significant contributor to cumulative selenium risks in MU-2 but not the other MUs. However, game organ and meat in MU-6, game organ in MU-1, and berries in MU-2 had small sample size (see Table 3-4), limiting our ability to draw conclusions.

Figure 6-12. Cumulative Selenium HI by MU and Reference Area for Ktunaxa Upper Percentile Consumer (Toddler and Adult)



The cumulative risk results demonstrate that Elk Valley foods are higher in selenium than market basket and reference area foods. Consumption of Elk Valley foods contributes to total risk differently by consumer: the impact of locally harvested foods on average consumers is relatively minor. For example, the average consumer (toddler) has an HI estimate that is 0.7 higher than the background diet (i.e., market basket foods only); the preferred diet consumer (toddler) has a HI estimate that is 5.4 higher than the background diet. Differences in cumulative selenium risk across MUs are mainly due to differences in fish HQs, which are likely attributable to differences in selenium concentration by MU and/or species sampled by MU.

Foods harvested in Elk Valley including fish, game meat and berries are higher in selenium than market basket and reference area foods. Therefore, the HI or the cumulative exposure to selenium and risk is higher for all Elk Valley food consumers than for people who consume market food only or fish, game meat and berries from reference sites (Figure 6-7 to Figure 6-11). Exposures and risks increase as consumption levels increase and exposures are higher for children than adults on a body weight basis. For example, the impact of locally harvested foods on average consumers is relatively minor; the average recreator toddler has an HI estimate of 1.9 compared with an HI of 1.2 calculated for the toddlers consuming the background diet (i.e., market basket foods only or consuming fish, game meat and berries from the reference site) (Figure 6-7). In comparison, the Upper Percentile Consumer Recreator toddler has a HI estimate of 2.7 which is more than 2 times higher than the HI for toddlers consuming market foods only or 1.2 or 80% higher than the HI of 1.5 for toddlers consuming fish, game meat and berries from the reference site (Figure 6-9).

The Ktunaxa consume more Elk Valley foods and hence have a higher selenium exposure and risk. For example, the Upper Percentile Consumer Ktunaxa toddler has a HI estimate of 3.1 which is more than 2 times higher than the HI of 1.2 for toddlers consuming market foods only or the HI of 1.5 for toddlers consuming fish, game meat and berries from the reference site (Figure 6-10). The Ktunaxa toddler with the preferred diet has the highest exposure and risk of all consumer groups assessed per body weight. The HI is 6.6, which is more than 5 times higher than the HI of 1.2 for toddlers consuming market foods only or 3 times higher than the HI of 2.3 calculated for toddlers consuming fish, game meat and berries from the reference site together with the background diet (Figure 6-11).

The HIs for adults are lower (about 50%) than those for toddlers within the same consumer group for all consumer groups that were assessed (Figure 6-7 to Figure 6-11). This is because toddlers have higher selenium exposure after adjusting for body weight. Because exposures are considered on a body weight basis, toddlers are the more sensitive sub-population. Like the toddler results, the impact of locally harvested foods varies by adult consumer group. For example, even though the HI for the average recreator adult doubled (0.8 vs 0.4) compared to adults consuming the background diet (i.e., market basket foods only or consuming fish, game meat and berries from the reference site) (Figure 6-7), all of them are below the ENV's risk management threshold of 1. In comparison, the Upper Percentile Consumer Ktunaxa adult has a HI of 1.5, which is more than double the HI of 0.4 for adults consuming market foods only or the HI of 0.6 for adults consuming fish, game meat and berries from the reference site and making it exceed the ENV's risk management threshold of 1 (Figure 6-10). The preferred consumer Ktunaxa adult has the highest exposure and risk of all adult consumer groups assessed. Their HI is 3.6, which is 9 times higher than the HI of 0.4 for adults consuming market foods only or up to 3 times higher than the HI of 1.1 for adults consuming fish, game meat and berries from the reference site together with the background diet (Figure 6-11).

There is also a site effect; the HIs for Ktunaxa Upper Percentile Consumer toddlers in MU-1, MU-2, MU-3 and MU-4 are around 3 or above, which is higher than the HIs for toddlers in MU-5 and MU-6 at around 2 (Figure 6-12). A similar site pattern is observed among Ktunaxa Upper Percentile Consumer adults; the HIs for adults in MU-1, MU-2, MU-3 and MU-4 are around 1.5, which is higher than the HIs for adults in MU-5 and MU-6 at around 0.8 (Figure 6-12). The differences in cumulative selenium risk across MUs are mainly due to differences in fish HQs, which are attributable to differences in selenium concentration by MU and/or species sampled by MU.

6.10.1 Characterizing Cumulative Selenium Risks

In summary, the HIs for the average adult recreator and average adult Consumer Ktunaxa are below 1, while the HIs for Elk Valley-wide adults range from 1.4 for the Upper Percentile Consumer recreator, 1.5 for the Upper Percentile Consumer Ktunaxa, to 3.6 for the Preferred Consumer Ktunaxa. The HIs for Elk Valley-wide toddlers are all above 1, ranging from 1.7 and 1.9 for average recreator and Ktunaxa toddlers, to 2.7 and 3.1 for the Upper Percentile consumer recreator and Ktunaxa toddlers, to 6.6 for Preferred consumer Ktunaxa toddlers.

In accordance with ENV (2023) and Health Canada DQRA (2010) guidance, this assessment compares the combined risks associated with the site and background sources with a target value of one. Therefore, the finding of HI estimates equal to or below the threshold of 1 indicate that the exposure is within the dose at which no noncancer adverse effects are expected. This means that the risk of selenium exposure from all routes related to the water sources has minimal health risk. When the estimated HIs are above 1, there is no standard approach to use the HIs to characterize the health risk. It is important to note that the finding of HI estimates above ENV's risk management threshold of 1 does not necessarily mean that there are expected adverse health effects but indicates that further evaluation is required, and risk management may be needed (ENV 2023, Health Canada 2010a). The HI values also do not give a quantification of the probability or severity of adverse health outcomes, and the interpretation must be based on the context (i.e., the degree above baseline), the level of exposure, and the conservatism and uncertainty in the concentration estimates, exposure estimates, and toxicity values (Health Canada 2019).

As discussed in Section 5.1.1, chronic selenium exposure may cause a health condition called selenosis. Symptoms observed include loss of hair and nails, skin lesions, tooth decay, and abnormalities of the nervous system (ENV 2014). The lowest observable adverse effect level (LOAEL) for the onset of selenosis occurs at or above daily selenium intakes of 910 µg/day, and no adverse effects are expected below 800 µg/day (Yang and Zhou 1994). The 0.0057 mg/kg-day TRV used by Health Canada and in this HHRA is based on the NOAEL of 800 µg/day. A UF of 2 was applied to the NOAEL, resulting in a UL of 400 µg/day (Health Canada 2021b).

A study of dietary selenium intake and health effects in a high-selenium area in the US (western South Dakota and eastern Wyoming) indicated daily intakes of 68 to 724 µg (0.9 to 9.2 µmol) in 142 subjects, and no evidence of selenosis was found, even in the subjects consuming the most selenium (Longnecker et al., 1991). The results of this study further support the NOAEL of 800 ug/day for adults.

The TRV for toddlers and children is more complicated because the Yang and Zhou study did not include children. The Health Canada TRVs for infants and children are based on background dietary intake (i.e., average selenium levels in human breast milk) NOAEL (IOM 2000, Health Canada 2021b). This explains why HQs/HIs are approximately equal to 1 for toddlers consuming market basket foods (1.2) and average recreator and Ktunaxa toddlers consuming foods from reference areas (1.2 and 1.1, respectively). Higher consumption rates result in higher background HIs. For example, Ktunaxa preferred diet toddlers have an HI of 2.3 when consuming foods from reference areas.

The Health Canada TRV for infants 0 to less than 6 months of age is 0.0055 mg/kg-day. For all other child and adolescent age ranges, the TRVs are slightly greater than 0.0057 mg/kg-day. Because the TRVs are similar on a body weight basis, therefore, the 0.0057 mg/kg-day TRV is applied to all ages in this assessment. There is some uncertainty in applying the 0.0057 mg/kg-day TRV to children; however, IOM (2000) states, "...there is no evidence indicating increased sensitivity to selenium toxicity for any age group." Section 6.11.5.1 provides additional context regarding selenium intakes potentially associated with adverse health effects.

As described previously, HQs are prioritized (ranked) in this HHRA based on their magnitude, and for fish, game, berries, and rose hips, based also on comparison with risks at reference locations. The ranking approach applied here is consistent with guidance from Health Canada (2019) which emphasizes the importance of baseline conditions (e.g., reference and background diet), the magnitude of risks, and the uncertainties in risk estimates. In this HHRA, HQs equal to or less than 0.2 are considered negligible; HQs equal to or less than 1, or consistent with reference areas are considered to have acceptable risks; and HQs greater than 1 and background warrant further evaluation or risk management.

The finding of fish HQ estimates for selenium above ENV's risk management threshold of 1 and cumulative HI estimates including background diet that are higher than cumulative reference HIs (i.e., greater than 2.3), indicates the need for ongoing monitoring and adaptive management. Although HIs cannot be directly linked to specific health effects, we assume as HIs increase the potential for health risk increases. For this reason, exposure pathways and receptors with the highest HIs (e.g., fish consumption by toddlers consuming at preferred levels) will be prioritized for data gathering and risk management, as needed. Uncertainty in concentration data, exposure estimates, and toxicity data are discussed in the following section and can be considered in evaluating next steps and data gathering activities.

6.11 Uncertainty Assessment

Risk assessments are subject to uncertainties throughout the entirety of the process, and every risk assessment will have some amount of uncertainty. In this section, we have attempted to capture uncertainties for each stage of the HHRA and provide some context for how the uncertainty may impact the results. In some cases, quantitative evaluations were performed to better understand the impact of specific uncertainties. Additional discussions are included as needed to provide further context for HHRA results, particularly where presentation of plausible upper and lower bounds on risk may be helpful to risk managers.

Awareness and consideration of these uncertainties is critical in understanding the risk assessment results and applying results to risk management decisions. Due to the uncertainty inherent in the models, health protective assumptions are made such that the probability of underestimating risks is quite low and that results lower than risk management levels provide confidence that adverse health effects are unlikely. Similarly, due to the protective assumptions embedded in the models, results greater than risk management levels do not necessarily indicate that adverse health effects will occur. This is particularly important in this HHRA where the dominant exposure scenario represents a high level consumer for whom multiple upper-bound assumptions may be compounded. Risk results greater than the noncancer threshold of 1 and cancer risk threshold of 1 in 100,000 (i.e., 1E-05) indicate that further investigation of assumptions and refining or bounding estimates will help inform risk management decisions.

Uncertainties potentially impacting the HHRA are summarized in Table 6-11, and discussed in detail in the following sections.

Table 6-11. Synthesis of Uncertainties

Section in HHRA		Description	Potential Conclusion of Uncertainty	Magnitude	Impacts Conclusions of the Risk Assessment (Y/N)
6.11.1 Uncertainties Related to the Exposure Pathways Evaluated					
6.11.1	Uncertainties Related to the Exposure Pathways Evaluated	This assessment was conducted to evaluate risks related to mine-related impacts on water quality. Some exposure pathways evaluated in the HHRA may not be directly influenced by mine-related impacts on water quality (e.g., berries, game), but could be impacted by other mine releases such as dust. Direct exposure to potential mine-impacted non-water quality pathways such as dust, soil, and air not evaluated.	Underestimate or Overestimate	Low	N
6.11.2 Uncertainties Related to Screening					
6.11.2	Uncertainties Related to Screening	Conservative screening values and guidelines ensure health protective screening. Example: A target HQ of 0.2 was used for this HHRA, which is more protective than the commonly applied HQ of 1.	No effect	Low	N
6.11.2.1	Constituents Not Evaluated in Screening	The exclusion of select innocuous constituents (Section 3.2.4) and organic constituents unlikely to increase total risk as these compounds lack toxicity criteria and/or were detected infrequently.	Underestimate	Low	N
6.11.2.2	Constituents with Detection Limits Exceeding RBSLs	Elevated detection limits were extensively reviewed. In fish, some non-detected constituents with detection limits exceeding risk-based screening were retained as COPCs. Though in surface water, some non-detected PAHs were not included.	Overestimate or Underestimate	Low	N

Section in HHRA		**Description**	**Potential Conclusion of Uncertainty**	**Magnitude**	**Impacts Conclusions of the Risk Assessment (Y/N)**
6.11.2.3	Exclusion of Evaluation of PAH in Fish and Wild Food Tissue	PAHs were not analyzed in berry and game. Fish consumption is not generally a significant exposure pathway for PAHs, as fish efficiently metabolize and eliminate PAHs from their tissues. Exclusion of additional PAH evaluation is unlikely to affect risk results.	Underestimate	Low	N
6.11.2.4	Agricultural Water Quality Guidelines	To understand possible risks for people consuming livestock or crops watered from Elk Valley water sources, surface water and groundwater were screened against agricultural guidelines. No additional COPCs identified.	No effect	NA	N
6.11.2.5	Assessment of Sulphate in Drinking Water	Sulphate chronic toxicity information is unavailable. Sulphate was screened against the drinking water aesthetic screening level (500 mg/L). Exceedances were identified in MU-4 in groundwater and MUs 1 through 4 in surface water. This assessment is unlikely to impact results of the risk assessment.	Underestimate	Low	N
6.11.3 Uncertainties Related to Data and EPCs for Mine-Influenced Locations					
6.11.3.1	COPC Concentrations in Fish Tissue: Sampling Design Bias	Fish sampling occurred based on availability, not on the species that most consume. Fish data analysis may not accurately represent the region or consumption patterns. The over-under estimation depends on which species are actually consumed and where fish were collected.	Overestimate	High	Y
6.11.3.1	COPC Concentrations in Fish Tissue: Fillet vs Whole Body	Fish fillet data were used to represent fish consumption in the HHRA. Selenium concentrations were greater in fillet tissue than whole body tissue, so risks are not underestimated if people consume whole-body fish.	No effect	Low	N

Section in HHRA		Description	Potential Conclusion of Uncertainty	Magnitude	Impacts Conclusions of the Risk Assessment (Y/N)
	COPC Concentrations in Fish Tissue: Mercury Concentrations for Koocanusa Reservoir Fish	Higher mercury concentrations were seen in northern pikeminnow in 2016 and reasons are unknown. Several studies indicate mercury in fish is likely due to regional, not mine-related sources. MU-6 mercury fish concentrations are similar to other regional lakes.	No effect	NA	N
6.11.3.2	Definition of Valley-wide	Valley-wide is generally defined as MUs 1-5, however some people may fish and/or recreate in MUs 1-6. For people consuming fish in MUs 1-6, selenium risks will slightly decrease, and mercury risks will slightly increase.	Overestimate or Underestimate	Medium	N
6.11.3.3	Evaluation of Uncertainties Related to Food Preparation Methods	Impact depends on the proportion of the total intake assumed in the consumption of food products. For instance, the HHRA's assumption of dried food consumptions may result in an underestimation of risks.	Underestimate	Low	N
6.11.3.4	Qualitative Evaluation for Shellfish Consumption	Shellfish consumption was not quantitatively evaluated in the HHRA because no samples were collected from mine-influenced waters in the DA.	No effect	NA	N
6.11.3.5	Use of Fish Ovary Tissue as a Surrogate for Fish Eggs	Studies indicate variation in GSI over or underestimates fish selenium concentrations in ovary tissue. While the GSI range in the HHRA dataset is unknown, the Koocanusa Reservoir study suggests GSI is more likely to overestimate Se concentrations.	Overestimate	Low	N
6.11.3.6	COPC Concentrations in Berries and Wild Game: Sample Size by MU	Some datasets for individual MUs were small, which limited representativeness. However, the valley-wide estimate can be considered to represent MUs without sufficient data.	Overestimate or Underestimate	Medium	N

Section in HHRA		Description	Potential Conclusion of Uncertainty	Magnitude	Impacts Conclusions of the Risk Assessment (Y/N)
	COPC Concentrations in Berries and Wild Game: Combining Elk and Deer Data	Data for large game, including elk and deer were combined in the HHRA. While species have different dietary patterns and some people may preferentially consume one species over another, selenium concentrations did not significantly differ by species.	Overestimate or Underestimate	Low	N
6.11.3.7	Inorganic Arsenic Fraction: berries and game	Berries were assumed to have 46% inorganic arsenic and game was assumed to have 0.78% inorganic arsenic. Assuming total arsenic is equivalent to inorganic arsenic would significantly overestimate the risk associated with consumption of these foods. Further analysis identified a wider range in potential inorganic arsenic concentrations in berries and beef, but input of the higher assumed inorganic arsenic concentrations did not affect conclusions of the risk assessment.	Underestimate	Low	N
	Inorganic Arsenic Fraction: fish tissue	Arsenic in fish tissue was assumed to be 10% inorganic arsenic based on the 75th percentile in Schoof and Yager (2007) and numerous other studies. However, some studies identify higher inorganic arsenic concentrations and an analysis was conducted assuming 20% inorganic arsenic in fish. This analysis did not affect the conclusions of the risk assessment.	Underestimate	Low	N
6.11.4 Exposure Assessment Uncertainties					
6.11.4.1	Consumption Rates for Fish and Game: 95th Percentile	Different individuals may be high consumers for different foods. Therefore, the combination of 95th percentile consumption rates for all fish consumed and all game consumed impacts estimated consumption rates and can overestimate risks if not all foods are consumed at the high consumption rate by the same individual, over the course of a lifetime.	Overestimate (KNC asserts this is not an overestimate; see text)	High	Y

Section in HHRA		Description	Potential Conclusion of Uncertainty	Magnitude	Impacts Conclusions of the Risk Assessment (Y/N)
	Consumption Rates for Fish and Game: Extrapolation of Ktunaxa adult consumption rates to other life stages	Extrapolation factors for adjusting adult rates to other life stages recommended by Health Canada (Richardson 1997) were reviewed by Ktunaxa 2019 dietary study expansion participants, and revised to be more appropriate for Ktunaxa consumers	Overestimate or Underestimate	Medium	N
	Consumption Rates for Fish and Game: Fish Consumption Rates for Recreational Anglers	Sport fishing regulations in Elk Valley streams reduce the number of available fishing days and may subsequently reduce fish consumption of Elk Valley fish.	Overestimate	Medium	N
6.11.4.2	Bioavailability of Metals in Fish and Game	Bioavailability is assumed to be 100% for metals in fish and game. Some research suggests bioaccessibility (which is used to calculate bioavailability) may be less than 100% for some metals in fish and game.	Overestimate	Medium	N
6.11.4.3	Sediment Contact	Soil ingestion rates are assumed to represent sediment ingestion for recreational visitors. High ingestion rates may overestimate risk for individuals.	Overestimate	Low	N
6.11.4.4	Groundwater Well-by-Well Evaluation	People are likely to consume drinking water primarily from one source (well) rather than MU-wide. The well-by-well evaluation identified HQs>1 for lithium or manganese for two wells.	Overestimate or Underestimate	Low	N
6.11.4.5	Manganese Concentrations in Berries	The toxicity literature has not identified adverse health outcomes associated with high dietary intake of manganese.	Overestimate	Low	N

Section in HHRA		Description	Potential Conclusion of Uncertainty	Magnitude	Impacts Conclusions of the Risk Assessment (Y/N)
6.11.5 Toxicity Assessment Uncertainties					
6.11.5	Toxicity Assessment Uncertainties	Extrapolation of results from animals to humans adds additional uncertainty. There is also uncertainty in sources as well as lack of well-supported toxicity criteria. However, where data are limited or uncertain, toxicity values are made more health protective so as to not underestimate risks.	Overestimate	Medium to High	N
6.11.5.1	Selenium Toxicity and Translation to Health Effects	The selenium risk results cannot be directly tied to health effects.	No effect	NA	N
6.11.5.1	Selenium Toxicity and Translation to Health Effects	New scientific literature on selenium toxicity which has not been included in the current TRV.	Unknown, but most likely underestimate	Medium to High	Y
6.11.5.2.1	Cobalt Toxicity Data Review and Alternate TRV Development	Limitations identified with the PPRTV for cobalt and alternative values derived by other entities suggest that the risks for cobalt in the main report may be overestimated.	Overestimate (KNC asserts this is not an overestimate)	High	Y
6.11.5.2.2	Lithium Toxicity Data Review and Alternate TRV Development	Limitations identified with the PPRTV for lithium and alternative values derived by Ramboll for this assessment suggest that the risks for lithium in the main report may be overestimated.	Overestimate (KNC asserts this is not an overestimate)	Medium	Y
6.11.5.4	Uncertainties Related to the Use of Chronic Toxicity Values and Exposure Analyses for Short-Term Exposures	Subchronic TRVs should be used for shorter-term exposures, such as seasonal contact with sediment and surface water. However, no subchronic TRVs are available in the toxicity values identified by ENV. Chronic TRVs are more conservative than subchronic TRVs	Overestimate	Low	N

Section in HHRA		Description	Potential Conclusion of Uncertainty	Magnitude	Impacts Conclusions of the Risk Assessment (Y/N)
6.11.6 Risk Characterization Uncertainties					
6.11.6.1	Antagonistic Effects in Cumulative Noncancer Risks	The interaction of selenium and mercury is antagonistic, which can reduce the toxicity of ingested mercury.	Overestimate	Low	N

Notes:

COPC = constituent(s) of potential concern; DA = designated area; ENV = British Columbia Ministry of Environment and Climate Change Strategy; EPC = exposure point concentration; GSI = gonado-somatic index; HHRA = human health risk assessment; HQ = hazard quotient; KNC = Ktunaxa Nation Council; mg/L = milligram(s) per litre; MU = management unit; NA = not applicable; PAH = polycyclic aromatic hydrocarbon(s); PPRTV = Provisional Peer Reviewed Toxicity Values for Superfund; RBSL = risk-based screening level; TRV = toxicity reference value(s); Y/N = yes/no

6.11.1 Uncertainties Related to the Exposure Pathways Evaluated

A human health exposure pathway includes a receptor population (e.g., recreational user), an exposure medium (e.g., surface water), an exposure route (e.g., ingestion of water), and a point of contact (e.g., Koocanusa Reservoir). The risk assessment evaluated a comprehensive set of exposure pathways. Risks were evaluated based on upper-end exposure assumptions designed not to underestimate risks and as such, risks may be overestimated.

To satisfy Permit 107517 Section 8.10 and inform the AMP while also addressing questions raised by the HHRA Workgroup, the HHRA evaluated risks directly associated with exposures to surface waters that may receive inputs from the mines and risks *indirectly associated* with exposures to mine-impacted surface water. The indirect exposure pathways may have limited association with surface water. For example, COPCs in berries sampled from locations remote from the river are unlikely to have been influenced by mining-related releases to the Elk River or its tributaries. Some game animals harvested in the valley may have had some influence from COPCs in the mine-impacted surface water, but this influence is expected to be minimal for most large game that range over wide areas relative to other possible exposure pathways that are not water quality-related. Thus, the assumption that the indirect exposure pathways are attributable to water quality-related exposures and risks is likely an overestimate of actual water quality-related exposure and risk. While assessment of terrestrial exposure media provides insights to total risk, additional evaluations are required to better characterize linkages between water quality and terrestrial foods (i.e., game, berries) and consider other potential sources of exposure to these foods. For example, influences from dust or air emissions from mine operations were not the subject of the HHRA and were not characterized. However, it is possible that airborne deposition has influenced COPC concentrations in berries and on forage consumed by game.

An additional analysis was completed that looked at the potential contribution of non-water quality pathways not evaluated in this HHRA to overall risk. Specifically, selenium intakes for contact with soil (including incidental ingestion, dermal contact, and inhalation as dust) and inhalation of particulates and vapors in air from mine operations estimated in the 2015 Baldy Ridge Extension EA HHRA were reviewed and compared with selenium intakes for other media in that EA HHRA and this Permit 107517 HHRA (Appendix J). Selenium intakes from soil and air pathways were found to contribute less than one percent to total selenium intake when all exposure pathways were reviewed.

6.11.2 Uncertainties Related to Screening

The COPC screening stage applied a high level of conservatism which ensures that no COPCs that should have been considered were excluded, i.e., the COPC screening has a very low level of uncertainty. Maximum detected concentrations of each constituent in each medium were compared to guidelines to identify COPCs although these concentrations are far greater than the average concentrations to which a person would typically be exposed throughout a lifetime. For example, in surface water there are occasions where the concentrations vary so significantly that the maximum is over 100 times higher than the mean.

The screening values were developed using a target HQ of 0.2, as directed by ENV. Given that health effects may not occur before reaching a HQ of 1 or greater, screening a maximum concentration with a guideline based on a HQ of 0.2 remains health protective even if exposure to a COPC is occurring from multiple pathways.

An additional source of conservatism in identification of COPCs is use of guidelines based on exposure pathways representing greater contact than is relevant to the local setting and receptor groups. For example, surface water data were compared to drinking water guidelines although surface water is not currently a drinking water source. This assumption is highly conservative given that groundwater is used by residents in the DA as the primary source for potable water. Similarly, residential soil guidelines based on daily contact with yard soil were applied to the evaluation of sediment COPCs even though sediment is contacted less than half the year during recreational (Table 4-3) or Ktunaxa cultural activities (Table 4-5).

Fish tissue screening levels were derived using the Ktunaxa preferred diet IR of 245 g/day. This is a conservative assumption for non-subsistence fish consumers that is six times higher than the Bureau of Constituent Safety's Canadian adult high fish consumer value (40 g/day) (Health Canada 2007). Additional conservatism comes from the fact that the screening values are applied assuming that an individual is solely ingesting fish that were caught from within bodies of water in the DA and from no other sources.

6.11.2.1 Constituents Not Evaluated in Screening

Some constituents analyzed in environmental media in Elk Valley were not included in the screening and subsequently excluded from the risk assessment. The majority of these constituents are generally considered to be nontoxic or nutrients essential to life and were excluded from the preliminary screening and risk calculations. Innocuous constituents excluded from the screening and HHRA are listed in Section 3.2.4.

Several organic constituents were excluded from the screening due to a lack of screening and toxicity criteria, which may contribute to a slight underestimate of risks. Acridine (in surface water and sediment), benzo(e)pyrene (sediment only), and perylene (sediment only) were excluded for this reason. Acridine was not detected in any surface water samples and was only detected in about 8 percent of sediment samples, suggesting a low presence and low risk in Elk Valley. Benzo(e)pyrene and perylene were detected in 76 percent and 43 percent of sediment samples, respectively. Both constituents are PAHs indicating they could have carcinogenic potential, but neither have been classified as carcinogens due to inadequate toxicity data. USEPA published a Provisional Peer Reviewed Toxicity Values for Superfund (PPRTV) document for perylene in 2007 but did not derive any toxicity values due to the lack of human and animal data. In the PPRTV document USEPA notes that although perylene was found to induce genotoxic effects in several assays and *in vitro* mammalian systems, it was a less potent agent than benzo(a)pyrene (USEPA 2007). Likewise, available animal studies and mutagenicity assays for benzo(e)pyrene suggest it is less potent than benzo(a)pyrene, with one animal study characterizing benzo(e)pyrene as a 'very weak tumor initiator' and 'weak complete carcinogen' (National Center for Biotechnology Information 2021). The screening level for benzo(a)pyrene in sediment is 5 mg/kg. Only one benzo(e)pyrene sample result and no perylene results exceeded 5 mg/kg in sediment. Thus, it is unlikely that exclusion of these constituents causes an appreciable increase in total risk.

6.11.2.2 Constituents with Detection Limits Exceeding RBSLs

Several constituents measured in fish and surface water had DLs that exceeded their respective RBSLs. As described in Section 3.1.3 and presented in Appendix A1, an extensive review of the non-detected and detected data was performed for fish, and it was found that application of 95 UCLM estimates produced by USEPA's ProUCL software were not biased by the elevated DLs. Additionally, constituents with DLs that exceeded RBSLs, but no detected results that exceeded RBSLs, were retained as COPCs for fish in the risk assessment if they were identified as COPCs in other media. Thus, fish risk results are unlikely to be biased by elevated DLs and risks may even be slightly overestimated in the HHRA.

In surface water, six PAHs (benz(a)anthracene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, indeno(1,2,3,-c,d)pyrene, benzo(b,j,k)fluoranthene) had DLs that consistently exceeded RBSLs, and results were 100 percent non-detect. These constituents were not included as COPCs in the HHRA. It is unlikely that exclusion of these compounds contributes significantly to risk estimates because almost all PAHs were non-detect in water, including 15 other PAH compounds with DLs below RBSLs. The six PAHs with elevated DLs have the most conservative screening levels (4E-06 and 4E-07 mg/L), which were likely unachievable by the laboratory. Benzo(a)pyrene, which has a screening level of 4E-05 mg/L, was detected in less than one percent of samples. Thus, it is likely that the six excluded PAHs are not present in Elk Valley water, or if present, would not contribute significantly to risk estimates.

6.11.2.3 Exclusion of Evaluation of PAHs in Fish, Game, and Berry Tissue

PAHs were evaluated in berry and game tissues in the 2016 HHRA but were rarely or never detected and as a result, risks were below thresholds of concern. In the current HHRA, PAHs were analyzed in sediment and surface water in Elk Valley; risks were below thresholds of concern. PAHs were not analyzed in berry and game for the current HHRA. Based in part on the results from the 2016 evaluation of PAHs in berry and game, PAHs are not thought to be a concern. Also, because PAHs are readily metabolized in fish they are not routinely analyzed in fish fillet tissue (Agency for Toxic Substances and Disease Registry [ATSDR] 1995; Meador et al. 1995; Replinger et al. 2017, Van der Oost et al. 1991, Van der Oost et al. 1994).

Obiakor et al. (2014) provides data regarding PAHs in the Anambra River in Nigeria and identifies fish consumption as the most important exposure pathway. The discussion identifies industrial and aerial inputs to the river. Metabolites of PAHs, i.e., alkylated PAHs, can be detected in fish in some settings (Chan et al. 2016); however, the lack of elevated PAHs in primary media (i.e., sediment, surface water) suggest no need for PAH monitoring in fish. In addition, PAHs present in coal are not highly soluble. Furthermore, the lack of accepted TRVs for alkylated PAHs would make interpretation of alkylated PAH data highly uncertain and challenging. There is some uncertainty associated with the decision not to analyze PAHs; however, this is unlikely to result in a substantial underestimate given the limited detections in the 2016 HHRA or in this current HHRA.

6.11.2.4 Agricultural Water Quality Guidelines

As noted in Section 2.2.2, people may consume livestock watered using surface water or groundwater sourced from the Elk Valley, as well as garden produce and agricultural crops irrigated with these water sources. The RBSLs used in this HHRA for surface water and groundwater were derived from BC WQGs for residential drinking water. Following guidance by the Canadian Council of Ministers of the Environment (CCME), ENV have established agricultural water quality standards for irrigation and livestock with intent to protect the most sensitive crops and livestock from contaminants (ENV 2021b; CCME 1993). In addition to drinking water guidelines, surface water and groundwater were also screened against the ENV's (2021b) agriculture guidelines (full list shown in Appendix B) for water quality. The following summary indicates that no constituent concentrations were greater than irrigation or livestock RBSLs that were not identified as COPCs in the HHRA for consumption of surface or groundwater.

Table C-5 in Appendix C summarizes the inorganic constituents in surface water with maximum detected concentrations that are greater than agricultural WQGs for livestock and/or irrigation. Analytical data for the dissolved and total fractions are presented separately. Monitored inorganic constituents present at concentrations below agricultural RBSLs are not shown in Table C-5. No organic constituents exceeded either the irrigation or livestock guidelines. Detailed results listing sample count, percent of detected samples, maximum detected concentrations, WQGs used to identify COPCs, ratios of maximum detected concentrations to WQGs, and the sample count exceeding WQGs for all constituents are provided in Appendix C.

Dissolved fraction constituents above agricultural WQGs in surface water include manganese, selenium, and uranium; and aluminum, cadmium, cobalt, manganese, nickel, selenium, and uranium were above agricultural WQGs in the total fraction. All constituents with concentrations above agricultural WQGs were also above drinking water WQGs in surface water and evaluated for recreational and drinking water exposures in the HHRA.

Only inorganic, dissolved fraction constituents in groundwater were above agricultural WQGs (Table C-6). No constituents in groundwater were above livestock WQGs. Manganese and selenium were above irrigation RBSLs. Manganese and selenium were also above drinking water WQGs, and evaluated for drinking water exposures in the HHRA. Detailed screening results (percent of detected samples, sample count, etc.) are provided in Appendix C.

6.11.2.5 Assessment of Sulphate in Groundwater and Surface Water

Sulphate was not identified as a COPC in the risk assessment due to lack of a health-based drinking water guideline. While sulphate occurs naturally in drinking water, ingestion of this chemical may lead to gastrointestinal discomfort, diarrhea, or dehydration (McKee and Wolf 1963; USEPA 1999). ENV recommends the adoption of Health Canada's aesthetic objective of less than or equal to 500 mg/L of sulphate in drinking water. This guideline is based on taste considerations and is not risk-based. The sulphate concentrations in groundwater were screened against this adopted value.

Groundwater samples were collected in MUs 3 through 5. Sulphate was identified in groundwater samples collected in these three MUs; however, exceedances were observed solely in MU-4. Of the 151 detected samples in this MU, a total of 20 samples exceeded the drinking water guideline (Table 6-12). All exceedances were located in private residential water sources (Well-05, Well-23, Well-24, and Well-25) within MU-4. The highest concentration of sulphate was identified at RG_DW-07-01 (670 mg/L).

Table 6-12. Screening Results of Sulphate in Groundwater

MU	Source/Well (MU-4 Only)[a]	Sample Count	Percent Detected (%)	Maximum Result (mg/L)	Drinking Water Guideline (mg/L) [b]	Total Exceedances
MU-3	All	46	100	69.2	500	0
MU-4	All	153	98.7	670	500	20
	Well-05	23	100	586	500	1
	Well-23	21	100	670	500	15
	Well-24	3	100	554	500	1
	Well-25	3	100	620	500	3
MU-5	All	91	100	129	500	0

Notes:

[a] Only wells with sulphate exceedances in drinking water are shown. Well IDs have been deidentified for privacy.

[b] BC Ministry of Environment and Climate Change Strategy

mg/L = milligram(s) per litre; MU = management unit

Table 6-13 lists all locations in which sulphate concentrations in surface water exceeded the 500 mg/L aesthetic objective. Exceedances were identified in MUs 1 through 4. All sulphate concentrations were below 500 mg/L in MU-5 and MU-6. The frequency of exceedance by MU is as follows: MU-3 (30%), MU-4 (24%), MU-1 (15%), MU-2 (12%).

Table 6-13. Exceedances of Sulphate in Surface Water

MU	Location	Sample Count	Percent Detected	Maximum Detect (mg/L)	Drinking Water Guideline (mg/L) [a]	Total Exceedances
MU-1	FR_CC1	93	100	702	500	46
	FR_FR2	176	100	508	500	1
	FR_FR4	72	99	721	500	8
	FR_FRCP1	227	100	2,070	500	60
	FR_KC1	74	100	863	500	38
	GH_CC1	93	100	2,110	500	93
	GH_GH1	123	100	906	500	67
	GH_GH2	44	100	943	500	32
	GH_PC1	92	100	1,770	500	2
	GH_SC1	84	100	1,950	500	78
	GH_SC2	37	100	1,850	500	29
MU-2	LC_LC3	331	100	523	500	3
	LC_WLC	230	99.6	1,410	500	219
MU-3	GH_ER1A	86	100	728	500	3
	GH_LC1	37	100	961	500	33
	GH_LC2	125	100	1,530	500	120
	GH_MC1	107	100	883	500	21
	GH_TC1	130	100	1,030	500	87
	GH_TC2	102	100	1,030	500	69
	GH_WC1	88	100	1,420	500	81
	GH_WC2	138	100	1,430	500	117
MU-4	CM_CC1	195	100	829	500	155
	CM_MC2	291	100	512	500	1
	EV_BC1	227	100	1,280	500	227
	EV_EC1	84	100	861	500	84
	EV_GT1	242	100	1,240	500	241
	EV_MG1	66	100	709	500	26
	EV_SP1	71	100	990	500	71

Notes:
[a] BC Ministry of Environment and Climate Change Strategy
mg/L = milligram(s) per litre; MU = management unit.

6.11.3 Uncertainties Related to Data and EPCs For Mine-Influenced Locations

The exposure assessment provides estimates of exposure for Elk Valley residents based on the best available information. Limitations in some of the site data result in uncertainty in the resulting exposure estimates. The parameters with greatest uncertainty are discussed here.

6.11.3.1 COPC Concentrations in Fish Tissue

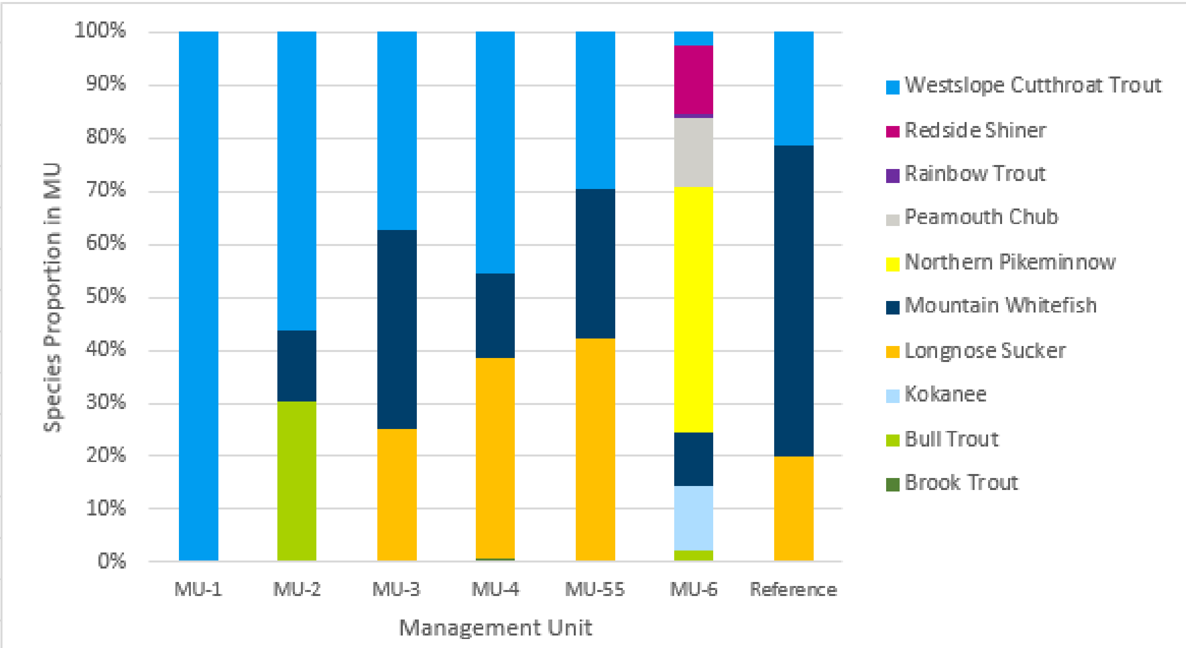
Sampling Design Bias

A variety of fish were sampled in Elk Valley and Koocanusa Reservoir and analyzed at a laboratory to measure concentrations of constituents (e.g., selenium) in the fillet. The fish sampling focused on aquatic effects of mining and included considerations of sentinel fish species and species availability rather than being focused on species that people most prefer to consume. Fish were collected in areas considered to be mine-influenced and in reference areas. Because fish species were not targeted based on what species are preferred, they may not represent the fish that people are consuming. In this risk assessment, EPCs for fish are calculated two ways:

- EPCs for all fish species combined within each of the MUs
- EPCs by fish species in which the entire consumption rate is applied to a single species of fish.

The 'all species combined' EPC suggests that the relative proportions of fish species sampled within each MU are proportional to the fish species consumed in each of the Elk Valley MUs. This method assumes that multiple fish species are consumed in Elk Valley, but the relative proportions for each fish species may not be representative of what individuals actually consume. For example, the MU-4 EPC assumes an individual consumes fish exclusively from MU-4, and that 40 percent of fish consumed are longnose sucker, 13 percent are mountain whitefish, and 48 percent are westslope cutthroat trout. Figure 6-13 provides a visual representation of relative proportions of fish species collected from each MU, conveying how MU-specific fish consumption risks may be biased by sample design.

Figure 6-13. Fish Species Proportion by MU



The EPCs calculated for each individual fish species provide an alternative approach to understanding fish consumption risk (see Table 6-3). EPCs based on a single species are used to identify hazards related to exclusive consumption of each fish species at the identified consumption rate. For example, in MU-4, risk estimates were calculated based on an assumption that 100 percent of the daily consumption rate could be exclusively westslope cutthroat trout, or mountain whitefish, or longnose sucker. The species-specific result represents an over- or underestimate of risk, depending on which species are actually consumed.

Risks calculated using species-specific EPCs and species-specific fish consumption rates would provide a more accurate risk estimate. If further information becomes available on which fish species people most prefer to eat, risk estimates can be refined to better represent risks.

Fillet vs. Whole Body

The HHRA evaluated exposure of edible tissue that is assumed to be consumed by Ktunaxa People and recreational anglers, which is fillet and eggs (evaluated using ovary data as a surrogate). In addition to fillet and ovary, a limited number of liver, testis, and whole-body samples have been analyzed in the Elk Valley. While some populations may consume these fish tissues, the available data were limited. For whole body tissue samples, only selenium was analyzed in longnose sucker samples from MUs 3, 4, and 5 in 2015. This whole body data was compared to the longnose sucker fillet tissue data that was used in the HHRA. As shown in Table 6-14, the maximum concentrations in ww were greater in fillet than in the whole body. A similar pattern occurs in the dry weight data. Therefore, assessing fish consumption risks using fillet tissue data is health protective, even for receptors who may consume whole fish.

Table 6-14. Selenium Concentrations in Longnose Sucker by Tissue Type

MU	Fillet Tissue				Whole Body Tissue			
	Sample Count	Minimum (mg/kg ww)	Average (mg/kg ww)	Maximum (mg/kg ww)	Sample Count	Minimum (mg/kg ww)	Average (mg/kg ww)	Maximum (mg/kg ww)
3	12	1.12	1.35	1.81	5	0.91	1.10	1.41
4	53	2.18	9.17	30	21	0.99	4.57	14.15
5	36	0.63	2.77	6	10	1.12	2.22	4.31

Notes:

mg/kg ww = milligram(s) per kilogram, wet weight; MU = management unit

Comparison of Selenium Concentrations in Fish Muscle with Concentrations in Organs

In addition to comparing fish and whole body tissue samples, differences between tissue types, or structures, (liver, muscle and ovaries) were also considered. Fish structure data were limited and only selenium was analyzed in bull trout and westslope cutthroat trout from MU-2. The maximum concentration in liver samples (25.58 mg/kg ww) exceeded the maximum concentrations for both muscle (12.12 mg/kg ww) and ovary (6.15 mg/kg ww) samples (Table 6-15 and Figure 6-14). While the selenium concentrations in liver or ovary are higher than those in muscle, these organs are small relative to the entire fish. However, those who prefer fish liver and eggs, represented in this analysis by ovary tissue data, may have higher selenium exposure than those who eat only fish muscle.

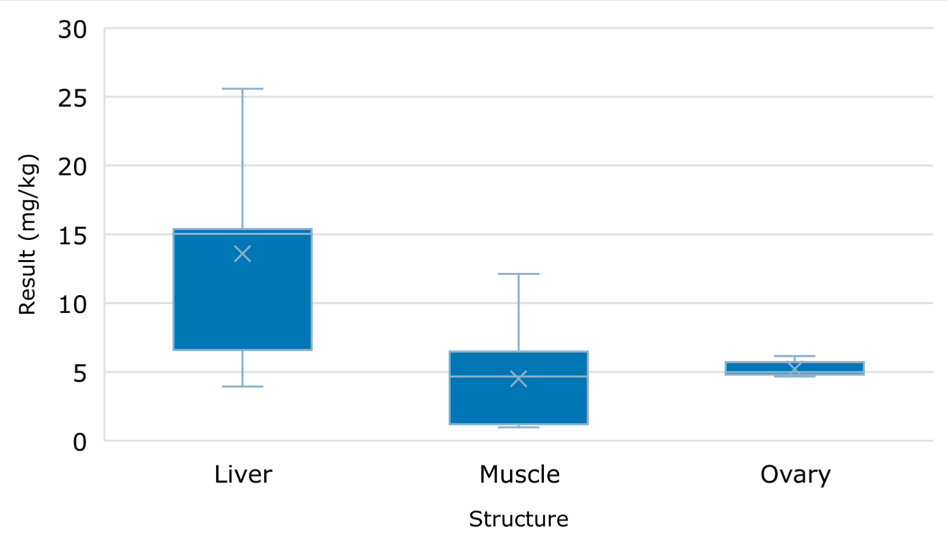
Table 6-15. Selenium Concentrations in Fish Liver, Muscle and Ovary

Structure	Sample Count	Minimum (mg/kg ww)	Average (mg/kg ww)	Maximum (mg/k-ww)
Liver	7	3.94	13.59	25.58
Muscle	19	0.98	4.51	12.12
Ovary	5	4.67	5.21	6.15

Notes:

mg/kg ww = milligram(s) per kilogram, wet weight

Figure 6-14. Distribution of Selenium Concentrations in Fish Liver, Muscle and Ovary



Mercury Tissue Concentrations for Koocanusa Reservoir Fish

Mercury measured in fish tissue samples from Koocanusa Reservoir is elevated relative to mercury in fish in MUs 1-5 and in reference locations and risks up to an HQ of 29 are calculated in MU-6 for a toddler when the Ktunaxa preferred rate is used. Koocanusa Reservoir differs from the other MUs for several reasons. It is a lentic environment (i.e., lake) whereas MUs 1-5 are primarily lotic environments, and regional inputs in MU-6 come from a variety of sources unlike MUs 1-5 which are primarily mine-influenced. Mercury levels are typically higher in fish from lentic versus lotic environments.

The higher mercury concentrations in Koocanusa Reservoir fish are due, in part, to northern pikeminnow sampled in 2016 which had significantly higher concentrations than other fish in Koocanusa Reservoir and elsewhere in the Elk Valley. The average mercury concentration in 2016 northern pikeminnow (1.4 mg/kg ww) is 5x that of northern pikeminnow sampled in Koocanusa Reservoir in 2019 (0.27 mg/kg ww), and 10x the average mercury concentration of most other fish species sampled in Koocanusa Reservoir. The reason for the elevated concentrations in 2016 northern pikeminnow is unknown. When these fish are excluded, the average mercury concentration in Koocanusa Reservoir fish is about 3x lower, which corresponds to a 3x decrease in the HQ. Other fish species sampled in Koocanusa Reservoir in both 2016 and 2019 (kokanee and mountain whitefish) also showed higher average mercury concentrations in 2016 in comparison to their 2019 samples (Table 6-16). Kokanee had average mercury concentrations of 0.18 vs. 0.052 mg/kg, and mountain whitefish had average concentrations of 0.096 vs. 0.044 mg/kg in 2016 and 2019, respectively. All other species were sampled in 2019 only. After northern pikeminnow, bull trout had the highest mercury concentrations, with an average of 0.30 mg/kg (sampled in 2019 only). This average concentration is 0.03 mg/kg greater than the northern pikeminnow average mercury concentration in 2019, however the maximum concentration in northern pikeminnow is higher than in bull trout (0.65 vs. 0.48 mg/kg). Kokanee sampled in 2016 and peamouth chub (2019) had the next highest concentrations, with 0.18 mg/kg and 0.11 mg/kg average concentrations, respectively.

Several evaluations performed for Elk Valley indicate that elevated levels of mercury occur naturally during periods of high flow and turbidity in the watershed, and are not due to mining activities (Azimuth 2018; Azimuth 2019; Windward et al. 2014). An analysis of all fish tissue concentrations in exposed and non-exposed lentic versus lotic environments by Windward et al. (2014) concluded there was no relationship between mercury tissue concentrations and proximity to mining operations. Windward et al. (2014) also note that mercury tissue concentrations in MU-6 were higher at locations in the Kootenay River upstream of the Elk River mouth than at other MU-6 locations. An evaluation of methyl mercury and total mercury in surface water data collected from 2015 to 2018 also concluded that mercury concentrations observed in Elk Valley surface water are not mining-related (Azimuth 2019). Surface water samples collected in reference areas had similar concentrations to samples collected immediately downstream of mining activity. Additionally, the evaluation conducted to identify surface water quality early warning triggers did not identify mercury as a parameter for which early warning triggers are warranted (Azimuth 2018). These studies suggest that mercury in fish tissue is more likely the result of regional rather than mine-related sources.

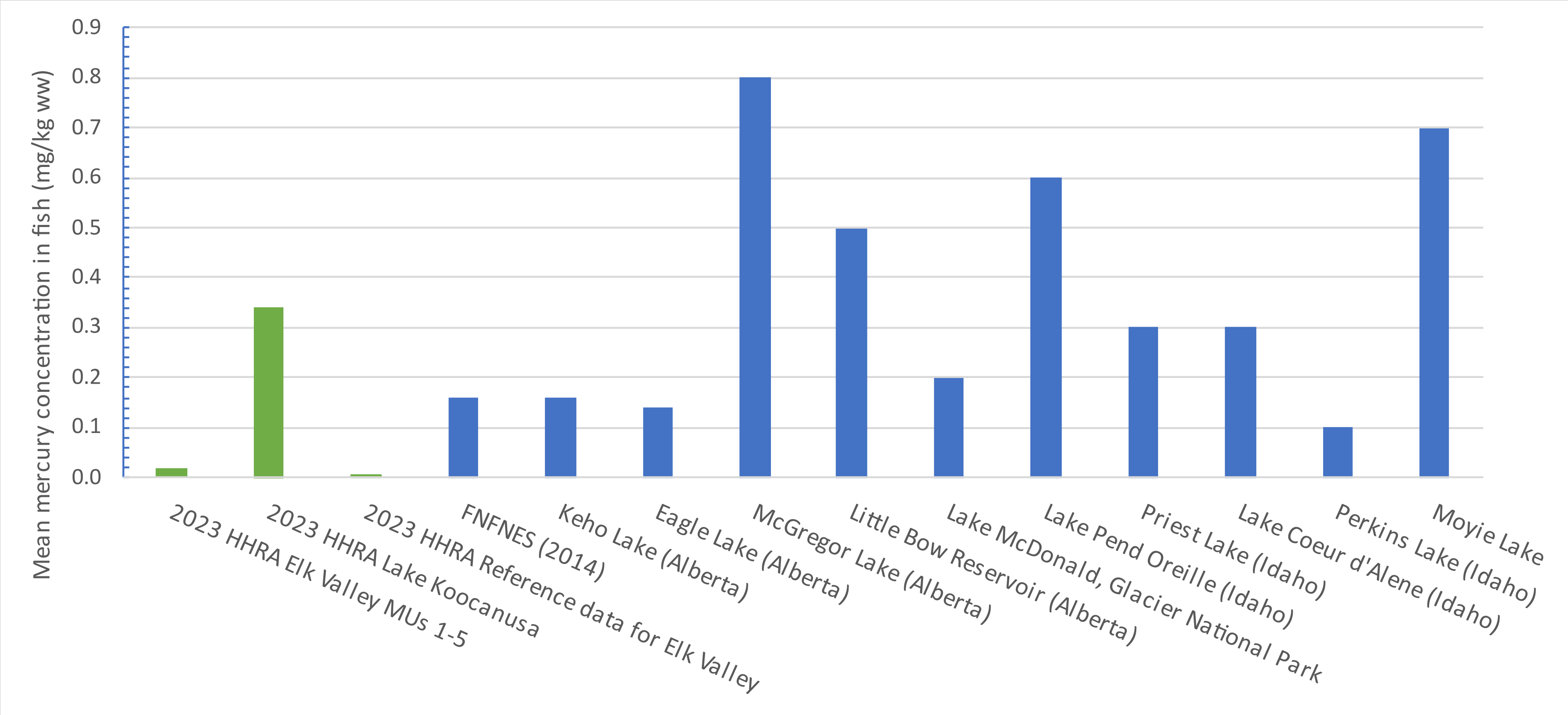
Comparisons of mercury in fish tissue to regional data are difficult because fish species, size, and age impact mercury concentrations. However, comparisons of mercury in MU-6 fish tissue to levels in similar fish species in regional lakes support the conclusion that mercury levels in MU-6 fish are comparable to concentrations in non-mining areas (Windward et al. 2014; Ramboll Environ 2017). Figure 6-15 compares average mercury fish tissue concentrations in Koocanusa Reservoir and Elk Valley MUs 1-5 with fish mercury concentrations in regional lakes. The presence of regionally elevated mercury in fish tissue also is reflected in the many fish consumption advisories established by the nearby state of Montana (Montana Fish, Wildlife and Parks et al. 2015).

Table 6-16. Mercury Concentrations (mg/kg) in Koocanusa Reservoir Fish Species

Fish Species	Year	Count	Average (mg/kg)	Maximum (mg/kg)	Minimum (mg/kg)
Kokanee	2016	14	0.18	0.22	0.15
	2019	15	0.05	0.07	0.03
	2016+2019	29	0.12	0.22	0.03
Mountain Whitefish	2016	15	0.10	0.20	0.06
	2019	8	0.04	0.07	0.03
	2016+2019	23	0.08	0.20	0.03
Northern Pikeminnow	2016	30	1.38	2.20	0.57
	2019	78	0.27	0.65	0.08
	2016+2019	109	0.58	2.20	0.08
Bull Trout	2019	18	0.12	0.48	0.01
Peamouth Chub	2019	30	0.11	0.27	0.05
Rainbow Trout	2019	2	0.04	0.04	0.04
Redside Shiner	2019	30	0.08	0.13	0.002
Westslope Cutthroat Trout	2019	21	0.02	0.08	0.01
All		**261**	**0.22**	**2.2**	**0.0022**

Notes:
mg/kg = milligram(s) per kilogram

Figure 6-15. Average Mercury Concentrations in Fish in Regional Waterways



6.11.3.2 Definition of Valley-wide

In the HHRA, 'valley-wide' generally refers to the combination of data from MUs 1 through 5. Specifically, analytical data for aquatic media (fish, surface water and sediment) from MUs 1-5 were combined to generate valley-wide risks. For game meat, game organ, berries, and rose hips, valley-wide includes data from MUs 1-6 because fewer samples were available, and these media are less directly influenced by water. Valley-wide groundwater estimates include data from MUs 3,4, and 5 only because groundwater data was only available in these MUs.

The valley-wide scenario was incorporated in the HHRA to account for people who contact environmental media throughout the Elk River watershed, not just in one MU. As described in Section 2.1.1, 'valley-wide' is defined as MUs 1-5 and not MUs 1-6 because MUs 1-5 are predominantly mine-influenced, while MU-6 (Koocanusa Reservoir) receives inputs from sources that are not mining-related in addition to potential mine influences from the Elk River. Defining valley-wide as MUs 1-5 is more conservative than using MUs 1-6 because EPCs are predominantly mine-influenced and not 'diluted' by non-mine influences present in MU-6. However, the current definition of valley-wide may not adequately characterize risk for people who regularly consume fish in MU-6 in addition to the rest of the Elk River watershed.

Selenium EPCs and HQs for fish are compared for MUs 1-5 and MUs 1-6 combined in Table 6-17. The selenium EPC and associated risks decrease by about 30% when MU-6 is included in the valley-wide definition. These estimates assume about 36% of a person's fish is sourced from MU-6 (due to the large number of fish sampled in MU-6). If a person primarily eats one species of fish, risks will differ than those shown here and may be higher or lower (refer to sections 6.3.1 and 6.11.3.1). In general, these results indicate that selenium risks will be slightly lower for individuals who consume fish in MUs 1-6 compared to just MUs 1-5. Although not quantitatively evaluated, mercury risks are expected to be somewhat higher for individuals consuming fish in MUs 1-6 compared to MUs 1-5 because of the higher mercury concentrations in Lake Koocanusa fish (see Figure 6-15).

Table 6-17. EPCs and HQs for Selenium in Fish Tissue (All Species Combined) by MU Combination (Toddler and Adult)

Valley-wide Definition	Sample Count	EPC (mg/kg ww)	HQ - Average Consumer - Ktunaxa		HQ - Upper Percentile Consumer - Ktunaxa		HQ - Upper Percentile Consumer - Recreator		HQ - Preferred Consumer - Ktunaxa	
			Toddler	Adult	Toddler	Adult	Toddler	Adult	Toddler	Adult
MUs 1-5 combined	422	3.39	0.2	0.1	0.7	0.4	0.6	0.3	3.8	2.1
MUs 1-6 combined	655	2.39	0.1	0.1	0.5	0.3	0.4	0.2	2.7	1.5

Notes:
EPC = exposure point concentration; HQ = hazard quotient; MU = management unit

No shading in HQ columns indicates HQ ≤ 0.249
HQ > 0.249 (i.e., 0.2), but does not exceed 1.49 (i.e., 1)
HQ > 1

6.11.3.3 Evaluation of Uncertainties Related to Food Preparation Methods

Foods (fish, game, berries) were evaluated based on ww concentrations and ww intake. However, it is recognized that the metals content in foods can change during cooking. Most simply the dry weight concentrations of metals are increased relative to the ww concentrations due to the removal of water. Other aspects of cooking may also alter metals concentrations. For example, a study by Mwale et al. (2018) evaluated the effect of cooking on inorganic arsenic and other metals or minerals in rice and their findings suggest that arsenic can be removed from rice by use of additional water in cooking that is discarded.

Charette et al. (2020) evaluated oral bioavailability of methyl mercury in pigs fed either cooked or uncooked tuna and determined that cooking did not decrease bioavailability. A review by (Inobeme et al. 2020) evaluated reductions in metals concentrations in meat, fish, and shellfish following cooking and found several studies that reported reduced concentrations of lead, cadmium, and chromium. No data for selenium were reported. Probably the most relevant study identified in this review was Moses et al. (2009), which evaluated the effect of various traditional cooking methods on levels of essential nutrients and non-essential elements in seal blubber and in eight samples of sheefish harvested near Kotzebue, Alaska. Data for sheefish from Moses et al. (2009) indicate the following: total arsenic percent changes ranging from -7.7 percent to +72.5 percent; total mercury percent increases ranging from +15 percent to +73.8 percent; selenium percent increases from +2.9 percent to +101 percent. These data showed that cooking sheefish, particularly drying of fish increases concentrations up to 100 percent for the metals of concern here, i.e., doubling. The impact of these changes will depend on the degree of consumption of foods prepared using these methods.

The consumption rates and the concentration data for foods analyzed in the HHRA are both based on ww. We understand that dried foods are consumed, but we do not know how much of the total intake they make up. Depending on the proportion of the total intake assumed in the HHRA that was consumed as dried foods, the estimates provided in the HHRA may underestimate risks.

6.11.3.4 Qualitative Evaluation for Shellfish Consumption

Shellfish consumption was not quantitatively evaluated in the HHRA because no samples were collected from mine-influenced waters in the DA. It was anecdotally reported by environmental monitoring staff that shellfish have not been observed when performing aquatic monitoring at compliance stations. Fourteen freshwater mussel samples were collected from reference areas. The Ktunaxa Preferred Rates Memo to Teck (KNC 2020) specifies a preferred consumption rate of 0.6 g/day for shellfish. This is lower than the preferred consumption rate for fish eggs (0.7 g/day), which were quantitatively evaluated in the HHRA. The maximum HQ for fish eggs was <0.04 and the maximum cancer risk was 1E-07. These risks are well below ENV thresholds, due in part to the low consumption rate. COPC concentrations in shellfish would need to be one order-of-magnitude higher than COPC concentrations in fish ovary to exceed the noncancer preliminary risk threshold of 0.2, and over two orders of magnitude higher to exceed the cancer risk threshold (1E-05) or noncancer ENV threshold HQ of 1. Because shellfish are filter feeders they often contain higher levels of metals than other fish. However, it is unknown what the concentrations are in Elk Valley and how shellfish in mine-influenced waters compare to shellfish in reference areas.

6.11.3.5 Use of Fish Ovary Tissue as a Surrogate for Fish Eggs

Fish ovary tissue is used as a surrogate for fish eggs in the HHRA because COPC concentration data for fish eggs were not available. Uncertainties associated with selenium concentrations in fish ovary are discussed here.

Previous fish ovary monitoring conducted in Koocanusa Reservoir indicate the gonado-somatic index (GSI; percent) can influence selenium concentrations in fish ovary (EcoTox et al. 2020). GSI is a measure of gonadal maturation stage calculated by dividing gonad weight (in this case, ovary) by the total body weight in fish. Another factor affecting selenium concentrations in fish ovary is fish size, with smaller fish having higher concentrations. Neither fish size nor GSI were assessed in the HHRA fish ovary data, but are briefly discussed here because they could influence selenium concentrations in fish ovary used in the HHRA.

In the Koocanusa Reservoir study, linear and multi-linear modeling was performed in order to assess selenium concentrations relating to various fish characteristics. The models indicated that smaller fish and fish with lower GSI had higher selenium concentrations. The GSI finding suggests that fish ovary collected early in the year, from February to May, have overestimated selenium concentrations from what they will be at the time of spawning. The study concluded that fish with a GSI of less than 5 percent should not be used because it overestimates selenium concentrations. GSI greater than or equal to 5 percent were determined to provide relatively unbiased estimates of selenium egg concentrations.

It is noted that the model developed in the Koocanusa Reservoir study indicating low GSI is associated with higher selenium concentrations is contradictory to the mechanism in fish proposed in other studies (Janz et al. 2010). Transfer of selenium into eggs is associated with vitellogenesis, which is associated with egg development and increasing GSI. Thus, an increase in egg selenium rather than a decrease in egg selenium would be expected with increasing GSI. However, there are many species-specific complexities to the process of vitellogenesis which could influence selenium concentrations in ovary (EcoTox et al. 2020). It is unclear what the mechanism is for the reduction in selenium concentrations with low GSI observed in the Koocanusa Reservoir study.

The GSI range is unknown in the HHRA ovary data, but the Koocanusa Study suggests variation in GSI is more likely to overestimate, not underestimate, selenium concentrations. Therefore, selenium HQs for fish egg consumption are unlikely to underestimate risk.

6.11.3.6 COPC Concentrations in Berries and Wild Game

Sample Size By MU

As described in Section 3.1.4, game, berries, and rose hips were collected under the Wild Foods Sampling Program and additional, opportunistic samples were collected by Teck and Ktunaxa staff and citizens. Data for berries, rose hips, game meats, and organ meats were evaluated within MUs by combining all sample results for that MU. Even though there were relatively large datasets available for use in the HHRA (i.e., 156 vegetation and 78 animal tissue samples within the DA and 41 vegetation and 31 animal tissue samples collected outside the DA), in some cases datasets for individual MUs were small which may limit the representativeness of sample results for human consumers. For this reason, risk estimates were considered both by MU and as valley-wide estimates and the latter estimates are likely more representative of human health risks as well as harvest patterns.

Combining Deer and Elk Data

Various game species such as deer and elk may have different dietary patterns, and therefore COPC concentrations in the game tissue may differ by species. As noted in above, some MUs (i.e. MUs 1-3) do not contain many animal tissue samples. Box and whisker plots for selenium in game tissue by species are shown in Appendix A2. Elk data are available for MUs 1, 2, 4, and 5 and deer data are available for MUs 4, 5 and 6. Table 6-18 shows summary statistics comparing selenium COPC concentrations in elk and deer by MU, valley-wide, and in reference areas, when available. The 'all game combined EPCs' that were used in the HHRA are also shown for comparison. Based on the sample counts in each dataset, the data are not considered robust enough to calculate both large game species-specific and MU-specific EPCs and risk estimates. Generally, the maximum concentrations in elk and deer do not differ significantly from the 'all game combined EPCs.' If risks were estimated separately for elk and deer, the HHRA conclusions would be similar. It is also important to recognize that people eat more than just deer and elk; however, sufficient data to evaluate other species are not available (e.g., bear, cougar).

Table 6-18. Selenium Concentrations in Elk and Deer

MU	Tissue Group	Elk				Mule Deer				Whitetail Deer				HHRA All Game		
		Count	Min	Avg	Max	Count	Min	Avg	Max	Count	Min	Avg	Max	Count	EPC	EPC Basis
1	Muscle	8	0.34	0.45	0.54	--	--	--	--	--	--	--	--	8	0.50	95% Student's-t UCL
2	Muscle	4	0.45	0.49	0.53	--	--	--	--	--	--	--	--	4	0.53	Maximum Detect
4	Muscle	22	0.22	0.59	0.77	10	0.63	0.68	0.76	3	0.29	0.42	0.62	41	0.61	95% Student's-t UCL
5	Muscle	2	0.06	0.17	0.27	3	0.13	0.17	0.22	1	0.08	0.08	0.08	6	0.22	95% Student's-t UCL
6	Muscle	--	--	--	--	--	--	--	--	2	0.21	0.30	0.40	2	0.40	Maximum Detect
Valley-Wide	Muscle	36	0.06	0.52	0.77	13	0.13	0.56	0.76	6	0.08	0.33	0.62	61	0.60	95% Chebyshev (Mean, Sd) UCL
Reference	Muscle	9	0.08	0.20	0.68	1	0.19	0.19	0.19	7	0.03	0.12	0.22	19	0.22	95% Adjusted Gamma UCL
1	Organ	2	1.28	1.93	2.58	--	--	--	--	--	--	--	--	3	2.58	Maximum Detect
2	Organ	1	0.51	0.51	0.51	--	--	--	--	--	--	--	--	1	0.51	Maximum Detect
4	Organ	5	0.95	2.02	3.96	1	1.60	1.60	1.60	3	0.46	1.11	1.91	10	2.45	95% Adjusted Gamma UCL
5	Organ	--	--	--	--	--	--	--	--	1	0.28	0.28	0.28	1	0.28	Maximum Detect
6	Organ	--	--	--	--	--	--	--	--	2	0.46	0.72	0.98	2	0.98	Maximum Detect
Valley-Wide	Organ	8	0.51	1.81	3.96	1	1.60	1.60	1.60	6	0.28	0.84	1.91	17	1.79	95% Student's-t UCL
Reference	Organ	4	0.12	0.31	0.53	2	0.27	0.37	0.48	6	0.14	0.43	1.13	12	0.58	95% Adjusted Gamma UCL

Notes:

'--' indicates no samples were collected for that species in the specified area.

Avg = average; EPC= exposure point concentration; HHRA = human health risk assessment; max = maximum; min = minimum; MU = management unit; UCL = upper confidence limit

6.11.3.7 Inorganic Arsenic Fraction

Berries and Game

The inorganic arsenic fractions applied to berries and game also contribute to the uncertainty in risk estimates. Market basket surveys analyzing total and inorganic arsenic in foods did not report berries or elk and deer meats specifically. Studies analyzing fruit (Schoof et al. 1999; Xue et al. 2010) have focused on stone fruits, bananas, melons, and apples, but not berries. The 48 percent inorganic arsenic fraction used in this analysis is one of the more conservative values presented in these studies. Lynch et al. (2014) conducted a review of inorganic arsenic data in prior studies and summarized total and inorganic arsenic results in 74 samples of 'non-apple' fruits. They reported inorganic arsenic made up 22 percent to 68 percent of the arsenic and 35 percent of the samples were undetected for inorganic arsenic. The upper-end value in Lynch et al. (2014) is slightly higher than the 48 percent inorganic arsenic fraction used in the assessment. However, use of this higher inorganic arsenic fraction assumption would not change the conclusions of the risk assessment, i.e., risk estimates for arsenic in berries would still be within acceptable levels (see Appendix H).

Deer and elk meat have not been analyzed for inorganic arsenic, but should be comparable to values measured in beef, considering they are ungulate mammals. The 0.78 percent inorganic arsenic fraction applied in this assessment is derived from one survey of published literature at the time of publication (Schoof et al. 1999). Lynch et al (2014) conducted a review of inorganic arsenic data in food and identified 64 samples of meat (other than chicken) analyzed for inorganic arsenic. The data reviewed by Lewis et al. had a range in inorganic arsenic percentages of 1 percent to 20 percent and 23 percent of the inorganic arsenic samples were undetected. Although research is limited, the current body of literature suggests the fraction of inorganic arsenic in these foods represents much less than 100 percent of total arsenic. Assuming total arsenic is equivalent to inorganic arsenic would significantly overestimate the risk associated with consumption of these foods. Application of the upper-end of the inorganic arsenic fractions in beef identified by Lynch et al. (2014) would not change the results of the risk assessment, i.e., risk estimates for arsenic would still be within acceptable levels (see Appendix H).

Fish Tissue

Because consumption of fish was a pathway with elevated risks and directly related to water quality, further analysis is provided here of inorganic arsenic in fish tissue. As noted in Section 4.1.2, an adjustment was applied to arsenic in fish tissue when calculating the EPC to account for the assumption that on average, less than 10 percent of total arsenic measured in freshwater fish filets is inorganic arsenic. A recent study by Tanamal et al. (2021) in which 180 samples of three species of commonly consumed fish in Yellowknife, Northwest Territories, Canada found that inorganic arsenic species accounted for less than 20 percent of the arsenic detected in fish. As requested by the HHRA Workgroup after reviewing this study, a sensitivity analysis was conducted on arsenic data in fish tissue used in this risk assessment.

For this analysis, the inorganic arsenic correction factor was adjusted to 20 percent rather than the 10 percent used in the HHRA. Increasing the inorganic arsenic fraction to 20 percent did not result in HQs greater than 0.2. As shown in Table 6 18, a 10 percent inorganic arsenic fraction resulted in cancer risk estimates for the preferred consumer between 1E-05 and 2E-05. The 20 percent inorganic arsenic correction factor yielded risk estimates between 2E-05 and 4E-05 for preferred consumers. Regardless of the arsenic fraction (10 percent or 20 percent), the cancer risks were less than or consistent with cancer risks for fish collected in reference areas.

Table 6-19. Comparison of Cancer Risks for Preferred Consumers with Adjusted Inorganic Arsenic Fraction (10% vs. 20%)

MU	Cancer Risk, 10%	Cancer Risk, 20%
MU-1	2E-05	3E-05
MU-2	1E-05	2E-05
MU-3	2E-05	4E-05
MU-4	2E-05	3E-05
MU-5	1E-05	2E-05
MU-6	2E-05	4E-05
Reference	2E-05	4E-05
Valley-wide	2E-05	3E-05

Notes:

ENV and Health Canada consider cancer risks less than 1 in 100,000 (or 1E-05) "essentially negligible"

ENV = British Columbia Ministry of Environment and Climate Change Strategy; MU = management unit; Valley = Elk Valley

6.11.4 Exposure Assessment Uncertainties

The exposure assessment provides the quantification of exposure for Elk Valley residents. Each parameter applied in the exposure models is based on the best available information. Ktunaxa-specific exposure parameters were selected in consultation with Ktunaxa Nation representatives and Firelight during EMC meetings held between December 2018 and April 2020. Varying levels of uncertainty underlie the databases from which each parameter is obtained. The parameters with greatest uncertainty are discussed here.

6.11.4.1 Consumption Rates for Fish and Game

Uncertainties related to limitations in understanding of consumption rates for specific fish species were discussed above.

Ktunaxa Consumption of ʔa·kpiɫ̓is Current and Preferred

Preferred consumption rates for Ktunaxa consumers were applied based on data provided in the Ktunaxa Preferred Rates Memo to Teck (KNC 2020). The mean and upper percentile consumption rates used in the HHRA were based on a study of 98 adult KNC members conducted in 2012 and 2013 (Firelight 2014; Fediuk and Firelight 2015) and estimates were based on 95th percentile consumption rates for consumers only of all fish combined, all game meats combined, and for all game organ meats combined. Generally, the degree of uncertainty with food consumption studies increases for the highest and lowest percentiles estimated. In other words, there is much greater confidence in the mean values than in the 90th percentile values, and more confidence in the 90th percentiles than in the 95th percentiles. The magnitude of uncertainty at the lower and upper ends of the distribution varies depending on the study sample size and variability in the reported values. Combining 95th percentile consumption rates for all fish consumed or all game consumed can overestimate high-end consumption rates because different individuals may be high consumers for different foods. The magnitude of this uncertainty varies depending on the uncertainty underlying each of the values. The KNC provide additional discussion of this topic, below, noting that the conservative approach taken by combining upper-end percentiles across multiple food groups is reasonable and appropriate.

This HHRA also extrapolated from adult consumption rates to rates for other life stages (e.g., toddlers, children) using assumptions from Richardson et al. (1997), which is another source of uncertainty.

Current Rates and Uncertainty (Prepared by KNC)

The Ktunaxa Nation Diet Study Final Report (2015) reported daily intake rates for ʔa·kpiɫis from a randomly selected population of Ktunaxa adults. Consumption rates were obtained using the best available methods and the use of the upper-end or 95th percentile of the population exposure distribution is a reasonable approach in assessing risk of exposure and determining if current practices are safe for most Ktunaxa. Combining rates for all fish or game consumed is adequately conservative and appropriate as:

1. there is wide variation in reliance on ʔa·kpiɫis;
2. harvesters relying more heavily supported by ʔa·kpiɫis may not have participated in the random survey or in the focus groups in 2015 which were not widely held with a cross-section of harvesters;
3. the rates are in alignment with the upper-end of traditional food intake reported in the First Nations Food, Nutrition and Environment Study at 648 grams and 797 grams for adults living in the Montane Cordillera ecozone in BC (Chan et al. 2019).

Therefore, the uncertainty should be considered as low to very low.

Preferred Consumption Rates and Uncertainty (Prepared by KNC):

A key focus of the Ktunaxa Nation Diet Study Expansion study in 2019 was to support the HHRA by reaching out to Ktunaxa citizens (who may or may not have participated in the earlier diet study) to confirm preferred rates, according to Ktunaxa laws and principles that govern how people acquire foods and which foods, and when. Inclusion of the preferred rates in the HHRA, covers off any uncertainty that the 95th percentile rates underestimate current use. The 2020 preferred consumption rates were derived from 10 focus group sessions with participation of 89 Ktunaxa participants as well as a verification session with a subset of participants. The rates are considered to represent a reasonable level of what would be needed to live largely off the land. The higher proportion of game relative to fish for both the current and preferred rates is reflective of the steep decline in both confidence and availability. If fish populations were to improve, it could be expected that preferred rates for fish would increase relative to game.

While the ability of Ktunaxa to attain the total per capita preferred amount of ʔa·kpiɫis of 1.36 kilograms (kg) is unlikely given the state of the environment, assessing the risk to human health at this level provides certainty to KNC about the relative safety. From a caloric perspective, as the preferred rates would provide about 1,500 active adult harvesters living largely off the land would still need to obtain additional calories from other locally harvested, cultivated or commercial food sources to meet needs. While there is some uncertainty that the rates are sufficiently adequate to fill the needs of a family living off the land, they can be considered to represent a reasonable intake for modeling risk exposure and are unlikely to overestimate risk.

Extrapolation of Adult Consumption Rates to Other Life Stages (Prepared by KNC):

The extrapolation from adults to other life stages is based on a standard method used by Health Canada. The rates are based on information found in the Compendium of Canadian Human Exposure Factors for Risk Assessment prepared by O'Connor Associates Environmental Inc. and G. Mark Richardson. As part of the 2019 Diet Expansion, participants in focus group reviewed the consumption rates proposed for each age group as per the information provided in the Ramboll's HHRA draft methodology report. Overall, consumption conversions for adolescents and toddlers were not considered adequately conservative and the risk assessors were asked to revise the conversion factors. From the KNC perspective, these changes have created a conservative estimate and the uncertainty can be considered as low.

Fish Consumption Rates for Recreational Anglers

There are uncertainties related to the use of the 43 g/day consumption rate for recreational anglers in the Elk Valley who are not Ktunaxa. As discussed in Section 2.1.3.2 there are general restrictions on fish consumption for anglers who are not Ktunaxa including the following:

- No fishing in any stream from April 1 to June 14, which removes 75 days for anglers for all species.
- Trout/char are catch-and-release in streams from November 1 to March 31 or 150 days of the year.

Together these restrictions greatly reduce the potential for consumption of fish from the Elk Valley area by anglers whose harvest is consistent with current fishing regulations. Table 6-20 provides a summary of HQs for recreational anglers considering the reduced potential for retaining and consuming fish related to quotas and seasonal restrictions. Specifically, HQs provided in Table 6-3 for the most sensitive receptors (toddlers), were adjusted as follows: HQs for all species have been reduced by 20 percent to reflect the 75 days per year that no fishing can occur, and, HQs for trout have been further reduced by 41 percent reflecting the additional 150 days when trout cannot be kept and consumed. These adjustments do not take into account the potential for further restrictions based on the daily catch limits during the legal season. As is shown in Table 6-20, before consideration of fishing restrictions there are few HQs greater than 2 for recreational anglers and consideration of the existing restrictions further reduces the HQs. In MU-1, there are additional restrictions on where fish can be legally harvested; no fish may be harvested from the segment of Fording River above Josephine Falls and Line Creek and its tributaries. These calculations indicate that HQs in Table 6-3 for recreational anglers overestimate risks for non-Ktunaxa anglers observing restrictions on fish consumption.

Table 6-20. Uncertainty Assessment Calculations of Selenium HQs for non-Ktunaxa Anglers Considering Restrictions on Fish Consumption

MU	Species*	HQ - Upper Percentile Consumer – Recreator	HQ Considering No Fishing from April-June	HQ Considering Trout Cannot be Kept November-March
1	Westslope Cutthroat Trout	0.6	0.5	0.3
	All Species	0.6	0.5	0.3
2	Bull Trout	1	0.9	0.5
	Mountain Whitefish	0.3	0.2	0.2
	Westslope Cutthroat Trout	0.6	0.5	0.3
	All Species	0.7	0.6	0.6
3	Longnose Sucker	0.3	0.2	0.2
	Mountain Whitefish	0.2	0.2	0.2
	Westslope Cutthroat Trout	0.3	0.2	0.1
	All Species	0.2	0.2	0.2
	All Species Except Longnose Sucker	0.2	0.2	0.2
4	Longnose Sucker	2	2	1

MU	Species*	HQ - Upper Percentile Consumer – Recreator	HQ Considering No Fishing from April-June	HQ Considering Trout Cannot be Kept November-March
	Mountain Whitefish	0.3	0.2	0.1
	Westslope Cutthroat Trout	0.3	0.3	0.2
	All Species	1	0.8	0.6
	All Species Except Longnose Sucker	0.3	0.3	0.2
5	Longnose Sucker	0.6	0.5	0.5
	Mountain Whitefish	0.4	0.3	0.3
	Westslope Cutthroat Trout	0.3	0.2	0.1
	All Species	0.4	0.3	0.3
	All Species Except Longnose Sucker	0.4	0.3	0.3
6	Kokanee	0.09	0.1	0.1
	Mountain Whitefish	0.2	0.2	0.1
	Northern Pikeminnow	0.09	0.1	0.1
	Peamouth Chub	0.1	0.1	0.1
	Redside Shiner	0.1	0.1	0.1
	Westslope Cutthroat Trout	0.2	0.2	0.1
	Bull Trout	0.1	0.1	0.05
	Rainbow Trout	0.05	0.04	0.02
	All Species	0.1	0.1	0.08
Reference	Longnose Sucker	0.2	0.1	0.1
	Mountain Whitefish	0.1	0.08	0.06
	Westslope Cutthroat Trout	0.2	0.1	0.1
	All Species	0.1	0.1	0.08
	All Species Except Longnose Sucker	0.1	0.1	0.07

MU	Species*	HQ - Upper Percentile Consumer – Recreator	HQ Considering No Fishing from April-June	HQ Considering Trout Cannot be Kept November-March
MUs 1- 5 Combined	Bull Trout	0.8	0.7	0.5
	Longnose Sucker	1.3	1	0.8
	Mountain Whitefish	0.3	0.2	0.2
	Westslope Cutthroat Trout	0.5	0.4	0.3
	All Species	0.6	0.5	0.4
	All Species Except Longnose Sucker	0.4	0.3	0.3

Notes:

Risks shown are for toddler (most sensitive life stage).

HQ = hazard quotient; MU = management unit

6.11.4.2 Bioavailability of Metals in Fish and Game

Many metals have reduced bioavailability in soil, dust, or sediment. Some data suggest that metals may also have reduced bioavailability in foods. The risk calculations reported in this HHRA assume that metals are fully absorbed from foods, i.e., the HHRA assumes 100 percent bioaccessibility. Laird and Chan (2013) discussed this question in a paper "Bioaccessibility of metals in the traditional foods of First Nations in British Columbia" which reported on *in vitro* bioaccessibility of metals (arsenic, cadmium, mercury, selenium, manganese, and copper) in marine fish, shellfish, wild game, and seaweed. Metal bioaccessibility was generally greater than 50%. The 95th percentile UCLM for selenium, cadmium, and manganese bioaccessibility in foods ranged from 34 to 100%. Arsenic had low bioaccessibility in wild game organs (7-19%) and rabbit meat (4%), and mercury bioaccessibility was low in salmon eggs (10%). These data suggest that the assumption of 100 percent bioaccessibility is a health protective assumption and may overestimate exposure and risks for some metals in some foods.

6.11.4.3 Sediment Contact

<u>Sediment Ingestion Rates</u>

As described above, no data are available on sediment IRs; therefore, for this assessment, soil IRs are assumed to represent sediment ingestion for recreational visitors. Specifically, a soil IR of 20 mg/day was used to assess exposure and risks for adults and children per Health Canada guidance (2019, 2021a). This may represent an overestimate of exposure, particularly for gravelly stream beds with lower proportions of fine size fractions (i.e., fine sediment particles less than 250 µm in diameter). It is noted that predominantly lower soil IRs including 14 mg/day for a toddler, 23 mg/day for a young child, 1.4 mg/day for a teen, and 1.6 mg/day for adults have been identified in the 2013 *Canadian Exposure Factors* Handbook (Richardson 2013), based on analyses by Wilson et al. (2013). Thus, the use of a 20 mg/day sediment IR may overestimate risks for recreational visitors.

The 200 mg/day sediment IR used for Ktunaxa cultural activities such as foraging and wading is likely to overestimate sediment exposures for most individuals. As discussed in Section 4.2.3.2, the 200 mg/day rate is slightly higher than the 90th percentile estimates produced in two studies evaluating soil ingestion in First Nations adults living a cultural lifestyle (Doyle et al. 2012; Irvine et al. 2014). The 200 mg/day is consistent with the standard default IR for young children applied by USEPA (2014), but is higher than that identified in updated soil analyses for children (von

Lindern et al. 2016). Additionally, these studies focus on soil ingestion instead of sediment, which contributes uncertainty to the sediment IR, but is likely to overestimate, not underestimate risks due to the potential for co-exposure to water which will slough off sediment adhering to skin.

6.11.4.4 Groundwater Well-by-Well Evaluation

Per the permit requirements, for each exposure medium, risks were presented by MU, which reasonably assumes a receptor may contact constituent concentrations over the entire MU throughout their exposure period. For drinking water exposures, it is recognized that receptors may consume water primarily from one source. Therefore, an additional analysis was conducted to estimate risks for individual wells/sources at the request of the HHRA Workgroup. All groundwater concentrations were below screening levels in MU-3, and no wells were sampled in MUs 1, 2, or 6, so this analysis focused on MU-4 (25 wells) and MU-5 (24 wells).

Groundwater EPCs were calculated for the COPCs (iron, manganese, lithium and selenium) detected at each well within MU-4 and MU-5 based on the 95 UCLM of the time series dataset for that well. ProUCL was used to calculate well-by-well EPCs, consistent with the EPC calculation methodology described in Section 4.1. If the sample size was not robust enough to calculate a 95 UCLM, the maximum detected concentration was used for the EPC. The individual well EPCs are shown in Appendix G-1b, using de-identified labels for the wells to protect privacy.

HQs for each COPC were calculated by life stage for each well based on the EPC for that well. These HQs are shown in Appendix H. Nine wells (six in MU-4 and three in MU-5) had HQs greater than 0.2 for lithium, manganese, or iron, and in 75 percent of these instances the EPC was the maximum detected concentration of the COPC at that well. Well-27 in MU-5 had an HQ of 2 for manganese and Well-34 in MU-5 had an HQ of 2 for lithium (for the most sensitive life stage). Both of these wells were only sampled once, and the EPCs were the detected concentrations. These HQs potentially overestimate or underestimate potential risks. Participation in the RDWMP should be encouraged to continue monitoring drinking water supplies, particularly in these wells which have been sampled only once.

6.11.4.5 Manganese Concentrations in Berries

Berries, particularly blueberries and huckleberries, are identified as a good source of manganese, an essential nutrient (USDA 2019, Womanfitness 2023). As previously discussed in Section 6.7.1, elevated risks for manganese were identified in toddlers consuming berries in MU-4 at the preferred and upper percentile levels. Although risks for toddlers consuming berries in MU-4 were higher than other MUs, no evidence has found high dietary intake of manganese to result in toxicity or significant health concerns (Finley et al. 2003). Moreover, for this HHRA, the HIs derived from the Valley-wide berry data did not exceed the HIs of their respective reference HIs (Appendix H, Table HQ-11). These findings suggest that risks associated with manganese may be overestimated and may be best managed by consuming berries from all areas rather than exclusively from MU-4.

6.11.5 Toxicity Assessment Uncertainties

TRVs are derived from epidemiology studies in workers or other highly exposed populations and toxicity studies in animals that often have high levels of uncertainty due to the need to extrapolate from very high exposure levels to much lower exposures experienced in environmental settings. Extrapolation of results from animals to humans adds additional uncertainty. TRVs incorporate UFs to ensure that risk estimates will be protective. This procedure provides assurance that risks will not be underestimated, but also may result in substantial overestimation of risks.

6.11.5.1 Selenium Toxicity and Translation to Health Effects

As described in Section 5.1.1, Health Canada has age-range specific TRVs for selenium which are based on ULs derived by IOM (2000). The TRV for adults $\geq$ 20 years (0.0057 mg/kg-day) was applied to all ages in this assessment because it was the most conservative for the relevant age ranges (i.e., 6 months to adult). The TRV derivations and application of selenium risk results to health effects are described here.

The TRV is derived from a NOAEL and LOAEL based on a study of five adult patients from a seleniferous region of China with overt clinical signs of selenosis over six years (Yang and Zhou 1994). The critical effect was hair and nail brittleness and loss, which are signs and symptoms of selenosis following chronic selenium exposure. Yang and Zhou identified the NOAEL of 800 µg/day and a LOAEL of 910 µg/day. This can be interpreted to mean that the onset of selenosis occurs at or above daily selenium intakes of 910 µg/day, and that no adverse effects are expected below 800 µg/day. The 0.0057 mg/kg-day TRV is based on a NOAEL of 800 µg/day from Yang and Zhou (1994). A UF of 2 was applied to the NOAEL, resulting in a UL of 400 µg/day. The 400 µg/day UL was then divided by an adult body weight of 70.7 kg to yield the TRV of 0.0057 mg/kg-day (IOM 2000, Health Canada 2021b). The 0.0057 mg/kg-day TRV was applied to all ages in this assessment. There is uncertainty in applying the Yang and Zhou findings to children because no children were included in the study. However, IOM (2000) states, "...there is no evidence indicating increased sensitivity to selenium toxicity for any age group."

IOM (2000) used background levels of selenium in human breast milk as reported in Shearer and Hadjimarkos (1975) to derive the selenium ULs for infants and children. Shearer and Hadjimarkos (1975) did not gather health information in their study, so it unknown if there were adverse effects associated with any of the levels reported. Nevertheless, IOM (2000) used the maximum selenium concentration in breast milk (60 µg/L) reported in Shearer and Hadjimarkos (1975) to derive a NOAEL of 45 µg/day for 0-to-6-month infants. IOM notes the selenium concentrations in breast milk reported in Shearer and Hadjimarkos (1975) were similar to selenium breast milk levels reported in another study (Brätter et al. 1991 as cited in IOM 2000). IOM did not apply UFs to the NOAEL because they concluded there was no evidence that intake associated with a human milk level of 60 µg (0.8 µmol)/L results in infant or maternal toxicity. Thus, the UL for 0-to-6-month infants was set equivalent to the NOAEL, 45 µg/day. IOM adjusted the ULs on a body weight basis for other age ranges. Health Canada adjusted the IOM ULs to correspond with Canadian-specific body weights and age ranges to derive the age-specific TRVs for selenium (ENV 2014, Health Canada 2021b). The resulting TRVs for infants (6 months of age and older), children, and adolescents ranged from 0.006 mg/kg-day to 0.0063 mg/kg-day. Thus, the TRVs based on background intakes are similar to and slightly less conservative than the TRV based on onset of selenosis symptoms from Yang and Zhou (1994), which was the basis for the TRV used in this assessment.

Exposures greater than the 0.0057 mg/kg-day TRV result in HIs greater than 1 and indicate the need for ongoing monitoring and adaptive management. A few considerations should be taken into account before translating the selenium risk results to health effects. Health Canada DQRA guidance states:

"It is important to note that the magnitude of the HQ does not necessarily correspond to the magnitude of expected health effects. A TDI or RfD does not distinguish between health and disease. The TDI represents a conservative estimate of human dose that will be free of health effects in the vast majority of the population. The extent by which a TDI must be exceeded before health effects could occur is not known." (Health Canada 2010, Section 6.3.1)

The presentation of adverse health effects varies across a population due to inter-individual variation in how the body processes selenium. Young children, the elderly, pregnant women, and immunocompromised individuals are generally considered most sensitive to any chemical or biological exposure. Toxicity criteria are developed to account for the more sensitive end of the range. The best approximation for when low level toxicity begins to occur is the lowest observed adverse effect level, or LOAEL. Yang and Zhou (1994) estimated a LOAEL of 910 µg/day for selenium. This is a conservative LOAEL that accounts for the lower end of the range in the study population in Yang and Zhou (1994) and considers a separate case where 913 µg selenium caused deformed fingernails in a male adult via daily supplementation with 2,000 µg sodium selenite. Yang and Zhou report a mean LOAEL of 1,540 +/- 653 µg/day using data from the 36 cases of selenosis in the study population. Yang and Zhou report that selenosis 'occasionally occurred' when average dietary selenium intakes in the population were 1,427 +/- 554 µg/day and no cases occurred when the average daily selenium intake of the population was 750 +/- 672 µg/day. Yang and Zhou note that the unexpected variation in the occurrence of selenosis could be due to factors such as genetics, past selenium intake (i.e., baseline selenium status), and environmental stressors. Other factors that influence selenium in the human body include physiological status, age, exposure time, nutrition patterns, and socioeconomic status (dos Santos et al. 2021). Interactions with other chemicals (e.g., mercury) and microbiome effects can also play a role in selenium toxicity (Rayman 2020).

Another important consideration in translating risk results to health effects is that the exposure intakes in the HHRA are conservative estimates intended to approximate reasonable maximum exposure. It is likely that actual selenium intakes, if measured through biomonitoring, would differ. Additionally, not all of the selenium estimated in an exposure intake stays in the body. Selenium can be excreted in the urine and urinary excretion is considered an adaptive mechanism for maintaining selenium homeostasis in the body (dos Santos et al. 2021).

It is possible excess selenium exposure could result in health effects at lower doses, or different health effects not accounted for in the review of selenium toxicity conducted by Health Canada in their derivation of the TRV. In addition to selenosis and selenosis symptoms (e.g., alopecia), health conditions that have been associated with excess selenium intake include non-melanoma skin cancer, increased mortality, type 2 diabetes, and increased prostate cancer risk (Rayman 2020).

Regulatory authorities must weigh the weight-of-evidence regarding potential health effects when developing toxicity criteria. Most of the more recent scientific literature regarding potential health effects associated with overexposure to selenium has come from clinical trials where selenium was given as a potential preventive treatment (e.g., SELECT, NPC trial, PRECISE pilot study). These studies are advantageous because of the large number of participants and controlled selenium intake, but do not provide information on the mechanism of action for selenium toxicity. The studies have generally yielded results with mixed findings. For example, The Selenium and Vitamin E Cancer Prevention Trial, or SELECT, was developed to determine whether selenium, vitamin E, or both could prevent prostate cancer and other diseases. The randomized trial recruited 35,533 men 50 years old and over from 2001 to 2004. Participants were sorted into four groups: Placebo, Vitamin E, Selenium, and Selenium + Vitamin E. Each group had approximately 8,700 men, who were followed for a minimum of 7 years and a maximum of 12 years. It was ultimately concluded that neither selenium nor Vitamin E, alone or in combination, prevented prostate cancer (Lippman et al. 2009). The study also evaluated potential adverse health effects associated with the study supplements. Lippman et al. (2009) reported the relative risk of developing alopecia and dermatitis (grades 1 to 2) was significant in the group given selenium supplementation (200 µg/day). Alopecia and dermatitis were not significant in the group given the same dose of selenium plus vitamin E, or in the vitamin E or placebo groups.

In 2023, the European Food Safety Authority (EFSA) delivered a scientific opinion on the tolerable upper intake level (UL) for selenium of 255 µg/day for adult men and women (including pregnant and lactating women) based on a LOAEL of 330 µg/day EFSA developed using the results of the SELECT study. Alopecia was the critical endpoint. The 330 µg/day LOAEL incorporates baseline selenium status (130 µg/day) and selenium supplementation (200 µg/day). EFSA applied a UF of 1.3, based on expert judgment. EFSA (2023) notes that application of a higher UF would result in ULs for younger age groups very close to background. To our knowledge, this is the first time chronic toxicity criteria has been developed for selenium that is not based on the studies by Yang and Zhou (1994).

The EFSA LOAEL and resulting UL are lower than the LOAEL (from Yang and Zhou 1994) and UL (from IOM 2000) used as the basis of the Health Canada TRV. Specifically, the EFSA adult UL is about 36 percent lower than the IOM UL. Of note, Canadian selenium market basket intakes for toddlers (approximately 100- 110 µg/day) are currently above the EFSA ULs for younger age groups (70-95 µg/day). The comparison of the EFSA LOAEL with the Canadian selenium dietary intake underscores the challenges associated with deriving protective and useful health-based guidelines for selenium, which is an essential nutrient, is unavoidable in the human diet, and causes adverse effects at higher levels. The EFSA ULs have not been recommended for application to Canadian populations at this time.

In summary, it cannot be concluded that a specific selenium intake, such as the 910 µg/day LOAEL, would result in observable health effects. However, it is possible that some individuals could exhibit low level selenium toxicity, such as hair loss, at this level. This is why the TRV is derived using the NOAEL and an additional uncertainty factor of 2 to protect sensitive individuals. The selenium HIs and associated intakes are estimated and intended to be conservative. It is likely that actual selenium intakes, if measured through biomonitoring, would differ. The HHRA is not a health study and is not able to predict levels of selenosis in the Elk Valley community or for a specific individual. However, it identifies environmental media that have unacceptable levels of selenium where further consideration and potential risk management action is needed.

6.11.5.2 Cobalt and Lithium Toxicity Criteria

Current toxicity criteria for cobalt and lithium are not well-supported and likely overestimate risks associated with exposure to these metals. The USEPA IRIS program has not developed toxicity values for these metals; instead, the USEPA developed 'provisional RfDs' with low confidence in the toxicity assessments. Provisional RfDs are typically developed for screening of constituents not associated with widespread health concerns, while the more rigorous IRIS process is reserved for constituents that may be associated with greater potential human health risks. Uncertainties in assessment of cobalt and lithium are discussed further here. Additionally, alternate TRVs for cobalt and lithium derived in *Interim Groundwater Screening Criteria for Cobalt and Lithium* (Ramboll 2021) are described. and risk results using these TRVs are presented in the Uncertainty Assessment. The alternate TRVs were reviewed by stakeholders including the Elk Valley Groundwater Working Group and HHRA Workgroup (with representatives from IH, ENV, and KNC), and Health Canada. Risk results for select scenarios using these TRVs are presented in the following sections to understand the potential overestimation of risks discussed in this HHRA.

6.11.5.3 Cobalt

Cobalt is an essential nutrient that is present in many foods and is a component of vitamin B12. Cobalt has been used historically to treat anemia and is taken by some athletes to increase the oxygen-loading capacity of the blood (Finley et al. 2012). At very high doses, adverse health effects have been observed. The available human and animal data demonstrate that cobalt produces adverse effects in multiple organs and systems. Cardiovascular, hematological, and endocrine effects have been consistently observed in humans and animals, while animal dosing studies have also shown neurological, reproductive, and developmental responses at much higher doses.

<u>Review of Provisional Cobalt RfD</u>

The USEPA (2008b) provisional RfD for cobalt (3E-04 mg/kg-day) that was used in this HHRA was derived based on thyroid toxicity (decreased iodine uptake) in twelve adults with normal thyroid function exposed in a two-week study (Roche and Layrisse 1956). The Roche and Layrisse study only assessed effects at one dose, 1 mg/kg-day. Consequently, this became the LOAEL. The USEPA applied a total UF of 3,000 to the LOAEL of 1 mg/kg-day in its derivation of the provisional chronic cobalt RfD. The following UFs were applied:

- UF of 10 for extrapolation of a LOAEL to a NOAEL. Normally the point of departure is based on a NOAEL, but no NOAEL was reported in the critical study (Roche and Layrisse 1956).
- UF of 10 for extrapolation from sub-chronic to chronic ED. The critical study used a two-week exposure period.
- UF of 3 for database uncertainty, specifically lack of a multi-generation toxicity study. This was applied because several animal studies indicate effects on sperm function and testicular degeneration, which raises concerns that cobalt may affect reproductive capability.
- UF of 10 for lack of data regarding inter-individual human variability or information on sensitive populations. This was applied because the critical study population consisted of healthy adults.

The resulting 3,000-fold UF is very high and reflects considerable uncertainty and low confidence in the chronic RfD. In the PPRTV document, the USEPA states the confidence in the principal study is low-to-medium, confidence in the toxicology study database is low-to-medium, and the confidence in the RfD is low. The reason for the low confidence rating is that a temporal relationship between prolonged oral cobalt exposure and increased severity of thyroid effects in humans or experimental animals is not clear based on the available data (USEPA 2008b).

Though intended to be protective of human health, the USEPA's provisional RfD is well within the range of normal daily intakes estimated for cobalt, as discussed in detail in Ramboll (2021). Using daily intake data reported for study populations in Canada, the United States, Australia, and the United Kingdom, Ramboll (2021) determined about half the studied population is exposed to levels of cobalt above the provisional RfD from diet alone. This suggests the RfD is not representative of a dose that may cause adverse effects.

Review of Additional Cobalt Toxicity Data and Alternate TRV Development

Toxicity values other than the USEPA's PPRTV have been developed for cobalt. The most recent was published by Finley et al. (2012), who proposed an RfD for cobalt of 3E-02 mg/kg-day, 100 times higher than the PPRTV (3E-04 mg/kg-day). Finely et al. (2012) reviewed multiple human exposure and animal toxicity studies, ultimately selecting Jaimet and Thode (1955) as the critical study because it was the only study from which a NOAEL and LOAEL could be identified in a multiple dose study in humans. Additional strengths of the study included the evaluation of multiple clinical endpoints, reversibility of clinical responses, and that the study involved children, a potentially sensitive subpopulation. It is unknown why this study was not included in the USEPA's PPRTV development for cobalt. Finley et al. (2012) applied a total UF of 30 in their derivation of the cobalt RfD, accounting for adequacy of the database (UF of 3) and sensitivity and variability in the population (UF of 10). Additional detail on the Finely et al. (2012) study is provided in Ramboll (2021).

Development of a value higher than the PPRTV is consistent with the recommendations of several international government agencies, including the Dutch National Institute of Public Health and Environment (RIVM), which has a tolerable daily intake about five times higher than the PPRTV (1.4E-03 mg/kg-day; RIVM 2001). The UK Food Standards Agency commissioned the Expert Group on Vitamins and Minerals (EVM), which suggested a vitamin/mineral supplement guidance level for cobalt equivalent to 2E-02 mg/kg-day for a 70 kg adult (EVM 2003), which is about 65 times higher than the PPRTV value. Because Finley et al.'s RfD was derived following applicable USEPA guidance, is based on a more robust toxicology database than the USEPA PPRTV, and has lower uncertainty and higher confidence, it was selected as the TDI in the development of a Health-based Value for cobalt in drinking water in Ramboll (2021). It is used as an alternate TRV for cobalt in this HHRA.

During review of the draft HHRA, Health Canada shared an alternate analysis of available cobalt toxicity literature and indicated support for use of a point of departure of 4.5E-01 mg/kg-day, modified by combined UFs of 30, resulting in an alternate TRV of 1.5E-02 mg/kg-day. This value is slightly lower than the TRV developed by Ramboll (3E-02 mg/kg-day), indicating use of a TRV about three orders of magnitude lower than the current USEPA PPRTV is warranted. Comments on the alternate TRV shared by Dr. Laurie Chan, consultant to the KNC, indicated support for the robust analysis by Finley et al. (2012) and, along with other members of the HHRA Workgroup, accepted use of the alternate TRV developed by Ramboll (2021) in the Uncertainty Assessment of this HHRA.

Table 6-20 provides a comparison of the HQs by cobalt TRV for fish tissue ingestion for the toddler preferred consumer, the most sensitive receptor. The TRV developed by USEPA and used in this HHRA (0.0003 mg/kg-day) yields HQs 100-fold higher than the alternate cobalt TRV from the Finley et al. (2012) study.

Table 6-21. HQs for Cobalt, Preferred Fish Consumer (Toddler) Using USEPA PPRTV TRV and Alternate TRV

Description of TRV	Used in HHRA?	TRV (mg/kg-day)	HQ by Location							
			MU-1	MU-2	MU-3	MU-4	MU-5	MU-6	Reference	Valley-Wide
p-RfD from USEPA PPRTV	Yes	0.0003	0.65	0.3	0.3	0.34	0.26	0.15	0.29	0.34
Alternate TRV developed by Finley et al. (2012)	No	0.03	0.0065	0.003	0.003	0.0034	0.0026	0.0015	0.0029	0.0034

Notes:

HHRA = human health risk assessment; HQ = hazard quotient; mg/kg-day = milligram(s) per kilogram per day; MU = management unit; PPRTV = provisional peer reviewed toxicity values; p-RfD = provisional reference dose; TRV = toxicity reference value; USEPA = United States Environmental Protection Agency; Valley = Elk Valley

6.11.5.4 Lithium

Lithium, in the forms of lithium carbonate and lithium citrate, is often used for therapeutic treatment of bipolar disorder and other mood disorders (Moore 1995). Because lithium is used therapeutically for the treatment of psychiatric conditions, there are clinical reports of adverse effects in human populations. The available human and animal data demonstrate that lithium produces adverse effects in multiple organs and systems. Adverse renal effects associated with lithium therapy have received extensive focus due to their serious nature and frequency of occurrence. The most common renal effect reported is impaired renal concentrating ability, resulting in the production of excessively dilute urine. Adverse neurological, endocrine, cardiovascular, gastrointestinal, hematological, and developmental effects have also been reported. The animal data have demonstrated adverse effects at exposure levels in the same range as that targeted for therapeutic treatment in humans.

<u>Review of Provisional Lithium RfD</u>

In 2008 the USEPA derived a provisional RfD for lithium by applying UFs to the dose equivalent of the lower bound of the therapeutic serum lithium concentration range. The daily serum concentration levels measured in patients receiving lithium for medical treatment have been reported to range from 0.5 to 1.5 millimoles per litre (mmol /L; Moore 1995, European Chemical Agency 2020). The USEPA (2008c) lithium PPRTV document cites a slightly narrower range (0.6 to 1.4 mmol/L). The entire target range for therapeutic serum lithium concentrations has been associated with adverse effects, which has caused treatment strategies to be based on a risk-benefit assessment for individual patients. Data reported in human studies are not sufficient to define the relationship between serum lithium concentrations and the development or severity of adverse effects, although it is generally accepted that the severity of adverse effects is related to serum lithium levels. The USEPA reviewed clinical reports along with studies in experimental animals, but no data were adequate for use in determining a NOAEL.

Ultimately, the USEPA selected the lower bound of the therapeutic serum lithium concentration range of 0.6 mmol/L as the basis for derivation for the provisional RfD. The USEPA calculated a corresponding daily lithium dose equivalent to 2.1 mg Li/kg-day. The provisional RfD of 2E-03 mg/kg-day was then calculated through application of a 1,000-fold UF. The following UFs were applied:

- UF of 10 for extrapolation of a LOAEL to a NOAEL. The lower bound of the therapeutic serum lithium range is associated with the development of adverse effects in several organs and systems; a NOAEL for adverse effects of therapeutic lithium has not been established in the clinical or animal literature.

- UF of 10 to account for database uncertainties. The renal effects of lithium have been extensively studied in humans and animals. However, much less information is available on the effects of lithium in other systems. Additionally, subchronic and chronic exposure studies in animals assessing comprehensive endpoints are not available, and the database lacks well-controlled epidemiology studies and multi-generation reproduction studies in animals although there is evidence of developmental effects in lithium patients.
- UF of 10 to account for sensitivity and variability in the population. Since lithium adversely affects several organs and systems, numerous pre-existing disease states (e.g., renal disease, cardiovascular disease, endocrine disease) may increase susceptibility to lithium.

The USEPA identified a low-to-medium confidence in the LOAEL, toxicology database, and resulting provisional RfD. Primary limitations include the lack of information regarding dose response, the inability to determine the relative sensitivity of different organ systems and establish a NOAEL, and the lack of well-controlled epidemiology studies and multi-generation reproduction studies in animals.

Although adverse effects have been reported for the entire target therapeutic serum lithium concentration range and there are numerous database uncertainties, the provisional RfD (2E-03 mg/kg-day) is roughly an order-of-magnitude below typical intakes in the Canadian diet (averaging around 2.6E-02 mg/kg-day). Also, the provisional RfD is around the middle of the range of worldwide dietary intakes (2.3E-04 to 4.2E-02 mg/kg-day). This RfD is also below provisional dietary recommendations (additional detail provided in Ramboll 2021). The application of the 1,000-fold UF to the low end of the therapeutic dose range results in the RfD being 1,000 times lower than the minimum treatment dose. Therapeutic doses may be associated with toxic effects, which may be considered acceptable for patients relative to the benefits of treatment; however, a 1,000-fold difference between the therapeutic dose and a "safe" dose is extremely conservative.

Review of Additional Lithium Toxicity Data and Alternate TRV Development

While lithium in not generally recognized as a required nutrient, lithium deficiency has resulted in behavioral abnormalities and reduced conception rates in animals. These effects have not been shown in humans, although some data suggest that behavioral defects may be associated with reduced lithium intake (Schrauzer 2002). A daily allowance of 1 mg/day has been recommended by Schrauzer (2002) for lithium as a micronutrient (equivalent to a dose of 1.3E-02 mg/kg-day based on an adult body weight of 74 kg). Marshall (2015) concluded that 1 mg/day is likely at the low end of a relevant nutrient intake level for optimal health-based on individual differences, stating that up to 20 mg/day "is very safe with a very low incidence of side effects." An intake of 20 mg/day for a 74 kg person is equivalent to a daily dose of 2.7E-01 mg/kg-day. While these recommendations and intake levels have not been used to establish toxicity values, and NOAELs have not been established in the clinical or animal literature (see exceptions below), these daily dose levels give some indication of the dose range at or above which potential NOAELs may be identified and are much greater than the PPRTV of 2E-03 mg/kg-day.

The only TRVs proposed for lithium by international governing agencies or in the literature, aside from the USEPA's PPRTV, are the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) Derived No Effect Levels (DNELs). The REACH oral DNEL of 1.2 mg/kg-day is considerably higher than the USEPA PPRTV (2E-03 mg/kg-day). The value is also above the range of provisional dietary intake recommendations and the naturally high exposure levels discussed above. While this DNEL value is supported under the European regulatory framework, complete documentation of its development, particularly the Uncertainty Assessment, is not available.

Ramboll (2021) developed an alternate TRV for lithium based on the same underlying toxicity data used to develop the PPRTV with a modified Uncertainty Assessment. Briefly, the UF of 10 used by the USEPA (2008c) for extrapolation from a LOAEL to a NOAEL was applied, based on the lack of established NOAELs in the clinical and animal literature. Ramboll (2021) applied UFs of 1 and 3 to account for sensitivity and variability in the population and database uncertainties, respectively, resulting in a TRV of 7E-02 mg/kg-day. This TRV is roughly midway between the DNEL of 1.2 mg/kg-day and the provisional RfD of 0.002 mg/kg-day, and is applied as an alternate TRV for lithium in this HHRA.

Comments received from Health Canada and Dr. Chan on the draft HHRA agreed that the published literature supporting evaluation of lithium toxicity is weak and for that reason, were not supportive of deviating from use of the USEPA PPRTV in this HHRA. However, they, along with other members of the HHRA Workgroup, agreed it was acceptable to include use of the alternate TRV proposed by Ramboll (2021) in the Uncertainty Assessment.

Table 6-22 provides an example comparing HQs calculated using the USEPA's TRV for lithium (0.002 mg/kg-day) and Ramboll's alternate lithium TRV discussed above (0.07 mg/kg-day). The HQs for an infant consuming surface water as drinking water are shown, as lithium was identified to have HQs greater than 0.2 for consumption of surface water when the USEPA TRV is applied. The alternative TRV developed by Ramboll yielded much smaller HQs than those obtained when applying USEPA's TRV for lithium.

Table 6-22. HQs for Lithium in Surface Water when Consumed as Drinking Water (0-6 Month Infant) Using USEPA PPRTV TRV and Alternate TRV

Description of TRV	Used in HHRA?	TRV (mg/kg-day)	HQ by Location						
			MU-1	MU-2	MU-3	MU-4	MU-5	MU-6	Valley-wide
p-RfD from USEPA PPRTV	Yes	0.002	0.4	0.41	0.91	0.32	0.14	0.06	0.45
Alternate TRV developed by Ramboll (2021)	No	0.07	0.011	0.012	0.026	0.009	0.004	0.002	0.013

Notes:

HQ = hazard quotient; mg/kg-day = milligram(s) per kilogram per day; MU = management unit; PPRTV = provisional peer reviewed toxicity values; p-RfD = provisional reference dose; TRV = toxicity reference value; USEPA = United States Environmental Protection Agency; Valley = Elk Valley

6.11.5.5 Uncertainties Related to the Use of Chronic Toxicity Values and Exposure Analyses for Short-Term Exposures

Exposure to sediments and surface water were evaluated based on assumed exposure during the summer for 52 days (EF = 52 days/year). This shorter-term exposure is considered a subchronic exposure. However, to properly evaluate subchronic exposures, subchronic TRVs are needed. No subchronic TRVs are available in the top tier toxicity values identified by ENV (2021a) (i.e, Health Canada, USEPA's IRIS, or WHO). Risk and hazard estimates for all sediment and surface water exposure scenarios were quite low, with all cancer risk estimates being less than 1E-05 and the only HQ exceeding 0.2 being cobalt in sediment. Specifically contact with cobalt in sediment in MU-4 while foraging/wading, had HQs of 0.6 for a toddler and 0.4 for a child. There is no subchronic TRV for cobalt in Health Canada (2021b), USEPA IRIS or WHO. However there a subchronic TRV of 0.003 mg/kg-day, for cobalt derived by PPRTV identified in the USEPA Regional Screening Level tables. This subchronic TRV is 10-fold less conservative than the TRV of 0.0003 mg/kg-day used in the assessment. Application of the subchronic TRV and a shorter subchronic averaging time of 120 days to reflect the summer months when the 52 days of exposure in place occur in place of the 365-day averaging time used in the assessment would result in HQs of less than 0.2 for both the toddler and child receptors. Thus, the use of chronic toxicity values and a chronic exposure averaging time does not appear to underestimate risks associated with sediments and surface water.

6.11.5.6 Lead in Game Meat

Risks were negligible for consumption of game meat for all COPCs and consumer groups except preferred consumers in MU-5, where toddlers had an HQ greater than 0.2 for lead (Appendix H, Table H-12). The source of lead in game samples in MU-5 are unknown. It is possible that the use of lead ammunition in hunting game may result in elevated residual lead in meat (Health Canada 2018). Risks related to lead in game can be reduced by using non-lead ammunition. In addition to ammunition, other possible sources of increased lead exposure in game include discarded batteries, farm machinery, lead-based paints on farm structures, and discarded engine oil (Alberta 2022). For this HHRA, some HQs for lead exceeded 0.2 (Appendix H, Table HQ-12) but the degree to which these may have been influenced by ammunition or the other sources listed is unknown. These HQs merely indicate the need to monitor tissue concentrations further and do not indicate an adverse health effect will occur.

6.11.6 Risk Characterization Uncertainties

Overall, we have high confidence that this risk characterization for water quality-related pathways (i.e., ingestion of groundwater, contact with surface water and sediment, and fish consumption) is protective, and in many instances errs on the side of overestimating risks, rather than underestimating risks. The underlying sources of the uncertainties are discussed in previous sections of this uncertainty analysis as well as in the risk characterization section. In the 2016 HHRA, the results of the HQs for game and berry consumption were difficult to interpret due to a lack of a reference dataset, resulting in a significant source of uncertainty in the HHRA. The game and berry dataset has greatly improved since 2016 with the implementation of the Wild Foods Sampling Program, which increases the level of confidence in the risk results and with the addition of samples collected from outside of the DA, allows for comparison of mine- and non-mine-affected tissue samples. However, it is still unknown to what degree the risk results for these media are due to mine influences, and the linkage of tissue COPC concentrations to water quality is highly uncertain. Ultimately, the focus of the Permit 107517 HHRA is placed on the water quality-related pathways and the significance of these findings with consideration of the uncertainties described in this section are discussed further in Section 7.

6.11.6.1 Antagonistic Effects in Cumulative Noncancer Risks

It is generally assumed that for threshold COPCs acting on a similar target organ, risks are additive and cumulative HIs are calculated by target organs for similarly-acting COPCs. The summed HIs for these COPCs provides a conservative estimate of noncancer risks. While mercury and selenium may act upon a similar target organ (nervous system), it is known that the interaction of mercury and selenium is antagonistic, i.e., the toxicity is reduced when both metals are present. Many studies have shown that exposure to selenium with mercury results in a health protective effect (Zhang et al. 2014). High molar ratios of selenium to methylmercury present in all but the highest trophic level fish have been proposed to reduce methylmercury absorption and toxicity (ATSDR 2022; ATSDR 2013; Ayotte et al. 2011). Mercury neurotoxicity may be mediated by irreversible inhibition of selenoenzymes. High Se/Hg ratios likely reduce the toxicity of ingested mercury by decreasing the inhibition of selenoenzymes (Afonso et al. 2015).

Nevertheless, HQs for mercury and selenium were still summed, which may cause an overestimation of risks. The only medium where mercury and selenium are both COPCs is fish tissue. To understand the magnitude of the overestimation, the nervous system HIs were reviewed for the pathway showing the highest risks (i.e., preferred rate fish ingestion by toddlers). The HIs are shown in Table 6-23. As discussed in Section 6.3.2, the nervous system HI is driven by selenium HQs for MUs 1 through 5 and mercury HQ for MU-6. For MUs 1 through 5, if mercury was not included in the HI summation, the nervous system HIs are still greater than 1. The same is true if selenium is not included in the MU-6 HI summation. Therefore, while the risks are lower when accounting for antagonistic effects, the conclusions are unlikely to change.

Table 6-23. Fish Tissue Nervous System Hazard Index (HI), Toddler Preferred Consumption

MU	COPC	HQ	HI All	HI Selenium	HI Mercury
MU-1	Aluminum	0.022	4	4	0.4
	Mercury	0.33			
	Selenium	3.5			
MU-2	Aluminum	0.023	7	4	2
	Mercury	2.3			
	Selenium	4.4			
MU-3	Aluminum	0.028	4	2	3
	Mercury	2.5			
	Selenium	1.5			
MU-4	Aluminum	0.022	7	6	1
	Mercury	0.94			
	Selenium	5.9			
MU-5	Aluminum	0.023	5	3	2
	Mercury	1.8			
	Selenium	2.7			
MU-6	Aluminum	0.03	30	1	29
	Mercury	29			
	Selenium	0.7			
Valley-wide	Aluminum	0.027	5	4	1
	Mercury	1.2			
	Selenium	3.8			

Notes:

COPC = constituent(s) of potential concern; HI = hazard index; HQ = hazard quotient; MU = management unit

6.12 Data Gaps and Data Needs

Data gaps were identified in the 2016 HHRA and measures were taken to address them to the greatest extent possible. In some cases, available information adequately addressed the gap and a need for further data collection to address the gap is not necessary. Data gaps become data needs when the available data do not adequately characterize exposures to allow for an order-of-magnitude assessment to determine if risks approach a risk management threshold, or if the data gap limits interpretation of the risk assessment results. Data gaps and identification of those gaps which are considered data needs are summarized here, in the event they may inform future health risk evaluations within the DA:

- Considerable effort was taken by the KNC to develop preferred consumption rates for Ktunaxa who consume fish, game, berries, and rose hips, and these data have been helpful in characterizing potential risks. One of the main findings of the current HHRA was elevated HQs for selenium exposure associated with consumption of longnose sucker from MU-4 or of bull trout from MU-2. These estimates assume consumers eat only longnose sucker or only bull trout at the preferred consumption rate, which is unlikely reflective of actual consumption.
  - Additional data on species-specific consumption rates and preferred species for consumption would improve accuracy of risk estimates and representativeness of a typical diet.
  - Because longnose sucker concentrations are higher in Goddard Marsh than other places, additional data on selenium within other areas in MU-4 would help refine risk estimates.
  - Locally caught fish are a vital and high quality food source. A better understanding of consumption rates as well as locations where people fish will enable a clearer understanding of the degree to which reductions related to contaminants in fish impact food security and nutritional needs of Ktunaxa consuming fish harvested within the DA (Marushka et al. 2021).
- Tissue concentrations of COPCs in game are limited within some MUs, but because game move between MUs and people may harvest game from more than one MU, the valley-wide estimates are likely the most representative of risk. For this reason, the limitations in data for samples of various game resources are not considered a critical data need, but opportunistic sampling of game should continue.
  - If sample size is increased, it may be possible to assess risks for deer and elk separately, providing helpful information to consumers.
  - Deer and elk are not the only animals consumed. Collection of other species that comprise a large portion of meat intake would inform consumers about potential risks associated with their food choices.
- Valley-wide estimates of berry tissue COPC concentrations are likely most representative of risk due to the potential for consumers to harvest berries (and rose hips) from a variety of locations within the valley, which reduces the need for large sample sizes for each MU.
  - While there may not be a strong need for additional berry data, the opportunistic collection and analysis of additional berries will continue to improve our understanding of potential berry risks.
  - People consume more than berries and rose hips. Collection of other species that comprise a large portion of vegetation intake, with consideration of changes in harvest by season, would provide an opportunity to better inform consumers about their foods.

No other data gaps or data needs were identified that are likely to influence risks or risk management decisions within the DA. However, discussion of data gaps and data needs with the HHRA Workgroup is expected to continue to better inform future assessment of potential health risk.

6.12.1 Ktunaxa Knowledge Relationships and Normative Research Approaches: Methodologies, Methods, and Processes for Engagement and Meaning Making (Prepared by KNC)

It is difficult to reconcile the data gaps and data needs generated within the current methodology employed which rely upon generic values and methods including data analyses, without the recognition that Ktunaxa knowledge relationships including how to use this study, are most absent, throughout this study for a variety of reasons. The intangible cultural heritage and resources of the Ktunaxa-specific to qukin ʔamakʔis have been subjected to the ‘inclusion model’ to be fit into the normative methodology, timelines and knowledge system. This has been problematic to the uptake of the importance of such a study as evidenced by this last iteration of the Ktunaxa Nation Diet Study approach and results. One limitation of this HHRA is that the data set is largely from permit requirements that require the samples for different reasons other than the HHRA – i.e. environmental management vs. human health risk characterization.

The assumptions about Ktunaxa knowledge and peoples and relationship to place, is reinforced by the methodology employed. There was considerable re-working to ensure the 2019 Diet Study expanded purposefully to reflect actual lived experiences of the Ktunaxa, but given the limited time allotted, there is still room for improvement.

A severe limitation is not having a communication or dissemination plan that is grounded in Ktunaxa knowledge relationships that privileges Teck and its requirements, suggesting Ktunaxa have been subjected to a data mining rather than high level partnership and investment. One opportunity for improvement would be to collect samples in preferred areas where locals and Ktunaxa are "on the land" in addition to the samples collected for other permit requirements.

The food list originally used, because values existed for certain foods only is a severe limitation of this study, in that plants that are ingested by non-humans, who are then harvested and eaten, have not been documented in relation to ethnobotanical studies undertaken by the Ktunaxa in the areas. This would increase the types of Ktunaxa foods collected as the samples--game and berries are not the only Ktunaxa foods consumed.

7. SUMMARY AND RECOMMENDATIONS

Teck was requested to perform a HHRA for the Elk Valley focused on examination of the potential risks of mine-related water quality constituents on human health and to include an analysis of both current and preferred consumption of berries, game, and fish harvested within the Elk Valley. This HHRA was completed to satisfy this request, which was specified under EMA Permit 107517, Section 8.10. Risk analyses include exposure pathways for constituents in or derived from surface water (i.e., exposure to constituents in groundwater, surface water or sediments, or through consumption of fish) and pathways that may have more limited influence from constituents in surface water (i.e., consumption of berries, rose hips, or game).

This 2021 HHRA is an update to the 2016 HHRA and technical memorandum, relying on more recently collected environmental monitoring data (2015-2020) and revised exposure scenarios developed in consultation with the HHRA Workgroup. The HHRA followed the BC CSR approved methodologies and acceptable risk levels to the extent possible while also addressing concerns and needs raised by the HHRA Workgroup. The HHRA Workgroup was composed of members of the EMC: representatives of the KNC–Lands and Resources Sector, IH, ENV, and others.

7.1 HHRA Summary

This HHRA assesses current conditions, using monitoring data rather than modeled concentrations. The HHRA utilizes data obtained between the years 2015 and 2020, and include surface water, sediment, fish tissue, groundwater, and wild plants and game collected through Teck's RAEMP and RDWMP, and also considers data collected from other studies as relevant. This includes wild game and berry sample data collected by Teck staff, Ktunaxa ʔaqłsmaknik, and KNC staff through the Wild Foods Sampling Program. Food consumption rates, including current (Firelight 2014; Fediuk and Firelight 2015) and preferred rates provided by the KNC (2020), and other exposure parameters provided by Health Canada (2010a; 2010b; 2019; 2021a; 2021b) and USEPA (2004, 2008a, 2011) were used to assess exposures. Other exposure parameters were obtained from federal and provincial risk assessment guidance and peer reviewed literature.

COPCs evaluated in the HHRA are naturally occurring and may be a source of exposure both in the environment and in the diet. Selenium is the largest contributing COPC to potential risk, and is present naturally and is associated with mining influences. Therefore, selenium risks were estimated using measured COPC concentrations in environmental media, in fish and game, and published "market basket" intake data. The cumulative risks for exposures via the diet and environmental exposure pathways inform risk managers on total estimated risks for the populations evaluated in the HHRA.

The HHRA results are summarized by exposure medium as follows:

Groundwater

- Consumption of groundwater as drinking water results in risks below risk management levels of concern when evaluated on a MU-basis for mining-related COPCs only. This assessment did not include all water quality parameters that can adversely affect human health. Moreover, water quality can change over time. Drinking water is monitored by Teck under the RDWMP in consultation with IH. Two wells were found to exceed a HQ of 1, for lithium or manganese, when evaluated on a well-by-well basis. These wells were sampled only once; due to the small sample size, HQs for these wells may reflect an over- or underestimate of risk.

Surface Water & Sediment

- Selenium is present in surface water at concentrations greater than the BC water quality guideline of 10 µg/L in numerous locations (See Appendix C, Table C-1), but HQs for consumption of drinking water do not exceed a threshold of 1.

- Elk River and Koocanusa Reservoir are safe areas for recreational and cultural activities that are associated with sediment and surface water contact (e.g., swimming, wading). This is based on evaluation of metals and PAHs. This summary does not pertain to consumption of fish, which was found to result in elevated risk, as noted below.
- Surface water should not be used as drinking water for infants to avoid exposure to nitrates, which can cause methemoglobinemia, i.e., blue baby syndrome. Furthermore, this assessment did not evaluate the presence for bacteriological or microbiological contamination that may be present and present a health risk to consumers. Interior Health recommends testing and treating surface water from rivers, streams, or lakes anywhere in the province before use as drinking water.

<u>Fish, Berries & Rose Hips, and Game</u>

- Comparison to reference area or market basket data is critical to interpreting results for fish, game, and berries.
- Risks for consumption of berries and game muscle and organ meat were below the risk management threshold HQ of 1 or consistent with background risks for all consumers except for toddlers consuming game meat (due to lead) from MU-5 (exclusively) at preferred consumption rates and toddlers consuming berries (due to manganese) from MU-4 (exclusively) at preferred or upper percentile rates.
- Risks for consumption of fish eggs were below the threshold HQ of 1 for all consumers.
- Risks for recreational anglers consuming fish harvested from areas studied in the Elk Valley and Koocanusa Reservoir at upper percentile rates (i.e., up to 43 g/day or approximately 60 meals/year) were below the HQ threshold of 1.
- Risks for people of all ages consuming fish at preferred consumption rates (i.e., up to 245 g/day or approximately 365 meals/year) from Koocanusa Reservoir were below the HQ threshold of 1 for selenium and consistent with HQs for consumption of fish from reference areas. Elevated HQs in Koocanusa Reservoir are due to mercury, which is introduced from regional and global sources via atmospheric deposition. Review of fish mercury concentrations in regional lakes (Section 6.11.3.1) suggests mercury concentrations in Koocanusa Reservoir fish are consistent with mercury concentrations in other regional lakes.
- Risks were greater than an HQ of 1 for all age groups consuming fish at preferred rates for fish harvested in MUs 1 through 5 and for valley wide estimates (due to selenium). An exception are HQs of 1 for adolescent and adult preferred anglers in MU-3 (due to selenium). This would indicate that consumption of fish from Elk Valley (i.e., MU-1 through MU-5) at preferred rates is associated with potential risk due to selenium and that ongoing monitoring and management is needed.
  - The highest risks are for MU-4 where toddlers consuming fish at the preferred level have an HQ of 5.9 indicating potential for overexposure to selenium.
  - Longnose sucker in Goddard Marsh, in particular, should not be consumed (due to selenium).

Additional, more detailed HHRA findings include the following:

- The cumulative risk results suggest that Elk Valley foods are higher in selenium than market basket and reference area foods.
  - Contribution of Elk Valley foods to total selenium exposure and risk varies by consumer. For example, the average consumer (toddler) has an HI estimate that is 0.7 higher than the background diet (i.e., market basket foods only); the preferred diet consumer (toddler) has a HI estimate that is 5.4 higher than the background diet. This demonstrates that differences in selenium concentrations in Elk Valley foods combined with consumption rates

strongly influence Elk Valley risks relative to background risks. Differences in cumulative selenium risk across MUs are mainly due to differences in fish HQs, which are likely attributable to differences in selenium concentration by MU and/or species sampled by MU.

- Cancer risks did not exceed the ENV threshold (1E-05) or were consistent with reference.
- Use of surface water and groundwater as irrigation water was evaluated semi-quantitatively in the Uncertainty Assessment. Based on this assessment, irrigation use is not expected to result in unacceptable risk.
- Selenium is primary contributor to elevated HQs in fish in MUs 1 through 5.
- Species-specific considerations are warranted when interpreting elevated HQs for consuming fish from MUs 1 through 5 at preferred consumption rates:
  - In MUs 1-5, risks *for constituents other than selenium* are generally consistent with background or below a HI of 1 (the ENV risk management threshold).
  - HQs are highest in estimates based on consumption of only longnose sucker from MU-4, or bull trout from MU-2 at preferred consumption rates. Additional data on species-specific consumption rates would improve accuracy of estimates.

7.2 HHRA Conclusions

The Permit 107517 HHRA provides a thorough and informative assessment of health risks associated with contacting surface water and sediment in MUs 1 through 6 and for consumption of fish, berries, rose hips, and game for a wide range of consumption levels, including Ktunaxa preferred consumption rates. The HHRA evaluated exposure pathways directly and indirectly influenced by water quality. Risks in the HHRA are ranked consistent with guidance from Health Canada and ENV. Selenium is the primary mine-related risk driver, and selenium risks are driven by fish consumption. Nitrate is also a concern for infants consuming surface water, such as when using to reconstitute powdered formula. Risk ranking includes the following: HQs equal to or less than 0.2 and cancer risks equal to or less than 1 additional cancer case in 100,000 are considered negligible; HQs equal to or less than 1, and HQs and cancer risks consistent with reference areas are considered to have acceptable risks; and HQs greater than 1 and background require further evaluation and may require risk management. No cancer risks were identified that were greater than 1 in 100,000 and reference, but some HQs were greater than 1 and reference. Although HQs cannot be directly linked to specific health effects, we assume as HQs increase the potential for health risk increases. For this reason, exposure pathways and receptors with the highest HQs (e.g., fish consumption by toddlers consuming at preferred levels) will be the highest priority for data gathering and risk management, as needed.

Influences from dust emissions from the mines were not directly evaluated; however, potential impacts from mine dust are considered to some degree through evaluation of berries, rose hips, and game. COPC concentrations in berries and rose hips will reflect deposition of dust to vegetation and uptake from soil, if any. Similarly, COPC concentrations in game meat reflect dust deposited on vegetation consumed by wildlife. The focus of the HHRA on risks associated with exposures to water and water-associated media inform water quality management practices, and risks for other media provide additional information informing other potential sources of exposures. While evaluation of incidental soil ingestion and inhalation of dust in air were not evaluated in this HHRA, these pathways have been shown in EA HHRAs to contribute less than 1 percent of the total HI for selenium. The omission of the soil ingestion and particulate inhalation pathways are not considered a source of uncertainty in understanding risks in the Elk Valley or result in a significant underestimation of risk because the combined results of the Permit 107417 HHRAs and EA HHRAs demonstrate that consumption of fish is the primary contributor to total HIs, along with consumption of other locally harvested foods and market basket foods, particularly for people consuming at preferred consumption levels. Future EA HHRAs will continue to provide a baseline estimate of risk via all the pathways discussed here, and can be used to verify the conclusion that a continued focus on food consumption pathways is most instructive in understanding health risk and that evaluation of soil and air in this context does not meaningfully inform risks.

The consistency in findings of the 2016 HHRA and in this final 2023 HHRA and previous EA HHRAs provide strong evidence for continued management of selenium in surface water, which contributes to elevated selenium in fish in MUs 1 through 5 and subsequently, elevated fish consumption risks for people consuming greater amounts of fish (i.e., upper percentile and preferred consumption rates). The HHRAs also indicate that variation in HIs by MU based on upper percentile and preferred consumption rates are most influenced by fish consumption risks and are relatively insensitive to risks contributed from other non-dietary exposure media.

Based on the findings of this risk assessment, exposure to selenium through fish consumption is the primary water quality-related exposure pathway-COPC combination resulting in risks greater than the ENV risk management thresholds. Selenium should continue to be monitored and evaluated in the event water quality changes result in increases across multiple MUs.

The HHRA also found that groundwater consumption does not present a risk for exposure to mining-related COPCs, but continued monitoring of drinking water supplies in compliance with federal and provincial guidelines and monitoring via the local and regional drinking water monitoring network will provide continued reassurance that potable water supplies are safe for consumption in the context of exposures to COPCs. Risk estimates for consumption of surface water as drinking water indicate nitrate exposure may sometimes be a risk for infants consuming surface water in MU-1 and MU-3. Risks are negligible for recreational contact with surface water and sediment.

Consumption of berries or game meats results in some elevated risks, but the tissue concentrations are generally consistent with reference area except selenium in game. Influences from dust emissions from the mine were not the subject of the HHRA and were not characterized. However, it is possible that airborne deposition has influenced concentrations in berries and on forage consumed by game. Due to some uncertainty in characterizing selenium and other COPC concentrations in berries and game, further evaluation may be warranted.

The HHRA in whole satisfies the conditions of Permit 107517 Section 8.10 and provides valuable information informing actions for continued assessment of potential health risk and identifies opportunities to improve monitoring data to improve future assessments. The ranking of risks can be used to prioritize future risk management activities by focusing on the exposure pathways yielding the highest risk estimates (e.g., fish consumption by toddlers consuming at preferred levels).

7.3 Recommendations

Based on the HHRA results, data gaps identified in Section 6.12, and feedback from the HHRA Workgroup, the following actions are recommended following submittal of the HHRA:

- Support HHRA Workgroup members in communicating results of the HHRA to stakeholders and communities.
- With input from the HHRA Workgroup, refine plans for the collection of monitoring data, particularly foods, to improve human health risk estimates. This may include:
  - Reviewing locations to ensure samples are collected from preferred locations for Ktunaxa cultural practices, including hunting and harvesting.
  - Adding additional mine-exposed locations that are representative of areas that are: 1) accessible locations for the public, 2) are legally open to fish harvest by recreational anglers, and 3) are commonly used by recreationally anglers.
  - Reviewing species collected and tissue types to reflect community preferences.

  - As a first step toward addressing community concerns about dust, collect additional vegetation samples from both mine-exposed and reference area locations, and analyze split samples with one subsample analyzed following a rinse and one subsample analyzed without rinsing.

- In consultation with the HHRA Workgroup, develop and implement a health risk-based data evaluation process in sequence with the monitoring data reporting cycle to inform health risks. This will include using risk assessment methodology to develop risk-based screening concentrations for fish tissue to help guide the need for further adaptive management, i.e., trigger concentrations.
- From the KNC: *Future study development be purposeful and mindful of Ktunaxa knowledge relationships including research processes and ethics reviews by Ktunaxa knowledge holders and language speakers. This would mean, prior to the undertaking of a study, the methodology be co-developed with Ktunaxa knowledge interests centered, with opportunity to engage in the restoration of knowledge relationships and capacity development for Ktunaxa ʔaqⱡsmaknik to fully appreciate the role of the HHRA assessment in their cultural perpetuation and decision making including a fulsome and Ktunaxa informed Wild food sampling in preferred locations. This would require a Ktunaxa literature review of reports and primary data from archives, not only the current model of secondary source data analyses completed in advance of a 'next iteration' of the HHRA process.*

7.4 Adaptive Management for Human Health

One purpose of the HHRA is to identify any needed adaptive management actions to address human health risks. The potential for impacts on human health resulting from exposures within the DA are evaluated as part of the adaptive management process, which asks under Management Question 6, "Is water quality being managed to be protective of human health?"

A health protective evaluation of potential human health risks that builds upon both the 2016 and on this final 2023 HHRA Report can support the adaptive management process. As described in more detail in Section 7.1, this 2023 report indicates that consumption of fish at a Ktunaxa preferred level is associated with unacceptable risks associated with selenium in MU-1 through MU-5 indicating the need for ongoing monitoring and adaptive management (i.e., additional water treatment as detailed in Teck's 2022 Implementation Plan Adjustment).

Consumption of fish at Ktunaxa preferred levels in MU-6 is associated with elevated risks related to mercury, but mercury concentrations are consistent with regional lakes. This assessment and the 2016 HHRA also identify unacceptable risks associated with nitrate exposures if surface water in MU-1 and MU-3 is used as drinking water for infants. Concentrations of selenium present in surface water at concentrations greater than the BC WQG of 10 µg/L in numerous locations, but HQs for consumption of drinking water do not exceed a threshold of 1.

Concurrent with any future health risk evaluation processes focused on assessing constituent concentrations in Ktunaxa foods, there are already programs in place addressing monitoring and assessment of drinking water and groundwater for protection of human health. In addition, there are ongoing programs addressing the evaluation of trends in constituent concentrations in surface water, sediment, and groundwater over time, and mechanisms are in place to trigger additional levels of scrutiny if concentrations are increasing. Thus, the Ktunaxa foods, which are also consumed by other residents and recreational foragers, are the remaining exposure media for which a process of risk-based evaluation is not yet established. Development and implementation of a food-focused program which informs adaptive management is a logical next step leading to a more meaningful and efficient evaluation process under Management Question 6.

The development of a process for addressing Management Question 6 is best performed in consultation with the HHRA Workgroup and with consideration of additional water treatment as detailed in Teck's 2022 Implementation Plan Adjustment which will reduce concentrations of selenium and nitrate, thereby reducing risk to consumers. Based on preliminary feedback received on “next steps” toward addressing protection of human health, the following considerations have been voiced:

- Identify risk communication needs for communities and audiences to whom HHRA Workgroup members are responsible to, and support development of risk communication materials.
- Develop a risk-based data evaluation process that can be implemented in synchrony with the completion of each RAEMP reporting cycle (i.e., every three years), as relevant, allowing time for QA/QC of monitoring data prior to risk analysis. Similarly, align assessments with Wild Foods Program data collection and analysis.
- Risk-based evaluation of exposure media prioritized in the Permit 107517 HHRA, specifically selenium in foods and selenium and nitrates in water, would be performed.
- In the event that unacceptable risks are identified, the data should be reviewed to better understand the source and possibly root cause of elevated concentrations to inform management decisions.

Continued work with the HHRA Workgroup should focus on establishing an approach that will ultimately be outlined in the Adaptive Management Plan.

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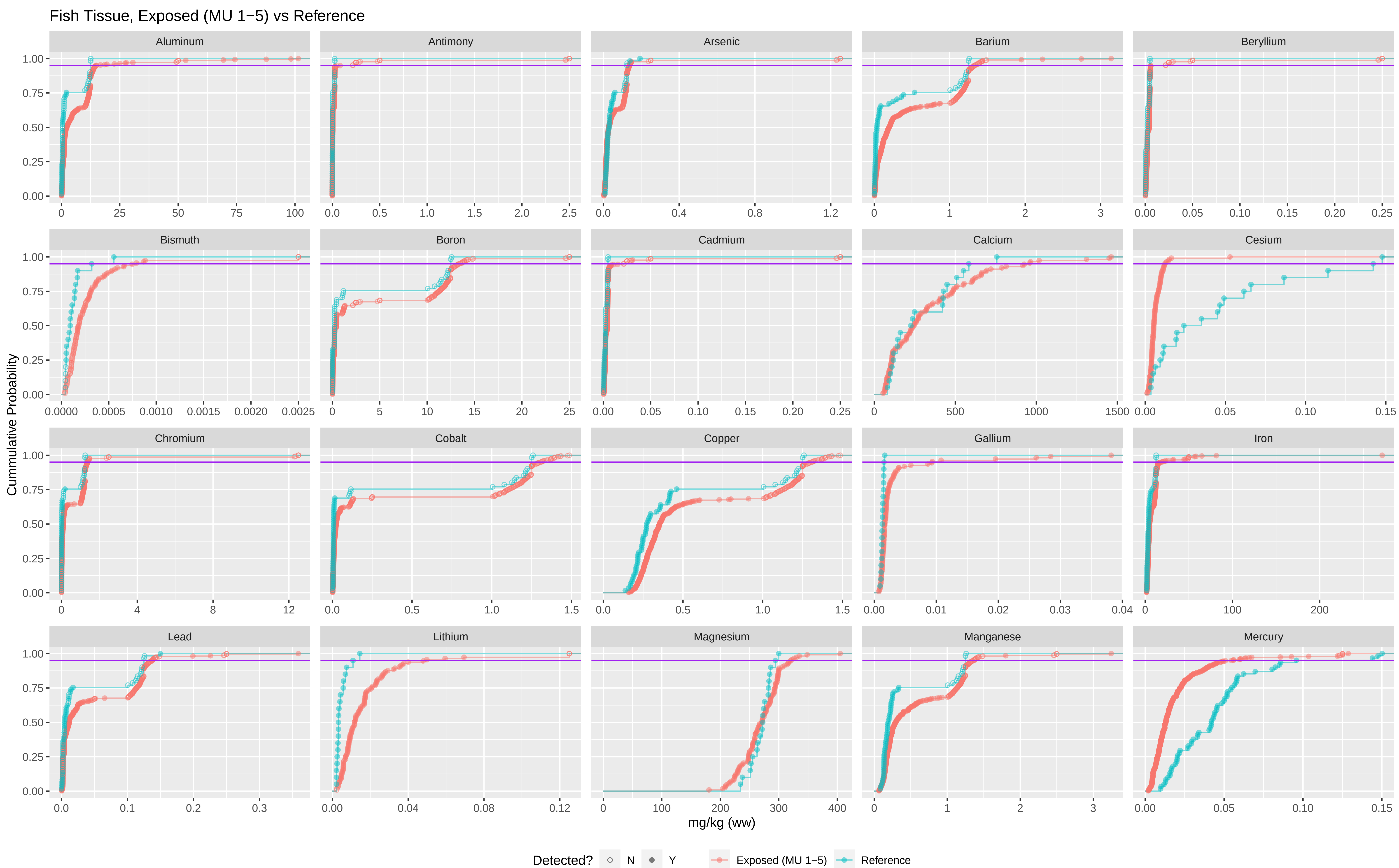
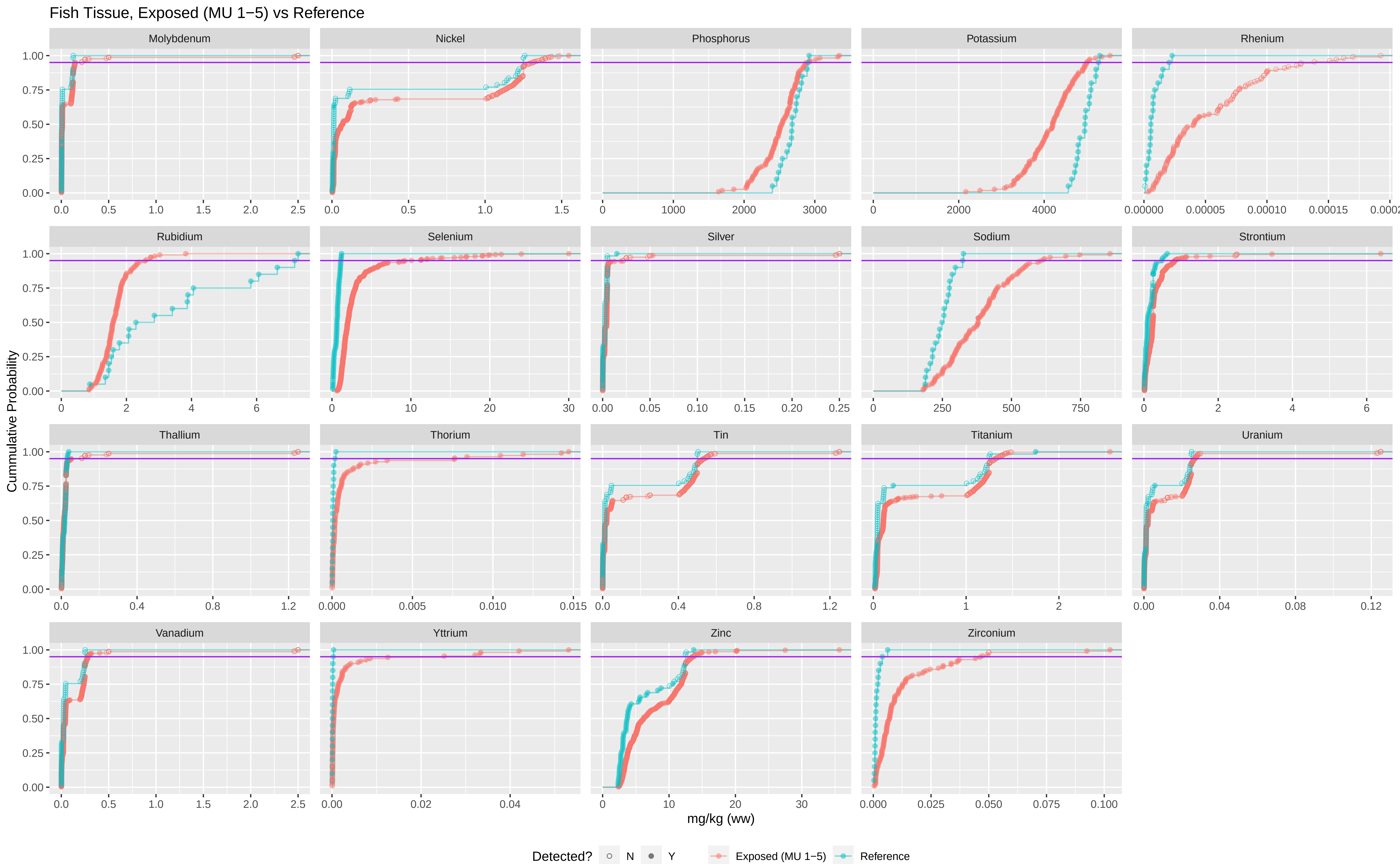
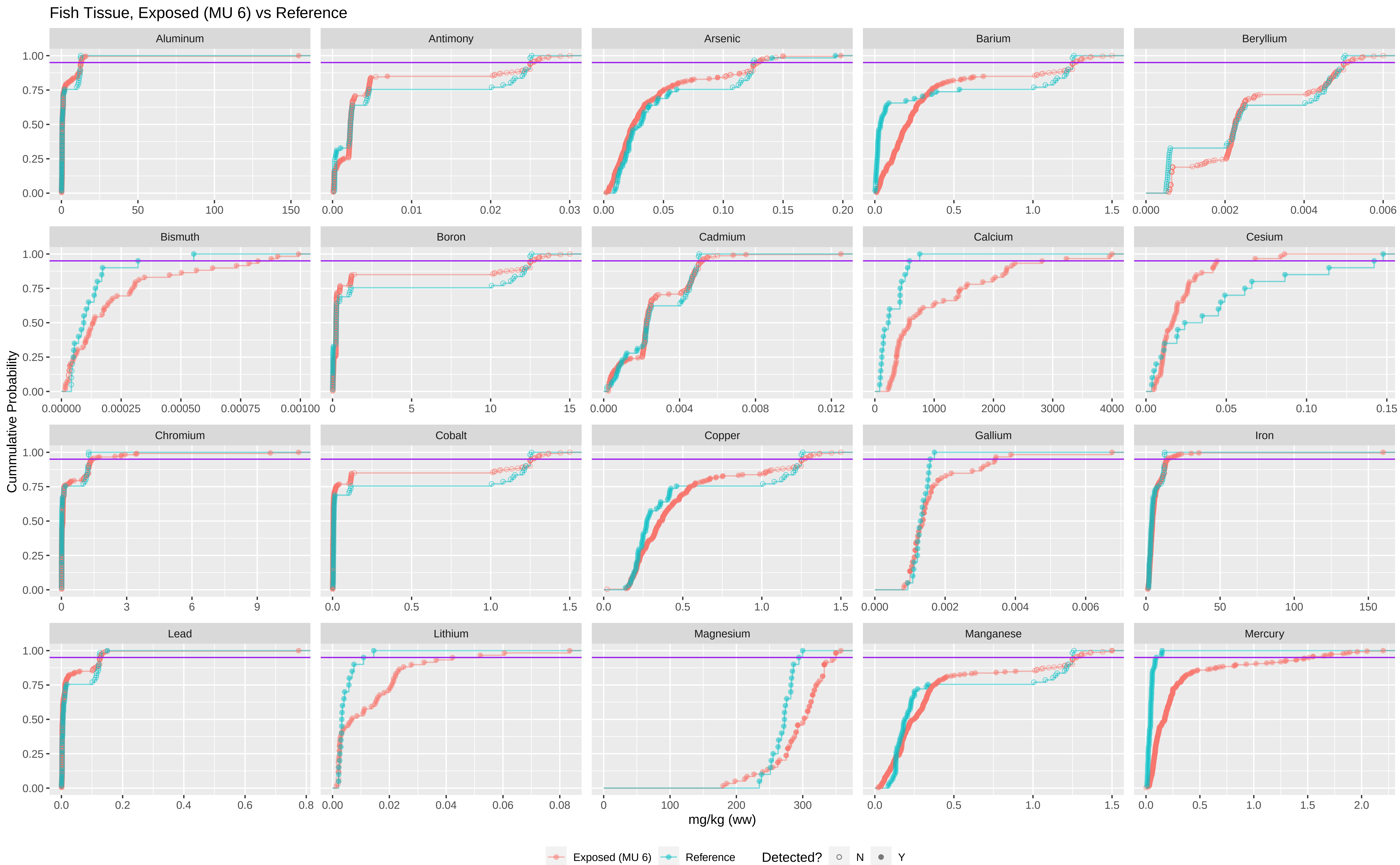
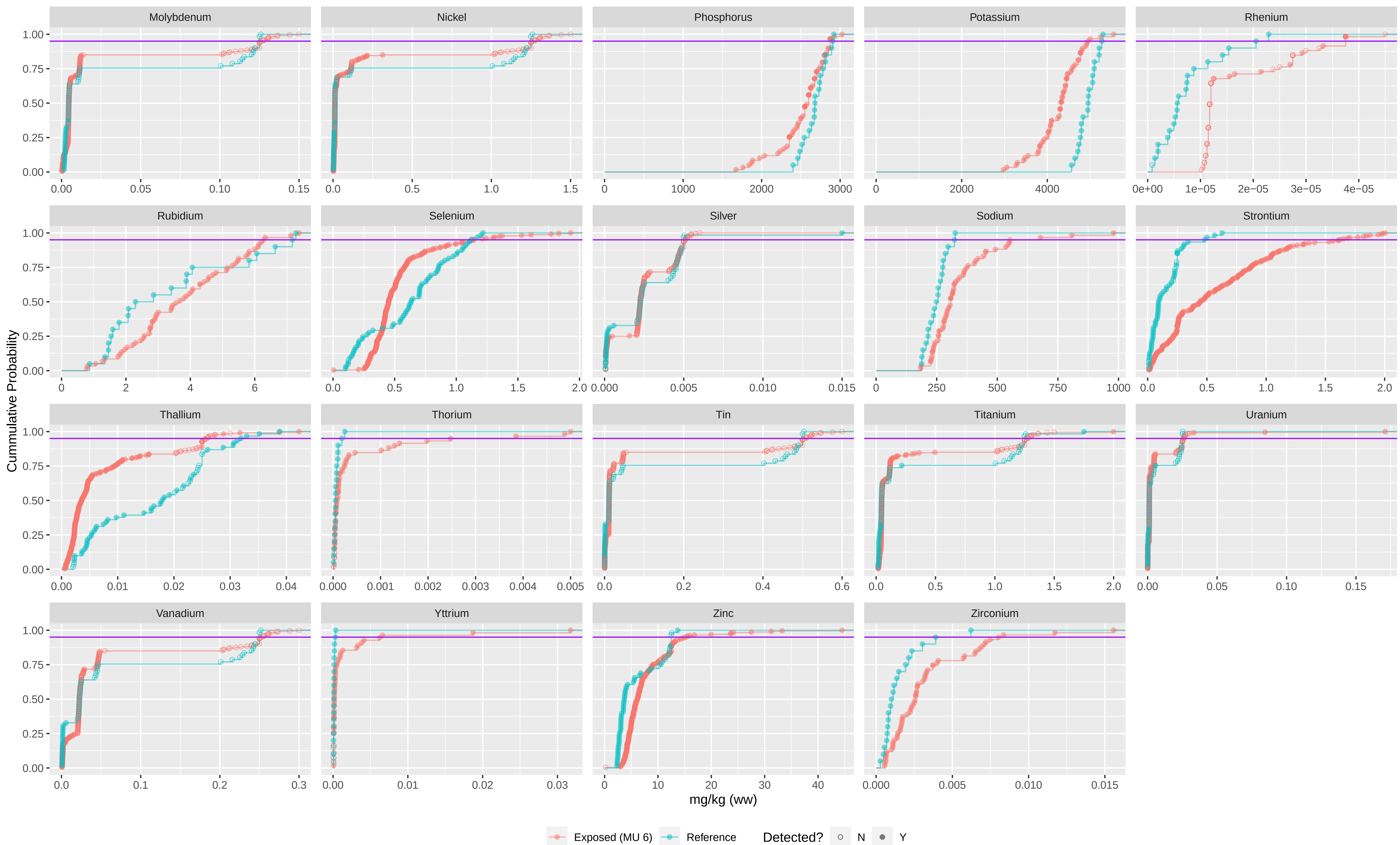
APPENDIX A
DISTRIBUTION PLOTS FOR ELK VALLEY FISH, GAME, BERRY AND ROSE HIP SAMPLES

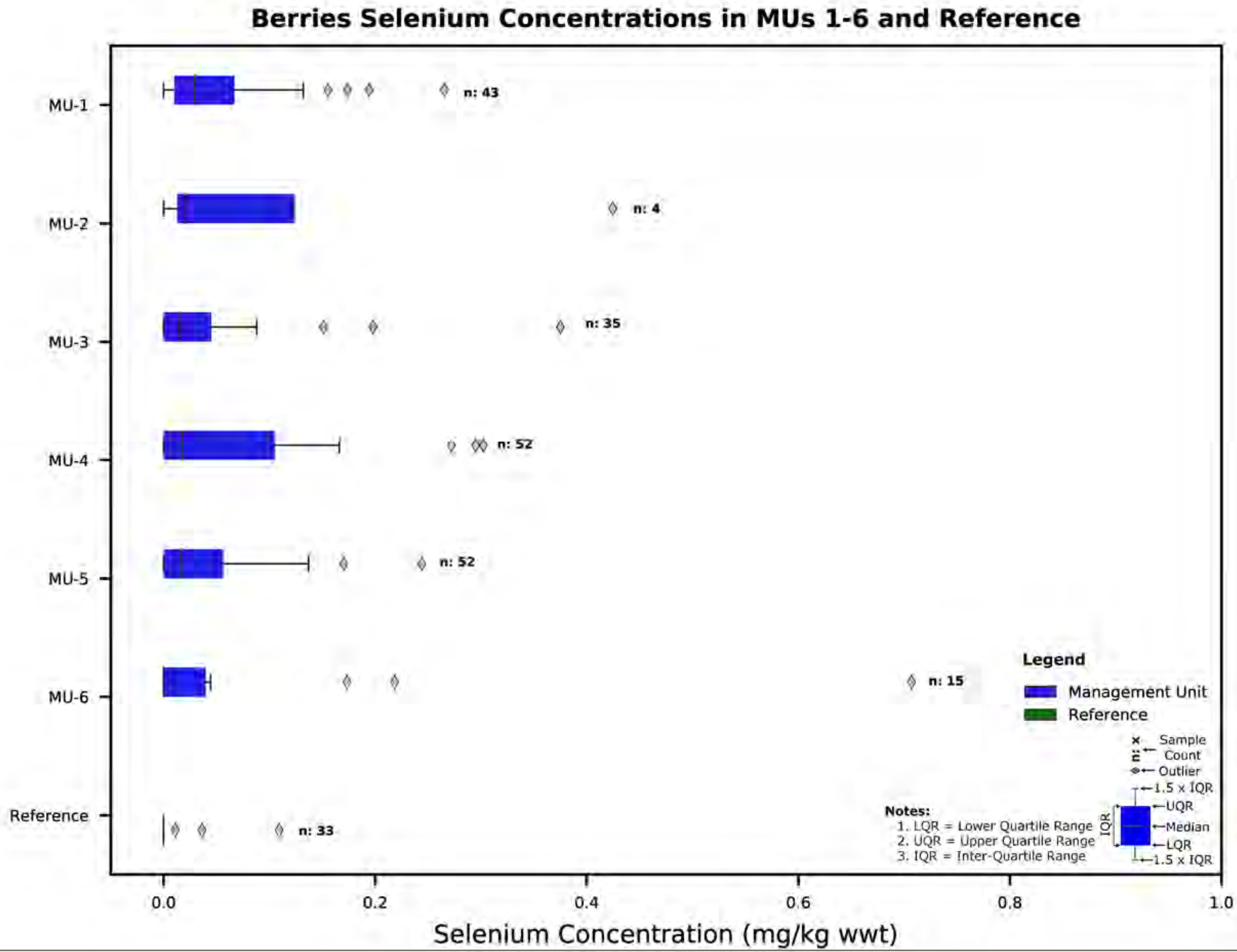

Fish Tissue, Exposed (MU 1−5) vs Reference
Aluminum
Antimony
Arsenic
Barium
Beryllium
Bismuth
Boron
Cadmium
Calcium
Cesium
Chromium
Cobalt
Copper
Gallium
Iron
Lead
Lithium
Magnesium
Manganese
Mercury
Cummulative Probability
mg/kg (ww)
Detected?
N
Y
Exposed (MU 1−5)
Reference


Fish Tissue, Exposed (MU 1−5) vs Reference
Molybdenum
Nickel
Phosphorus
Potassium
Rhenium
Rubidium
Selenium
Silver
Sodium
Strontium
Thallium
Thorium
Tin
Titanium
Uranium
Vanadium
Yttrium
Zinc
Zirconium
Cummulative Probability
mg/kg (ww)
Detected? N Y
Exposed (MU 1−5)
Reference


Fish Tissue, Exposed (MU 6) vs Reference
Aluminum
Antimony
Arsenic
Barium
Beryllium
Bismuth
Boron
Cadmium
Calcium
Cesium
Chromium
Cobalt
Copper
Gallium
Iron
Lead
Lithium
Magnesium
Manganese
Mercury
Cummulative Probability
mg/kg (ww)
Exposed (MU 6)
Reference
Detected?
N
Y

Fish Tissue, Exposed (MU 6) vs Reference



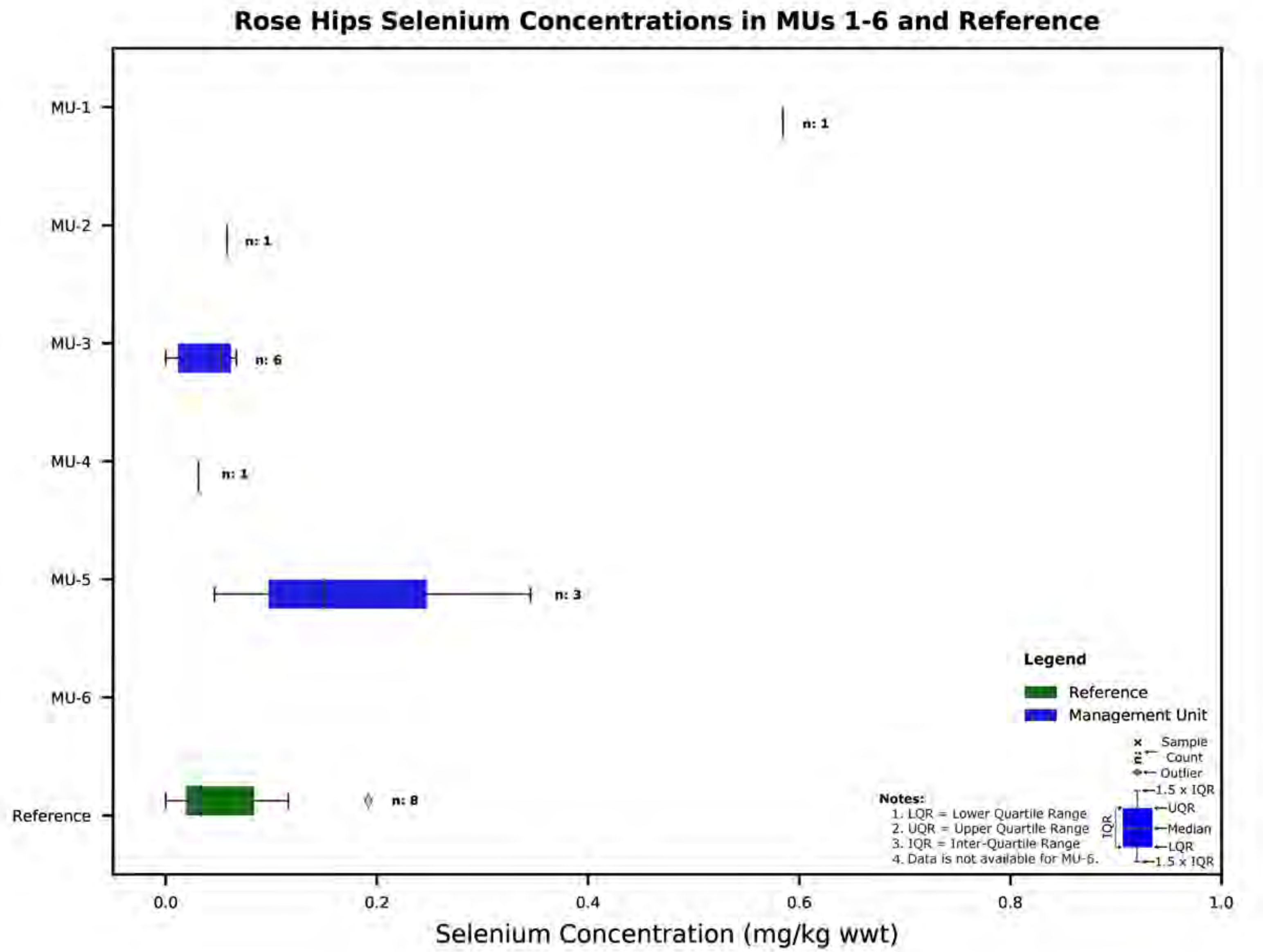


BERRIES SELENIUM CONCENTRATIONS IN MUs 1-6 AND REFERENCE

FIGURE A2-1

RAMBOLL US CORPORATION
A RAMBOLL COMPANY

Elk Valley
British Columbia, Canada

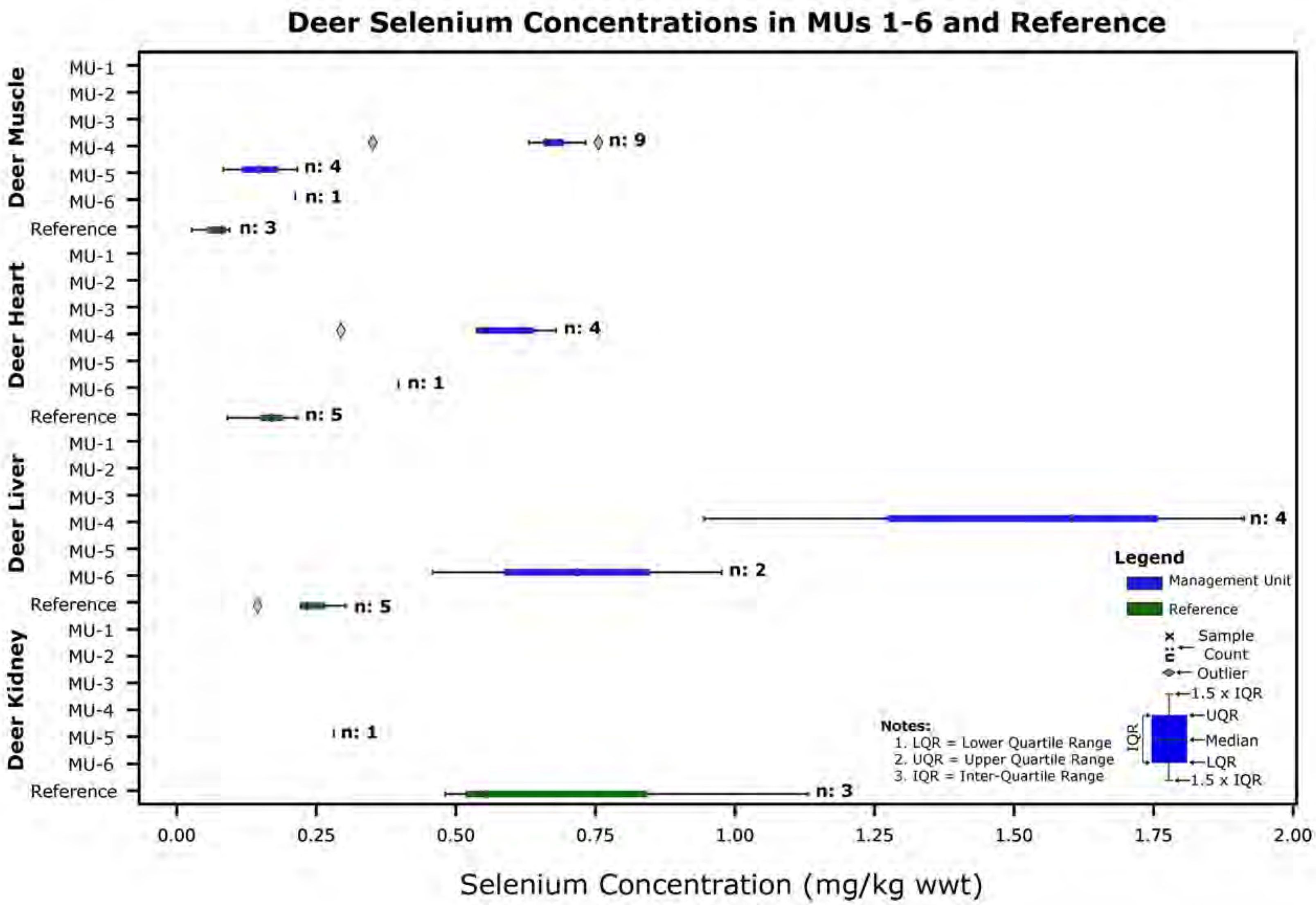


ROSE HIPS SELENIUM CONCENTRATIONS IN MUs 1-6 AND REFERENCE

FIGURE A2-2

Elk Valley
British Columbia, Canada

RAMBOLL US CORPORATION
A RAMBOLL COMPANY

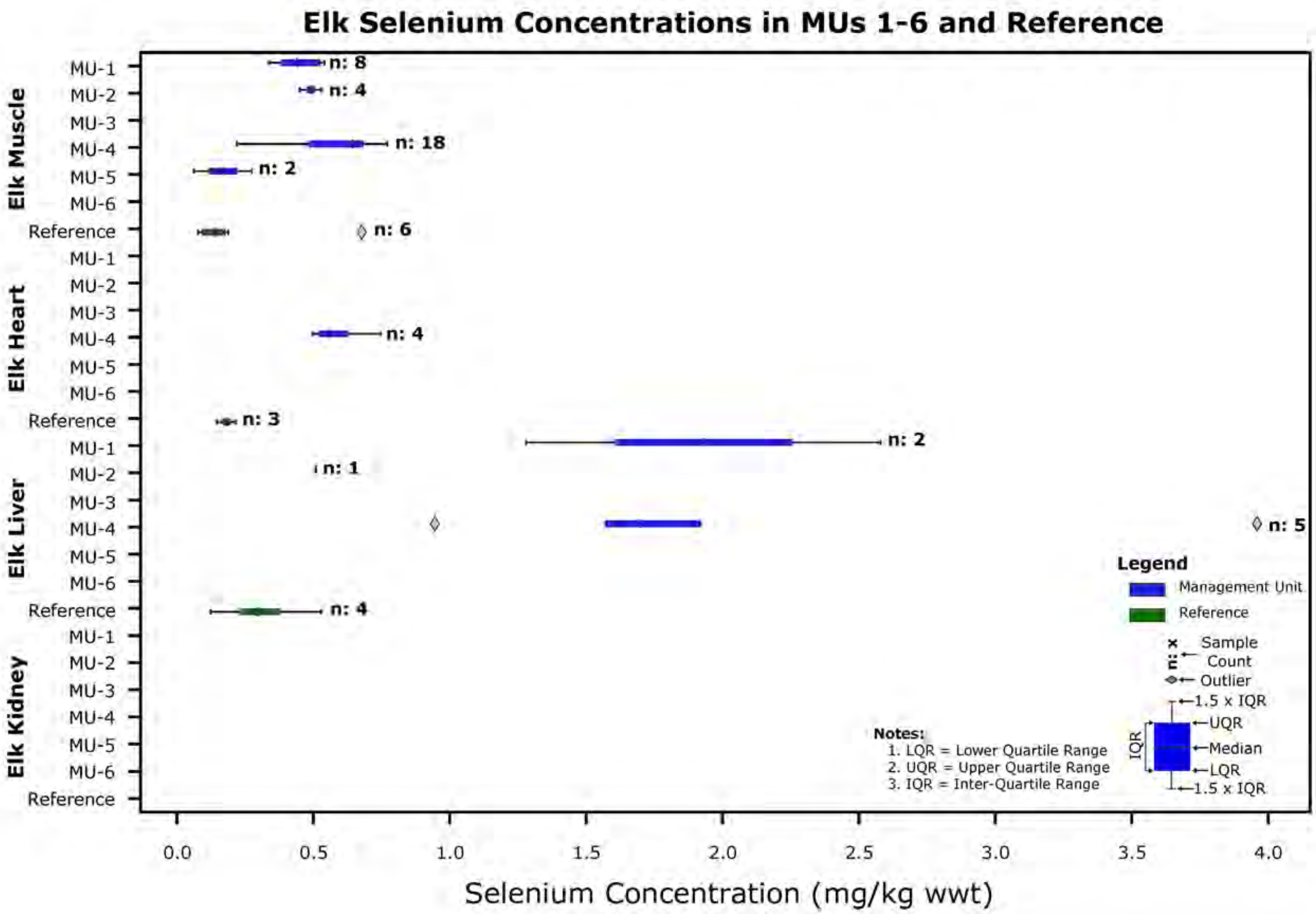


DEER SELENIUM CONCENTRATIONS IN MUs 1-6 AND REFERENCE

FIGURE A2-3

RAMBOLL US CORPORATION
A RAMBOLL COMPANY

Elk Valley
British Columbia, Canada



ELK SELENIUM CONCENTRATIONS IN MUs 1-6 AND REFERENCE

FIGURE A2-4

RAMBOLL US CORPORATION
A RAMBOLL COMPANY

Elk Valley
British Columbia, Canada

APPENDIX B
RISK-BASED SCREENING LEVELS RELATED TO HUMAN HEALTH

Table B-1. Guidelines Related to Drinking Water Quality for Human Health

Constituent	Source	Drinking Water Guideline (mg/L) (2020) [a]
Inorganic		
Aluminum	BC ENV WQG	9.5
Antimony	BC ENV WQG	0.006
Arsenic	BC ENV WQG	0.01
Barium	Health Canada	1
Beryllium	BC ENV CSR	0.008
Boron	BC ENV WQG	5
Cadmium	BC ENV WQG	0.005
Chromium, total	BC ENV WQG	0.05
Cobalt	BC ENV WQG	0.001
Copper	BC ENV WQG	2
Fluoride	BC ENV WQG	1.5
Iron	BC ENV WQG	0.3 [b]
Lead	BC ENV WQG	0.005
Lithium	BC ENV CSR	0.008
Manganese	BC ENV WQG	0.12
Mercury	BC ENV WQG	0.001
Molybdenum	BC ENV WQG	0.088
Nickel	BC ENV WQG	0.08
Nitrate (as N)	BC ENV WQG	10
Selenium	BC ENV WQG	0.01
Silver	BC ENV CSR	0.02
Thallium	USEPA MCL	0.002 [c]
Tin	BC ENV CSR	2.5
Uranium	BC ENV WQG	0.02
Vanadium	BC ENV CSR	0.02
Zinc	BC ENV WQG	3
Organic - PAHs [d]		
1-Methylnaphthalene	BC ENV CSR	0.0055
2-Methylnaphthalene	BC ENV CSR	0.015
Acenaphthene	BC ENV CSR	0.25
Acenaphthylene	BC ENV CSR (Acenaphthene) [e]	0.25
Anthracene	BC ENV CSR	1

Benzo(a)anthracene	BC ENV WQG	4E-06
Benzo(a)pyrene	BC ENV WQG	4E-05
Benzo(b&j)fluoranthene	BC ENV CSR	7E-05
Benzo(b)fluoranthene	BC ENV CSR (Benzo(b&j)fluoranthene) [e]	7E-05
Benzo(b,j,k)fluoranthene	BC ENV WQG	4E-06
Benzo(g,h,i)perylene	BC ENV WQG	4E-07
Benzo(k)fluoranthene	BC ENV WQG (Benzo(b,j,k)fluoranthene) [e]	4E-06
Chrysene	BC ENV WQG	4E-07
Dibenz(a,h)anthracene	BC ENV WQG	4E-05
Fluoranthene	BC ENV CSR	0.15
Fluorene	BC ENV CSR	0.15
Indeno(1,2,3-c,d)pyrene	BC ENV WQG	4E-06
Naphthalene	BC ENV CSR	0.08
Phenanthrene	BC ENV CSR (Anthracene) [e]	1
Pyrene	BC ENV CSR	0.1
Organic – Other		
Quinoline	BC ENV CSR	5E-05

Notes

[a] Water quality guidelines for residential drinking water are used as risk-based screening levels for surface water and groundwater. Values are Maximum Allowable Concentration (MAC), the level established at which adverse health effects are known or suspected, unless otherwise indicated.

[b] No MAC value available. Aesthetic Objective (AO) value used, which represents parameters that may impair taste, smell, or color; or impact water quality. The AO value does not cause adverse health effects.

[c] USEPA MCL for thallium, based on lowest level to which water systems can reasonably be required to remove thallium given present technology and resources (standard established 1992).

[d] Values preferentially sourced from BC ENV WQG, followed by BC ENV CSR. Values sourced from BC ENV WQG were quantified using an adopted benzo[a]pyrene guideline (b[a]p; 0.00004 mg/L) representing total carcinogenic polycyclic aromatic hydrocarbons (PAH) as total potency equivalents (TPE). TPEs were calculated by multiplying the concentration of each PAH in a sample by its b[a]p Potency Equivalence Factor.

[e] Guideline not available for analyte so a surrogate guideline for the analyte specified in parentheses was applied. This surrogate approach is consistent with the 2016 EVWQP HHRA.

BC ENV = Ministry of Environment and Climate Change Strategy; CSR = contaminated sites regulations; EVWQP = Elk Valley Water Quality Plan; MAC = maximum allowable concentration; mg/L = milligram per liter; USEPA MCL = United States Environmental Protection Agency Maximum Contaminant Level; WQG = Water quality guideline.

(Continued on next page)

Sources

BC ENV CSR: BCMoE. 2019. Environmental Management Act, Contaminated Sites Regulation – Consolidated Regulations of British Columbia (current to March 19, 2019) B.C. Reg. 375/96 Last amended January 24, 2019.

BC ENV WQG: British Columbia Ministry of Environment and Climate Change Strategy (BCMoE). 2020. B.C. Source Drinking Water Quality Guidelines: Guideline Summary. Water Quality Guideline Series, WQG-01. Prov. B.C., Victoria B.C.

Health Canada: Health Canada. 2020. Guidelines for Canadian Drinking Water Quality – Summary Table. Water and Air Quality Bureau, Health Environments and Consumer Safety Branch, Health Canada, Ottawa, Ontario. May 13.

USEPA MCL: United Stated Environmental Protection Agency. 2021. National Primary Drinking Water Regulations. Accessed from: https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations

Table B-2. Risk-Based Screening Levels Related to Soil/Sediment for Human Health

Constituents	Source	Numerical Soil Standards (mg/kg)[a]
Inorganic Constituents		
Aluminum	BC ENV CSR	40,000
Antimony	BC ENV CSR	250
Arsenic	BC ENV CSR	20
Barium	BC ENV CSR	8,500
Beryllium	BC ENV CSR	85
Boron	BC ENV CSR	8,500
Cadmium	BC ENV CSR	20
Chromium (all species)	BC ENV CSR	100
Cobalt	BC ENV CSR	25
Copper	BC ENV CSR	3,500
Iron	BC ENV CSR	35,000
Lead	BC ENV CSR	120
Lithium	BC ENV CSR	30
Manganese	BC ENV CSR	6,000
Mercury	BC ENV CSR	10
Molybdenum	BC ENV CSR	200
Nickel	BC ENV CSR	450
Selenium	BC ENV CSR	200
Silver	BC ENV CSR	200
Thallium	CCME	1
Tin	BC ENV CSR	25,000
Uranium	BC ENV CSR	100
Vanadium	BC ENV CSR	200
Zinc	BC ENV CSR	10,000
Organic Constituents		
1-Methylnaphthalene	BC ENV CSR	250
2-Methyl naphthalene	BC ENV CSR	60

Acenaphthylene	BC ENV CSR (Acenapthene) [b]	950
Acenaphthene	BC ENV CSR	950
Anthracene	BC ENV CSR	10,000
Benz(a)anthracene	BC ENV CSR	50
Benzo(a)pyrene	BC ENV CSR	5
Benzo(b)fluoranthene	BC ENV CSR (Benzo(b&j)fluoranthene) [b]	50
Benzo(b&j)fluoranthene	BC ENV CSR	50
Benzo(g,h,i)perylene	BC ENV CSR (Pyrene) [b]	1,000
Benzo(k)fluoranthene	BC ENV CSR	50
Chrysene	BC ENV CSR	200
Dibenz(a,h)anthracene	BC ENV CSR	5
Fluoranthene	BC ENV CSR	1,500
Fluorene	BC ENV CSR	600
Indeno(1,2,3-c,d) pyrene	BC ENV CSR	50
Naphthalene	BC ENV CSR	850
Phenanthrene	BC ENV CSR	1,500
Pyrene	BC ENV CSR	1,000
Quinoline	BC ENV CSR	2.5

Notes

[a] Risk-based screening levels for soil are based on matrix numerical soil standards, residential low-density values (intake of contaminated soil) from BC ENV CSR unless otherwise indicated.

[b] Guideline not available for analyte so guideline for analyte specified in parentheses applied. This surrogate approach is consistent with the 2016 EVWQP HHRA.

BC ENV = British Columbia Ministry of Environment and Climate Change Strategy; CCME = Canadian Council of Ministers of the Environment; CSR = contaminated sites regulation; mg/kg = milligram per kilogram

Table B-3. Risk-Based Screening Levels Related to Fish Consumption for Human Health

Constituent	Risk-Based Screening Levels (mg/kg ww)[a]
Aluminum	5.77E+01
Antimony	2.31E-02
Arsenic	8.66E-01
Barium	1.15E+01
Beryllium	1.15E-01
Boron	1.01E+00
Cadmium	5.77E-02
Chromium (total)	5.77E-02
Chromium III	8.66E+01
Chromium VI	1.73E-01
Cobalt	1.73E-02
Copper	8.14E+00
Iron	4.04E+01
Lead	7.50E-02
Lithium	1.15E-01
Manganese	9.00E+00
Mercury	1.15E-02
Molybdenum	1.62E+03
Nickel	6.35E-01
Selenium	3.29E-01
Silver	2.89E-01
Thallium	4.04E-03
Tin	1.73E+01
Vanadium	2.89E-01
Zinc	3.29E+01

Notes

[a] Site-specific risk-based screening levels were calculated using a consumption rate of 245 g/day, hazard index of 0.2, and an excess cancer risk level of $1x10^{-5}$

mg/kg = milligram per kilogram; ww = wet weight.

Table B-4. Guidelines Related to Water Quality for Agriculture

Constituent	Agricultural Water Guideline (mg/L) (2021) [a]	Type [b]
Irrigation		
Aluminum	5	Short-term acute
Arsenic [c]	0.1	Short-term acute
Cadmium [d]	0.0051	Short-term acute
Chromium (III) [d]	0.0049	Long-term chronic
Cobalt [d,e]	0.05	Long-term chronic
Lead [f]	0.2	Short-term acute
Lead [g]	0.4	Short-term acute
Lithium [h]	2.5	Long-term chronic
Lithium [d,i]	0.75	Long-term chronic
Manganese [d]	0.2	Long-term chronic
Mercury	0.002	Short-term acute
Nickel [d]	0.2	Long-term chronic
Selenium	0.01	Long-term chronic
Uranium [d]	0.01	Long-term chronic
Vanadium [d]	0.1	Long-term chronic
Livestock		
Aluminum	5	Short-term acute
Arsenic [c]	0.025	Short-term acute
Cadmium [d]	0.08	Short-term acute
Chromium (III) [d]	0.05	Long-term chronic
Cobalt [d]	1	Long-term chronic
Lead	0.1	Short-term acute
Mercury	0.003	Short-term acute
Nickel [d]	1	Long-term chronic
Nitrate [j]	100	Short-term acute
Selenium	0.03	Long-term chronic
Uranium [d]	0.2	Long-term chronic
Vanadium [d]	0.1	Long-term chronic

Notes

[a] All guidelines from BC ENV (2021). Approved WQGs are those guidelines that were derived in B.C., consider the species and other factors unique to B.C., and are officially adopted as policy by ENV.

[b] Long-term chronic (i.e. "average") WQGs are intended to protect the most sensitive species and life state against sub-lethal effect for indefinite exposures. Short-term acute (i.e. "maximum") WQGs are set to protect against severe effects such as lethality or other equivalent measures to the most species and life stage over a defined short-term exposure period. (BC ENV 2021)

[c] Arsenic is an interim guideline. WQGs can be either, approved, approved but interim (denoted as "interim" in the summary table) or working. Interim guidelines can be updated to approved WQGs as additional data are generated by the scientific community. (BC ENV 2021)

[d] WQGs can be either, approved, approved but interim (denoted as "interim" in the summary table) or working. Working WQGs include cadmium, chromium, cobalt, lithium, manganese, nickel, uranium, and vanadium. Working WQGs are obtained from various Canadian provincial and federal jurisdictions (primarily the Canadian Council of the Ministers of the Environment or CCME), as well as the United States, Europe, and Australia/New Zealand, and from published scientific literature. Working WQGs provide benchmarks for those substances that have not yet been fully assessed and formally endorsed by the B.C. Ministry of Environment and Climate Change Strategy." (BC ENV 2021)

[e] Continuous or intermittent use on all soils. Older 20 year maximum concentrations have been removed as it is no longer considered appropriate to provide a guideline limit which will result in soil concentrations above the guideline after 20 years of exposure.

[f] All other soils (except neutral and alkaline fine textured soils).

[g] Neutral and alkaline fine textured soils.

[h] For all crops except citrus, barley and other cereal crops; 1.0 mg/L suggested for cereal crops.

[i] For citrus fruits.

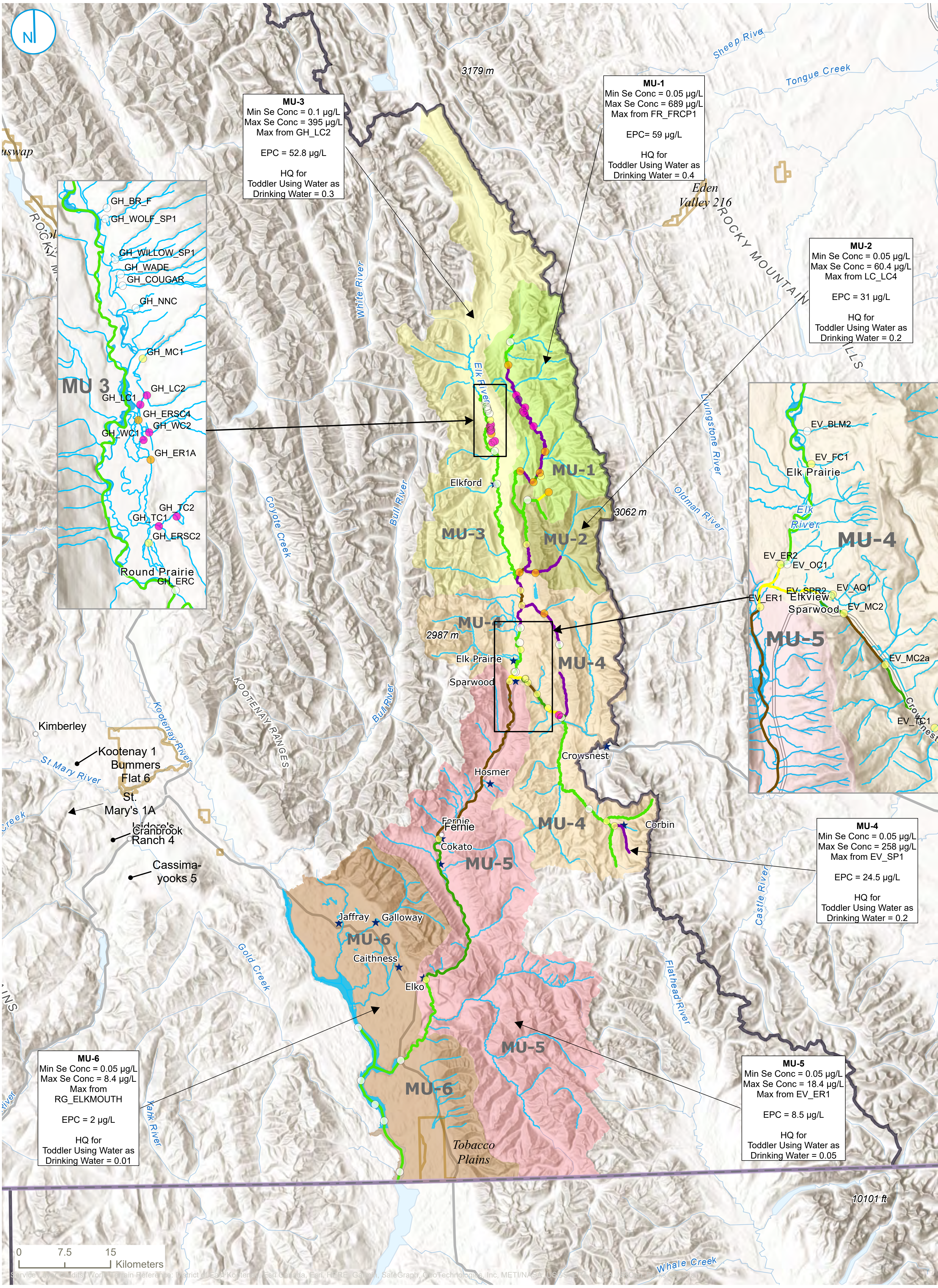
[j] When nitrate and nitrite are present, total nitrate plus nitrite-nitrogen should not exceed the nitrate WQG. Limit is reported as Nitrogen.

BC ENV = Ministry of Environment and Climate Change Strategy; mg/L = milligram per liter; WQG = water quality guideline.

Source

BC ENV WQG: British Columbia Ministry of Environment and Climate Change Strategy (BC ENV). 2021. British Columbia Approved Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture – Guideline Summary. Water Quality Guideline Series, WQG-20. Prov. B.C., Victoria B.C.

APPENDIX C
SCREENING RESULTS



LEGEND

- MU-1
- MU-2
- MU-3
- MU-4
- MU-5
- MU-6
- Provincial Boundary
- Local Waterbodies
- Local First Nations
- ★ Local Communities

2015–2020 Average Number of Months with Surface Water Selenium Concentation Exceeding 10 µg/L
- 0
- 1– 3
- 4– 6
- 7– 9
- 10–12

2015–2020 Maximum Surface Water Selenium Concentration in µg/L
- <10
- 10–50
- 50–100
- 100–500
- >500

TOTAL SELENIUM CONCENTRATIONS IN SURFACE WATER (UG/L) AND EXPOSURE POINT CONCENTRATIONS (EPCS) OF SELENIUM IN SURFACE WATER

Elk Valley
British Columbia

FIGURE C-1

RAMBOLL US CONSULTING, INC.
A RAMBOLL COMPANY

RAMBOLL

Table C-1. Surface water screening results

MU	Chem Group	Constituent	Fraction	Sample Count	% Detected	Minimum Detected Concentration (mg/L)	Mean Detected Concentration (mg/L)	Maximum Detected Concentration (mg/L)	Minimum Detection Limit (mg/L)	Average Limit (mg/L)	Maximum Detection Limit (mg/L)	Screening Level (mg/L)	Count Detected Result Exceeding Screening Level	Ratio of Max Detected to Screening Level (mg/L)	Count Detection Limit Exceeding Screening Level	Reference Concentration (mg/L)	Count Detected Result Exceeding Reference Concentration	Ratio Max Detected to Reference Concentration (mg/L)
MU-1	SVOC	1-Methylnaphthalene	N	2	0	NA	NA	NA	5.0E-05	5.0E-05	5.0E-05	5.5E-03	0	NA	0	NA	2	NA
MU-1	SVOC	2-Methylnaphthalene	N	2	0	NA	NA	NA	2.0E-05	2.0E-05	2.0E-05	1.5E-02	0	NA	0	NA	2	NA
MU-1	SVOC	Acenaphthene	N	41	0	NA	NA	NA	1.0E-05	1.1E-05	5.0E-05	2.5E-01	0	NA	0	NA	41	NA
MU-1	SVOC	Acenaphthylene	N	41	0	NA	NA	NA	1.0E-05	1.1E-05	5.0E-05	2.5E-01	0	NA	0	NA	41	NA
MU-1	INORG	Aluminum	D	1641	22	1.0E-03	1.3E-02	2.7E-01	1.0E-03	2.9E-03	5.0E-03	9.5E+00	0	2.9E-02	0	8.7E-03	1641	3.1E+01
MU-1	INORG	Aluminum	T	1642	88	3.0E-03	5.7E-02	3.4E+00	3.0E-03	3.1E-03	1.5E-02	9.5E+00	0	3.6E-01	0	3.1E-01	1642	1.1E+01
MU-1	SVOC	Anthracene	N	41	0	NA	NA	NA	1.0E-05	1.1E-05	5.0E-05	1.0E+00	0	NA	0	NA	41	NA
MU-1	INORG	Antimony	D	1641	70	1.0E-04	2.3E-04	1.7E-03	1.0E-04	1.0E-04	5.0E-04	6.0E-03	0	2.8E-01	0	1.0E-04	1641	1.7E+01
MU-1	INORG	Antimony	T	1642	76	1.0E-04	2.4E-04	1.6E-03	1.0E-04	1.0E-04	5.5E-04	6.0E-03	0	2.7E-01	0	1.1E-04	1642	1.5E+01
MU-1	INORG	Arsenic	D	1641	48	1.0E-04	1.9E-04	6.1E-04	1.0E-04	1.0E-04	5.0E-04	1.0E-02	0	6.1E-02	0	2.4E-04	1641	2.5E+00
MU-1	INORG	Arsenic	T	1642	83	1.0E-04	2.1E-04	2.2E-03	1.0E-04	1.0E-04	5.0E-04	1.0E-02	0	2.2E-01	0	5.0E-04	1642	4.5E+00
MU-1	INORG	Barium	D	1640	100	1.3E-02	1.1E-01	3.0E-01	5.0E-05	7.6E-05	2.5E-04	1.0E+00	0	3.0E-01	0	6.9E-02	1640	4.4E+00
MU-1	INORG	Barium	T	1642	100	1.7E-02	1.1E-01	2.9E-01	5.0E-05	7.6E-05	2.5E-04	1.0E+00	0	2.9E-01	0	6.9E-02	1642	4.2E+00
MU-1	SVOC	Benzo(A)Anthracene	N	41	0	NA	NA	NA	1.0E-05	1.1E-05	5.0E-05	4.0E-06	0	NA	41	NA	41	NA
MU-1	SVOC	Benzo(A)Pyrene	N	41	0	NA	NA	NA	5.0E-06	9.8E-06	1.0E-05	4.0E-05	0	NA	0	NA	41	NA
MU-1	SVOC	Benzo(B&J)Fluoranthene	N	2	0	NA	NA	NA	1.0E-05	1.0E-05	1.0E-05	7.0E-05	0	NA	0	NA	2	NA
MU-1	SVOC	Benzo(B)Fluoranthene	N	39	0	NA	NA	NA	1.0E-05	1.1E-05	5.0E-05	7.0E-05	0	NA	0	NA	39	NA
MU-1	SVOC	Benzo(G,H,I)Perylene	N	41	0	NA	NA	NA	1.0E-05	1.1E-05	5.0E-05	4.0E-07	0	NA	41	NA	41	NA
MU-1	SVOC	Benzo(K)Fluoranthene	N	41	0	NA	NA	NA	1.0E-05	1.1E-05	5.0E-05	4.0E-06	0	NA	41	NA	41	NA
MU-1	INORG	Beryllium	D	1640	0	2.1E-05	3.0E-05	4.3E-05	2.0E-05	4.0E-05	5.0E-04	8.0E-03	0	5.4E-03	0	1.0E-04	1640	4.3E-01
MU-1	INORG	Beryllium	T	1641	3	2.0E-05	5.1E-05	4.2E-04	2.0E-05	4.0E-05	5.0E-04	8.0E-03	0	5.2E-02	0	1.0E-04	1641	4.2E+00
MU-1	INORG	Boron	D	1641	22	1.0E-02	1.2E-02	6.1E-02	1.0E-02	1.0E-02	5.0E-02	5.0E+00	0	1.2E-02	0	1.6E-02	1641	3.8E+00
MU-1	INORG	Boron	T	1642	28	1.0E-02	1.2E-02	5.7E-02	1.0E-02	1.0E-02	5.0E-02	5.0E+00	0	1.1E-02	0	1.6E-02	1642	3.6E+00
MU-1	INORG	Cadmium	D	1641	96	5.0E-06	3.4E-05	2.1E-04	5.0E-06	5.4E-06	2.5E-05	5.0E-03	0	4.1E-02	0	1.5E-05	1641	1.4E+01
MU-1	INORG	Cadmium	T	1642	99	5.1E-06	5.0E-05	4.6E-04	5.0E-06	5.5E-06	1.0E-04	5.0E-03	0	9.2E-02	0	4.3E-05	1642	1.1E+01
MU-1	INORG	Chromium	D	1641	39	1.0E-04	1.4E-04	5.5E-04	1.0E-04	1.1E-04	6.0E-04	5.0E-02	0	1.1E-02	0	2.8E-04	1641	2.0E+00
MU-1	INORG	Chromium	T	1642	86	1.0E-04	2.5E-04	5.6E-03	1.0E-04	1.1E-04	8.0E-04	5.0E-02	0	1.1E-01	0	7.3E-04	1642	7.6E+00
MU-1	SVOC	Chrysene	N	41	0	NA	NA	NA	1.0E-05	1.1E-05	5.0E-05	4.0E-07	0	NA	41	NA	41	NA
MU-1	INORG	Cobalt	D	1641	19	1.0E-04	1.7E-04	1.1E-03	1.0E-04	1.0E-04	5.0E-04	1.0E-03	1	1.1E+00	0	1.0E-04	1641	1.1E+01
MU-1	INORG	Cobalt	T	1642	36	1.0E-04	2.1E-04	2.6E-03	1.0E-04	1.0E-04	5.0E-04	1.0E-03	4	2.6E+00	0	3.3E-04	1642	7.7E+00
MU-1	INORG	Copper	D	1641	14	2.0E-04	3.6E-04	1.9E-03	2.0E-04	4.2E-04	1.0E-03	2.0E+00	0	9.6E-04	0	5.0E-04	1641	3.8E+00
MU-1	INORG	Copper	T	1642	14	5.0E-04	1.2E-03	2.4E-02	5.0E-04	5.2E-04	2.5E-03	2.0E+00	0	1.2E-02	0	1.3E-03	1642	1.9E+01
MU-1	SVOC	Dibenz(A,H)Anthracene	N	41	0	NA	NA	NA	5.0E-06	1.1E-05	5.0E-05	4.0E-05	0	NA	1	NA	41	NA
MU-1	SVOC	Fluoranthene	N	41	0	NA	NA	NA	1.0E-05	1.1E-05	5.0E-05	1.5E-01	0	NA	0	NA	41	NA
MU-1	SVOC	Fluorene	N	41	0	NA	NA	NA	1.0E-05	1.1E-05	5.0E-05	1.5E-01	0	NA	0	NA	41	NA
MU-1	SVOC	Indeno(1,2,3-C,D)Pyrene	N	41	0	NA	NA	NA	1.0E-05	1.1E-05	5.0E-05	4.0E-06	0	NA	41	NA	41	NA
MU-1	INORG	Iron	D	1641	7	1.0E-02	2.9E-02	5.1E-01	1.0E-02	1.0E-02	5.0E-02	3.0E-01	1	1.7E+00	0	1.4E-02	1641	3.6E+01
MU-1	INORG	Iron	T	1642	76	1.0E-02	8.9E-02	5.9E+00	1.0E-02	1.0E-02	5.0E-02	3.0E-01	76	2.0E+01	0	2.8E-01	1642	2.1E+01
MU-1	INORG	Lead	D	1641	1	5.0E-05	1.7E-04	5.0E-04	5.0E-05	5.2E-05	2.5E-04	5.0E-03	0	1.0E-01	0	5.0E-05	1641	1.0E+01
MU-1	INORG	Lead	T	1642	23	5.0E-05	2.0E-04	4.1E-03	5.0E-05	5.2E-05	2.5E-04	5.0E-03	0	8.3E-01	0	2.7E-04	1642	1.5E+01
MU-1	INORG	Lithium	D	1641	99	1.0E-03	2.0E-02	2.7E-01	5.0E-04	1.0E-03	5.0E-03	8.0E-03	1340	3.4E+01	0	5.0E-03	1641	5.4E+01
MU-1	INORG	Lithium	T	1642	99	1.1E-03	2.0E-02	2.8E-01	5.0E-04	1.0E-03	5.0E-03	8.0E-03	1345	3.5E+01	0	5.1E-03	1642	5.5E+01
MU-1	INORG	Manganese	D	1640	95	5.4E-05	2.3E-03	4.1E-02	5.0E-05	1.0E-04	1.0E-03	1.2E-01	0	3.5E-01	0	1.9E-03	1640	2.2E+01
MU-1	INORG	Manganese	T	1642	100	1.2E-04	5.4E-03	2.9E-01	5.0E-05	1.0E-04	5.0E-04	1.2E-01	1	2.4E+00	0	1.3E-02	1642	2.1E+01
MU-1	INORG	Mercury	D	1616	0	5.1E-06	9.0E-06	2.3E-05	5.0E-06	5.2E-06	2.5E-05	1.0E-03	0	2.3E-02	0	5.0E-06	1616	4.6E+00
MU-1	INORG	Mercury	T	1632	38	5.0E-07	1.6E-06	2.4E-05	5.0E-07	1.7E-06	2.5E-05	1.0E-03	0	2.4E-02	0	2.4E-06	1632	1.0E+01
MU-1	INORG	Molybdenum	D	1641	100	3.7E-04	1.4E-03	1.6E-02	5.0E-05	5.2E-05	2.5E-04	8.8E-02	0	1.8E-01	0	1.3E-03	1641	1.2E+01
MU-1	INORG	Molybdenum	T	1642	100	4.0E-04	1.4E-03	1.5E-02	5.0E-05	5.2E-05	2.5E-04	8.8E-02	0	1.7E-01	0	1.3E-03	1642	1.1E+01
MU-1	SVOC	Naphthalene	N	41	0	NA	NA	NA	2.0E-05	4.9E-05	5.0E-05	8.0E-02	0	NA	0	NA	41	NA
MU-1	INORG	Nickel	D	1641	75	5.0E-04	3.5E-03	4.4E-02	5.0E-04	5.2E-04	2.5E-03	8.0E-02	0	5.6E-01	0	6.2E-04	1641	7.2E+01
MU-1	INORG	Nickel	T	1642	79	5.0E-04	3.7E-03	4.6E-02	5.0E-04	5.2E-04	2.5E-03	8.0E-02	0	5.7E-01	0	1.7E-03	1642	2.7E+01
MU-1	INORG	Nitrate Nitrogen (No3), As N	N	1646	98	5.0E-03	1.0E+01	1.1E+02	5.0E-03	1.2E-02	4.0E-01	1.0E+01	777	1.1E+01	0	2.8E-01	1646	4.0E+02
MU-1	SVOC	Phenanthrene	N	41	10	2.4E-05	3.0E-05	4.4E-05	2.0E-05	2.1E-05	5.0E-05	1.0E+00	0	4.4E-05	0	NA	41	NA
MU-1	SVOC	Pyrene	N	41	0	NA	NA	NA	1.0E-05	1.1E-05	5.0E-05	1.0E-01	0	NA	0	NA	41	NA
MU-1	SVOC	Quinoline	N	41	0	NA	NA	NA	1.0E-05	2.5E-05	5.0E-05	5.0E-05	0	NA	0	NA	41	NA
MU-1	INORG	Selenium	D	1663	100	3.9E-04	5.4E-02	8.0E-01	5.0E-05	5.4E-05	2.5E-04	1.0E-02	1240	8.0E+01	0	2.0E-03	1663	4.0E+02
MU-1	INORG	Selenium	T	1664	100	4.0E-04	5.1E-02	6.9E-01	5.0E-05	5.4E-05	5.0E-04	1.0E-02	1239	6.9E+01	0	2.0E-03	1664	3.5E+02
MU-1	INORG	Silver	D	1641	0	1.2E-05	1.4E-05	1.7E-05	1.0E-05	1.0E-05	5.0E-05	2.0E-02	0	8.5E-04	0	1.0E-05	1641	1.7E+00
MU-1	INORG	Silver	T	1642	5	1.0E-05	2.4E-05	1.6E-04	1.0E-05	1.0E-05	5.0E-05	2.0E-02	0	8.1E-03	0	1.7E-05	1642	9.7E+00
MU-1	INORG	Thallium	D	1641	16	1.0E-05	1.5E-05	4.8E-05	1.0E-05	1.0E-05	5.0E-05	2.0E-03	0	2.4E-02	0	1.0E-05	1641	4.8E+00
MU-1	INORG	Thallium	T	1642	27	1.0E-05	1.7E-05	1.5E-04	1.0E-05	1.0E-05	5.0E-05	2.0E-03	0	7.6E-02	0	4.7E-05	1642	3.2E+00
MU-1	INORG	Tin	D	1641	1	1.0E-04	1.3E-04	2.0E-04	1.0E-04	1.0E-04	5.0E-04	2.5E+00	0	8.0E-05	0	1.0E-04	1641	2.0E+00
MU-1	INORG	Tin	T	1642	2	1.0E-04	2.4E-04	1.1E-03	1.0E-04	1.0E-04	5.0E-04	2.5E+00	0	4.5E-04	0	1.0E-04	1642	1.1E+01
MU-1	INORG	Uranium	D	1641	100	1.5E-04	2.4E-03	2.3E-02	1.0E-05	1.0E-05	5.0E-05	2.0E-02	10	1.2E+00	0	1.7E-03	1641	1.4E+01
MU-1	INORG	Uranium	T	1642	100	1.7E-04	2.4E-03	2.5E-02	1.0E-05	1.0E-05	5.0E-05	2.0E-02	13	1.2E+00	0	1.7E-03	1642	1.4E+01
MU-1	INORG	Vanadium	D	1641	21	5.1E-04	1.0E-03	2.4E-03	5.0E-04	5.4E-04	2.5E-03	2.0E-02	0	1.2E-01	0	1.0E-03	1641	2.4E+00
MU-1	INORG	Vanadium	T	1642	38	5.0E-04	1.3E-03	1.3E-02	5.0E-04	5.4E-04	5.0E-03	2.0E-02	0	6.5E-01	0	2.4E-03	1642	5.3E+00
MU-1	INORG	Zinc	D	1641	30	1.0E-03	3.5E-03	6.4E-02	1.0E-03	1.9E-03	5.0E-03	3.0E+00	0	2.1E-02	0	3.0E-03	1641	2.1E+01

Table C-1. Surface water screening results

MU	Chem Group	Constituent	Fraction	Sample Count	% Detected	Minimum Detected Concentration (mg/L)	Mean Detected Concentration (mg/L)	Maximum Detected Concentration (mg/L)	Minimum Detection Limit (mg/L)	Average Limit (mg/L)	Maximum Detection Limit (mg/L)	Screening Level (mg/L)	Count Detected Result Exceeding Screening Level	Ratio of Max Detected to Screening Level (mg/L)	Count Detection Limit Exceeding Screening Level	Reference Concentration (mg/L)	Count Detected Result Exceeding Reference Concentration	Ratio Max Detected to Reference Concentration (mg/L)
MU-1	INORG	Zinc	T	1642	28	3.0E-03	6.0E-03	4.1E-02	3.0E-03	3.1E-03	1.5E-02	3.0E+00	0	1.4E-02	0	7.9E-03	1642	5.2E+00
MU-2	INORG	Aluminum	D	535	12	1.0E-03	5.6E-03	1.2E-01	1.0E-03	2.8E-03	5.0E-03	9.5E+00	0	1.3E-02	0	8.7E-03	535	1.4E+01
MU-2	INORG	Aluminum	T	536	93	3.1E-03	5.0E-02	2.6E+00	3.0E-03	3.2E-03	1.5E-02	9.5E+00	0	2.8E-01	0	3.1E-01	536	8.5E+00
MU-2	INORG	Antimony	D	535	73	1.0E-04	1.5E-04	2.7E-04	1.0E-04	1.0E-04	5.0E-04	6.0E-03	0	4.5E-02	0	1.0E-04	535	2.7E+00
MU-2	INORG	Antimony	T	536	79	1.0E-04	1.7E-04	1.3E-03	1.0E-04	1.1E-04	5.0E-04	6.0E-03	0	2.2E-01	0	1.1E-04	536	1.2E+01
MU-2	INORG	Arsenic	D	535	44	1.0E-04	1.2E-04	2.4E-04	1.0E-04	1.0E-04	5.0E-04	1.0E-02	0	2.4E-02	0	2.4E-04	535	1.0E+00
MU-2	INORG	Arsenic	T	536	84	1.0E-04	1.6E-04	2.2E-03	1.0E-04	1.1E-04	5.0E-04	1.0E-02	0	2.2E-01	0	5.0E-04	536	4.3E+00
MU-2	INORG	Barium	D	535	100	3.0E-02	7.7E-02	1.3E-01	5.0E-05	7.5E-05	2.5E-04	1.0E+00	0	1.3E-01	0	6.9E-02	535	1.9E+00
MU-2	INORG	Barium	T	536	100	3.0E-02	7.6E-02	1.4E-01	5.0E-05	7.6E-05	2.5E-04	1.0E+00	0	1.4E-01	0	6.9E-02	536	2.0E+00
MU-2	INORG	Beryllium	D	535	0	NA	NA	NA	2.0E-05	4.0E-05	5.0E-04	8.0E-03	0	NA	0	1.0E-04	535	NA
MU-2	INORG	Beryllium	T	535	4	2.1E-05	5.1E-05	1.8E-04	2.0E-05	4.0E-05	5.0E-04	8.0E-03	0	2.2E-02	0	1.0E-04	535	1.8E+00
MU-2	INORG	Boron	D	535	48	1.0E-02	1.2E-02	1.7E-02	1.0E-02	1.0E-02	5.0E-02	5.0E+00	0	3.4E-03	0	1.6E-02	535	1.1E+00
MU-2	INORG	Boron	T	536	54	1.0E-02	1.2E-02	2.1E-02	1.0E-02	1.1E-02	5.0E-02	5.0E+00	0	4.2E-03	0	1.6E-02	536	1.3E+00
MU-2	INORG	Cadmium	D	535	88	5.0E-06	2.9E-05	1.7E-04	5.0E-06	5.4E-06	2.5E-05	5.0E-03	0	3.3E-02	0	1.5E-05	535	1.1E+01
MU-2	INORG	Cadmium	T	536	96	5.1E-06	7.6E-05	6.1E-04	5.0E-06	5.6E-06	5.0E-05	5.0E-03	0	1.2E-01	0	4.3E-05	536	1.4E+01
MU-2	INORG	Chromium	D	535	78	1.0E-04	1.5E-04	3.4E-03	1.0E-04	1.1E-04	5.0E-04	5.0E-02	0	6.8E-02	0	2.8E-04	535	1.2E+01
MU-2	INORG	Chromium	T	536	94	1.0E-04	3.1E-04	8.5E-03	1.0E-04	1.1E-04	5.0E-04	5.0E-02	0	1.7E-01	0	7.3E-04	536	1.2E+01
MU-2	INORG	Cobalt	D	535	1	1.0E-04	1.5E-04	3.1E-04	1.0E-04	1.0E-04	5.0E-04	1.0E-03	0	3.1E-01	0	1.0E-04	535	3.1E+00
MU-2	INORG	Cobalt	T	536	13	1.0E-04	2.5E-04	1.8E-03	1.0E-04	1.1E-04	5.0E-04	1.0E-03	2	1.8E+00	0	3.3E-04	536	5.5E+00
MU-2	INORG	Copper	D	535	9	2.0E-04	3.7E-04	1.4E-03	2.0E-04	4.3E-04	1.2E-03	2.0E+00	0	7.1E-04	0	5.0E-04	535	2.8E+00
MU-2	INORG	Copper	T	536	11	5.1E-04	1.4E-03	2.4E-02	5.0E-04	5.3E-04	2.5E-03	2.0E+00	0	1.2E-02	0	1.3E-03	536	1.9E+01
MU-2	INORG	Iron	D	535	1	1.1E-02	1.1E-01	3.4E-01	1.0E-02	1.0E-02	5.0E-02	3.0E-01	1	1.1E+00	0	1.4E-02	535	2.4E+01
MU-2	INORG	Iron	T	536	63	1.0E-02	1.1E-01	3.4E+00	1.0E-02	1.1E-02	5.0E-02	3.0E-01	23	1.1E+01	0	2.8E-01	536	1.2E+01
MU-2	INORG	Lead	D	535	1	5.0E-05	1.2E-04	3.7E-04	5.0E-05	5.2E-05	2.5E-04	5.0E-03	0	7.3E-02	0	5.0E-05	535	7.3E+00
MU-2	INORG	Lead	T	536	21	5.1E-05	2.2E-04	2.8E-03	5.0E-05	5.3E-05	2.5E-04	5.0E-03	0	5.6E-01	0	2.7E-04	536	1.1E+01
MU-2	INORG	Lithium	D	535	100	3.5E-03	2.0E-02	4.6E-02	5.0E-04	1.0E-03	5.0E-03	8.0E-03	464	5.7E+00	0	5.0E-03	535	9.2E+00
MU-2	INORG	Lithium	T	536	100	3.9E-03	2.1E-02	7.0E-02	5.0E-04	1.0E-03	5.0E-03	8.0E-03	465	8.7E+00	0	5.1E-03	536	1.4E+01
MU-2	INORG	Manganese	D	535	91	9.4E-05	6.1E-04	4.7E-02	5.0E-05	1.0E-04	5.0E-04	1.2E-01	0	3.9E-01	0	1.9E-03	535	2.4E+01
MU-2	INORG	Manganese	T	536	99	1.9E-04	4.7E-03	2.5E-01	5.0E-05	1.1E-04	1.0E-03	1.2E-01	1	2.1E+00	0	1.3E-02	536	1.8E+01
MU-2	INORG	Mercury	D	535	0	1.3E-05	1.3E-05	1.3E-05	5.0E-06	5.2E-06	1.0E-05	1.0E-03	0	1.3E-02	0	5.0E-06	535	2.6E+00
MU-2	INORG	Mercury	T	537	25	5.0E-07	1.6E-06	3.3E-05	5.0E-07	1.4E-06	1.0E-05	1.0E-03	0	3.3E-02	0	2.4E-06	537	1.4E+01
MU-2	INORG	Molybdenum	D	535	100	7.9E-04	1.4E-03	8.3E-03	5.0E-05	5.2E-05	2.5E-04	8.8E-02	0	9.5E-02	0	1.3E-03	535	6.3E+00
MU-2	INORG	Molybdenum	T	536	100	8.1E-04	1.5E-03	1.4E-02	5.0E-05	5.3E-05	2.5E-04	8.8E-02	0	1.6E-01	0	1.3E-03	536	1.1E+01
MU-2	INORG	Nickel	D	535	85	5.0E-04	2.1E-03	5.0E-03	5.0E-04	5.2E-04	2.5E-03	8.0E-02	0	6.2E-02	0	6.2E-04	535	8.0E+00
MU-2	INORG	Nickel	T	536	86	5.0E-04	2.4E-03	1.2E-02	5.0E-04	5.4E-04	4.5E-03	8.0E-02	0	1.5E-01	0	1.7E-03	536	7.1E+00
MU-2	INORG	Nitrate Nitrogen (No3), As N	N	538	100	1.0E-02	6.9E+00	1.5E+01	5.0E-03	7.6E-03	2.5E-02	1.0E+01	84	1.5E+00	0	2.8E-01	538	5.3E+01
MU-2	INORG	Selenium	D	541	100	9.3E-04	3.0E-02	6.1E-02	5.0E-05	5.5E-05	4.1E-04	1.0E-02	470	6.1E+00	0	2.0E-03	541	3.0E+01
MU-2	INORG	Selenium	T	542	100	9.8E-04	2.8E-02	6.0E-02	5.0E-05	5.6E-05	5.0E-04	1.0E-02	470	6.0E+00	0	2.0E-03	542	3.1E+01
MU-2	INORG	Silver	D	535	0	NA	NA	NA	1.0E-05	1.0E-05	5.0E-05	2.0E-02	0	NA	0	1.0E-05	535	NA
MU-2	INORG	Silver	T	536	2	1.0E-05	2.5E-05	7.4E-05	1.0E-05	1.1E-05	5.0E-05	2.0E-02	0	3.7E-03	0	1.7E-05	536	4.5E+00
MU-2	INORG	Thallium	D	535	1	1.1E-05	1.4E-05	1.8E-05	1.0E-05	1.0E-05	5.0E-05	2.0E-03	0	9.0E-03	0	1.0E-05	535	1.8E+00
MU-2	INORG	Thallium	T	536	11	1.0E-05	2.1E-05	1.5E-04	1.0E-05	1.1E-05	5.0E-05	2.0E-03	0	7.6E-02	0	4.7E-05	536	3.2E+00
MU-2	INORG	Tin	D	535	1	1.3E-04	2.5E-04	4.4E-04	1.0E-04	1.0E-04	5.0E-04	2.5E+00	0	1.8E-04	0	1.0E-04	535	4.4E+00
MU-2	INORG	Tin	T	536	2	1.0E-04	2.1E-04	8.1E-04	1.0E-04	1.1E-04	5.0E-04	2.5E+00	0	3.2E-04	0	1.0E-04	536	8.1E+00
MU-2	INORG	Uranium	D	535	100	5.4E-04	2.2E-03	4.1E-03	1.0E-05	1.0E-05	5.0E-05	2.0E-02	0	2.1E-01	0	1.7E-03	535	2.4E+00
MU-2	INORG	Uranium	T	536	100	5.2E-04	2.2E-03	4.0E-03	1.0E-05	1.1E-05	5.0E-05	2.0E-02	0	2.0E-01	0	1.7E-03	536	2.3E+00
MU-2	INORG	Vanadium	D	535	0	NA	NA	NA	5.0E-04	5.4E-04	2.5E-03	2.0E-02	0	NA	0	1.0E-03	535	NA
MU-2	INORG	Vanadium	T	536	12	5.0E-04	1.2E-03	8.1E-03	5.0E-04	5.6E-04	5.0E-03	2.0E-02	0	4.1E-01	0	2.4E-03	536	3.4E+00
MU-2	INORG	Zinc	D	535	50	1.0E-03	4.4E-03	1.3E-01	1.0E-03	1.9E-03	5.0E-03	3.0E+00	0	4.4E-02	0	3.0E-03	535	4.4E+01
MU-2	INORG	Zinc	T	536	53	3.0E-03	6.8E-03	5.6E-02	3.0E-03	3.2E-03	1.5E-02	3.0E+00	0	1.9E-02	0	7.9E-03	536	7.1E+00
MU-3	SVOC	1-Methylnaphthalene	N	95	3	6.5E-05	7.9E-04	2.2E-03	5.0E-05	5.0E-05	5.0E-05	5.5E-03	0	4.1E-01	0	NA	95	NA
MU-3	SVOC	2-Methylnaphthalene	N	103	4	3.3E-05	1.3E-03	4.8E-03	2.0E-05	2.3E-05	5.0E-05	1.5E-02	0	3.2E-01	0	NA	103	NA
MU-3	SVOC	Acenaphthene	N	251	0	NA	NA	NA	1.0E-05	1.1E-05	2.0E-04	2.5E-01	0	NA	0	NA	251	NA
MU-3	SVOC	Acenaphthylene	N	251	0	NA	NA	NA	1.0E-05	1.0E-05	3.0E-05	2.5E-01	0	NA	0	NA	251	NA
MU-3	INORG	Aluminum	D	1561	32	1.1E-03	1.4E-02	4.0E-01	1.0E-03	3.0E-03	8.0E-03	9.5E+00	0	4.2E-02	0	8.7E-03	1561	4.6E+01
MU-3	INORG	Aluminum	T	1561	92	3.0E-03	2.3E-01	2.7E+01	3.0E-03	3.2E-03	1.5E-02	9.5E+00	2	2.8E+00	0	3.1E-01	1561	8.6E+01
MU-3	SVOC	Anthracene	N	251	0	NA	NA	NA	1.0E-05	1.0E-05	6.0E-05	1.0E+00	0	NA	0	NA	251	NA
MU-3	INORG	Antimony	D	1561	54	1.0E-04	1.3E-03	7.4E-03	1.0E-04	1.1E-04	5.0E-04	6.0E-03	3	1.2E+00	0	1.0E-04	1561	7.4E+01
MU-3	INORG	Antimony	T	1561	62	1.0E-04	1.2E-03	7.0E-03	1.0E-04	1.1E-04	5.0E-04	6.0E-03	4	1.2E+00	0	1.1E-04	1561	6.4E+01
MU-3	INORG	Arsenic	D	1561	80	1.0E-04	2.3E-04	8.9E-04	1.0E-04	1.1E-04	5.0E-04	1.0E-02	0	8.9E-02	0	2.4E-04	1561	3.7E+00
MU-3	INORG	Arsenic	T	1561	93	1.0E-04	3.6E-04	2.1E-02	1.0E-04	1.1E-04	7.0E-04	1.0E-02	1	2.1E+00	0	5.0E-04	1561	4.3E+01
MU-3	INORG	Barium	D	1561	100	3.2E-02	7.8E-02	3.4E-01	5.0E-05	8.2E-05	2.5E-04	1.0E+00	0	3.4E-01	0	6.9E-02	1561	5.0E+00
MU-3	INORG	Barium	T	1561	100	3.1E-02	8.3E-02	1.6E+00	5.0E-05	8.3E-05	2.5E-04	1.0E+00	1	1.6E+00	0	6.9E-02	1561	2.4E+01
MU-3	SVOC	Benzo(A)Anthracene	N	251	0	NA	NA	NA	1.0E-05	1.1E-05	1.0E-04	4.0E-06	0	NA	251	NA	251	NA
MU-3	SVOC	Benzo(A)Pyrene	N	251	1	1.3E-05	2.4E-05	4.1E-05	5.0E-06	7.9E-06	1.0E-05	4.0E-05	1	1.0E+00	0	NA	251	NA
MU-3	SVOC	Benzo(B&J)Fluoranthene	N	103	0	NA	NA	NA	1.0E-05	1.0E-05	1.0E-05	7.0E-05	0	NA	0	NA	103	NA
MU-3	SVOC	Benzo(B)Fluoranthene	N	148	3	1.7E-05	6.1E-05	1.4E-04	1.0E-05	1.0E-05	1.0E-05	7.0E-05	1	1.9E+00	0	NA	148	NA
MU-3	SVOC	Benzo(B,J,K)Fluoranthene	N	3	0	NA	NA	NA	1.5E-05	1.5E-05	1.5E-05	4.0E-06	0	NA	3	NA	3	NA
MU-3	SVOC	Benzo(G,H,I)Perylene	N	251	1	1.1E-05	2.7E-05	5.9E-05	1.0E-05	1.1E-05	4.0E-05	4.0E-07	3	1.5E+02	251	NA	251	NA
MU-3	SVOC	Benzo(K)Fluoranthene	N	251	0	NA	NA	NA	1.0E-05	1.0E-05	3.0E-05	4.0E-06	0	NA	251	NA	251	NA
MU-3	INORG	Beryllium	D	1561	0	2.1E-05	3.1E-05	4.5E-05	2.0E-05	3.8E-05	2.0E-04	8.0E-03	0	5.6E-03	0	1.0E-04	1561	4.5E-01
MU-3	INORG	Beryllium	T	1561	10	2.0E-05	1.0E-04	2.0E-03	2.0E-05	3.8E-05	2.0E-04	8.0E-03	0	2.5E-01	0	1.0E-04	1561	2.0E+01
MU-3	INORG	Boron	D	1561	61	1.0E-02	2.5E-02	7.2E-02	1.0E-02	1.1E-02	5.0E-02	5.0E+00	0	1.4E-02	0	1.6E-02	1561	4.5E+00
MU-3	INORG	Boron	T	1561	62	1.0E-02	2.6E-02	7.2E-02	1.0E-02	1.1E-02	5.0E-02	5.0E+00	0	1.4E-02	0	1.6E-02	1561	4.5E+00

Table C-1. Surface water screening results

MU	Chem Group	Constituent	Fraction	Sample Count	% Detected	Minimum Detected Concentration (mg/L)	Mean Detected Concentration (mg/L)	Maximum Detected Concentration (mg/L)	Minimum Detection Limit (mg/L)	Average Limit (mg/L)	Maximum Detection Limit (mg/L)	Screening Level (mg/L)	Count Detected Result Exceeding Screening Level	Ratio of Max Detected to Screening Level (mg/L)	Count Detection Limit Exceeding Screening Level	Reference Concentration (mg/L)	Count Detected Result Exceeding Reference Concentration	Ratio Max Detected to Reference Concentration (mg/L)
MU-3	INORG	Cadmium	D	1561	84	5.0E-06	2.0E-05	5.2E-04	5.0E-06	5.7E-06	4.0E-05	5.0E-03	0	1.0E-01	0	1.5E-05	1561	3.4E+01
MU-3	INORG	Cadmium	T	1561	95	5.1E-06	6.8E-05	9.3E-03	5.0E-06	6.0E-06	2.9E-04	5.0E-03	1	1.9E+00	0	4.3E-05	1561	2.2E+02
MU-3	INORG	Chromium	D	1560	37	1.0E-04	2.2E-04	9.9E-04	1.0E-04	1.1E-04	5.0E-04	5.0E-02	0	2.0E-02	0	2.8E-04	1560	3.5E+00
MU-3	INORG	Chromium	T	1561	66	1.0E-04	6.8E-04	3.2E-02	1.0E-04	1.1E-04	7.0E-04	5.0E-02	0	6.4E-01	0	7.3E-04	1561	4.4E+01
MU-3	SVOC	Chrysene	N	251	0	4.1E-05	4.1E-05	4.1E-05	1.0E-05	1.2E-05	3.0E-04	4.0E-07	1	1.0E+02	251	NA	251	NA
MU-3	INORG	Cobalt	D	1561	27	1.0E-04	9.4E-04	1.3E-02	1.0E-04	1.1E-04	5.0E-04	1.0E-03	101	1.3E+01	0	1.0E-04	1561	1.3E+02
MU-3	INORG	Cobalt	T	1561	44	1.0E-04	1.1E-03	6.2E-02	1.0E-04	1.1E-04	5.0E-04	1.0E-03	157	6.2E+01	0	3.3E-04	1561	1.9E+02
MU-3	INORG	Copper	D	1561	39	2.0E-04	6.4E-04	3.4E-03	2.0E-04	4.4E-04	1.5E-03	2.0E+00	0	1.7E-03	0	5.0E-04	1561	6.7E+00
MU-3	INORG	Copper	T	1561	50	5.0E-04	1.4E-03	7.7E-02	5.0E-04	5.4E-04	3.0E-03	2.0E+00	0	3.8E-02	0	1.3E-03	1561	6.1E+01
MU-3	SVOC	Dibenz(A,H)Anthracene	N	251	0	5.6E-06	5.6E-06	5.6E-06	5.0E-06	8.1E-06	4.0E-05	4.0E-05	0	1.4E-01	0	NA	251	NA
MU-3	SVOC	Fluoranthene	N	251	0	1.7E-05	1.7E-05	1.7E-05	1.0E-05	1.0E-05	8.0E-05	1.5E-01	0	1.1E-04	0	NA	251	NA
MU-3	SVOC	Fluorene	N	251	8	1.1E-05	8.8E-05	6.2E-04	1.0E-05	1.0E-05	1.0E-05	1.5E-01	0	4.1E-03	0	NA	251	NA
MU-3	SVOC	Indeno(1,2,3-C,D)Pyrene	N	251	0	1.7E-05	1.7E-05	1.7E-05	1.0E-05	1.0E-05	1.0E-05	4.0E-06	1	4.3E+00	251	NA	251	NA
MU-3	INORG	Iron	D	1560	11	1.0E-02	3.6E-02	4.1E-01	1.0E-02	1.1E-02	5.0E-02	3.0E-01	1	1.4E+00	0	1.4E-02	1560	2.9E+01
MU-3	INORG	Iron	T	1561	75	1.0E-02	3.9E-01	5.5E+01	1.0E-02	1.1E-02	5.0E-02	3.0E-01	240	1.8E+02	0	2.8E-01	1561	1.9E+02
MU-3	INORG	Lead	D	1561	2	5.2E-05	1.6E-04	4.0E-04	5.0E-05	5.3E-05	2.5E-04	5.0E-03	0	8.0E-02	0	5.0E-05	1561	8.0E+00
MU-3	INORG	Lead	T	1561	40	5.0E-05	5.1E-04	3.4E-02	5.0E-05	5.3E-05	2.5E-04	5.0E-03	5	6.8E+00	0	2.7E-04	1561	1.3E+02
MU-3	INORG	Lithium	D	1561	100	1.1E-03	4.3E-02	2.9E-01	5.0E-04	1.0E-03	5.0E-03	8.0E-03	861	3.6E+01	0	5.0E-03	1561	5.8E+01
MU-3	INORG	Lithium	T	1561	100	1.1E-03	4.3E-02	2.9E-01	5.0E-04	1.1E-03	5.0E-03	8.0E-03	862	3.6E+01	0	5.1E-03	1561	5.6E+01
MU-3	INORG	Manganese	D	1561	96	5.4E-05	2.0E-03	1.7E-01	5.0E-05	1.1E-04	7.0E-03	1.2E-01	1	1.4E+00	0	1.9E-03	1561	8.7E+01
MU-3	INORG	Manganese	T	1561	100	7.1E-05	1.3E-02	1.7E+00	5.0E-05	1.1E-04	7.0E-04	1.2E-01	23	1.4E+01	0	1.3E-02	1561	1.2E+02
MU-3	INORG	Mercury	D	1557	1	5.2E-06	6.5E-06	1.1E-05	5.0E-06	5.2E-06	5.0E-05	1.0E-03	0	1.1E-02	0	5.0E-06	1557	2.3E+00
MU-3	INORG	Mercury	T	1557	56	5.0E-07	2.4E-06	1.8E-04	5.0E-07	2.0E-06	5.0E-05	1.0E-03	0	1.8E-01	0	2.4E-06	1557	7.5E+01
MU-3	INORG	Molybdenum	D	1561	100	2.6E-04	4.4E-03	4.1E-02	5.0E-05	5.3E-05	4.5E-04	8.8E-02	0	4.6E-01	0	1.3E-03	1561	3.1E+01
MU-3	INORG	Molybdenum	T	1561	100	3.1E-04	4.4E-03	4.0E-02	5.0E-05	5.3E-05	2.5E-04	8.8E-02	0	4.6E-01	0	1.3E-03	1561	3.0E+01
MU-3	SVOC	Naphthalene	N	251	8	5.2E-05	2.5E-04	1.6E-03	2.0E-05	4.2E-05	5.0E-05	8.0E-02	0	2.0E-02	0	NA	251	NA
MU-3	INORG	Nickel	D	1561	60	5.1E-04	3.2E-02	1.9E-01	5.0E-04	5.3E-04	2.5E-03	8.0E-02	144	2.4E+00	0	6.2E-04	1561	3.1E+02
MU-3	INORG	Nickel	T	1561	72	5.0E-04	2.9E-02	2.8E-01	5.0E-04	5.3E-04	2.5E-03	8.0E-02	159	3.5E+00	0	1.7E-03	1561	1.7E+02
MU-3	INORG	Nitrate Nitrogen (No3), As N	N	1586	100	5.5E-03	1.3E+01	8.6E+01	5.0E-03	1.6E-02	5.0E-01	1.0E+01	497	8.6E+00	0	2.8E-01	1586	3.1E+02
MU-3	SVOC	Phenanthrene	N	251	16	2.1E-05	1.5E-04	2.0E-03	2.0E-05	2.0E-05	2.0E-05	1.0E+00	0	2.0E-03	0	NA	251	NA
MU-3	SVOC	Pyrene	N	251	4	1.0E-05	3.5E-05	1.4E-04	1.0E-05	1.0E-05	2.0E-05	1.0E-01	0	1.4E-03	0	NA	251	NA
MU-3	SVOC	Quinoline	N	251	0	NA	NA	NA	1.0E-05	3.6E-05	5.0E-05	5.0E-05	0	NA	0	NA	251	NA
MU-3	INORG	Selenium	D	1572	100	8.8E-05	4.8E-02	4.0E-01	5.0E-05	5.6E-05	4.1E-04	1.0E-02	635	4.0E+01	0	2.0E-03	1572	2.0E+02
MU-3	INORG	Selenium	T	1572	100	1.0E-04	4.5E-02	4.0E-01	5.0E-05	5.6E-05	2.5E-04	1.0E-02	633	4.0E+01	0	2.0E-03	1572	2.0E+02
MU-3	INORG	Silver	D	1560	0	1.1E-05	1.4E-05	2.6E-05	1.0E-05	1.1E-05	5.0E-05	2.0E-02	0	1.3E-03	0	1.0E-05	1560	2.6E+00
MU-3	INORG	Silver	T	1561	14	1.0E-05	3.5E-05	8.1E-04	1.0E-05	1.1E-05	5.0E-05	2.0E-02	0	4.0E-02	0	1.7E-05	1561	4.8E+01
MU-3	INORG	Thallium	D	1559	29	1.0E-05	3.0E-05	8.1E-05	1.0E-05	1.1E-05	5.0E-05	2.0E-03	0	4.1E-02	0	1.0E-05	1559	8.1E+00
MU-3	INORG	Thallium	T	1561	46	1.0E-05	3.9E-05	1.3E-03	1.0E-05	1.1E-05	5.0E-05	2.0E-03	0	6.7E-01	0	4.7E-05	1561	2.8E+01
MU-3	INORG	Tin	D	1560	1	1.1E-04	2.1E-04	9.1E-04	1.0E-04	1.1E-04	5.0E-04	2.5E+00	0	3.6E-04	0	1.0E-04	1560	9.1E+00
MU-3	INORG	Tin	T	1561	3	1.0E-04	1.7E-04	4.6E-04	1.0E-04	1.1E-04	5.0E-04	2.5E+00	0	1.8E-04	0	1.0E-04	1561	4.6E+00
MU-3	INORG	Uranium	D	1560	100	9.4E-05	4.2E-03	2.3E-02	1.0E-05	1.1E-05	5.0E-05	2.0E-02	9	1.2E+00	0	1.7E-03	1560	1.4E+01
MU-3	INORG	Uranium	T	1561	100	8.9E-05	4.2E-03	2.2E-02	1.0E-05	1.1E-05	5.0E-05	2.0E-02	6	1.1E+00	0	1.7E-03	1561	1.3E+01
MU-3	INORG	Vanadium	D	1560	1	5.7E-04	8.4E-04	1.2E-03	5.0E-04	5.4E-04	2.5E-03	2.0E-02	0	6.0E-02	0	1.0E-03	1560	1.2E+00
MU-3	INORG	Vanadium	T	1561	35	5.0E-04	2.2E-03	7.3E-02	5.0E-04	5.5E-04	2.5E-03	2.0E-02	2	3.6E+00	0	2.4E-03	1561	3.0E+01
MU-3	INORG	Zinc	D	1560	16	1.0E-03	4.4E-03	3.7E-02	1.0E-03	1.9E-03	5.0E-03	3.0E+00	0	1.2E-02	0	3.0E-03	1560	1.2E+01
MU-3	INORG	Zinc	T	1561	29	3.0E-03	1.5E-02	7.4E-01	3.0E-03	3.2E-03	1.8E-02	3.0E+00	0	2.5E-01	0	7.9E-03	1561	9.3E+01
MU-4	INORG	Aluminum	D	2387	28	1.0E-03	1.1E-02	5.3E-01	1.0E-03	3.0E-03	1.5E-02	9.5E+00	0	5.6E-02	0	8.7E-03	2387	6.1E+01
MU-4	INORG	Aluminum	T	2394	92	3.0E-03	1.4E-01	5.0E+00	3.0E-03	3.3E-03	3.0E-02	9.5E+00	0	5.2E-01	0	3.1E-01	2394	1.6E+01
MU-4	INORG	Antimony	D	2387	49	1.0E-04	2.9E-04	1.2E-03	1.0E-04	1.1E-04	5.0E-04	6.0E-03	0	2.0E-01	0	1.0E-04	2387	1.2E+01
MU-4	INORG	Antimony	T	2394	66	1.0E-04	2.6E-04	1.2E-03	1.0E-04	1.1E-04	1.0E-03	6.0E-03	0	2.1E-01	0	1.1E-04	2394	1.1E+01
MU-4	INORG	Arsenic	D	2387	94	1.0E-04	2.0E-04	9.4E-04	1.0E-04	1.1E-04	5.0E-04	1.0E-02	0	9.4E-02	0	2.4E-04	2387	3.9E+00
MU-4	INORG	Arsenic	T	2394	96	1.0E-04	2.9E-04	3.6E-03	1.0E-04	1.1E-04	1.0E-03	1.0E-02	0	3.6E-01	0	5.0E-04	2394	7.2E+00
MU-4	INORG	Barium	D	2387	100	9.7E-03	9.0E-02	6.5E-01	5.0E-05	7.9E-05	2.5E-04	1.0E+00	0	6.5E-01	0	6.9E-02	2387	9.4E+00
MU-4	INORG	Barium	T	2394	100	1.1E-02	9.3E-02	5.9E-01	5.0E-05	7.9E-05	1.0E-03	1.0E+00	0	5.9E-01	0	6.9E-02	2394	8.6E+00
MU-4	INORG	Beryllium	D	2387	0	2.5E-05	3.2E-05	4.9E-05	2.0E-05	4.2E-05	5.0E-04	8.0E-03	0	6.1E-03	0	1.0E-04	2387	4.9E-01
MU-4	INORG	Beryllium	T	2393	7	2.0E-05	7.6E-05	4.0E-04	2.0E-05	4.2E-05	5.0E-04	8.0E-03	0	5.0E-02	0	1.0E-04	2393	4.0E+00
MU-4	INORG	Boron	D	2387	56	1.0E-02	3.1E-02	1.1E-01	1.0E-02	1.1E-02	5.0E-02	5.0E+00	0	2.2E-02	0	1.6E-02	2387	7.0E+00
MU-4	INORG	Boron	T	2394	60	1.0E-02	3.1E-02	1.2E-01	1.0E-02	1.1E-02	1.0E-01	5.0E+00	0	2.3E-02	0	1.6E-02	2394	7.3E+00
MU-4	INORG	Cadmium	D	2387	88	5.0E-06	5.0E-05	1.6E-03	5.0E-06	5.8E-06	5.0E-05	5.0E-03	0	3.1E-01	0	1.5E-05	2387	1.0E+02
MU-4	INORG	Cadmium	T	2394	97	5.0E-06	8.2E-05	1.9E-03	5.0E-06	5.8E-06	5.0E-05	5.0E-03	0	3.7E-01	0	4.3E-05	2394	4.3E+01
MU-4	INORG	Chromium	D	2387	68	1.0E-04	1.6E-04	3.1E-03	1.0E-04	1.1E-04	8.0E-04	5.0E-02	0	6.2E-02	0	2.8E-04	2387	1.1E+01
MU-4	INORG	Chromium	T	2394	86	1.0E-04	3.9E-04	9.3E-03	1.0E-04	1.2E-04	1.0E-03	5.0E-02	0	1.9E-01	0	7.3E-04	2394	1.3E+01
MU-4	INORG	Cobalt	D	2387	26	1.0E-04	4.1E-03	2.6E-02	1.0E-04	1.1E-04	5.0E-04	1.0E-03	393	2.6E+01	0	1.0E-04	2387	2.6E+02
MU-4	INORG	Cobalt	T	2394	43	1.0E-04	2.9E-03	2.9E-02	1.0E-04	1.1E-04	1.0E-03	1.0E-03	463	2.9E+01	0	3.3E-04	2394	8.7E+01
MU-4	INORG	Copper	D	2387	18	2.0E-04	4.4E-04	2.0E-03	2.0E-04	4.4E-04	1.0E-03	2.0E+00	0	1.0E-03	0	5.0E-04	2387	4.1E+00
MU-4	INORG	Copper	T	2394	23	5.0E-04	1.3E-03	1.4E-02	5.0E-04	5.5E-04	5.0E-03	2.0E+00	0	7.2E-03	0	1.3E-03	2394	1.2E+01
MU-4	INORG	Iron	D	2387	10	1.0E-02	2.8E-02	6.4E-01	1.0E-02	1.1E-02	5.0E-02	3.0E-01	1	2.1E+00	0	1.4E-02	2387	4.6E+01
MU-4	INORG	Iron	T	2394	79	1.0E-02	2.1E-01	7.7E+00	1.0E-02	1.1E-02	1.0E-01	3.0E-01	315	2.6E+01	0	2.8E-01	2394	2.7E+01
MU-4	INORG	Lead	D	2387	1	5.0E-05	1.2E-04	6.7E-04	5.0E-05	5.5E-05	2.5E-04	5.0E-03	0	1.3E-01	0	5.0E-05	2387	1.3E+01
MU-4	INORG	Lead	T	2394	33	5.0E-05	3.3E-04	5.8E-03	5.0E-05	5.5E-05	5.0E-04	5.0E-03	1	1.2E+00	0	2.7E-04	2394	2.2E+01
MU-4	INORG	Lithium	D	2387	99	1.0E-03	1.6E-02	1.4E-01	5.0E-04	1.1E-03	5.0E-03	8.0E-03	1473	1.8E+01	0	5.0E-03	2387	2.9E+01
MU-4	INORG	Lithium	T	2394	99	1.0E-03	1.6E-02	1.4E-01	5.0E-04	1.1E-03	1.0E-02	8.0E-03	1516	1.8E+01	1	5.1E-03	2394	2.8E+01
MU-4	INORG	Manganese	D	2387	93	5.9E-05	9.9E-03	4.6E-01	5.0E-05	1.1E-04	1.0E-03	1.2E-01	21	3.9E+00	0	1.9E-03	2387	2.4E+02
MU-4	INORG	Manganese	T	2394	96	5.9E-05	1.8E-02	5.0E-01	5.0E-05	1.1E-04	1.0E-03	1.2E-01	55	4.2E+00	0	1.3E-02	2394	3.7E+01
MU-4	INORG	Mercury	D	2258	6	5.1E-07	1.4E-06	2.1E-05	5.0E-07	4.2E-06	2.5E-05	1.0E-03	0	2.1E-02	0	5.0E-06	2258	4.1E+00
MU-4	INORG	Mercury	T	2298	40	5.0E-07	2.1E-06	3.4E-05	5.0E-07	1.6E-06	2.5E-05	1.0E-03	0	3.4E-02	0	2.4E-06	2298	1.4E+01
MU-4	INORG	Molybdenum	D	2387	100	3.1E-04	1.4E-03	9.4E-03	5.0E-05	5.5E-05	2.5E-04	8.8E-02	0	1.1E-01	0	1.3E-03	2387	7.1E+00
MU-4	INORG	Molybdenum	T	2394	100	8.8E-05	1.4E-03	9.3E-03	5.0E-05	5.5E-05	5.0E-04	8.8E-02	0	1.1E-01	0	1.3E-03	2394	7.1E+00
MU-4	INORG	Nickel	D	2387	76	5.0E-04	1.3E-02	1.5E-01	5.0E-04	5.5E-04	2.5E-03	8.0E-02	54	1.9E+00	0	6.2E-04	2387	2.4E+02
MU-4	INORG	Nickel	T	2394	84	5.0E-04	1.2E-02	1.6E-01	5.0E-04	5.5E-04	5.0E-03	8.0E-02	56	1.9E+00	0	1.7E-03	2394	9.2E+01
MU-4	INORG	Nitrate Nitrogen (No3), As N	N	2307	98	6.0E-03	2.5E+00	1.6E+01	5.0E-03	1.1E-02	5.0E-02	1.0E+01	99	1.6E+00	0	2.8E-01	2307	5.8E+01
MU-4	INORG	Selenium	D	2486	100	1.5E-04	2.2E-02	2.7E-01	5.0E-05	6.0E-05	1.1E-03	1.0E-02	1168	2.7E+01	0	2.0E-03	2486	1.4E+02
MU-4	INORG	Selenium	T	2510	100	1.7E-04	2.1E-02	2.6E-01	5.0E-05	6.0E-05	1.1E-03	1.0E-02	1146	2.6E+01	0	2.0E-03	2510	1.3E+02

Table C-1. Surface water screening results

MU	Chem Group	Constituent	Fraction	Sample Count	% Detected	Minimum Detected Concentration (mg/L)	Mean Detected Concentration (mg/L)	Maximum Detected Concentration (mg/L)	Minimum Detection Limit (mg/L)	Average Limit (mg/L)	Maximum Detection Limit (mg/L)	Screening Level (mg/L)	Count Detected Result Exceeding Screening Level	Ratio of Max Detected to Screening Level (mg/L)	Count Detection Limit Exceeding Screening Level	Reference Concentration (mg/L)	Count Detected Result Exceeding Reference Concentration	Ratio Max Detected to Reference Concentration (mg/L)
MU-4	INORG	Silver	D	2387	0	1.2E-05	1.3E-05	1.3E-05	1.0E-05	1.1E-05	5.0E-05	2.0E-02	0	6.5E-04	0	1.0E-05	2387	1.3E+00
MU-4	INORG	Silver	T	2394	9	1.0E-05	2.8E-05	2.0E-04	1.0E-05	1.1E-05	1.0E-04	2.0E-02	0	1.0E-02	0	1.7E-05	2394	1.2E+01
MU-4	INORG	Thallium	D	2387	27	1.0E-05	4.0E-05	2.1E-04	1.0E-05	1.1E-05	5.0E-05	2.0E-03	0	1.1E-01	0	1.0E-05	2387	2.1E+01
MU-4	INORG	Thallium	T	2394	45	1.0E-05	3.6E-05	2.5E-04	1.0E-05	1.1E-05	1.0E-04	2.0E-03	0	1.2E-01	0	4.7E-05	2394	5.2E+00
MU-4	INORG	Tin	D	2387	2	1.0E-04	2.1E-04	7.7E-04	1.0E-04	1.1E-04	5.0E-04	2.5E+00	0	3.1E-04	0	1.0E-04	2387	7.7E+00
MU-4	INORG	Tin	T	2394	3	1.0E-04	4.7E-04	1.9E-02	1.0E-04	1.1E-04	1.0E-03	2.5E+00	0	7.7E-03	0	1.0E-04	2394	1.9E+02
MU-4	INORG	Uranium	D	2387	100	1.4E-04	2.2E-03	1.4E-02	1.0E-05	1.1E-05	5.0E-05	2.0E-02	0	6.8E-01	0	1.7E-03	2387	8.0E+00
MU-4	INORG	Uranium	T	2394	100	1.7E-04	2.3E-03	1.4E-02	1.0E-05	1.1E-05	1.0E-04	2.0E-02	0	7.1E-01	0	1.7E-03	2394	8.2E+00
MU-4	INORG	Vanadium	D	2387	1	5.0E-04	7.0E-04	1.8E-03	5.0E-04	5.8E-04	5.0E-03	2.0E-02	0	9.2E-02	0	1.0E-03	2387	1.8E+00
MU-4	INORG	Vanadium	T	2394	27	5.0E-04	1.8E-03	2.1E-02	5.0E-04	5.8E-04	5.0E-03	2.0E-02	1	1.1E+00	0	2.4E-03	2394	8.8E+00
MU-4	INORG	Zinc	D	2387	31	1.0E-03	9.2E-03	2.1E-01	1.0E-03	2.0E-03	1.5E-02	3.0E+00	0	7.0E-02	0	3.0E-03	2387	7.0E+01
MU-4	INORG	Zinc	T	2394	33	3.0E-03	1.3E-02	7.7E-02	3.0E-03	3.3E-03	3.0E-02	3.0E+00	0	2.6E-02	0	7.9E-03	2394	9.7E+00
MU-5	INORG	Aluminum	D	612	46	1.8E-03	1.2E-02	1.1E-01	1.0E-03	3.0E-03	5.0E-03	9.5E+00	0	1.1E-02	0	8.7E-03	612	1.2E+01
MU-5	INORG	Aluminum	T	613	100	3.1E-03	2.5E-01	6.0E+00	3.0E-03	3.0E-03	1.5E-02	9.5E+00	0	6.3E-01	0	3.1E-01	613	1.9E+01
MU-5	INORG	Antimony	D	612	19	5.0E-05	1.1E-04	1.5E-04	1.0E-04	1.0E-04	5.0E-04	6.0E-03	0	2.5E-02	0	1.0E-04	612	1.5E+00
MU-5	INORG	Antimony	T	613	56	5.0E-05	1.4E-04	4.1E-04	1.0E-04	1.0E-04	5.0E-04	6.0E-03	0	6.8E-02	0	1.1E-04	613	3.7E+00
MU-5	INORG	Arsenic	D	612	99	1.1E-04	1.9E-04	3.5E-04	1.0E-04	1.0E-04	5.0E-04	1.0E-02	0	3.5E-02	0	2.4E-04	612	1.5E+00
MU-5	INORG	Arsenic	T	613	99	1.6E-04	3.5E-04	5.1E-03	1.0E-04	1.0E-04	5.0E-04	1.0E-02	0	5.1E-01	0	5.0E-04	613	1.0E+01
MU-5	INORG	Barium	D	612	100	1.2E-04	7.6E-02	1.2E-01	5.0E-05	7.6E-05	2.5E-04	1.0E+00	0	1.2E-01	0	6.9E-02	612	1.8E+00
MU-5	INORG	Barium	T	613	100	3.6E-02	8.1E-02	2.3E-01	5.0E-05	7.6E-05	2.5E-04	1.0E+00	0	2.3E-01	0	6.9E-02	613	3.4E+00
MU-5	INORG	Beryllium	D	612	0	3.8E-05	4.4E-05	5.0E-05	2.0E-05	3.8E-05	1.0E-04	8.0E-03	0	6.3E-03	0	1.0E-04	612	5.0E-01
MU-5	INORG	Beryllium	T	613	16	2.1E-05	8.3E-05	5.3E-04	2.0E-05	3.8E-05	1.0E-04	8.0E-03	0	6.6E-02	0	1.0E-04	613	5.3E+00
MU-5	INORG	Boron	D	612	9	5.0E-03	1.1E-02	1.3E-02	1.0E-02	1.0E-02	5.0E-02	5.0E+00	0	2.6E-03	0	1.6E-02	612	8.1E-01
MU-5	INORG	Boron	T	613	21	5.0E-03	1.1E-02	1.7E-02	1.0E-02	1.0E-02	5.0E-02	5.0E+00	0	3.4E-03	0	1.6E-02	613	1.1E+00
MU-5	INORG	Cadmium	D	612	99	3.0E-06	1.4E-05	1.3E-04	5.0E-06	5.3E-06	2.5E-05	5.0E-03	0	2.7E-02	0	1.5E-05	612	8.8E+00
MU-5	INORG	Cadmium	T	613	99	6.0E-06	5.1E-05	1.2E-03	5.0E-06	5.5E-06	4.0E-05	5.0E-03	0	2.4E-01	0	4.3E-05	613	2.7E+01
MU-5	INORG	Chromium	D	612	97	5.0E-05	2.1E-04	1.6E-03	1.0E-04	1.0E-04	6.0E-04	5.0E-02	0	3.1E-02	0	2.8E-04	612	5.6E+00
MU-5	INORG	Chromium	T	613	95	2.0E-04	6.9E-04	1.2E-02	1.0E-04	1.2E-04	7.0E-04	5.0E-02	0	2.3E-01	0	7.3E-04	613	1.6E+01
MU-5	INORG	Cobalt	D	612	0	5.0E-05	1.9E-04	3.6E-04	1.0E-04	1.0E-04	5.0E-04	1.0E-03	0	3.6E-01	0	1.0E-04	612	3.6E+00
MU-5	INORG	Cobalt	T	613	31	1.0E-04	4.7E-04	4.8E-03	1.0E-04	1.0E-04	5.0E-04	1.0E-03	19	4.8E+00	0	3.3E-04	613	1.5E+01
MU-5	INORG	Copper	D	612	15	2.0E-04	4.3E-04	1.8E-03	2.0E-04	4.4E-04	1.0E-03	2.0E+00	0	9.2E-04	0	5.0E-04	612	3.7E+00
MU-5	INORG	Copper	T	613	31	5.0E-04	1.5E-03	1.4E-02	5.0E-04	5.2E-04	2.5E-03	2.0E+00	0	6.8E-03	0	1.3E-03	613	1.1E+01
MU-5	INORG	Iron	D	612	16	5.0E-03	2.4E-02	2.0E-01	1.0E-02	1.0E-02	5.0E-02	3.0E-01	0	6.6E-01	0	1.4E-02	612	1.4E+01
MU-5	INORG	Iron	T	613	92	1.0E-02	3.5E-01	1.1E+01	1.0E-02	1.0E-02	5.0E-02	3.0E-01	125	3.6E+01	0	2.8E-01	613	3.8E+01
MU-5	INORG	Lead	D	612	3	2.5E-05	1.1E-04	5.4E-04	5.0E-05	5.1E-05	2.5E-04	5.0E-03	0	1.1E-01	0	5.0E-05	612	1.1E+01
MU-5	INORG	Lead	T	613	55	5.0E-05	4.2E-04	8.6E-03	5.0E-05	5.1E-05	2.5E-04	5.0E-03	4	1.7E+00	0	2.7E-04	613	3.2E+01
MU-5	INORG	Lithium	D	612	100	1.6E-03	7.3E-03	1.5E-02	5.0E-04	9.9E-04	5.0E-03	8.0E-03	233	1.9E+00	0	5.0E-03	612	3.1E+00
MU-5	INORG	Lithium	T	613	100	1.9E-03	7.7E-03	1.5E-02	5.0E-04	9.9E-04	5.0E-03	8.0E-03	246	1.9E+00	0	5.1E-03	613	2.9E+00
MU-5	INORG	Manganese	D	612	98	1.0E-04	1.9E-03	5.2E-02	5.0E-05	9.9E-05	5.0E-04	1.2E-01	0	4.4E-01	0	1.9E-03	612	2.7E+01
MU-5	INORG	Manganese	T	613	100	9.8E-04	1.6E-02	5.2E-01	5.0E-05	9.9E-05	5.0E-04	1.2E-01	13	4.4E+00	0	1.3E-02	613	3.9E+01
MU-5	INORG	Mercury	D	611	3	5.1E-07	1.2E-06	5.6E-06	5.0E-07	4.9E-06	2.5E-05	1.0E-03	0	5.6E-03	0	5.0E-06	611	1.1E+00
MU-5	INORG	Mercury	T	614	44	5.1E-07	3.0E-06	3.5E-05	5.0E-07	1.8E-06	2.5E-05	1.0E-03	0	3.5E-02	0	2.4E-06	614	1.5E+01
MU-5	INORG	Molybdenum	D	612	100	5.5E-04	1.0E-03	1.7E-03	5.0E-05	5.1E-05	2.5E-04	8.8E-02	0	1.9E-02	0	1.3E-03	612	1.3E+00
MU-5	INORG	Molybdenum	T	613	100	4.9E-04	1.1E-03	1.7E-03	5.0E-05	5.1E-05	2.5E-04	8.8E-02	0	1.9E-02	0	1.3E-03	613	1.3E+00
MU-5	INORG	Nickel	D	612	67	2.5E-04	7.7E-04	2.1E-03	5.0E-04	5.1E-04	2.5E-03	8.0E-02	0	2.6E-02	0	6.2E-04	612	3.4E+00
MU-5	INORG	Nickel	T	613	85	2.5E-04	1.4E-03	1.9E-02	5.0E-04	5.1E-04	2.5E-03	8.0E-02	0	2.4E-01	0	1.7E-03	613	1.1E+01
MU-5	INORG	Nitrate Nitrogen (No3), As N	N	612	100	2.4E-01	1.7E+00	3.3E+00	5.0E-03	5.1E-03	2.5E-02	1.0E+01	0	3.3E-01	0	2.8E-01	612	1.2E+01
MU-5	INORG	Selenium	D	612	100	7.6E-04	8.6E-03	2.1E-02	5.0E-05	5.3E-05	2.5E-04	1.0E-02	192	2.1E+00	0	2.0E-03	612	1.0E+01
MU-5	INORG	Selenium	T	613	100	8.4E-04	8.3E-03	1.8E-02	5.0E-05	5.3E-05	2.5E-04	1.0E-02	169	1.8E+00	0	2.0E-03	613	9.3E+00
MU-5	INORG	Silver	D	612	0	5.0E-06	5.0E-06	5.0E-06	1.0E-05	1.0E-05	5.0E-05	2.0E-02	0	2.5E-04	0	1.0E-05	612	5.0E-01
MU-5	INORG	Silver	T	613	16	1.0E-05	3.2E-05	2.2E-04	1.0E-05	1.0E-05	5.0E-05	2.0E-02	0	1.1E-02	0	1.7E-05	613	1.3E+01
MU-5	INORG	Thallium	D	612	1	5.0E-06	9.6E-06	1.1E-05	1.0E-05	1.0E-05	5.0E-05	2.0E-03	0	5.5E-03	0	1.0E-05	612	1.1E+00
MU-5	INORG	Thallium	T	613	28	5.0E-06	3.5E-05	2.9E-04	1.0E-05	1.0E-05	5.0E-05	2.0E-03	0	1.4E-01	0	4.7E-05	613	6.1E+00
MU-5	INORG	Tin	D	612	8	5.0E-05	6.2E-04	1.4E-02	1.0E-04	1.0E-04	5.0E-04	2.5E+00	0	5.4E-03	0	1.0E-04	612	1.4E+02
MU-5	INORG	Tin	T	613	3	5.0E-05	1.7E-04	3.5E-04	1.0E-04	1.0E-04	5.0E-04	2.5E+00	0	1.4E-04	0	1.0E-04	613	3.5E+00
MU-5	INORG	Uranium	D	612	100	4.7E-04	1.0E-03	1.9E-03	1.0E-05	1.0E-05	5.0E-05	2.0E-02	0	9.4E-02	0	1.7E-03	612	1.1E+00
MU-5	INORG	Uranium	T	613	100	4.6E-04	1.0E-03	2.1E-03	1.0E-05	1.0E-05	5.0E-05	2.0E-02	0	1.0E-01	0	1.7E-03	613	1.2E+00
MU-5	INORG	Vanadium	D	612	1	2.5E-04	5.9E-04	7.4E-04	5.0E-04	5.3E-04	2.5E-03	2.0E-02	0	3.7E-02	0	1.0E-03	612	7.4E-01
MU-5	INORG	Vanadium	T	613	46	2.5E-04	2.1E-03	2.3E-02	5.0E-04	5.3E-04	2.5E-03	2.0E-02	2	1.1E+00	0	2.4E-03	613	9.3E+00
MU-5	INORG	Zinc	D	612	24	1.0E-03	8.4E-03	8.7E-02	1.0E-03	2.0E-03	5.0E-03	3.0E+00	0	2.9E-02	0	3.0E-03	612	2.9E+01
MU-5	INORG	Zinc	T	613	26	1.5E-03	1.1E-02	9.1E-02	3.0E-03	3.1E-03	1.5E-02	3.0E+00	0	3.0E-02	0	7.9E-03	613	1.1E+01
MU-6	INORG	Aluminum	D	720	93	1.5E-03	1.1E-02	2.0E-01	3.0E-03	3.1E-03	1.8E-02	9.5E+00	0	2.1E-02	0	3.0E-02	720	6.8E+00
MU-6	INORG	Aluminum	T	720	100	6.3E-03	3.8E-01	1.0E+01	3.0E-03	3.0E-03	3.0E-03	9.5E+00	1	1.0E+00	0	2.1E+00	720	4.8E+00
MU-6	INORG	Antimony	D	720	71	5.0E-05	5.1E-05	1.2E-04	1.0E-04	1.0E-04	1.0E-04	6.0E-03	0	2.0E-02	0	1.0E-04	720	1.2E+00
MU-6	INORG	Antimony	T	720	83	5.0E-05	7.0E-05	4.1E-04	1.0E-04	1.0E-04	2.0E-04	6.0E-03	0	6.8E-02	0	1.1E-04	720	3.7E+00
MU-6	INORG	Arsenic	D	720	100	1.7E-04	3.3E-04	9.1E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-02	0	9.1E-02	0	5.3E-04	720	1.7E+00
MU-6	INORG	Arsenic	T	720	100	2.0E-04	5.4E-04	7.1E-03	1.0E-04	1.0E-04	4.0E-04	1.0E-02	0	7.1E-01	0	1.4E-03	720	5.2E+00
MU-6	INORG	Barium	D	720	100	2.0E-02	5.1E-02	1.2E-01	5.0E-05	7.3E-05	1.0E-04	1.0E+00	0	1.2E-01	0	5.0E-02	720	2.4E+00
MU-6	INORG	Barium	T	720	100	2.4E-02	5.5E-02	3.4E-01	5.0E-05	7.3E-05	1.0E-04	1.0E+00	0	3.4E-01	0	5.2E-02	720	6.6E+00
MU-6	INORG	Beryllium	D	720	71	1.0E-05	1.9E-05	5.5E-05	2.0E-05	3.7E-05	1.0E-04	8.0E-03	0	6.9E-03	0	1.0E-04	720	5.5E-01
MU-6	INORG	Beryllium	T	720	81	1.0E-05	3.5E-05	8.1E-04	2.0E-05	3.7E-05	1.0E-04	8.0E-03	0	1.0E-01	0	1.0E-04	720	8.1E+00
MU-6	INORG	Boron	D	720	74	5.0E-03	6.0E-03	2.0E-02	1.0E-02	1.0E-02	1.0E-02	5.0E+00	0	4.0E-03	0	1.9E-02	720	1.0E+00
MU-6	INORG	Boron	T	720	76	5.0E-03	6.3E-03	2.0E-02	1.0E-02	1.0E-02	1.0E-02	5.0E+00	0	4.0E-03	0	2.0E-02	720	9.9E-01
MU-6	INORG	Cadmium	D	720	94	3.0E-06	5.1E-06	6.2E-05	5.0E-06	5.0E-06	1.0E-05	5.0E-03	0	1.2E-02	0	7.4E-06	720	8.3E+00
MU-6	INORG	Cadmium	T	720	100	3.0E-06	2.4E-05	1.0E-03	5.0E-06	5.1E-06	3.5E-05	5.0E-03	0	2.1E-01	0	4.0E-05	720	2.6E+01
MU-6	INORG	Chromium	D	720	92	5.0E-05	9.4E-05	1.1E-03	1.0E-04	1.0E-04	1.0E-04	5.0E-02	0	2.2E-02	0	1.0E-04	720	1.1E+01
MU-6	INORG	Chromium	T	720	98	5.0E-05	6.2E-04	1.2E-02	1.0E-04	1.1E-04	7.0E-04	5.0E-02	0	2.5E-01	0	2.9E-03	720	4.3E+00
MU-6	INORG	Cobalt	D	720	73	5.0E-05	5.4E-05	7.6E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-03	0	7.6E-01	0	1.0E-04	720	7.6E+00
MU-6	INORG	Cobalt	T	720	86	5.0E-05	3.0E-04	7.5E-03	1.0E-04	1.0E-04	1.0E-04	1.0E-03	38	7.5E+00	0	1.5E-03	720	5.0E+00
MU-6	INORG	Copper	D	720	74	1.0E-04	2.9E-04	2.1E-03	2.0E-04	4.5E-04	5.0E-04	2.0E+00	0	1.1E-03	0	5.0E-04	720	4.2E+00
MU-6	INORG	Copper	T	720	86	2.5E-04	8.8E-04	1.8E-02	5.0E-04	5.0E-04	1.0E-03	2.0E+00	0	9.1E-03	0	3.4E-03	720	5.3E+00
MU-6	INORG	Iron	D	720	82	5.0E-03	1.1E-02	8.3E-01	1.0E-02	1.0E-02	1.0E-02	3.0E-01	1	2.8E+00	0	2.9E-02	720	2.9E+01
MU-6	INORG	Iron	T	720	99	5.0E-03	5.4E-01	1.6E+01	1.0E-02	1.0E-02	1.0E-02	3.0E-01	202	5.2E+01	0	3.3E+00	720	4.7E+00

Table C-1. Surface water screening results

MU	Chem Group	Constituent	Fraction	Sample Count	% Detected	Minimum Detected Concentration (mg/L)	Mean Detected Concentration (mg/L)	Maximum Detected Concentration (mg/L)	Minimum Detection Limit (mg/L)	Average Limit (mg/L)	Maximum Detection Limit (mg/L)	Screening Level (mg/L)	Count Detected Result Exceeding Screening Level	Ratio of Max Detected to Screening Level (mg/L)	Count Detection Limit Exceeding Screening Level	Reference Concentration (mg/L)	Count Detected Result Exceeding Reference Concentration	Ratio Max Detected to Reference Concentration (mg/L)
MU-6	INORG	Lead	D	720	74	2.5E-05	3.6E-05	2.8E-03	5.0E-05	5.0E-05	5.0E-05	5.0E-03	0	5.6E-01	0	7.7E-05	720	3.6E+01
MU-6	INORG	Lead	T	720	94	2.5E-05	5.3E-04	1.5E-02	5.0E-05	5.0E-05	3.0E-04	5.0E-03	10	3.0E+00	0	2.8E-03	720	5.3E+00
MU-6	INORG	Lithium	D	720	99	5.0E-04	2.6E-03	8.2E-03	5.0E-04	1.0E-03	1.0E-03	8.0E-03	1	1.0E+00	0	2.4E-03	720	3.4E+00
MU-6	INORG	Lithium	T	720	100	5.0E-04	3.2E-03	2.0E-02	5.0E-04	1.0E-03	1.0E-03	8.0E-03	17	2.4E+00	0	4.3E-03	720	4.5E+00
MU-6	INORG	Manganese	D	720	99	5.0E-05	3.5E-03	1.0E-01	5.0E-05	1.0E-04	5.0E-04	1.2E-01	0	8.6E-01	0	1.3E-02	720	7.7E+00
MU-6	INORG	Manganese	T	720	100	7.2E-04	2.1E-02	6.7E-01	5.0E-05	1.0E-04	1.0E-04	1.2E-01	23	5.6E+00	0	8.6E-02	720	7.8E+00
MU-6	INORG	Mercury	D	720	71	3.0E-06	3.1E-06	1.7E-05	5.0E-06	5.1E-06	2.5E-05	1.0E-03	0	1.7E-02	0	5.0E-06	720	3.3E+00
MU-6	INORG	Mercury	T	722	89	2.5E-07	2.1E-06	5.6E-05	5.0E-07	1.6E-06	1.0E-05	1.0E-03	0	5.6E-02	0	5.2E-06	722	1.1E+01
MU-6	INORG	Molybdenum	D	720	100	3.9E-04	6.7E-04	1.3E-03	5.0E-05	5.0E-05	5.0E-05	8.8E-02	0	1.4E-02	0	8.7E-04	720	1.5E+00
MU-6	INORG	Molybdenum	T	720	100	3.9E-04	7.0E-04	1.2E-03	5.0E-05	5.0E-05	5.0E-05	8.8E-02	0	1.4E-02	0	9.0E-04	720	1.4E+00
MU-6	INORG	Nickel	D	720	72	2.5E-04	2.6E-04	9.9E-04	5.0E-04	5.0E-04	5.0E-04	8.0E-02	0	1.2E-02	0	5.0E-04	720	2.0E+00
MU-6	INORG	Nickel	T	720	92	2.5E-04	8.6E-04	2.0E-02	5.0E-04	5.0E-04	5.0E-04	8.0E-02	0	2.5E-01	0	3.1E-03	720	6.5E+00
MU-6	INORG	Nitrate Nitrogen (No3), As N	N	720	100	3.4E-02	4.2E-01	1.7E+00	5.0E-03	5.0E-03	5.0E-03	1.0E+01	0	1.7E-01	0	2.2E-01	720	7.9E+00
MU-6	INORG	Selenium	D	720	100	7.0E-05	2.0E-03	8.3E-03	5.0E-05	5.0E-05	1.0E-04	1.0E-02	0	8.3E-01	0	4.7E-04	720	1.8E+01
MU-6	INORG	Selenium	T	720	100	7.5E-05	1.9E-03	8.4E-03	5.0E-05	5.0E-05	1.0E-04	1.0E-02	0	8.4E-01	0	4.9E-04	720	1.7E+01
MU-6	INORG	Silver	D	720	71	5.0E-06	5.0E-06	5.0E-06	1.0E-05	1.0E-05	1.0E-05	2.0E-02	0	2.5E-04	0	1.0E-05	720	5.0E-01
MU-6	INORG	Silver	T	720	78	5.0E-06	8.1E-06	1.7E-04	1.0E-05	1.0E-05	3.0E-05	2.0E-02	0	8.5E-03	0	1.1E-05	720	1.5E+01
MU-6	INORG	Thallium	D	720	71	5.0E-06	5.0E-06	1.0E-05	1.0E-05	1.0E-05	1.0E-05	2.0E-03	0	5.0E-03	0	1.0E-05	720	1.0E+00
MU-6	INORG	Thallium	T	720	84	5.0E-06	1.2E-05	2.9E-04	1.0E-05	1.0E-05	2.0E-05	2.0E-03	0	1.5E-01	0	2.4E-05	720	1.2E+01
MU-6	INORG	Tin	D	720	76	5.0E-05	9.9E-05	4.1E-03	1.0E-04	1.0E-04	1.0E-04	2.5E+00	0	1.6E-03	0	1.6E-04	720	2.5E+01
MU-6	INORG	Tin	T	720	73	5.0E-05	5.6E-05	4.0E-04	1.0E-04	1.0E-04	1.0E-04	2.5E+00	0	1.6E-04	0	1.0E-04	720	4.0E+00
MU-6	INORG	Uranium	D	720	100	4.0E-04	6.9E-04	1.1E-03	1.0E-05	1.0E-05	1.0E-05	2.0E-02	0	5.6E-02	0	1.0E-03	720	1.1E+00
MU-6	INORG	Uranium	T	720	100	4.7E-04	7.2E-04	1.3E-03	1.0E-05	1.0E-05	1.0E-05	2.0E-02	0	6.7E-02	0	1.1E-03	720	1.3E+00
MU-6	INORG	Vanadium	D	720	71	2.5E-04	2.5E-04	7.8E-04	5.0E-04	5.0E-04	1.0E-03	2.0E-02	0	3.9E-02	0	5.0E-04	720	1.6E+00
MU-6	INORG	Vanadium	T	720	89	2.5E-04	9.2E-04	2.1E-02	5.0E-04	5.0E-04	1.0E-03	2.0E-02	1	1.0E+00	0	2.6E-03	720	8.0E+00
MU-6	INORG	Zinc	D	720	73	5.0E-04	1.3E-03	2.5E-02	1.0E-03	2.0E-03	3.0E-03	3.0E+00	0	8.3E-03	0	3.0E-03	720	8.3E+00
MU-6	INORG	Zinc	T	720	83	1.5E-03	3.9E-03	8.4E-02	3.0E-03	3.0E-03	3.0E-03	3.0E+00	0	2.8E-02	0	1.3E-02	720	6.4E+00

Notes:

INORG - inorganic
mg/L– milligrams per liter
MU – management unit
NA – not applicable
SVOC – semi-volatile organic compound
D - dissolved fraction
T – total fraction

Table C-2a. Groundwater screening results

MU	Chem Group	Constituent	Fraction	Sample Count	% Detected	Minimum Detected Concentration (mg/L)	Mean Detected Concentration (mg/L)	Maximum Detected Concentration (mg/L)	Minimum Detection Limit (mg/L)	Maximum Detection Limit (mg/L)	Screening Level (mg/L)	Count Detected Result Exceed Screening Level	Ratio of Max Detected to Screening Level (mg/L)	Count Detection Limit Exceeding Screening Level
MU-3	INORG	Aluminum	D	30	3	3.8E-03	3.8E-03	3.8E-03	3.0E-03	3.0E-03	9.5E+00	0	4.0E-04	0
MU-3	INORG	Antimony	D	30	0	NA	NA	NA	1.0E-04	1.0E-04	6.0E-03	0	NA	0
MU-3	INORG	Arsenic	D	30	0	NA	NA	NA	1.0E-04	1.0E-04	1.0E-02	0	NA	0
MU-3	INORG	Barium	D	30	100	6.4E-02	9.7E-02	1.4E-01	NA	NA	1.0E+00	0	1.4E-01	0
MU-3	INORG	Beryllium	D	30	0	NA	NA	NA	2.0E-05	2.0E-05	8.0E-03	0	NA	0
MU-3	INORG	Bismuth	D	30	0	NA	NA	NA	5.0E-05	5.0E-05	NA	0	NA	0
MU-3	INORG	Boron	D	30	43	1.7E-02	1.8E-02	2.0E-02	1.0E-02	1.0E-02	5.0E+00	0	4.0E-03	0
MU-3	INORG	Cadmium	D	30	90	5.4E-06	2.6E-05	5.5E-05	5.0E-06	5.0E-06	5.0E-03	0	1.1E-02	0
MU-3	INORG	Calcium	D	30	100	5.0E+01	8.3E+01	1.3E+02	NA	NA	NA	0	NA	0
MU-3	INORG	Chloride	D	46	100	5.1E-01	1.2E+01	7.0E+01	NA	NA	NA	0	NA	0
MU-3	INORG	Chromium	D	30	90	1.4E-04	2.2E-04	3.4E-04	1.0E-04	3.0E-04	5.0E-02	0	6.8E-03	0
MU-3	INORG	Chromium	D	30	90	1.4E-04	2.2E-04	3.4E-04	1.0E-04	3.0E-04	NA	0	NA	0
MU-3	INORG	Cobalt	D	30	0	NA	NA	NA	1.0E-04	1.0E-04	1.0E-03	0	NA	0
MU-3	INORG	Copper	D	30	100	6.8E-04	2.4E-03	6.0E-03	NA	NA	2.0E+00	0	3.0E-03	0
MU-3	INORG	Fluoride	D	34	82	6.4E-02	1.3E-01	1.6E-01	1.0E-01	1.0E-01	1.5E+00	0	1.1E-01	0
MU-3	INORG	Iron	D	30	7	1.0E-02	1.3E-02	1.5E-02	1.0E-02	1.0E-02	3.0E-01	0	5.0E-02	0
MU-3	INORG	Lead	D	30	83	5.3E-05	1.7E-04	1.0E-03	5.0E-05	5.0E-05	5.0E-03	0	2.1E-01	0
MU-3	INORG	Lithium	D	30	100	2.2E-03	4.3E-03	7.7E-03	NA	NA	8.0E-03	0	9.6E-01	0
MU-3	INORG	Magnesium	D	30	100	1.2E+01	2.6E+01	4.7E+01	NA	NA	NA	0	NA	0
MU-3	INORG	Manganese	D	30	53	1.1E-04	2.7E-04	6.5E-04	1.0E-04	2.0E-04	1.2E-01	0	5.4E-03	0
MU-3	INORG	Mercury	D	30	0	NA	NA	NA	5.0E-06	5.0E-06	1.0E-03	0	NA	0
MU-3	INORG	Molybdenum	D	30	100	8.3E-04	2.3E-03	7.8E-03	NA	NA	8.8E-02	0	8.9E-02	0
MU-3	INORG	Nickel	D	30	10	5.1E-04	6.0E-04	7.2E-04	5.0E-04	5.0E-04	8.0E-02	0	9.0E-03	0
MU-3	INORG	Nitrate Nitrogen (No3), as N	N	46	100	2.3E-01	7.5E-01	1.6E+00	NA	NA	1.0E+01	0	1.6E-01	0
MU-3	INORG	Potassium	D	30	100	3.6E-01	6.5E-01	1.1E+00	NA	NA	NA	0	NA	0
MU-3	INORG	Selenium	D	46	100	1.5E-03	2.7E-03	5.6E-03	NA	NA	1.0E-02	0	5.6E-01	0
MU-3	INORG	Silver	D	30	0	NA	NA	NA	1.0E-05	1.0E-05	2.0E-02	0	NA	0
MU-3	INORG	Sodium	D	30	100	1.0E+00	3.7E+00	9.5E+00	NA	NA	NA	0	NA	0
MU-3	INORG	Strontium	D	30	100	1.9E-01	2.5E-01	3.6E-01	NA	NA	NA	0	NA	0
MU-3	INORG	Sulphate (as So4)	D	46	100	2.7E+01	5.0E+01	6.9E+01	NA	NA	5.0E+02	0	1.4E-01	0
MU-3	INORG	Thallium	D	30	3	1.1E-05	1.1E-05	1.1E-05	1.0E-05	1.0E-05	2.0E-03	0	5.5E-03	0
MU-3	INORG	Tin	D	30	7	1.0E-04	1.1E-04	1.2E-04	1.0E-04	1.0E-04	2.5E+00	0	4.8E-05	0
MU-3	INORG	Titanium	D	30	0	NA	NA	NA	1.0E-02	1.0E-02	NA	0	NA	0
MU-3	INORG	Uranium	D	30	100	7.3E-04	1.2E-03	2.0E-03	NA	NA	2.0E-02	0	1.0E-01	0
MU-3	INORG	Vanadium	D	30	0	NA	NA	NA	5.0E-04	5.0E-04	2.0E-02	0	NA	0
MU-3	INORG	Zinc	D	30	100	3.0E-03	1.2E-02	4.0E-02	NA	NA	3.0E+00	0	1.3E-02	0
MU-4	INORG	Aluminum	D	109	3	1.6E-03	9.1E-03	1.7E-02	3.0E-03	3.0E-03	9.5E+00	0	1.8E-03	0
MU-4	INORG	Antimony	D	109	20	1.2E-04	3.0E-04	1.9E-03	1.0E-04	1.0E-04	6.0E-03	0	3.1E-01	0
MU-4	INORG	Arsenic	D	109	26	1.1E-04	2.3E-04	8.0E-04	1.0E-04	1.0E-04	1.0E-02	0	8.0E-02	0
MU-4	INORG	Barium	D	109	100	2.5E-04	1.3E-01	3.0E-01	NA	NA	1.0E+00	0	3.0E-01	0
MU-4	INORG	Beryllium	D	109	0	NA	NA	NA	2.0E-05	2.0E-05	8.0E-03	0	NA	0
MU-4	INORG	Bismuth	D	109	0	NA	NA	NA	5.0E-05	5.0E-05	NA	0	NA	0
MU-4	INORG	Boron	D	109	37	1.1E-02	3.7E-02	7.5E-02	1.0E-02	1.0E-02	5.0E+00	0	1.5E-02	0
MU-4	INORG	Cadmium	D	109	94	5.1E-06	2.4E-05	9.1E-05	5.0E-06	5.0E-06	5.0E-03	0	1.8E-02	0
MU-4	INORG	Calcium	D	109	100	1.8E-01	9.7E+01	2.4E+02	NA	NA	NA	0	NA	0
MU-4	INORG	Chloride	D	153	100	1.4E+00	1.0E+01	4.0E+01	NA	NA	NA	0	NA	0
MU-4	INORG	Chromium	D	109	83	1.2E-04	2.9E-04	4.0E-03	1.0E-04	1.0E-03	5.0E-02	0	8.0E-02	0
MU-4	INORG	Chromium	D	109	83	1.2E-04	2.9E-04	4.0E-03	1.0E-04	1.0E-03	NA	0	NA	0
MU-4	INORG	Cobalt	D	109	8	1.0E-04	1.6E-04	4.3E-04	1.0E-04	1.0E-04	1.0E-03	0	4.3E-01	0
MU-4	INORG	Copper	D	109	85	2.1E-04	5.5E-03	5.2E-02	2.0E-04	5.0E-04	2.0E+00	0	2.6E-02	0
MU-4	INORG	Fluoride	D	114	97	8.2E-02	1.8E-01	2.9E-01	1.0E-01	1.0E-01	1.5E+00	0	2.0E-01	0
MU-4	INORG	Iron	D	109	25	1.5E-02	3.9E-01	7.6E+00	1.0E-02	1.0E-02	3.0E-01	1	2.5E+01	0
MU-4	INORG	Lead	D	109	75	5.4E-05	3.9E-04	2.8E-03	5.0E-05	5.0E-05	5.0E-03	0	5.5E-01	0

Table C-2a. Groundwater screening results

MU	Chem Group	Constituent	Fraction	Sample Count	% Detected	Minimum Detected Concentration (mg/L)	Mean Detected Concentration (mg/L)	Maximum Detected Concentration (mg/L)	Minimum Detection Limit (mg/L)	Maximum Detection Limit (mg/L)	Screening Level (mg/L)	Count Detected Result Exceed Screening Level	Ratio of Max Detected to Screening Level (mg/L)	Count Detection Limit Exceeding Screening Level
MU-4	INORG	Lithium	D	109	99	1.3E-03	1.1E-02	3.3E-02	1.0E-03	1.0E-03	8.0E-03	32	4.2E+00	0
MU-4	INORG	Magnesium	D	109	99	1.3E+01	3.3E+01	1.0E+02	1.0E-01	1.0E-01	NA	0	NA	0
MU-4	INORG	Manganese	D	109	63	1.1E-04	3.6E-02	2.0E-01	1.0E-04	1.0E-04	1.2E-01	13	1.7E+00	0
MU-4	INORG	Mercury	D	109	0	NA	NA	NA	5.0E-06	5.0E-06	1.0E-03	0	NA	0
MU-4	INORG	Molybdenum	D	109	99	5.6E-04	1.4E-03	3.3E-03	5.0E-05	5.0E-05	8.8E-02	0	3.8E-02	0
MU-4	INORG	Nickel	D	109	32	5.3E-04	1.6E-03	3.2E-03	5.0E-04	5.0E-04	8.0E-02	0	4.0E-02	0
MU-4	INORG	Nitrate Nitrogen (No3), as N	N	153	96	1.1E-02	2.2E+00	5.9E+00	5.0E-03	2.5E-02	1.0E+01	0	5.9E-01	0
MU-4	INORG	Potassium	D	109	100	1.6E-01	1.3E+00	2.9E+00	NA	NA	NA	0	NA	0
MU-4	INORG	Selenium	D	153	98	5.6E-05	7.7E-03	1.5E-02	5.0E-05	1.0E-04	1.0E-02	50	1.5E+00	0
MU-4	INORG	Silver	D	109	0	NA	NA	NA	1.0E-05	1.0E-05	2.0E-02	0	NA	0
MU-4	INORG	Sodium	D	109	100	1.9E+00	1.0E+01	1.2E+02	NA	NA	NA	0	NA	0
MU-4	INORG	Strontium	D	109	100	5.5E-04	3.0E-01	7.8E-01	NA	NA	NA	0	NA	0
MU-4	INORG	Sulphate (as So4)	D	153	100	4.0E+00	1.4E+02	6.7E+02	NA	NA	5.0E+02	20	1.3E+00	0
MU-4	INORG	Thallium	D	109	26	1.1E-05	5.2E-05	1.1E-04	1.0E-05	1.0E-05	2.0E-03	0	5.5E-02	0
MU-4	INORG	Tin	D	109	12	1.1E-04	5.6E-04	4.6E-03	1.0E-04	1.0E-04	2.5E+00	0	1.8E-03	0
MU-4	INORG	Titanium	D	109	0	NA	NA	NA	1.0E-02	1.0E-02	NA	0	NA	0
MU-4	INORG	Uranium	D	109	100	1.5E-05	1.4E-03	4.3E-03	NA	NA	2.0E-02	0	2.1E-01	0
MU-4	INORG	Vanadium	D	109	0	NA	NA	NA	5.0E-04	5.0E-04	2.0E-02	0	NA	0
MU-4	INORG	Zinc	D	109	94	1.1E-03	2.1E-02	4.4E-01	3.0E-03	3.0E-03	3.0E+00	0	1.5E-01	0
MU-5	INORG	Aluminum	D	66	5	3.6E-03	7.3E-03	1.3E-02	3.0E-03	3.0E-03	9.5E+00	0	1.4E-03	0
MU-5	INORG	Antimony	D	66	17	1.0E-04	1.1E-04	1.5E-04	1.0E-04	1.0E-04	6.0E-03	0	2.5E-02	0
MU-5	INORG	Arsenic	D	66	20	1.0E-04	1.5E-04	5.8E-04	1.0E-04	1.0E-04	1.0E-02	0	5.8E-02	0
MU-5	INORG	Barium	D	66	100	5.9E-02	1.4E-01	8.6E-01	NA	NA	1.0E+00	0	8.6E-01	0
MU-5	INORG	Beryllium	D	66	0	NA	NA	NA	2.0E-05	2.0E-05	8.0E-03	0	NA	0
MU-5	INORG	Bismuth	D	66	0	NA	NA	NA	5.0E-05	5.0E-05	NA	0	NA	0
MU-5	INORG	Boron	D	66	39	1.0E-02	2.6E-02	3.8E-01	1.0E-02	1.0E-02	5.0E+00	0	7.6E-02	0
MU-5	INORG	Cadmium	D	66	95	7.7E-06	2.2E-05	1.3E-04	5.0E-06	5.0E-06	5.0E-03	0	2.6E-02	0
MU-5	INORG	Calcium	D	66	100	1.4E+01	6.8E+01	1.0E+02	NA	NA	NA	0	NA	0
MU-5	INORG	Chloride	D	91	100	1.8E-01	6.4E+00	4.7E+01	NA	NA	NA	0	NA	0
MU-5	INORG	Chromium	D	66	73	1.0E-04	1.7E-04	5.5E-04	1.0E-04	3.0E-04	5.0E-02	0	1.1E-02	0
MU-5	INORG	Chromium	D	66	73	1.0E-04	1.7E-04	5.5E-04	1.0E-04	3.0E-04	NA	0	NA	0
MU-5	INORG	Cobalt	D	66	3	4.1E-04	6.2E-04	8.3E-04	1.0E-04	1.0E-04	1.0E-03	0	8.3E-01	0
MU-5	INORG	Copper	D	66	89	4.3E-04	6.9E-03	3.4E-02	5.0E-04	5.0E-04	2.0E+00	0	1.7E-02	0
MU-5	INORG	Fluoride	D	69	100	1.0E-01	1.7E-01	7.6E-01	NA	NA	1.5E+00	0	5.1E-01	0
MU-5	INORG	Iron	D	66	29	1.0E-02	1.0E-01	6.5E-01	1.0E-02	1.0E-02	3.0E-01	2	2.2E+00	0
MU-5	INORG	Lead	D	66	67	5.0E-05	1.8E-04	1.6E-03	5.0E-05	5.0E-05	5.0E-03	0	3.2E-01	0
MU-5	INORG	Lithium	D	66	98	1.2E-03	8.8E-03	1.2E-01	1.0E-03	1.0E-03	8.0E-03	17	1.4E+01	0
MU-5	INORG	Magnesium	D	66	100	1.0E+01	1.9E+01	2.9E+01	NA	NA	NA	0	NA	0
MU-5	INORG	Manganese	D	66	86	1.2E-04	2.8E-02	1.2E+00	1.0E-04	1.0E-04	1.2E-01	2	9.6E+00	0
MU-5	INORG	Mercury	D	66	0	NA	NA	NA	5.0E-06	5.0E-06	1.0E-03	0	NA	0
MU-5	INORG	Molybdenum	D	66	100	3.4E-04	1.1E-03	5.7E-03	NA	NA	8.8E-02	0	6.5E-02	0
MU-5	INORG	Nickel	D	66	20	5.8E-04	2.4E-03	1.2E-02	5.0E-04	5.0E-04	8.0E-02	0	1.5E-01	0
MU-5	INORG	Nitrate Nitrogen (No3), as N	N	91	98	5.7E-03	1.1E+00	2.3E+00	5.0E-03	5.0E-03	1.0E+01	0	2.3E-01	0
MU-5	INORG	Potassium	D	66	100	3.0E-01	7.5E-01	3.4E+00	NA	NA	NA	0	NA	0
MU-5	INORG	Selenium	D	91	96	1.4E-04	6.8E-03	1.6E-02	5.0E-05	1.0E-04	1.0E-02	19	1.6E+00	0
MU-5	INORG	Silver	D	66	0	NA	NA	NA	1.0E-05	1.0E-05	2.0E-02	0	NA	0
MU-5	INORG	Sodium	D	66	100	7.5E-01	6.7E+00	8.4E+01	NA	NA	NA	0	NA	0
MU-5	INORG	Strontium	D	66	100	1.2E-01	2.1E-01	9.0E-01	NA	NA	NA	0	NA	0
MU-5	INORG	Sulphate (as So4)	D	91	100	5.2E+00	5.4E+01	1.3E+02	NA	NA	5.0E+02	0	2.6E-01	0
MU-5	INORG	Thallium	D	66	3	3.1E-05	8.3E-05	1.4E-04	1.0E-05	1.0E-05	2.0E-03	0	6.8E-02	0
MU-5	INORG	Tin	D	66	6	1.1E-04	2.8E-04	6.5E-04	1.0E-04	1.0E-04	2.5E+00	0	2.6E-04	0
MU-5	INORG	Titanium	D	66	0	NA	NA	NA	1.0E-02	1.0E-02	NA	0	NA	0
MU-5	INORG	Uranium	D	66	100	6.4E-05	8.2E-04	1.5E-03	NA	NA	2.0E-02	0	7.3E-02	0

Table C-2a. Groundwater screening results

MU	Chem Group	Constituent	Fraction	Sample Count	% Detected	Minimum Detected Concentration (mg/L)	Mean Detected Concentration (mg/L)	Maximum Detected Concentration (mg/L)	Minimum Detection Limit (mg/L)	Maximum Detection Limit (mg/L)	Screening Level (mg/L)	Count Detected Result Exceed Screening Level	Ratio of Max Detected to Screening Level (mg/L)	Count Detection Limit Exceeding Screening Level
MU-5	INORG	Vanadium	D	66	0	NA	NA	NA	5.0E-04	5.0E-04	2.0E-02	0	NA	0
MU-5	INORG	Zinc	D	66	92	1.7E-03	3.3E-02	1.7E-01	1.0E-03	3.0E-03	3.0E+00	0	5.7E-02	0

Notes:

INORG - inorganic
mg/L – milligrams per liter
MU – management unit
NA – not applicable
D - dissolved fraction
T – total fraction

Reference concentrations (95th percentiles) not available for screening.
Groundwater sampled in MUs 3, 4, and 5 only.

Table C-2b. Municipal Fernie (James White Park wells) groundwater screening results

MU	Chem Group	Constituent	Fraction	Sample Count	% Detected	Minimum Detected Concentration (mg/L)	Mean Detected Concentration (mg/L)	Maximum Detected Concentration (mg/L)	Minimum Detection Limit (mg/L)	Maximum Detection Limit (mg/L)	Screening Level (mg/L)	Count Detected Result Exceed Screening Level	Ratio of Max Detected to Screening Level (mg/L)	Count Detection Limit Exceeding Screening Level
MU-5	INORG	Aluminum	D	5	40	1.2E-03	2.5E-03	3.7E-03	1.0E-03	3.0E-03	9.5E+00	0	3.9E-04	0
MU-5	INORG	Antimony	D	5	0	NA	NA	NA	1.0E-04	1.0E-04	6.0E-03	0	NA	0
MU-5	INORG	Arsenic	D	5	100	1.2E+04	1.3E-04	1.4E-04	1.0E-04	1.0E-04	1.0E-02	0	1.4E-02	0
MU-5	INORG	Barium	D	5	100	1.1E-01	1.4E-01	1.6E-01	1.0E-04	1.0E-04	1.0E+00	0	1.6E-01	0
MU-5	INORG	Beryllium	D	5	0	NA	NA	NA	2.0E-05	2.0E-05	8.0E-03	0	NA	0
MU-5	INORG	Bismuth	D	5	0	NA	NA	NA	5.0E-05	5.0E-05	NA	0	NA	0
MU-5	INORG	Boron	D	5	0	NA	NA	NA	1.0E-02	1.0E-02	5.0E+00	0	NA	0
MU-5	INORG	Cadmium	D	5	100	8.2E-06	1.3E-05	1.7E-05	5.0E-06	5.0E-06	5.0E-03	0	3.4E-03	0
MU-5	INORG	Calcium	D	5	100	5.1E+01	6.1E+01	6.7E+01	5.0E-02	5.0E-02	NA	0	NA	0
MU-5	INORG	Chloride	D	5	100	1.8E+00	3.2E+00	4.5E+00	1.0E-01	1.0E-01	NA	0	NA	0
MU-5	INORG	Chromium	D	5	100	2.0E-04	2.2E-04	2.6E-04	1.0E-04	1.0E-04	5.0E-02	0	5.2E-03	0
MU-5	INORG	Cobalt	D	5	0	NA	NA	NA	1.0E-04	1.0E-04	1.0E-03	0	NA	0
MU-5	INORG	Copper	D	5	80	3.4E-04	1.1E-03	1.9E-03	2.0E-04	2.0E-04	2.0E+00	0	9.7E-04	0
MU-5	INORG	Fluoride	D	5	100	7.0E-02	1.2E-01	1.6E-01	2.0E-02	2.0E-02	NA	0	NA	0
MU-5	INORG	Iron	D	5	0	NA	NA	NA	1.0E-02	1.0E-02	3.0E-01	0	NA	0
MU-5	INORG	Lead	D	5	40	7.8E-05	7.9E-05	8.0E-05	5.0E-05	5.0E-05	5.0E-03	0	1.6E-02	0
MU-5	INORG	Lithium	D	5	100	6.5E-03	6.8E-04	7.1E-03	1.0E-03	1.0E-03	8.0E-03	0	8.9E-01	0
MU-5	INORG	Magnesium	D	5	100	1.5E+01	1.7E+01	2.0E+01	5.0E-03	1.0E-01	NA	0	NA	0
MU-5	INORG	Manganese	D	5	0	NA	NA	NA	1.0E-04	1.0E-04	1.2E-01	0	NA	0
MU-5	INORG	Molybdenum	D	5	100	7.8E-04	8.7E-04	9.6E-04	5.0E-05	5.0E-05	8.8E-02	0	1.1E-02	0
MU-5	INORG	Nickel	D	5	0	NA	NA	NA	5.0E-04	5.0E-04	8.0E-02	0	NA	0
MU-5	INORG	Nitrate	D	5	100	8.9E-01	1.3E+00	1.8E+00	5.0E-03	5.0E-03	1.0E+01	0	1.8E-01	0
MU-5	INORG	Potassium	D	5	100	6.3E-01	6.6E-01	6.9E-01	5.0E-02	5.0E-02	NA	0	NA	0
MU-5	INORG	Selenium	D	5	100	4.9E-03	7.9E-03	9.9E-03	5.0E-05	5.0E-05	1.0E-02	0	9.9E-01	0
MU-5	INORG	Silver	D	5	0	NA	NA	NA	1.0E-05	1.0E-05	2.0E-02	0	NA	0
MU-5	INORG	Sodium	D	5	100	2.9E+00	3.4E+00	3.8E+00	5.0E-02	5.0E-02	NA	0	NA	0
MU-5	INORG	Strontium	D	5	100	1.7E-01	2.0E-01	2.2E-01	2.0E-04	2.0E-04	NA	0	NA	0
MU-5	INORG	Sulfate	D	5	100	3.5E+01	5.2E+01	6.6E+01	3.0E-01	3.0E-01	NA	0	NA	0
MU-5	INORG	Thallium	D	5	0	NA	NA	NA	1.0E-05	1.0E-05	2.0E-03	0	NA	0
MU-5	INORG	Tin	D	5	0	NA	NA	NA	1.0E-04	1.0E-04	2.5E+00	0	NA	0
MU-5	INORG	Titanium	D	5	0	NA	NA	NA	3.0E-04	1.0E-02	NA	0	NA	0
MU-5	INORG	Uranium	D	5	100	7.8E-04	9.0E-04	1.0E-03	1.0E-05	1.0E-05	2.0E-02	0	5.2E-02	0
MU-5	INORG	Vanadium	D	5	0	NA	NA	NA	5.0E-04	5.0E-04	2.0E-02	0	NA	0
MU-5	INORG	Zinc	D	5	100	1.3E-03	3.3E-03	4.8E-03	1.0E-03	1.0E-03	NA	0	NA	0

Notes:

INORG - inorganic
mg/L – milligrams per liter
MU – management unit
NA – not applicable
D - dissolved fraction

Reference concentrations (95th percentiles) not available for screening.

Table C-2c. Sparwood wells 1 & 2 groundwater selenium screening results

Location	Date	Chem Group	Analyte	CAS	UNIT	Fraction	Sample Count	Result (mg/L)	Screening Level (mg/L)	Count Result Exceed DW Guideline	Ratio of Max Result to DW Guideline
RG_DW-03-08	1/7/2015	INORG	Selenium	7782-49-2	MG/L	T	1	1.1E-03	1.0E-02	0	1.1E-01
RG_DW-03-08	2/3/2015	INORG	Selenium	7782-49-2	MG/L	T	1	1.1E-03	1.0E-02	0	1.1E-01
RG_DW-03-08	3/3/2015	INORG	Selenium	7782-49-2	MG/L	T	1	1.0E-03	1.0E-02	0	1.0E-01
RG_DW-03-08	4/14/2015	INORG	Selenium	7782-49-2	MG/L	T	1	1.0E-03	1.0E-02	0	1.0E-01
RG_DW-03-08	5/12/2015	INORG	Selenium	7782-49-2	MG/L	T	1	7.0E-03	1.0E-02	0	7.0E-01
RG_DW-03-08	6/3/2015	INORG	Selenium	7782-49-2	MG/L	T	1	1.1E-03	1.0E-02	0	1.1E-01
RG_DW-03-08	7/7/2015	INORG	Selenium	7782-49-2	MG/L	T	1	9.5E-04	1.0E-02	0	9.5E-02
RG_DW-03-08	8/5/2015	INORG	Selenium	7782-49-2	MG/L	T	1	1.1E-03	1.0E-02	0	1.1E-01
RG_DW-03-08	9/2/2015	INORG	Selenium	7782-49-2	MG/L	T	1	1.1E-03	1.0E-02	0	1.1E-01
RG_DW-03-08	10/6/2015	INORG	Selenium	7782-49-2	MG/L	T	1	1.1E-03	1.0E-02	0	1.1E-01
RG_DW-03-08	11/4/2015	INORG	Selenium	7782-49-2	MG/L	T	1	9.4E-04	1.0E-02	0	9.4E-02
RG_DW-03-08	12/1/2015	INORG	Selenium	7782-49-2	MG/L	T	1	1.0E-03	1.0E-02	0	1.0E-01
RG_DW-03-08	1/5/2016	INORG	Selenium	7782-49-2	MG/L	T	1	9.8E-04	1.0E-02	0	9.8E-02
RG_DW-03-08	2/2/2016	INORG	Selenium	7782-49-2	MG/L	T	1	1.1E-03	1.0E-02	0	1.1E-01
RG_DW-03-08	3/8/2016	INORG	Selenium	7782-49-2	MG/L	T	1	1.1E-03	1.0E-02	0	1.1E-01
RG_DW-03-08	4/5/2016	INORG	Selenium	7782-49-2	MG/L	T	1	1.0E-03	1.0E-02	0	1.0E-01
RG_DW-03-08	5/3/2016	INORG	Selenium	7782-49-2	MG/L	T	1	9.1E-04	1.0E-02	0	9.1E-02
RG_DW-03-08	6/1/2016	INORG	Selenium	7782-49-2	MG/L	T	1	9.9E-04	1.0E-02	0	9.9E-02
RG_DW-03-08	8/3/2016	INORG	Selenium	7782-49-2	MG/L	T	1	1.1E-03	1.0E-02	0	1.1E-01
RG_DW-03-08	9/7/2016	INORG	Selenium	7782-49-2	MG/L	T	1	1.2E-03	1.0E-02	0	1.2E-01
RG_DW-03-08	10/4/2016	INORG	Selenium	7782-49-2	MG/L	T	1	1.1E-03	1.0E-02	0	1.1E-01
RG_DW-03-08	11/2/2016	INORG	Selenium	7782-49-2	MG/L	T	1	1.1E-03	1.0E-02	0	1.1E-01
RG_DW-03-08	12/7/2016	INORG	Selenium	7782-49-2	MG/L	T	1	9.3E-04	1.0E-02	0	9.3E-02
RG_DW-03-08	1/11/2017	INORG	Selenium	7782-49-2	MG/L	T	1	1.0E-03	1.0E-02	0	1.0E-01
RG_DW-03-08	2/8/2017	INORG	Selenium	7782-49-2	MG/L	T	1	1.2E-03	1.0E-02	0	1.2E-01
RG_DW-03-08	3/7/2017	INORG	Selenium	7782-49-2	MG/L	T	1	1.0E-03	1.0E-02	0	1.0E-01
RG_DW-03-08	5/2/2017	INORG	Selenium	7782-49-2	MG/L	T	1	1.0E-03	1.0E-02	0	1.0E-01
RG_DW-03-08	6/6/2017	INORG	Selenium	7782-49-2	MG/L	T	1	1.1E-03	1.0E-02	0	1.1E-01
RG_DW-03-08	7/11/2017	INORG	Selenium	7782-49-2	MG/L	T	1	1.1E-03	1.0E-02	0	1.1E-01
RG_DW-03-08	8/1/2017	INORG	Selenium	7782-49-2	MG/L	T	1	1.2E-03	1.0E-02	0	1.2E-01
RG_DW-03-08	9/12/2017	INORG	Selenium	7782-49-2	MG/L	T	1	1.0E-03	1.0E-02	0	1.0E-01
RG_DW-03-08	10/3/2017	INORG	Selenium	7782-49-2	MG/L	T	1	1.0E-03	1.0E-02	0	1.0E-01
RG_DW-03-08	11/7/2017	INORG	Selenium	7782-49-2	MG/L	T	1	1.0E-03	1.0E-02	0	1.0E-01
RG_DW-03-08	12/5/2017	INORG	Selenium	7782-49-2	MG/L	T	1	1.0E-03	1.0E-02	0	1.0E-01
RG_DW-03-08	1/9/2018	INORG	Selenium	7782-49-2	MG/L	T	1	1.1E-03	1.0E-02	0	1.1E-01
RG_DW-03-08	2/14/2018	INORG	Selenium	7782-49-2	MG/L	T	1	9.4E-04	1.0E-02	0	9.4E-02
RG_DW-03-08	3/7/2018	INORG	Selenium	7782-49-2	MG/L	T	1	1.0E-03	1.0E-02	0	1.0E-01
RG_DW-03-08	4/4/2018	INORG	Selenium	7782-49-2	MG/L	T	1	9.9E-04	1.0E-02	0	9.9E-02

Table C-2c. Sparwood wells 1 & 2 groundwater selenium screening results

Location	Date	Chem Group	Analyte	CAS	UNIT	Fraction	Sample Count	Result (mg/L)	Screening Level (mg/L)	Count Result Exceed DW Guideline	Ratio of Max Result to DW Guideline
RG_DW-03-08	5/1/2018	INORG	Selenium	7782-49-2	MG/L	T	1	9.2E-04	1.0E-02	0	9.2E-02
RG_DW-03-08	6/5/2018	INORG	Selenium	7782-49-2	MG/L	T	1	1.1E-03	1.0E-02	0	1.1E-01
RG_DW-03-08	7/4/2018	INORG	Selenium	7782-49-2	MG/L	T	1	1.1E-03	1.0E-02	0	1.1E-01
RG_DW-03-08	8/8/2018	INORG	Selenium	7782-49-2	MG/L	T	1	1.1E-03	1.0E-02	0	1.1E-01
RG_DW-03-08	9/5/2018	INORG	Selenium	7782-49-2	MG/L	T	1	9.6E-04	1.0E-02	0	9.6E-02
RG_DW-03-08	10/2/2018	INORG	Selenium	7782-49-2	MG/L	T	1	1.0E-03	1.0E-02	0	1.0E-01
RG_DW-03-08	11/6/2018	INORG	Selenium	7782-49-2	MG/L	T	1	9.7E-04	1.0E-02	0	9.7E-02
RG_DW-03-08	12/11/2018	INORG	Selenium	7782-49-2	MG/L	T	1	1.1E-03	1.0E-02	0	1.1E-01
RG_DW-03-08	2/5/2019	INORG	Selenium	7782-49-2	MG/L	T	1	9.5E-04	1.0E-02	0	9.5E-02
RG_DW-03-08	3/5/2019	INORG	Selenium	7782-49-2	MG/L	T	1	1.1E-03	1.0E-02	0	1.1E-01
RG_DW-03-08	4/2/2019	INORG	Selenium	7782-49-2	MG/L	T	1	1.2E-03	1.0E-02	0	1.2E-01
RG_DW-03-08	5/7/2019	INORG	Selenium	7782-49-2	MG/L	T	1	1.1E-03	1.0E-02	0	1.1E-01
RG_DW-03-08	6/4/2019	INORG	Selenium	7782-49-2	MG/L	T	1	1.0E-03	1.0E-02	0	1.0E-01
RG_DW-03-08	7/3/2019	INORG	Selenium	7782-49-2	MG/L	T	1	1.1E-03	1.0E-02	0	1.1E-01
RG_DW-03-08	8/7/2019	INORG	Selenium	7782-49-2	MG/L	T	1	1.1E-03	1.0E-02	0	1.1E-01
RG_DW-03-08	9/4/2019	INORG	Selenium	7782-49-2	MG/L	T	1	1.1E-03	1.0E-02	0	1.1E-01
RG_DW-03-08	10/8/2019	INORG	Selenium	7782-49-2	MG/L	T	1	1.2E-03	1.0E-02	0	1.2E-01
RG_DW-03-09	1/7/2015	INORG	Selenium	7782-49-2	MG/L	T	1	9.7E-04	1.0E-02	0	9.7E-02
RG_DW-03-09	2/3/2015	INORG	Selenium	7782-49-2	MG/L	T	1	9.6E-04	1.0E-02	0	9.6E-02
RG_DW-03-09	3/3/2015	INORG	Selenium	7782-49-2	MG/L	T	1	9.9E-04	1.0E-02	0	9.9E-02
RG_DW-03-09	4/14/2015	INORG	Selenium	7782-49-2	MG/L	T	1	9.4E-04	1.0E-02	0	9.4E-02
RG_DW-03-09	5/12/2015	INORG	Selenium	7782-49-2	MG/L	T	1	1.0E-03	1.0E-02	0	1.0E-01
RG_DW-03-09	6/3/2015	INORG	Selenium	7782-49-2	MG/L	T	1	9.8E-04	1.0E-02	0	9.8E-02
RG_DW-03-09	7/7/2015	INORG	Selenium	7782-49-2	MG/L	T	1	9.5E-04	1.0E-02	0	9.5E-02
RG_DW-03-09	8/5/2015	INORG	Selenium	7782-49-2	MG/L	T	1	1.1E-03	1.0E-02	0	1.1E-01
RG_DW-03-09	9/2/2015	INORG	Selenium	7782-49-2	MG/L	T	1	1.0E-03	1.0E-02	0	1.0E-01
RG_DW-03-09	10/6/2015	INORG	Selenium	7782-49-2	MG/L	T	1	1.1E-03	1.0E-02	0	1.1E-01
RG_DW-03-09	11/4/2015	INORG	Selenium	7782-49-2	MG/L	T	1	9.6E-04	1.0E-02	0	9.6E-02
RG_DW-03-09	12/1/2015	INORG	Selenium	7782-49-2	MG/L	T	1	1.0E-03	1.0E-02	0	1.0E-01
RG_DW-03-09	1/5/2016	INORG	Selenium	7782-49-2	MG/L	T	1	9.3E-04	1.0E-02	0	9.3E-02
RG_DW-03-09	2/2/2016	INORG	Selenium	7782-49-2	MG/L	T	1	1.0E-03	1.0E-02	0	1.0E-01
RG_DW-03-09	4/5/2016	INORG	Selenium	7782-49-2	MG/L	T	1	9.3E-04	1.0E-02	0	9.3E-02
RG_DW-03-09	5/3/2016	INORG	Selenium	7782-49-2	MG/L	T	1	1.0E-03	1.0E-02	0	1.0E-01
RG_DW-03-09	6/1/2016	INORG	Selenium	7782-49-2	MG/L	T	1	1.1E-03	1.0E-02	0	1.1E-01
RG_DW-03-09	7/5/2016	INORG	Selenium	7782-49-2	MG/L	T	1	9.4E-04	1.0E-02	0	9.4E-02
RG_DW-03-09	8/3/2016	INORG	Selenium	7782-49-2	MG/L	T	1	1.2E-03	1.0E-02	0	1.2E-01
RG_DW-03-09	9/7/2016	INORG	Selenium	7782-49-2	MG/L	T	1	1.1E-03	1.0E-02	0	1.1E-01
RG_DW-03-09	10/4/2016	INORG	Selenium	7782-49-2	MG/L	T	1	1.1E-03	1.0E-02	0	1.1E-01
RG_DW-03-09	11/2/2016	INORG	Selenium	7782-49-2	MG/L	T	1	1.2E-03	1.0E-02	0	1.2E-01
RG_DW-03-09	12/7/2016	INORG	Selenium	7782-49-2	MG/L	T	1	9.7E-04	1.0E-02	0	9.7E-02

Table C-2c. Sparwood wells 1 & 2 groundwater selenium screening results

Location	Date	Chem Group	Analyte	CAS	UNIT	Fraction	Sample Count	Result (mg/L)	Screening Level (mg/L)	Count Result Exceed DW Guideline	Ratio of Max Result to DW Guideline
RG_DW-03-09	1/11/2017	INORG	Selenium	7782-49-2	MG/L	T	1	9.6E-04	1.0E-02	0	9.6E-02
RG_DW-03-09	2/8/2017	INORG	Selenium	7782-49-2	MG/L	T	1	1.1E-03	1.0E-02	0	1.1E-01
RG_DW-03-09	3/7/2017	INORG	Selenium	7782-49-2	MG/L	T	1	1.0E-03	1.0E-02	0	1.0E-01
RG_DW-03-09	5/2/2017	INORG	Selenium	7782-49-2	MG/L	T	1	9.8E-04	1.0E-02	0	9.8E-02
RG_DW-03-09	6/6/2017	INORG	Selenium	7782-49-2	MG/L	T	1	9.7E-04	1.0E-02	0	9.7E-02
RG_DW-03-09	7/11/2017	INORG	Selenium	7782-49-2	MG/L	T	1	9.7E-04	1.0E-02	0	9.7E-02
RG_DW-03-09	8/1/2017	INORG	Selenium	7782-49-2	MG/L	T	1	1.0E-03	1.0E-02	0	1.0E-01
RG_DW-03-09	9/12/2017	INORG	Selenium	7782-49-2	MG/L	T	1	1.0E-03	1.0E-02	0	1.0E-01
RG_DW-03-09	10/3/2017	INORG	Selenium	7782-49-2	MG/L	T	1	1.1E-03	1.0E-02	0	1.1E-01
RG_DW-03-09	11/7/2017	INORG	Selenium	7782-49-2	MG/L	T	1	8.2E-04	1.0E-02	0	8.2E-02
RG_DW-03-09	12/5/2017	INORG	Selenium	7782-49-2	MG/L	T	1	1.0E-03	1.0E-02	0	1.0E-01
RG_DW-03-09	1/9/2018	INORG	Selenium	7782-49-2	MG/L	T	1	1.0E-03	1.0E-02	0	1.0E-01
RG_DW-03-09	2/14/2018	INORG	Selenium	7782-49-2	MG/L	T	1	9.3E-04	1.0E-02	0	9.3E-02
RG_DW-03-09	3/7/2018	INORG	Selenium	7782-49-2	MG/L	T	1	1.0E-03	1.0E-02	0	1.0E-01
RG_DW-03-09	4/4/2018	INORG	Selenium	7782-49-2	MG/L	T	1	1.0E-03	1.0E-02	0	1.0E-01
RG_DW-03-09	5/1/2018	INORG	Selenium	7782-49-2	MG/L	T	1	8.3E-04	1.0E-02	0	8.3E-02
RG_DW-03-09	6/5/2018	INORG	Selenium	7782-49-2	MG/L	T	1	9.6E-04	1.0E-02	0	9.6E-02
RG_DW-03-09	7/4/2018	INORG	Selenium	7782-49-2	MG/L	T	1	9.4E-04	1.0E-02	0	9.4E-02
RG_DW-03-09	8/8/2018	INORG	Selenium	7782-49-2	MG/L	T	1	9.2E-04	1.0E-02	0	9.2E-02
RG_DW-03-09	9/5/2018	INORG	Selenium	7782-49-2	MG/L	T	1	9.0E-04	1.0E-02	0	9.0E-02
RG_DW-03-09	10/2/2018	INORG	Selenium	7782-49-2	MG/L	T	1	9.8E-04	1.0E-02	0	9.8E-02
RG_DW-03-09	11/6/2018	INORG	Selenium	7782-49-2	MG/L	T	1	9.8E-04	1.0E-02	0	9.8E-02
RG_DW-03-09	12/11/2018	INORG	Selenium	7782-49-2	MG/L	T	1	9.9E-04	1.0E-02	0	9.9E-02
RG_DW-03-09	2/5/2019	INORG	Selenium	7782-49-2	MG/L	T	1	9.7E-04	1.0E-02	0	9.7E-02
RG_DW-03-09	3/5/2019	INORG	Selenium	7782-49-2	MG/L	T	1	9.9E-04	1.0E-02	0	9.9E-02
RG_DW-03-09	4/2/2019	INORG	Selenium	7782-49-2	MG/L	T	1	1.0E-03	1.0E-02	0	1.0E-01
RG_DW-03-09	5/7/2019	INORG	Selenium	7782-49-2	MG/L	T	1	1.1E-03	1.0E-02	0	1.1E-01
RG_DW-03-09	6/4/2019	INORG	Selenium	7782-49-2	MG/L	T	1	1.1E-03	1.0E-02	0	1.1E-01
RG_DW-03-09	7/3/2019	INORG	Selenium	7782-49-2	MG/L	T	1	9.9E-04	1.0E-02	0	9.9E-02
RG_DW-03-09	8/7/2019	INORG	Selenium	7782-49-2	MG/L	T	1	9.9E-04	1.0E-02	0	9.9E-02
RG_DW-03-09	9/4/2019	INORG	Selenium	7782-49-2	MG/L	T	1	9.7E-04	1.0E-02	0	9.7E-02
RG_DW-03-09	10/8/2019	INORG	Selenium	7782-49-2	MG/L	T	1	1.1E-03	1.0E-02	0	1.1E-01

Notes:

INORG - inorganic
mg/L – milligrams per liter
NA – not applicable
T – total fraction

No concentrations were above the screening level.

Table C-3. Sediment screening results

MU	Chem Group	Constituent	Sample Count	% Detected	Minimum Detected Concentration (mg/kg)	Mean Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)	Minimum Detection Limit (mg/kg)	Maximum Detection Limit (mg/kg)	Screening Level (mg/kg)	Count Detected Result Exceeding Screening Level	Ratio of Max Detected to Screening Level (mg/kg)	Count Detection Limit Exceeding Screening Level	Reference Concentration (mg/kg)	Count Detected Result Exceeding Reference Concentration	Ratio of Max Detected to Reference Concentration (mg/kg)
MU-1	SVOC	1-Methylnaphthalene	60	100	4.5E-02	7.0E-01	4.7E+00	NA	NA	250	0	1.9E-02	0	4.0E-01	33	1.2E+01
MU-1	SVOC	2-Methylnaphthalene	85	100	8.1E-02	1.2E+00	9.0E+00	NA	NA	60	0	1.5E-01	0	4.2E-01	54	2.1E+01
MU-1	SVOC	Acenaphthene	85	29	5.0E-03	1.4E-02	7.0E-02	8.0E-03	3.6E-01	950	0	7.4E-05	0	1.7E-02	6	4.1E+00
MU-1	SVOC	Acenaphthylene	85	42	5.0E-03	1.2E-02	4.8E-02	5.0E-03	3.4E-02	950	0	5.0E-05	0	1.8E-02	5	2.7E+00
MU-1	INORG	Aluminum	165	88	2.1E+02	5.7E+03	1.7E+04	5.0E+01	5.0E+01	40,000	0	4.1E-01	0	1.8E+04	0	9.2E-01
MU-1	SVOC	Anthracene	85	29	4.0E-03	9.6E-03	3.4E-02	4.0E-03	8.0E-02	10,000	0	3.4E-06	0	1.4E-02	5	2.4E+00
MU-1	INORG	Antimony	125	84	1.0E-01	6.2E-01	1.5E+00	1.0E-01	1.0E-01	250	0	6.1E-03	0	1.1E+00	2	1.4E+00
MU-1	INORG	Arsenic	165	90	5.4E-02	3.5E+00	1.2E+01	5.0E-02	5.0E-02	20	0	5.8E-01	0	8.6E+00	2	1.4E+00
MU-1	INORG	Barium	185	100	6.9E+00	1.4E+02	5.5E+02	NA	NA	8,500	0	6.4E-02	0	5.0E+02	1	1.1E+00
MU-1	SVOC	Benz(a)anthracene	85	72	1.1E-02	5.3E-02	2.9E-01	1.0E-02	1.8E-01	50	0	5.8E-03	0	4.9E-02	20	6.0E+00
MU-1	SVOC	Benzo(a)pyrene	85	72	1.0E-02	3.8E-02	1.6E-01	1.0E-02	3.8E-02	5	0	3.1E-02	0	4.7E-02	17	3.4E+00
MU-1	SVOC	Benzo(b&j)fluoranthene	85	91	1.2E-02	1.1E-01	4.9E-01	2.0E-02	3.8E-02	50	0	9.7E-03	0	6.7E-02	38	7.3E+00
MU-1	SVOC	Benzo(e)pyrene	60	87	1.3E-02	1.1E-01	4.7E-01	2.0E-02	3.8E-02	NA	0	NA	0	5.7E-02	31	8.2E+00
MU-1	SVOC	Benzo(g,h,i)perylene	85	69	1.0E-02	5.0E-02	2.4E-01	1.0E-02	3.8E-02	1,000	0	2.4E-04	0	4.2E-02	24	5.7E+00
MU-1	SVOC	Benzo(k)fluoranthene	85	32	1.0E-02	1.4E-02	3.0E-02	1.0E-02	4.0E-02	50	0	6.0E-04	0	3.6E-02	0	8.4E-01
MU-1	INORG	Beryllium	139	86	2.0E-01	5.1E-01	1.5E+00	2.0E-01	2.0E-01	85	0	1.7E-02	0	1.0E+00	1	1.4E+00
MU-1	INORG	Boron	85	95	5.1E+00	9.6E+00	1.6E+01	5.0E+00	5.0E+00	8,500	0	1.9E-03	0	1.8E+01	0	9.0E-01
MU-1	INORG	Cadmium	184	97	5.2E-02	7.4E-01	2.4E+00	5.0E-02	5.0E-02	20	0	1.2E-01	0	2.1E+00	4	1.2E+00
MU-1	INORG	Chromium	180	78	5.3E-01	1.1E+01	3.5E+01	5.0E-01	5.0E+00	100	0	3.5E-01	0	2.6E+01	5	1.4E+00
MU-1	SVOC	Chrysene	85	100	3.0E-02	2.3E-01	1.6E+00	NA	NA	200	0	7.9E-03	0	1.2E-01	47	1.3E+01
MU-1	INORG	Cobalt	185	93	1.1E-01	4.4E+00	2.1E+01	1.0E-01	1.0E-01	25	0	8.4E-01	0	1.0E+01	9	2.1E+00
MU-1	INORG	Copper	147	86	5.0E-01	1.3E+01	4.0E+01	5.0E-01	5.0E-01	3,500	0	1.1E-02	0	2.6E+01	1	1.5E+00
MU-1	SVOC	Dibenz(a,h)anthracene	85	47	5.0E-03	3.1E-02	1.6E-01	5.0E-03	7.4E-02	5	0	3.2E-02	0	1.9E-02	22	8.5E+00
MU-1	SVOC	Fluoranthene	85	81	1.1E-02	4.7E-02	2.1E-01	1.0E-02	3.8E-02	1,500	0	1.4E-04	0	6.1E-02	17	3.5E+00
MU-1	SVOC	Fluorene	85	93	1.8E-02	1.5E-01	9.4E-01	2.0E-02	3.8E-02	600	0	1.6E-03	0	6.0E-02	44	1.6E+01
MU-1	INORG	Iron	165	88	5.3E+02	1.1E+04	3.5E+04	5.0E+01	5.0E+01	35,000	0	9.9E-01	0	2.6E+04	2	1.3E+00
MU-1	INORG	Lead	162	88	5.1E-01	7.2E+00	2.7E+01	5.0E-01	5.0E-01	120	0	2.2E-01	0	1.7E+01	1	1.6E+00
MU-1	INORG	Lithium	120	83	3.1E+00	1.0E+01	2.2E+01	5.0E+00	5.0E+00	30	0	7.5E-01	0	2.9E+01	0	7.8E-01
MU-1	INORG	Manganese	185	100	1.7E+00	2.5E+02	2.5E+03	NA	NA	6,000	0	4.1E-01	0	5.3E+02	19	4.7E+00
MU-1	INORG	Mercury	85	100	1.9E-02	5.7E-02	1.2E-01	NA	NA	10	0	1.2E-02	0	1.0E-01	4	1.2E+00
MU-1	INORG	Molybdenum	125	84	4.6E-01	1.4E+00	3.6E+00	5.0E-01	5.0E-01	200	0	1.8E-02	0	4.7E+00	0	7.7E-01
MU-1	SVOC	Naphthalene	85	100	3.3E-02	3.4E-01	2.7E+00	NA	NA	850	0	3.2E-03	0	1.6E-01	51	1.7E+01
MU-1	INORG	Nickel	184	99	5.9E-01	2.4E+01	1.4E+02	5.0E-01	5.0E-01	450	0	3.2E-01	0	3.2E+01	34	4.5E+00
MU-1	SVOC	Perylene	60	42	1.1E-02	1.1E-01	3.7E-01	1.0E-02	1.7E-01	NA	0	NA	0	5.5E-02	11	6.7E+00
MU-1	SVOC	Phenanthrene	85	100	8.7E-02	6.9E-01	3.5E+00	NA	NA	1,500	0	2.3E-03	0	2.5E-01	64	1.4E+01
MU-1	SVOC	Pyrene	85	88	1.0E-02	8.3E-02	4.1E-01	2.0E-02	3.8E-02	1,000	0	4.1E-04	0	6.5E-02	30	6.3E+00
MU-1	SVOC	Quinoline	60	0	NA	NA	NA	1.0E-02	4.0E-02	2.5	0	NA	0	5.0E-02	0	NA
MU-1	INORG	Selenium	165	92	2.0E-01	6.8E+00	4.9E+01	2.0E-01	2.0E-01	200	0	2.5E-01	0	5.6E+00	50	8.8E+00
MU-1	INORG	Silver	121	83	1.1E-01	2.2E-01	5.3E-01	1.0E-01	1.0E-01	200	0	2.7E-03	0	3.1E-01	8	1.7E+00
MU-1	INORG	Thallium	128	84	5.0E-02	2.0E-01	4.7E-01	5.0E-02	5.0E-02	1	0	4.7E-01	0	5.6E-01	0	8.5E-01
MU-1	INORG	Tin	85	29	2.0E+00	3.6E+00	4.0E+00	2.0E+00	2.0E+00	25,000	0	1.6E-04	0	4.0E+00	0	1.0E+00
MU-1	RADIO	Uranium	181	91	6.0E-02	9.4E-01	6.2E+00	5.0E-02	5.0E-02	100	0	6.2E-02	0	2.5E+00	16	2.5E+00
MU-1	INORG	Vanadium	165	88	1.1E+00	2.1E+01	5.4E+01	2.0E-01	2.0E-01	200	0	2.7E-01	0	5.3E+01	1	1.0E+00
MU-1	INORG	Zinc	184	89	4.4E+00	7.2E+01	2.4E+02	1.0E+00	1.0E+00	10,000	0	2.4E-02	0	1.7E+02	1	1.4E+00
MU-2	SVOC	1-Methylnaphthalene	15	100	2.3E-01	4.2E-01	6.8E-01	NA	NA	250	0	2.7E-03	0	4.0E-01	6	1.7E+00
MU-2	SVOC	2-Methylnaphthalene	20	100	6.2E-02	4.9E-01	9.8E-01	NA	NA	60	0	1.6E-02	0	4.2E-01	14	2.3E+00
MU-2	SVOC	Acenaphthene	20	45	5.0E-03	1.6E-02	3.9E-02	1.9E-02	5.0E-02	950	0	4.1E-05	0	1.7E-02	4	2.3E+00
MU-2	SVOC	Acenaphthylene	20	25	5.0E-03	5.0E-03	5.0E-03	5.0E-03	5.0E-02	950	0	5.3E-06	0	1.8E-02	0	2.8E-01
MU-2	INORG	Aluminum	20	100	4.1E+03	6.5E+03	8.8E+03	NA	NA	40,000	0	2.2E-01	0	1.8E+04	0	4.9E-01
MU-2	SVOC	Anthracene	20	30	4.0E-03	5.1E-03	1.0E-02	4.0E-03	4.0E-02	10,000	0	1.0E-06	0	1.4E-02	0	7.4E-01
MU-2	INORG	Antimony	20	100	2.9E-01	5.1E-01	8.4E-01	NA	NA	250	0	3.4E-03	0	1.1E+00	0	7.6E-01
MU-2	INORG	Arsenic	20	100	3.8E+00	5.4E+00	8.2E+00	NA	NA	20	0	4.1E-01	0	8.6E+00	0	9.5E-01
MU-2	INORG	Barium	20	100	1.9E+02	2.2E+02	2.5E+02	NA	NA	8,500	0	3.0E-02	0	5.0E+02	0	5.1E-01
MU-2	SVOC	Benz(a)anthracene	20	70	1.0E-02	2.0E-02	4.1E-02	2.5E-02	1.0E-01	50	0	8.2E-04	0	4.9E-02	0	8.4E-01
MU-2	SVOC	Benzo(a)pyrene	20	30	1.0E-02	1.3E-02	2.6E-02	1.0E-02	1.0E-01	5	0	5.2E-03	0	4.7E-02	0	5.6E-01
MU-2	SVOC	Benzo(b&j)fluoranthene	20	95	1.0E-02	3.9E-02	6.3E-02	1.0E-01	1.0E-01	50	0	1.3E-03	0	6.7E-02	0	9.4E-01
MU-2	SVOC	Benzo(e)pyrene	15	93	3.0E-02	4.6E-02	7.0E-02	1.0E-01	1.0E-01	NA	0	NA	0	5.7E-02	3	1.2E+00
MU-2	SVOC	Benzo(g,h,i)perylene	20	55	1.0E-02	1.4E-02	3.1E-02	1.0E-02	1.0E-01	1,000	0	3.1E-05	0	4.2E-02	0	7.4E-01
MU-2	SVOC	Benzo(k)fluoranthene	20	25	1.0E-02	1.0E-02	1.0E-02	1.0E-02	1.0E-01	50	0	2.0E-04	0	3.6E-02	0	2.8E-01
MU-2	INORG	Beryllium	20	100	3.7E-01	5.6E-01	8.7E-01	NA	NA	85	0	1.0E-02	0	1.0E+00	0	8.4E-01
MU-2	INORG	Boron	20	100	7.9E+00	1.9E+01	4.9E+01	NA	NA	8,500	0	5.7E-03	0	1.8E+01	7	2.7E+00
MU-2	INORG	Cadmium	20	100	6.0E-01	1.9E+00	5.7E+00	NA	NA	20	0	2.9E-01	0	2.1E+00	8	2.8E+00
MU-2	INORG	Chromium	20	100	9.6E+00	1.4E+01	1.9E+01	NA	NA	100	0	1.9E-01	0	2.6E+01	0	7.4E-01
MU-2	SVOC	Chrysene	20	100	3.0E-02	1.0E-01	1.6E-01	NA	NA	200	0	8.0E-04	0	1.2E-01	5	1.3E+00

Table C-3. Sediment screening results

MU	Chem Group	Constituent	Sample Count	% Detected	Minimum Detected Concentration (mg/kg)	Mean Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)	Minimum Detection Limit (mg/kg)	Maximum Detection Limit (mg/kg)	Screening Level (mg/kg)	Count Detected Result Exceeding Screening Level	Ratio of Max Detected to Screening Level (mg/kg)	Count Detection Limit Exceeding Screening Level	Reference Concentration (mg/kg)	Count Detected Result Exceeding Reference Concentration	Ratio of Max Detected to Reference Concentration (mg/kg)
MU-2	INORG	Cobalt	20	100	4.4E+00	6.5E+00	9.0E+00	NA	NA	25	0	3.6E-01	0	1.0E+01	0	9.1E-01
MU-2	INORG	Copper	20	100	9.2E+00	1.4E+01	2.3E+01	NA	NA	3,500	0	6.6E-03	0	2.6E+01	0	8.9E-01
MU-2	SVOC	Dibenz(a,h)anthracene	20	35	5.0E-03	7.5E-03	1.3E-02	5.0E-03	5.0E-02	5	0	2.6E-03	0	1.9E-02	0	7.0E-01
MU-2	SVOC	Fluoranthene	20	75	1.0E-02	2.2E-02	3.8E-02	2.5E-02	1.0E-01	1,500	0	2.5E-05	0	6.1E-02	0	6.3E-01
MU-2	SVOC	Fluorene	20	95	1.0E-02	5.7E-02	1.4E-01	1.0E-01	1.0E-01	600	0	2.3E-04	0	6.0E-02	7	2.3E+00
MU-2	INORG	Iron	20	100	1.1E+04	1.5E+04	2.1E+04	NA	NA	35,000	0	5.9E-01	0	2.6E+04	0	8.0E-01
MU-2	INORG	Lead	20	100	5.7E+00	8.4E+00	1.3E+01	NA	NA	120	0	1.0E-01	0	1.7E+01	0	7.5E-01
MU-2	INORG	Lithium	20	100	7.0E+00	9.4E+00	1.5E+01	NA	NA	30	0	5.1E-01	0	2.9E+01	0	5.3E-01
MU-2	INORG	Manganese	20	100	5.4E+02	9.1E+02	1.6E+03	NA	NA	6,000	0	2.7E-01	0	5.3E+02	20	3.1E+00
MU-2	INORG	Mercury	20	100	2.4E-02	4.5E-02	8.8E-02	NA	NA	10	0	8.8E-03	0	1.0E-01	0	8.7E-01
MU-2	INORG	Molybdenum	20	100	1.0E+00	1.6E+00	2.6E+00	NA	NA	200	0	1.3E-02	0	4.7E+00	0	5.5E-01
MU-2	SVOC	Naphthalene	20	100	3.7E-02	1.4E-01	2.7E-01	NA	NA	850	0	3.2E-04	0	1.6E-01	7	1.7E+00
MU-2	INORG	Nickel	20	100	1.9E+01	2.9E+01	4.2E+01	NA	NA	450	0	9.3E-02	0	3.2E+01	5	1.3E+00
MU-2	SVOC	Perylene	15	7	1.2E-02	1.2E-02	1.2E-02	1.0E-02	1.0E-01	NA	0	NA	0	5.5E-02	0	2.2E-01
MU-2	SVOC	Phenanthrene	20	100	8.4E-02	3.5E-01	5.8E-01	NA	NA	1,500	0	3.9E-04	0	2.5E-01	16	2.3E+00
MU-2	SVOC	Pyrene	20	85	1.0E-02	3.2E-02	5.4E-02	5.0E-02	1.0E-01	1,000	0	5.4E-05	0	6.5E-02	0	8.4E-01
MU-2	SVOC	Quinoline	15	0	NA	NA	NA	1.0E-02	1.0E-01	2.5	0	NA	0	5.0E-02	0	NA
MU-2	INORG	Selenium	20	100	2.7E+00	5.3E+00	9.3E+00	NA	NA	200	0	4.6E-02	0	5.6E+00	8	1.7E+00
MU-2	INORG	Silver	20	100	1.1E-01	1.8E-01	3.1E-01	NA	NA	200	0	1.6E-03	0	3.1E-01	1	1.0E+00
MU-2	INORG	Thallium	20	100	1.3E-01	2.3E-01	3.5E-01	NA	NA	1	0	3.5E-01	0	5.6E-01	0	6.4E-01
MU-2	INORG	Tin	20	25	4.0E+00	4.0E+00	4.0E+00	2.0E+00	2.0E+00	25,000	0	1.6E-04	0	4.0E+00	0	1.0E+00
MU-2	RADIO	Uranium	20	100	7.9E-01	1.1E+00	1.6E+00	NA	NA	100	0	1.6E-02	0	2.5E+00	0	6.2E-01
MU-2	INORG	Vanadium	20	100	1.5E+01	2.4E+01	3.4E+01	NA	NA	200	0	1.7E-01	0	5.3E+01	0	6.4E-01
MU-2	INORG	Zinc	20	100	7.1E+01	1.2E+02	2.3E+02	NA	NA	10,000	0	2.3E-02	0	1.7E+02	3	1.4E+00
MU-3	SVOC	1-Methylnaphthalene	70	100	1.2E-02	1.2E-01	1.7E+00	NA	NA	250	0	6.7E-03	0	4.0E-01	2	4.1E+00
MU-3	SVOC	2-Methylnaphthalene	80	100	1.6E-02	1.8E-01	3.1E+00	NA	NA	60	0	5.2E-02	0	4.2E-01	8	7.4E+00
MU-3	SVOC	Acenaphthene	80	13	5.0E-03	5.0E-03	5.0E-03	5.0E-03	1.4E-01	950	0	5.3E-06	0	1.7E-02	0	2.9E-01
MU-3	SVOC	Acenaphthylene	80	14	5.0E-03	5.7E-03	1.3E-02	5.0E-03	8.0E-03	950	0	1.4E-05	0	1.8E-02	0	7.3E-01
MU-3	INORG	Aluminum	80	99	4.6E+03	7.4E+03	1.2E+04	5.0E+01	5.0E+01	40,000	0	3.1E-01	0	1.8E+04	0	6.8E-01
MU-3	SVOC	Anthracene	80	15	4.0E-03	4.6E-03	9.4E-03	4.0E-03	6.4E-03	10,000	0	9.4E-07	0	1.4E-02	0	6.7E-01
MU-3	INORG	Antimony	80	99	3.5E-01	5.2E-01	9.1E-01	1.0E-01	1.0E-01	250	0	3.6E-03	0	1.1E+00	0	8.3E-01
MU-3	INORG	Arsenic	80	99	4.2E+00	5.8E+00	9.8E+00	1.0E-01	1.0E-01	20	0	4.9E-01	0	8.6E+00	3	1.1E+00
MU-3	INORG	Barium	80	99	9.6E+01	1.5E+02	3.0E+02	5.0E-01	5.0E-01	8,500	0	3.6E-02	0	5.0E+02	0	6.1E-01
MU-3	SVOC	Benz(a)anthracene	80	28	1.0E-02	1.7E-02	5.6E-02	1.0E-02	1.6E-02	50	0	1.1E-03	0	4.9E-02	1	1.1E+00
MU-3	SVOC	Benzo(a)pyrene	80	15	1.0E-02	1.2E-02	2.3E-02	1.0E-02	1.6E-02	5	0	4.6E-03	0	4.7E-02	0	4.9E-01
MU-3	SVOC	Benzo(b&j)fluoranthene	80	60	1.0E-02	3.2E-02	1.7E-01	1.0E-02	1.0E-02	50	0	3.3E-03	0	6.7E-02	2	2.5E+00
MU-3	SVOC	Benzo(e)pyrene	70	46	1.1E-02	2.8E-02	1.4E-01	1.0E-02	2.0E-02	NA	0	NA	0	5.7E-02	2	2.5E+00
MU-3	SVOC	Benzo(g,h,i)perylene	80	23	1.0E-02	1.6E-02	3.8E-02	1.0E-02	1.6E-02	1,000	0	3.8E-05	0	4.2E-02	0	9.0E-01
MU-3	SVOC	Benzo(k)fluoranthene	80	14	1.0E-02	1.0E-02	1.1E-02	1.0E-02	1.6E-02	50	0	2.2E-04	0	3.6E-02	0	3.1E-01
MU-3	INORG	Beryllium	80	99	4.0E-01	5.8E-01	8.8E-01	1.0E-01	1.0E-01	85	0	1.0E-02	0	1.0E+00	0	8.5E-01
MU-3	INORG	Boron	80	98	5.0E+00	9.2E+00	1.8E+01	5.0E+00	5.0E+00	8,500	0	2.1E-03	0	1.8E+01	0	9.9E-01
MU-3	INORG	Cadmium	80	99	5.1E-01	9.7E-01	1.8E+00	2.0E-02	2.0E-02	20	0	8.8E-02	0	2.1E+00	0	8.6E-01
MU-3	INORG	Chromium	80	99	1.2E+01	1.9E+01	4.3E+01	5.0E-01	5.0E-01	100	0	4.3E-01	0	2.6E+01	6	1.7E+00
MU-3	SVOC	Chrysene	80	94	1.0E-02	5.3E-02	4.4E-01	1.0E-02	1.0E-02	200	0	2.2E-03	0	1.2E-01	5	3.6E+00
MU-3	INORG	Cobalt	80	99	3.0E+00	4.9E+00	8.1E+00	1.0E-01	1.0E-01	25	0	3.2E-01	0	1.0E+01	0	8.1E-01
MU-3	INORG	Copper	80	99	6.5E+00	1.3E+01	2.6E+01	5.0E-01	5.0E-01	3,500	0	7.5E-03	0	2.6E+01	0	1.0E+00
MU-3	SVOC	Dibenz(a,h)anthracene	80	21	5.0E-03	9.4E-03	2.9E-02	5.0E-03	8.0E-03	5	0	5.7E-03	0	1.9E-02	2	1.6E+00
MU-3	SVOC	Fluoranthene	80	33	1.0E-02	2.1E-02	8.5E-02	1.0E-02	1.6E-02	1,500	0	5.7E-05	0	6.1E-02	2	1.4E+00
MU-3	SVOC	Fluorene	80	45	1.0E-02	2.6E-02	1.9E-01	1.0E-02	1.0E-02	600	0	3.1E-04	0	6.0E-02	1	3.1E+00
MU-3	INORG	Iron	80	99	9.4E+03	1.3E+04	2.1E+04	5.0E+01	5.0E+01	35,000	0	6.1E-01	0	2.6E+04	0	8.2E-01
MU-3	INORG	Lead	80	99	4.6E+00	7.6E+00	1.3E+01	5.0E-01	5.0E-01	120	0	1.1E-01	0	1.7E+01	0	7.8E-01
MU-3	INORG	Lithium	80	99	6.8E+00	1.2E+01	2.0E+01	2.0E+00	2.0E+00	30	0	6.7E-01	0	2.9E+01	0	7.0E-01
MU-3	INORG	Manganese	80	99	2.2E+02	5.1E+02	1.2E+03	1.0E+00	1.0E+00	6,000	0	2.0E-01	0	5.3E+02	22	2.2E+00
MU-3	INORG	Mercury	80	100	1.6E-02	5.0E-02	1.4E-01	NA	NA	10	0	1.4E-02	0	1.0E-01	7	1.4E+00
MU-3	INORG	Molybdenum	80	99	9.1E-01	1.5E+00	2.9E+00	1.0E-01	1.0E-01	200	0	1.4E-02	0	4.7E+00	0	6.2E-01
MU-3	SVOC	Naphthalene	80	89	1.0E-02	6.0E-02	7.2E-01	1.0E-02	1.0E-02	850	0	8.5E-04	0	1.6E-01	4	4.5E+00
MU-3	INORG	Nickel	80	99	1.3E+01	2.1E+01	3.6E+01	5.0E-01	5.0E-01	450	0	8.0E-02	0	3.2E+01	4	1.1E+00
MU-3	SVOC	Perylene	70	39	1.0E-02	2.4E-02	4.7E-02	1.0E-02	2.0E-02	NA	0	NA	0	5.5E-02	0	8.6E-01
MU-3	SVOC	Phenanthrene	80	100	1.6E-02	1.4E-01	1.5E+00	NA	NA	1,500	0	9.7E-04	0	2.5E-01	6	5.8E+00
MU-3	SVOC	Pyrene	80	46	1.0E-02	2.6E-02	1.3E-01	1.0E-02	1.6E-02	1,000	0	1.3E-04	0	6.5E-02	2	2.1E+00
MU-3	SVOC	Quinoline	70	0	NA	NA	NA	1.0E-02	1.6E-02	2.5	0	NA	0	5.0E-02	0	NA
MU-3	INORG	Selenium	80	99	4.3E-01	1.4E+00	4.5E+00	2.0E-01	2.0E-01	200	0	2.2E-02	0	5.6E+00	0	8.0E-01
MU-3	INORG	Silver	80	95	1.0E-01	2.0E-01	3.8E-01	1.0E-01	1.0E-01	200	0	1.9E-03	0	3.1E-01	5	1.2E+00
MU-3	INORG	Thallium	80	99	1.5E-01	2.4E-01	5.1E-01	5.0E-02	5.0E-02	1	0	5.1E-01	0	5.6E-01	0	9.1E-01

Table C-3. Sediment screening results

MU	Chem Group	Constituent	Sample Count	% Detected	Minimum Detected Concentration (mg/kg)	Mean Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)	Minimum Detection Limit (mg/kg)	Maximum Detection Limit (mg/kg)	Screening Level (mg/kg)	Count Detected Result Exceeding Screening Level	Ratio of Max Detected to Screening Level (mg/kg)	Count Detection Limit Exceeding Screening Level	Reference Concentration (mg/kg)	Count Detected Result Exceeding Reference Concentration	Ratio of Max Detected to Reference Concentration (mg/kg)
MU-3	INORG	Tin	80	13	2.0E+00	2.0E+00	2.0E+00	2.0E+00	2.0E+00	25,000	0	8.0E-05	0	4.0E+00	0	5.0E-01
MU-3	RADIO	Uranium	80	99	8.6E-01	1.2E+00	2.6E+00	5.0E-02	5.0E-02	100	0	2.6E-02	0	2.5E+00	1	1.0E+00
MU-3	INORG	Vanadium	80	99	2.2E+01	3.2E+01	5.3E+01	2.0E-01	2.0E-01	200	0	2.7E-01	0	5.3E+01	0	1.0E+00
MU-3	INORG	Zinc	80	99	5.8E+01	8.9E+01	1.5E+02	2.0E+00	2.0E+00	10,000	0	1.5E-02	0	1.7E+02	0	9.0E-01
MU-4	SVOC	1-Methylnaphthalene	189	99	1.4E-02	5.5E-01	5.6E+00	1.0E-02	1.0E-02	250	0	2.2E-02	0	4.0E-01	46	1.4E+01
MU-4	SVOC	2-Methylnaphthalene	214	100	1.3E-02	1.0E+00	1.0E+01	NA	NA	60	0	1.7E-01	0	4.2E-01	81	2.4E+01
MU-4	SVOC	Acenaphthene	214	26	5.0E-03	5.9E-02	3.2E-01	5.0E-03	3.1E-01	950	0	3.4E-04	0	1.7E-02	19	1.9E+01
MU-4	SVOC	Acenaphthylene	214	33	5.0E-03	1.4E-02	5.9E-02	5.0E-03	7.1E-02	950	0	6.2E-05	0	1.8E-02	16	3.3E+00
MU-4	INORG	Aluminum	214	100	9.7E+02	7.9E+03	1.9E+04	NA	NA	40,000	0	4.8E-01	0	1.8E+04	3	1.1E+00
MU-4	SVOC	Anthracene	214	30	4.0E-03	3.2E-02	2.3E-01	4.0E-03	6.0E-02	10,000	0	2.3E-05	0	1.4E-02	28	1.7E+01
MU-4	INORG	Antimony	213	100	1.3E-01	5.3E-01	1.3E+00	1.0E-01	1.0E-01	250	0	5.0E-03	0	1.1E+00	10	1.1E+00
MU-4	INORG	Arsenic	214	100	1.0E+00	5.0E+00	1.4E+01	NA	NA	20	0	6.8E-01	0	8.6E+00	17	1.6E+00
MU-4	INORG	Barium	214	100	8.9E+01	2.3E+02	6.9E+02	NA	NA	8,500	0	8.1E-02	0	5.0E+02	6	1.4E+00
MU-4	SVOC	Benz(a)anthracene	214	53	1.0E-02	8.3E-02	7.0E-01	1.0E-02	1.4E-01	50	0	1.4E-02	0	4.9E-02	43	1.4E+01
MU-4	SVOC	Benzo(a)pyrene	214	44	1.0E-02	7.5E-02	5.6E-01	1.0E-02	1.4E-01	5	0	1.1E-01	0	4.7E-02	37	1.2E+01
MU-4	SVOC	Benzo(b&j)fluoranthene	214	85	1.0E-02	1.3E-01	1.3E+00	1.0E-02	1.4E-01	50	0	2.7E-02	0	6.7E-02	81	2.0E+01
MU-4	SVOC	Benzo(e)pyrene	189	84	1.0E-02	1.3E-01	1.3E+00	1.0E-02	1.4E-01	NA	0	NA	0	5.7E-02	77	2.2E+01
MU-4	SVOC	Benzo(g,h,i)perylene	214	57	1.0E-02	8.6E-02	5.7E-01	1.0E-02	1.4E-01	1,000	0	5.7E-04	0	4.2E-02	54	1.4E+01
MU-4	SVOC	Benzo(k)fluoranthene	214	35	1.0E-02	3.1E-02	1.8E-01	1.0E-02	1.4E-01	50	0	3.6E-03	0	3.6E-02	16	5.0E+00
MU-4	INORG	Beryllium	214	100	1.7E-01	6.0E-01	1.4E+00	NA	NA	85	0	1.7E-02	0	1.0E+00	9	1.4E+00
MU-4	INORG	Boron	214	97	5.2E+00	1.1E+01	2.7E+01	5.0E+00	5.0E+00	8,500	0	3.2E-03	0	1.8E+01	11	1.5E+00
MU-4	INORG	Cadmium	214	100	4.4E-01	1.6E+00	1.2E+01	NA	NA	20	0	6.0E-01	0	2.1E+00	27	5.9E+00
MU-4	INORG	Chromium	214	100	1.5E+00	1.5E+01	4.4E+01	NA	NA	100	0	4.4E-01	0	2.6E+01	6	1.7E+00
MU-4	SVOC	Chrysene	214	97	1.0E-02	2.2E-01	2.3E+00	1.0E-02	1.4E-01	200	0	1.2E-02	0	1.2E-01	75	1.9E+01
MU-4	INORG	Cobalt	214	100	1.1E+00	3.0E+01	4.3E+02	NA	NA	25	32	1.7E+01	0	1.0E+01	57	4.4E+01
MU-4	INORG	Copper	214	100	3.0E+00	1.4E+01	3.0E+01	NA	NA	3,500	0	8.6E-03	0	2.6E+01	5	1.2E+00
MU-4	SVOC	Dibenz(a,h)anthracene	214	39	5.0E-03	4.1E-02	2.6E-01	5.0E-03	1.5E-01	5	0	5.2E-02	0	1.9E-02	37	1.4E+01
MU-4	SVOC	Fluoranthene	214	70	1.0E-02	8.6E-02	8.2E-01	1.0E-02	1.4E-01	1,500	0	5.4E-04	0	6.1E-02	46	1.3E+01
MU-4	SVOC	Fluorene	214	80	1.0E-02	1.6E-01	1.8E+00	1.0E-02	1.4E-01	600	0	3.1E-03	0	6.0E-02	67	3.1E+01
MU-4	INORG	Iron	214	100	1.3E+03	1.3E+04	3.4E+04	NA	NA	35,000	0	9.7E-01	0	2.6E+04	11	1.3E+00
MU-4	INORG	Lead	214	100	1.2E+00	8.5E+00	1.7E+01	NA	NA	120	0	1.4E-01	0	1.7E+01	1	1.0E+00
MU-4	INORG	Lithium	214	100	2.3E+00	1.1E+01	3.3E+01	2.0E+00	2.0E+00	30	2	1.1E+00	0	2.9E+01	4	1.1E+00
MU-4	INORG	Manganese	214	100	2.7E+01	4.6E+02	3.2E+03	NA	NA	6,000	0	5.4E-01	0	5.3E+02	40	6.1E+00
MU-4	INORG	Mercury	214	100	6.3E-03	4.2E-02	1.3E-01	5.0E-03	5.0E-03	10	0	1.3E-02	0	1.0E-01	2	1.3E+00
MU-4	INORG	Molybdenum	214	100	3.2E-01	1.5E+00	4.9E+00	NA	NA	200	0	2.5E-02	0	4.7E+00	1	1.1E+00
MU-4	SVOC	Naphthalene	214	97	1.1E-02	3.2E-01	3.4E+00	1.0E-02	6.6E-02	850	0	3.9E-03	0	1.6E-01	77	2.1E+01
MU-4	INORG	Nickel	214	100	6.1E+00	4.5E+01	3.7E+02	NA	NA	450	0	8.1E-01	0	3.2E+01	75	1.2E+01
MU-4	SVOC	Perylene	189	35	1.0E-02	3.5E-02	1.5E-01	1.0E-02	1.4E-01	NA	0	NA	0	5.5E-02	9	2.7E+00
MU-4	SVOC	Phenanthrene	214	100	1.6E-02	6.2E-01	6.2E+00	NA	NA	1,500	0	4.1E-03	0	2.5E-01	106	2.5E+01
MU-4	SVOC	Pyrene	214	79	1.0E-02	1.0E-01	1.0E+00	1.0E-02	1.4E-01	1,000	0	1.0E-03	0	6.5E-02	58	1.6E+01
MU-4	SVOC	Quinoline	189	13	1.0E-02	1.8E-02	3.4E-02	1.0E-02	1.4E-01	2.5	0	1.4E-02	0	5.0E-02	0	6.8E-01
MU-4	INORG	Selenium	214	100	5.2E-01	8.3E+00	8.6E+01	NA	NA	200	0	4.3E-01	0	5.6E+00	80	1.5E+01
MU-4	INORG	Silver	214	85	1.0E-01	1.8E-01	4.7E-01	1.0E-01	1.0E-01	200	0	2.4E-03	0	3.1E-01	18	1.5E+00
MU-4	INORG	Thallium	214	100	8.1E-02	2.8E-01	6.3E-01	5.0E-02	5.0E-02	1	0	6.3E-01	0	5.6E-01	2	1.1E+00
MU-4	INORG	Tin	212	23	2.0E+00	2.6E+00	4.0E+00	2.0E+00	2.0E+00	25,000	0	1.6E-04	0	4.0E+00	0	1.0E+00
MU-4	RADIO	Uranium	214	100	4.9E-01	1.2E+00	3.9E+00	NA	NA	100	0	3.9E-02	0	2.5E+00	6	1.6E+00
MU-4	INORG	Vanadium	214	100	3.1E+00	2.6E+01	7.8E+01	NA	NA	200	0	3.9E-01	0	5.3E+01	2	1.5E+00
MU-4	INORG	Zinc	214	100	3.4E+01	1.4E+02	1.2E+03	NA	NA	10,000	0	1.2E-01	0	1.7E+02	25	7.3E+00
MU-5	SVOC	1-Methylnaphthalene	75	99	3.0E-02	1.4E-01	5.0E-01	2.6E-02	2.6E-02	250	0	2.0E-03	0	4.0E-01	3	1.2E+00
MU-5	SVOC	2-Methylnaphthalene	90	100	3.3E-02	2.1E-01	8.0E-01	NA	NA	60	0	1.3E-02	0	4.2E-01	9	1.9E+00
MU-5	SVOC	Acenaphthene	90	22	5.0E-03	1.5E-02	8.7E-02	5.0E-03	4.7E-02	950	0	9.1E-05	0	1.7E-02	2	5.1E+00
MU-5	SVOC	Acenaphthylene	90	48	5.0E-03	1.2E-02	2.8E-02	5.0E-03	1.9E-02	950	0	2.9E-05	0	1.8E-02	6	1.6E+00
MU-5	INORG	Aluminum	90	100	2.3E+03	6.8E+03	2.5E+04	NA	NA	40,000	0	6.3E-01	0	1.8E+04	1	1.4E+00
MU-5	SVOC	Anthracene	90	58	4.1E-03	6.2E-02	8.2E-01	4.0E-03	6.0E-02	10,000	0	8.2E-05	0	1.4E-02	30	5.8E+01
MU-5	INORG	Antimony	90	100	1.5E-01	5.6E-01	1.8E+00	NA	NA	250	0	7.3E-03	0	1.1E+00	5	1.7E+00
MU-5	INORG	Arsenic	90	100	1.2E+00	4.4E+00	1.4E+01	NA	NA	20	0	6.9E-01	0	8.6E+00	3	1.6E+00
MU-5	INORG	Barium	90	100	1.0E+02	1.9E+02	4.9E+02	NA	NA	8,500	0	5.7E-02	0	5.0E+02	0	9.8E-01
MU-5	SVOC	Benz(a)anthracene	90	81	1.1E-02	3.7E-01	6.7E+00	1.0E-02	3.8E-02	50	0	1.3E-01	0	4.9E-02	41	1.4E+02
MU-5	SVOC	Benzo(a)pyrene	90	72	1.4E-02	5.7E-01	8.4E+00	1.0E-02	3.8E-02	5	2	1.7E+00	0	4.7E-02	39	1.8E+02
MU-5	SVOC	Benzo(b&j)fluoranthene	90	93	1.0E-02	7.5E-01	1.4E+01	1.0E-02	3.4E-02	50	0	2.9E-01	0	6.7E-02	49	2.1E+02
MU-5	SVOC	Benzo(e)pyrene	75	87	1.1E-02	4.0E-01	8.1E+00	1.0E-02	3.8E-02	NA	0	NA	0	5.7E-02	29	1.4E+02
MU-5	SVOC	Benzo(g,h,i)perylene	90	77	1.0E-02	4.0E-01	7.3E+00	1.0E-02	3.8E-02	1,000	0	7.3E-03	0	4.2E-02	31	1.7E+02
MU-5	SVOC	Benzo(k)fluoranthene	90	62	1.0E-02	3.5E-01	5.3E+00	1.0E-02	3.8E-02	50	0	1.1E-01	0	3.6E-02	26	1.5E+02
MU-5	INORG	Beryllium	90	100	1.2E-01	4.8E-01	1.7E+00	NA	NA	85	0	2.0E-02	0	1.0E+00	1	1.6E+00

Table C-3. Sediment screening results

MU	Chem Group	Constituent	Sample Count	% Detected	Minimum Detected Concentration (mg/kg)	Mean Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)	Minimum Detection Limit (mg/kg)	Maximum Detection Limit (mg/kg)	Screening Level (mg/kg)	Count Detected Result Exceeding Screening Level	Ratio of Max Detected to Screening Level (mg/kg)	Count Detection Limit Exceeding Screening Level	Reference Concentration (mg/kg)	Count Detected Result Exceeding Reference Concentration	Ratio of Max Detected to Reference Concentration (mg/kg)
MU-5	INORG	Boron	90	89	5.1E+00	8.5E+00	2.8E+01	5.0E+00	5.0E+00	8,500	0	3.3E-03	0	1.8E+01	1	1.5E+00
MU-5	INORG	Cadmium	90	100	4.9E-01	1.0E+00	2.4E+00	NA	NA	20	0	1.2E-01	0	2.1E+00	1	1.1E+00
MU-5	INORG	Chromium	90	100	5.4E+00	1.6E+01	5.4E+01	NA	NA	100	0	5.4E-01	0	2.6E+01	2	2.1E+00
MU-5	SVOC	Chrysene	90	98	2.0E-02	5.4E-01	9.9E+00	2.4E-02	2.6E-02	200	0	4.9E-02	0	1.2E-01	33	8.0E+01
MU-5	INORG	Cobalt	90	100	1.3E+00	4.2E+00	1.3E+01	NA	NA	25	0	5.1E-01	0	1.0E+01	1	1.3E+00
MU-5	INORG	Copper	90	100	4.5E+00	1.3E+01	3.4E+01	NA	NA	3,500	0	9.7E-03	0	2.6E+01	3	1.3E+00
MU-5	SVOC	Dibenz(a,h)anthracene	90	53	6.4E-03	1.2E-01	1.3E+00	5.0E-03	6.5E-02	5	0	2.7E-01	0	1.9E-02	27	7.2E+01
MU-5	SVOC	Fluoranthene	90	92	1.2E-02	1.0E+00	2.1E+01	1.0E-02	3.8E-02	1,500	0	1.4E-02	0	6.1E-02	44	3.4E+02
MU-5	SVOC	Fluorene	90	77	1.1E-02	4.0E-02	2.1E-01	1.0E-02	3.8E-02	600	0	3.6E-04	0	6.0E-02	13	3.6E+00
MU-5	INORG	Iron	90	100	6.0E+03	1.2E+04	3.7E+04	NA	NA	35,000	1	1.0E+00	0	2.6E+04	1	1.4E+00
MU-5	INORG	Lead	90	100	2.8E+00	8.6E+00	2.5E+01	NA	NA	120	0	2.1E-01	0	1.7E+01	4	1.5E+00
MU-5	INORG	Lithium	90	100	2.7E+00	9.5E+00	3.3E+01	NA	NA	30	1	1.1E+00	0	2.9E+01	1	1.1E+00
MU-5	INORG	Manganese	90	100	5.2E+01	2.5E+02	9.4E+02	NA	NA	6,000	0	1.6E-01	0	5.3E+02	5	1.8E+00
MU-5	INORG	Mercury	90	100	1.8E-02	3.8E-02	7.9E-02	NA	NA	10	0	7.9E-03	0	1.0E-01	0	7.9E-01
MU-5	INORG	Molybdenum	90	100	6.1E-01	1.4E+00	3.4E+00	NA	NA	200	0	1.7E-02	0	4.7E+00	0	7.3E-01
MU-5	SVOC	Naphthalene	90	96	2.2E-02	9.3E-02	3.8E-01	1.0E-02	3.0E-02	850	0	4.5E-04	0	1.6E-01	9	2.4E+00
MU-5	INORG	Nickel	90	100	4.7E+00	1.7E+01	5.0E+01	NA	NA	450	0	1.1E-01	0	3.2E+01	1	1.6E+00
MU-5	SVOC	Perylene	75	72	1.0E-02	1.6E-01	3.0E+00	1.0E-02	7.3E-02	NA	0	NA	0	5.5E-02	17	5.5E+01
MU-5	SVOC	Phenanthrene	90	100	3.2E-02	4.1E-01	6.4E+00	NA	NA	1,500	0	4.2E-03	0	2.5E-01	26	2.6E+01
MU-5	SVOC	Pyrene	90	91	1.0E-02	8.0E-01	1.6E+01	1.6E-02	3.8E-02	1,000	0	1.6E-02	0	6.5E-02	37	2.5E+02
MU-5	SVOC	Quinoline	75	0	NA	NA	NA	1.0E-02	3.8E-02	2.5	0	NA	0	5.0E-02	0	NA
MU-5	INORG	Selenium	90	100	5.1E-01	4.1E+00	1.9E+01	NA	NA	200	0	9.7E-02	0	5.6E+00	24	3.5E+00
MU-5	INORG	Silver	90	93	1.0E-01	1.7E-01	4.2E-01	1.0E-01	1.0E-01	200	0	2.1E-03	0	3.1E-01	1	1.4E+00
MU-5	INORG	Thallium	90	100	6.9E-02	2.1E-01	6.4E-01	NA	NA	1	0	6.4E-01	0	5.6E-01	1	1.2E+00
MU-5	INORG	Tin	90	18	2.0E+00	3.9E+00	4.0E+00	2.0E+00	2.0E+00	25,000	0	1.6E-04	0	4.0E+00	0	1.0E+00
MU-5	RADIO	Uranium	90	100	6.8E-01	1.0E+00	2.4E+00	NA	NA	100	0	2.4E-02	0	2.5E+00	0	9.7E-01
MU-5	INORG	Vanadium	90	100	8.5E+00	2.7E+01	9.3E+01	NA	NA	200	0	4.6E-01	0	5.3E+01	1	1.7E+00
MU-5	INORG	Zinc	90	100	4.4E+01	9.3E+01	2.5E+02	NA	NA	10,000	0	2.5E-02	0	1.7E+02	6	1.5E+00
MU-6	SVOC	1-Methylnaphthalene	15	0	1.6E-02	2.2E-02	3.0E-02	1.0E-02	5.0E-02	250	0	1.2E-04	0	4.0E-01	0	7.4E-02
MU-6	SVOC	2-Methylnaphthalene	25	20	1.6E-02	4.4E-02	8.1E-02	1.6E-02	8.1E-02	60	0	1.4E-03	0	4.2E-01	0	1.9E-01
MU-6	SVOC	Acenaphthene	25	0	5.4E-03	5.4E-03	5.4E-03	5.0E-03	5.4E-03	950	0	5.7E-06	0	1.7E-02	0	3.1E-01
MU-6	SVOC	Acenaphthylene	25	0	NA	NA	NA	5.0E-03	5.0E-03	950	0	NA	0	1.8E-02	0	NA
MU-6	INORG	Aluminum	35	14	1.1E+04	1.3E+04	1.6E+04	1.1E+04	1.6E+04	40,000	0	4.0E-01	0	1.8E+04	0	8.8E-01
MU-6	SVOC	Anthracene	25	0	4.0E-03	4.2E-03	4.4E-03	4.0E-03	4.4E-03	10,000	0	4.4E-07	0	1.4E-02	0	3.1E-01
MU-6	INORG	Antimony	35	14	3.3E-01	4.6E-01	7.2E-01	3.3E-01	7.2E-01	250	0	2.9E-03	0	1.1E+00	0	6.5E-01
MU-6	INORG	Arsenic	35	14	5.9E+00	7.1E+00	8.8E+00	5.9E+00	8.8E+00	20	0	4.4E-01	0	8.6E+00	1	1.0E+00
MU-6	INORG	Barium	35	14	1.1E+02	1.5E+02	2.2E+02	1.1E+02	2.2E+02	8,500	0	2.6E-02	0	5.0E+02	0	4.3E-01
MU-6	SVOC	Benz(a)anthracene	25	4	1.0E-02	1.3E-02	1.7E-02	1.0E-02	2.0E-02	50	0	3.4E-04	0	4.9E-02	0	3.5E-01
MU-6	SVOC	Benzo(a)pyrene	25	0	1.0E-02	1.1E-02	1.2E-02	1.0E-02	1.2E-02	5	0	2.4E-03	0	4.7E-02	0	2.6E-01
MU-6	SVOC	Benzo(b&j)fluoranthene	25	20	1.1E-02	1.8E-02	3.1E-02	1.0E-02	3.1E-02	50	0	6.2E-04	0	6.7E-02	0	4.6E-01
MU-6	SVOC	Benzo(e)pyrene	15	27	1.0E-02	1.2E-02	1.5E-02	1.0E-02	1.3E-02	NA	0	NA	0	5.7E-02	0	2.7E-01
MU-6	SVOC	Benzo(g,h,i)perylene	25	0	1.1E-02	1.3E-02	1.4E-02	1.0E-02	1.4E-02	1,000	0	1.4E-05	0	4.2E-02	0	3.3E-01
MU-6	SVOC	Benzo(k)fluoranthene	25	0	NA	NA	NA	1.0E-02	1.0E-02	50	0	NA	0	3.6E-02	0	NA
MU-6	INORG	Beryllium	35	14	4.5E-01	6.0E-01	8.5E-01	4.5E-01	8.5E-01	85	0	1.0E-02	0	1.0E+00	0	8.2E-01
MU-6	INORG	Boron	35	6	5.0E+00	6.8E+00	1.0E+01	5.0E+00	1.0E+01	8,500	0	1.2E-03	0	1.8E+01	0	5.7E-01
MU-6	INORG	Cadmium	35	14	2.7E-01	5.4E-01	1.0E+00	2.7E-01	1.0E+00	20	0	5.0E-02	0	2.1E+00	0	4.9E-01
MU-6	INORG	Chromium	35	14	1.7E+01	2.0E+01	2.6E+01	1.7E+01	2.6E+01	100	0	2.6E-01	0	2.6E+01	1	1.0E+00
MU-6	SVOC	Chrysene	25	0	1.0E-02	2.1E-02	3.4E-02	1.0E-02	3.4E-02	200	0	1.7E-04	0	1.2E-01	0	2.8E-01
MU-6	INORG	Cobalt	35	14	7.6E+00	9.5E+00	1.1E+01	7.6E+00	1.1E+01	25	0	4.6E-01	0	1.0E+01	12	1.1E+00
MU-6	INORG	Copper	35	14	1.5E+01	1.9E+01	3.0E+01	1.5E+01	3.0E+01	3,500	0	8.5E-03	0	2.6E+01	1	1.1E+00
MU-6	SVOC	Dibenz(a,h)anthracene	25	0	5.7E-03	6.0E-03	6.3E-03	5.0E-03	6.3E-03	5	0	1.3E-03	0	1.9E-02	0	3.4E-01
MU-6	SVOC	Fluoranthene	25	20	1.0E-02	1.5E-02	2.4E-02	1.0E-02	2.4E-02	1,500	0	1.6E-05	0	6.1E-02	0	3.9E-01
MU-6	SVOC	Fluorene	25	0	NA	NA	NA	1.0E-02	1.0E-02	600	0	NA	0	6.0E-02	0	NA
MU-6	INORG	Iron	35	14	1.9E+04	2.3E+04	2.5E+04	1.9E+04	2.5E+04	35,000	0	7.1E-01	0	2.6E+04	0	9.5E-01
MU-6	INORG	Lead	35	14	1.3E+01	1.5E+01	1.6E+01	1.3E+01	1.6E+01	120	0	1.3E-01	0	1.7E+01	0	9.6E-01
MU-6	INORG	Lithium	35	14	2.2E+01	2.5E+01	3.0E+01	2.2E+01	3.0E+01	30	0	1.0E+00	0	2.9E+01	2	1.0E+00
MU-6	INORG	Manganese	35	14	5.0E+02	5.7E+02	7.4E+02	5.0E+02	7.4E+02	6,000	0	1.2E-01	0	5.3E+02	27	1.4E+00
MU-6	INORG	Mercury	35	14	2.1E-02	3.8E-02	5.8E-02	2.1E-02	5.8E-02	10	0	5.8E-03	0	1.0E-01	0	5.7E-01
MU-6	INORG	Molybdenum	35	14	7.1E-01	1.1E+00	1.8E+00	7.1E-01	1.8E+00	200	0	9.0E-03	0	4.7E+00	0	3.9E-01
MU-6	SVOC	Naphthalene	25	20	1.0E-02	1.9E-02	3.3E-02	1.0E-02	3.3E-02	850	0	3.9E-05	0	1.6E-01	0	2.1E-01
MU-6	INORG	Nickel	35	14	2.1E+01	2.4E+01	3.1E+01	2.1E+01	3.1E+01	450	0	6.9E-02	0	3.2E+01	0	9.8E-01
MU-6	SVOC	Perylene	15	33	1.0E-02	1.3E-02	1.9E-02	1.0E-02	1.5E-02	NA	0	NA	0	5.5E-02	0	3.5E-01
MU-6	SVOC	Phenanthrene	25	20	1.7E-02	4.3E-02	7.8E-02	1.7E-02	7.8E-02	1,500	0	5.2E-05	0	2.5E-01	0	3.1E-01
MU-6	SVOC	Pyrene	25	16	1.0E-02	1.4E-02	2.2E-02	1.0E-02	2.2E-02	1,000	0	2.2E-05	0	6.5E-02	0	3.4E-01

Table C-3. Sediment screening results

MU	Chem Group	Constituent	Sample Count	% Detected	Minimum Detected Concentration (mg/kg)	Mean Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)	Minimum Detection Limit (mg/kg)	Maximum Detection Limit (mg/kg)	Screening Level (mg/kg)	Count Detected Result Exceeding Screening Level	Ratio of Max Detected to Screening Level (mg/kg)	Count Detection Limit Exceeding Screening Level	Reference Concentration (mg/kg)	Count Detected Result Exceeding Reference Concentration	Ratio of Max Detected to Reference Concentration (mg/kg)
MU-6	SVOC	Quinoline	15	0	NA	NA	NA	1.0E-02	5.0E-02	2.5	0	NA	0	5.0E-02	0	NA
MU-6	INORG	Selenium	35	14	2.7E-01	6.2E-01	9.2E-01	2.7E-01	9.2E-01	200	0	4.6E-03	0	5.6E+00	0	1.7E-01
MU-6	INORG	Silver	35	9	6.4E-02	1.2E-01	2.0E-01	6.4E-02	2.0E-01	200	0	9.9E-04	0	3.1E-01	0	6.4E-01
MU-6	INORG	Thallium	35	14	1.1E-01	1.8E-01	3.4E-01	1.1E-01	3.4E-01	1	0	3.4E-01	0	5.6E-01	0	6.1E-01
MU-6	INORG	Tin	35	0	2.7E-01	4.4E-01	7.9E-01	2.7E-01	2.0E+00	25,000	0	3.2E-05	0	4.0E+00	0	2.0E-01
MU-6	RADIO	Uranium	35	14	6.7E-01	8.4E-01	1.1E+00	7.6E-01	1.1E+00	100	0	1.1E-02	0	2.5E+00	0	4.4E-01
MU-6	INORG	Vanadium	35	14	1.6E+01	2.3E+01	3.8E+01	1.7E+01	3.8E+01	200	0	1.9E-01	0	5.3E+01	0	7.2E-01
MU-6	INORG	Zinc	35	14	7.0E+01	8.4E+01	1.2E+02	7.0E+01	1.2E+02	10,000	0	1.2E-02	0	1.7E+02	0	6.9E-01

Notes:

INORG - inorganic
mg/kg ww – milligrams per kilogram
MU – management unit
NA – not applicable
SVOC – semi-volatile organic compound

Table C-4. Fish Tissue screening results

MU	Chemical Group	Constituent	Sample Count	% Detected	Minimum Detected Concentration (mg/kg ww)	Mean Detected Concentration (mg/kg ww)	Maximum Detected Concentration (mg/kg ww)	Minimum Detection Limit (mg/kg ww)	Maximum Detection Limit (mg/kg ww)	Screening Level (mg/kg ww)	Count Detected Result Exceeding Screening Level	Ratio of Max Detected to Screening Level	Count Detection Limit Exceeding Screening Level	Ratio of Max Detected to Reference Concentration (mg/kg ww)
MU-1	INORG	Aluminum	53	57	1.4E-01	2.9E+00	2.8E+01	4.3E+00	1.4E+01	5.8E+01	0	4.8E-01	0	2.4E-01
MU-1	INORG	Antimony	53	45	3.6E-04	2.2E-03	1.7E-02	3.8E-04	2.9E-01	2.3E-02	0	7.3E-01	18	1.3E+01
MU-1	INORG	Arsenic	53	55	7.2E-03	2.4E-02	5.5E-02	1.0E-01	1.5E-01	8.7E-01	0	6.4E-02	0	1.7E-01
MU-1	INORG	Barium	53	62	9.2E-03	1.3E-01	6.2E-01	1.1E-01	1.4E+00	1.2E+01	0	5.4E-02	0	1.2E-01
MU-1	INORG	Beryllium	53	0	NA	NA	NA	7.1E-04	2.9E-02	1.2E-01	0	NA	0	2.6E-01
MU-1	INORG	Boron	53	0	NA	NA	NA	3.0E-02	1.4E+01	1.0E+00	0	NA	24	1.4E+01
MU-1	INORG	Cadmium	53	53	7.7E-04	1.5E-03	2.8E-03	4.5E-04	2.9E-02	5.8E-02	0	4.9E-02	0	5.1E-01
MU-1	INORG	Chromium	53	55	1.8E-02	6.9E-02	2.4E-01	1.0E+00	1.5E+00	5.8E-02	13	4.1E+00	24	2.6E+01
MU-1	INORG	Cobalt	53	60	6.2E-03	2.7E-02	7.1E-02	2.2E-02	1.4E+00	1.7E-02	22	4.1E+00	21	8.1E+01
MU-1	INORG	Copper	53	70	2.0E-01	3.6E-01	5.8E-01	1.0E+00	1.4E+00	8.1E+00	0	7.1E-02	0	1.7E-01
MU-1	INORG	Iron	53	62	2.3E+00	7.0E+00	5.0E+01	4.3E+00	1.4E+01	4.0E+01	1	1.2E+00	0	3.5E-01
MU-1	INORG	Lead	53	55	2.0E-03	2.1E-02	3.6E-01	2.2E-02	1.4E-01	7.5E-02	1	4.8E+00	16	1.9E+00
MU-1	INORG	Lithium	29	100	8.2E-03	1.8E-02	3.7E-02	NA	NA	1.2E-01	0	3.2E-01	0	NA
MU-1	INORG	Manganese	53	57	7.1E-02	1.9E-01	6.3E-01	2.2E-01	1.4E+00	9.0E+00	0	7.0E-02	0	1.5E-01
MU-1	INORG	Mercury	53	60	2.0E-03	5.3E-03	1.6E-02	4.2E-03	1.5E-02	1.2E-02	2	1.4E+00	6	1.3E+00
MU-1	INORG	Molybdenum	53	55	1.4E-03	4.0E-03	2.1E-02	1.0E-01	2.9E-01	1.6E+03	0	1.3E-05	0	1.8E-04
MU-1	INORG	Nickel	53	55	9.9E-03	5.1E-02	2.5E-01	1.1E-01	1.4E+00	6.3E-01	0	4.0E-01	16	2.2E+00
MU-1	INORG	Selenium	53	100	1.6E+00	3.0E+00	5.9E+00	NA	NA	3.3E-01	45	1.8E+01	0	NA
MU-1	INORG	Silver	53	13	8.0E-05	2.5E-03	7.9E-03	1.6E-04	2.9E-02	2.9E-01	0	2.7E-02	0	1.0E-01
MU-1	INORG	Strontium	53	60	1.6E-02	1.3E-01	5.9E-01	2.0E-01	2.8E-01	3.5E+01	0	1.7E-02	0	8.1E-03
MU-1	INORG	Thallium	53	55	3.9E-03	6.9E-03	1.1E-02	2.0E-02	1.5E-01	4.0E-03	28	2.6E+00	24	3.6E+01
MU-1	INORG	Tin	53	49	5.6E-04	1.4E-03	3.4E-03	4.0E-04	5.6E-01	1.7E+01	0	2.0E-04	0	3.2E-02
MU-1	INORG	Vanadium	53	55	7.7E-04	9.9E-03	7.7E-02	2.0E-01	2.9E-01	2.9E-01	0	2.7E-01	1	1.0E+00
MU-1	INORG	Zinc	53	70	3.0E+00	5.0E+00	1.2E+01	1.0E+01	1.4E+01	3.3E+01	0	3.7E-01	0	4.2E-01
MU-1	RADIO	Uranium	53	55	8.8E-05	5.1E-04	1.7E-03	1.1E-02	2.8E-02	3.5E-02	0	5.0E-02	0	8.1E-01
MU-2	INORG	Aluminum	75	37	2.0E-01	4.1E+00	2.7E+01	4.6E-01	5.0E+01	5.8E+01	0	4.7E-01	0	8.7E-01
MU-2	INORG	Antimony	75	19	2.5E-04	2.0E-03	1.3E-02	2.5E-04	2.5E+00	2.3E-02	0	5.6E-01	38	1.1E+02
MU-2	INORG	Arsenic	75	37	7.0E-03	2.0E-02	4.5E-02	1.0E-01	1.3E+00	8.7E-01	0	5.2E-02	5	1.4E+00
MU-2	INORG	Barium	75	37	4.9E-03	1.0E-01	7.1E-01	1.0E+00	1.4E+00	1.2E+01	0	6.1E-02	0	1.2E-01
MU-2	INORG	Beryllium	75	1	1.3E-03	1.3E-03	1.3E-03	4.9E-04	2.5E-01	1.2E-01	0	1.1E-02	5	2.2E+00
MU-2	INORG	Boron	75	4	2.0E-02	2.8E-02	4.2E-02	1.7E-02	2.5E+01	1.0E+00	0	4.1E-02	49	2.5E+01
MU-2	INORG	Cadmium	75	25	8.9E-04	4.8E-03	3.1E-02	5.5E-04	2.5E-01	5.8E-02	0	5.4E-01	5	4.3E+00
MU-2	INORG	Chromium	75	25	1.4E-02	8.6E-02	3.5E-01	1.1E-02	1.3E+01	5.8E-02	7	6.0E+00	49	2.2E+02
MU-2	INORG	Cobalt	75	35	4.6E-03	1.2E-02	3.5E-02	1.2E-01	1.4E+00	1.7E-02	4	2.0E+00	49	8.3E+01
MU-2	INORG	Copper	75	37	1.9E-01	3.3E-01	8.0E-01	1.0E+00	1.4E+00	8.1E+00	0	9.8E-02	0	1.8E-01
MU-2	INORG	Iron	75	40	2.2E+00	8.2E+00	5.8E+01	1.0E+01	5.0E+01	4.0E+01	1	1.4E+00	5	1.2E+00
MU-2	INORG	Lead	75	28	1.4E-03	2.7E-02	2.3E-01	2.2E-03	2.5E-01	7.5E-02	2	3.0E+00	46	3.3E+00
MU-2	INORG	Lithium	18	83	1.4E-02	3.0E-02	6.9E-02	1.3E-01	1.3E-01	1.2E-01	0	6.0E-01	3	1.1E+00
MU-2	INORG	Manganese	75	37	9.1E-02	2.5E-01	8.9E-01	1.0E+00	2.5E+00	9.0E+00	0	9.9E-02	0	2.8E-01
MU-2	INORG	Mercury	73	93	5.7E-03	2.2E-02	1.3E-01	1.2E-01	1.3E-01	1.2E-02	43	1.1E+01	5	1.1E+01
MU-2	INORG	Molybdenum	75	21	1.6E-03	4.3E-03	1.9E-02	4.3E-03	2.5E+00	1.6E+03	0	1.2E-05	0	1.5E-03
MU-2	INORG	Nickel	75	27	3.5E-03	1.5E-01	1.5E+00	1.1E-02	1.4E+00	6.3E-01	1	2.4E+00	46	2.3E+00
MU-2	INORG	Selenium	96	100	9.8E-01	2.9E+00	1.2E+01	NA	NA	3.3E-01	96	3.7E+01	0	NA
MU-2	INORG	Silver	72	8	7.0E-05	3.7E-03	2.0E-02	6.8E-05	2.5E-01	2.9E-01	0	6.8E-02	0	8.7E-01
MU-2	INORG	Strontium	75	61	1.3E-02	2.6E-01	7.5E-01	2.1E-01	2.5E+00	3.5E+01	0	2.2E-02	0	7.2E-02
MU-2	INORG	Thallium	75	37	5.1E-03	1.1E-02	2.1E-02	2.0E-02	1.3E+00	4.0E-03	28	5.2E+00	47	3.1E+02
MU-2	INORG	Tin	75	20	2.7E-04	3.8E-03	3.3E-02	5.7E-04	1.3E+00	1.7E+01	0	1.9E-03	0	7.2E-02
MU-2	INORG	Vanadium	75	21	8.9E-04	1.4E-02	9.0E-02	2.2E-02	2.5E+00	2.9E-01	0	3.1E-01	5	8.7E+00
MU-2	INORG	Zinc	75	37	2.5E+00	4.2E+00	7.9E+00	1.0E+01	1.4E+01	3.3E+01	0	2.4E-01	0	4.3E-01
MU-2	RADIO	Uranium	75	23	3.0E-05	9.2E-04	9.1E-03	5.0E-04	1.3E-01	3.5E-02	0	2.6E-01	5	3.6E+00
MU-3	INORG	Aluminum	45	69	1.1E-01	4.5E+00	6.9E+01	4.4E-01	1.5E+01	5.8E+01	1	1.2E+00	0	2.6E-01
MU-3	INORG	Antimony	45	31	1.2E-04	7.6E-04	1.5E-03	9.2E-04	3.0E-02	2.3E-02	0	6.5E-02	6	1.3E+00
MU-3	INORG	Arsenic	45	80	4.3E-03	3.2E-02	1.1E-01	1.2E-02	1.5E-01	8.7E-01	0	1.3E-01	0	1.7E-01
MU-3	INORG	Barium	45	82	4.4E-03	1.9E-01	3.1E+00	1.0E+00	1.5E+00	1.2E+01	0	2.7E-01	0	1.3E-01
MU-3	INORG	Beryllium	45	2	1.5E-03	1.5E-03	1.5E-03	3.1E-04	5.9E-03	1.2E-01	0	1.3E-02	0	5.2E-02
MU-3	INORG	Boron	45	2	9.0E-02	9.0E-02	9.0E-02	2.4E-02	1.5E+01	1.0E+00	0	9.0E-02	10	1.5E+01
MU-3	INORG	Cadmium	45	42	6.5E-04	2.5E-03	6.8E-03	1.3E-03	5.9E-03	5.8E-02	0	1.2E-01	0	1.0E-01
MU-3	INORG	Chromium	45	53	1.1E-02	8.3E-02	6.8E-01	1.1E-02	1.5E+00	5.8E-02	9	1.2E+01	9	2.6E+01
MU-3	INORG	Cobalt	45	73	2.1E-03	1.2E-02	4.7E-02	4.5E-03	1.5E+00	1.7E-02	6	2.7E+00	10	8.6E+01
MU-3	INORG	Copper	45	82	1.7E-01	3.1E-01	9.1E-01	1.0E+00	1.5E+00	8.1E+00	0	1.1E-01	0	1.8E-01
MU-3	INORG	Iron	45	87	2.0E+00	5.1E+00	2.6E+01	1.2E+01	1.5E+01	4.0E+01	0	6.4E-01	0	3.7E-01
MU-3	INORG	Lead	45	42	7.0E-04	1.6E-02	1.3E-01	2.1E-03	1.5E-01	7.5E-02	1	1.7E+00	8	2.0E+00
MU-3	INORG	Lithium	15	93	4.5E-03	8.7E-03	2.7E-02	6.2E-03	6.2E-03	1.2E-01	0	2.4E-01	0	5.4E-02
MU-3	INORG	Manganese	45	82	8.9E-02	2.6E-01	5.8E-01	1.0E+00	1.5E+00	9.0E+00	0	6.4E-02	0	1.7E-01
MU-3	INORG	Mercury	49	100	7.5E-03	2.6E-02	1.0E-01	NA	NA	1.2E-02	39	9.0E+00	0	NA
MU-3	INORG	Molybdenum	45	33	1.6E-03	2.9E-03	4.1E-03	4.2E-03	1.5E-01	1.6E+03	0	2.5E-06	0	9.2E-05
MU-3	INORG	Nickel	45	40	2.3E-03	3.7E-02	1.1E-01	1.1E-02	1.5E+00	6.3E-01	0	1.8E-01	8	2.3E+00
MU-3	INORG	Selenium	48	100	7.8E-01	1.3E+00	1.8E+00	NA	NA	3.3E-01	48	5.5E+00	0	NA
MU-3	INORG	Silver	45	13	8.5E-05	1.8E-04	3.6E-04	1.8E-04	5.9E-03	2.9E-01	0	1.3E-03	0	2.1E-02
MU-3	INORG	Strontium	45	89	2.0E-02	2.7E-01	1.4E+00	2.0E-01	3.0E-01	3.5E+01	0	4.1E-02	0	8.6E-03
MU-3	INORG	Thallium	45	64	6.3E-03	1.5E-02	5.2E-02	1.1E-03	3.0E-02	4.0E-03	29	1.3E+01	7	7.4E+00
MU-3	INORG	Tin	45	33	3.5E-04	1.5E-03	4.7E-03	1.1E-02	5.9E-01	1.7E+01	0	2.7E-04	0	3.4E-02
MU-3	INORG	Vanadium	45	33	7.9E-04	1.8E-02	1.9E-01	2.1E-02	3.0E-01	2.9E-01	0	6.7E-01	1	1.0E+00
MU-3	INORG	Zinc	45	82	2.5E+00	4.9E+00	1.1E+01	1.0E+01	1.5E+01	3.3E+01	0	3.4E-01	0	4.5E-01
MU-3	RADIO	Uranium	45	36	1.6E-05	3.1E-03	2.5E-02	1.1E-03	3.0E-02	3.5E-02	0	7.2E-01	0	8.6E-01
MU-4	INORG	Aluminum	135	57	1.3E-01	6.0E+00	1.0E+02	4.3E-01	1.5E+01	5.8E+01	2	1.8E+00	0	2.6E-01
MU-4	INORG	Antimony	135	27	2.7E-04	2.3E-03	1.1E-02	1.6E-04	5.0E-01	2.3E-02	0	4.6E-01	33	2.2E+01
MU-4	INORG	Arsenic	135	64	4.3E-03	2.6E-02	1.3E-01	2.5E-03	2.5E-01	8.7E-01	0	1.4E-01	0	2.9E-01
MU-4	INORG	Barium	135	73	6.4E-03	2.2E-01	1.4E+00	1.3E-01	1.5E+00	1.2E+01	0	1.2E-01	0	1.3E-01
MU-4	INORG	Beryllium	135	1	3.4E-03	3.4E-03	3.4E-03	3.2E-04	5.0E-02	1.2E-01	0	2.9E-02	0	4.3E-01
MU-4	INORG	Boron	135	4	5.3E-02	8.6E-02	1.3E-01	2.8E-02	1.5E+01	1.0E+00	0	1.2E-01	53	1.5E+01
MU-4	INORG	Cadmium	135	29	8.4E-04	2.6E-03	8.0E-03	4.3E-04	5.0E-02	5.8E-02	0	1.4E-01	0	8.7E-01
MU-4	INORG	Chromium	135	41	1.4E-02	8.6E-02	5.0E-01	1.0E-02	2.5E+00	5.8E-02	26	8.7E+00	52	4.3E+01
MU-4	INORG	Cobalt	135	50	2.2E-03	1.6E-02	6.9E-02	4.0E-03	1.5E+00	1.7E-02	18	4.0E+00	53	8.5E+01
MU-4	INORG	Copper	135	74	1.8E-01	3.2E-01	5.6E-01	1.0E+00	1.5E+00	8.1E+00	0	6.9E-02	0	1.8E-01

Table C-4. Fish Tissue Screening Results

MU	Chemical Group	Constituent	Sample Count	% Detected	Minimum Detected Concentration (mg/kg ww)	Mean Detected Concentration (mg/kg ww)	Maximum Detected Concentration (mg/kg ww)	Minimum Detection Limit (mg/kg ww)	Maximum Detection Limit (mg/kg ww)	Screening Level (mg/kg ww)	Count Detected Result Exceeding Screening Level	Ratio of Max Detected to Screening Level	Count Detection Limit Exceeding Screening Level	Ratio of Max Detected to Reference Concentration (mg/kg ww)
MU-4	INORG	Iron	135	73	1.6E+00	9.5E+00	2.7E+02	5.0E+00	1.5E+01	4.0E+01	4	6.7E+00	0	3.7E-01
MU-4	INORG	Lead	135	39	1.4E-03	1.9E-02	2.0E-01	2.1E-03	1.5E-01	7.5E-02	2	2.7E+00	33	2.0E+00
MU-4	INORG	Lithium	37	84	3.1E-03	9.7E-03	5.0E-02	2.3E-03	7.5E-03	1.2E-01	0	4.3E-01	0	6.5E-02
MU-4	INORG	Manganese	135	73	6.6E-02	3.3E-01	3.2E+00	4.8E-01	1.5E+00	9.0E+00	0	3.6E-01	0	1.6E-01
MU-4	INORG	Mercury	142	87	2.2E-03	1.4E-02	4.5E-02	2.2E-03	2.5E-02	1.2E-02	56	3.9E+00	7	2.2E+00
MU-4	INORG	Molybdenum	135	29	1.2E-03	4.0E-03	1.7E-02	4.1E-03	5.0E-01	1.6E+03	0	1.1E-05	0	3.1E-04
MU-4	INORG	Nickel	135	36	8.5E-03	5.7E-02	2.8E-01	1.0E-02	1.5E+00	6.3E-01	0	4.5E-01	35	2.3E+00
MU-4	INORG	Selenium	140	100	9.2E-01	4.6E+00	3.0E+01	NA	NA	3.3E-01	134	9.1E+01	0	NA
MU-4	INORG	Silver	135	9	1.8E-03	1.1E-02	5.3E-02	6.4E-05	5.0E-02	2.9E-01	0	1.8E-01	0	1.7E-01
MU-4	INORG	Strontium	135	84	1.5E-02	4.1E-01	6.4E+00	2.1E-01	5.0E-01	3.5E+01	0	1.8E-01	0	1.4E-02
MU-4	INORG	Thallium	135	69	1.3E-03	1.4E-02	4.7E-02	1.1E-03	2.5E-01	4.0E-03	80	1.2E+01	32	6.2E+01
MU-4	INORG	Tin	135	26	5.9E-04	5.3E-03	5.1E-02	7.5E-04	5.9E-01	1.7E+01	0	2.9E-03	0	3.4E-02
MU-4	INORG	Vanadium	135	29	7.0E-04	2.8E-02	4.1E-01	2.1E-02	5.0E-01	2.9E-01	1	1.4E+00	5	1.7E+00
MU-4	INORG	Zinc	135	76	2.6E+00	6.5E+00	2.0E+01	1.0E+01	1.5E+01	3.3E+01	0	6.1E-01	0	4.5E-01
MU-4	RADIO	Uranium	135	28	3.0E-05	6.2E-04	6.1E-03	5.3E-05	3.0E-02	3.5E-02	0	1.8E-01	0	8.5E-01
MU-5	INORG	Aluminum	81	35	7.9E-02	1.1E+01	9.8E+01	4.1E-01	1.4E+01	5.8E+01	2	1.7E+00	0	2.4E-01
MU-5	INORG	Antimony	81	17	8.6E-05	6.8E-03	8.2E-02	7.5E-04	2.5E-02	2.3E-02	1	3.6E+00	10	1.1E+00
MU-5	INORG	Arsenic	81	73	6.1E-03	1.8E-02	8.3E-02	1.0E-02	1.4E-01	8.7E-01	0	9.6E-02	0	1.6E-01
MU-5	INORG	Barium	81	79	2.8E-03	3.0E-01	2.7E+00	4.3E-03	1.3E+00	1.2E+01	0	2.4E-01	0	1.1E-01
MU-5	INORG	Beryllium	81	1	1.8E-03	1.8E-03	1.8E-03	3.0E-04	5.5E-03	1.2E-01	0	1.5E-02	0	4.8E-02
MU-5	INORG	Boron	81	1	1.8E-01	1.8E-01	1.8E-01	2.3E-02	1.4E+01	1.0E+00	0	1.8E-01	26	1.4E+01
MU-5	INORG	Cadmium	81	25	1.1E-03	3.2E-03	1.1E-02	7.5E-04	5.1E-03	5.8E-02	0	1.9E-01	0	8.8E-02
MU-5	INORG	Chromium	81	38	1.2E-02	6.5E-02	2.8E-01	1.0E-02	1.4E+00	5.8E-02	10	4.8E+00	25	2.4E+01
MU-5	INORG	Cobalt	81	56	2.0E-03	1.2E-02	4.2E-02	2.2E-03	1.4E+00	1.7E-02	9	2.4E+00	26	7.9E+01
MU-5	INORG	Copper	81	79	1.6E-01	3.1E-01	7.9E-01	1.0E+00	1.4E+00	8.1E+00	0	9.7E-02	0	1.7E-01
MU-5	INORG	Iron	81	81	1.5E+00	6.1E+00	8.2E+01	1.0E+01	1.3E+01	4.0E+01	2	2.0E+00	0	3.1E-01
MU-5	INORG	Lead	81	27	5.3E-04	1.9E-02	1.4E-01	2.0E-03	1.3E-01	7.5E-02	1	1.8E+00	16	1.7E+00
MU-5	INORG	Lithium	14	100	6.9E-03	1.8E-02	5.9E-02	NA	NA	1.2E-01	0	5.2E-01	0	NA
MU-5	INORG	Manganese	81	79	1.0E-01	2.9E-01	1.8E+00	1.0E+00	1.4E+00	9.0E+00	0	2.0E-01	0	1.5E-01
MU-5	INORG	Mercury	81	99	4.6E-03	2.5E-02	6.8E-02	4.9E-03	4.9E-03	1.2E-02	62	5.8E+00	0	4.2E-01
MU-5	INORG	Molybdenum	81	19	1.6E-03	6.4E-03	3.0E-02	4.1E-03	1.4E-01	1.6E+03	0	1.9E-05	0	8.5E-05
MU-5	INORG	Nickel	81	23	2.5E-03	4.9E-02	1.9E-01	1.0E-02	1.4E+00	6.3E-01	0	3.0E-01	17	2.2E+00
MU-5	INORG	Selenium	85	100	6.3E-01	2.2E+00	6.0E+00	NA	NA	3.3E-01	85	1.8E+01	0	NA
MU-5	INORG	Silver	81	9	7.7E-05	3.8E-04	1.1E-03	1.6E-04	5.5E-03	2.9E-01	0	3.9E-03	0	1.9E-02
MU-5	INORG	Strontium	81	90	1.3E-02	3.1E-01	1.1E+00	2.1E-01	2.5E-01	3.5E+01	0	3.2E-02	0	7.3E-03
MU-5	INORG	Thallium	81	54	1.1E-03	1.0E-02	4.9E-02	1.1E-03	2.7E-02	4.0E-03	34	1.2E+01	17	6.8E+00
MU-5	INORG	Tin	81	15	2.0E-04	3.3E-03	2.3E-02	1.6E-04	5.5E-01	1.7E+01	0	1.3E-03	0	3.2E-02
MU-5	INORG	Vanadium	81	17	5.4E-04	5.4E-02	3.2E-01	2.0E-02	2.7E-01	2.9E-01	2	1.1E+00	0	9.5E-01
MU-5	INORG	Zinc	81	80	2.4E+00	6.5E+00	3.6E+01	1.0E+01	1.3E+01	3.3E+01	1	1.1E+00	0	3.8E-01
MU-5	RADIO	Uranium	81	17	1.7E-05	1.0E-03	6.5E-03	1.0E-03	2.7E-02	3.5E-02	0	1.9E-01	0	7.9E-01
MU-6	INORG	Aluminum	228	43	1.1E-01	3.2E+00	1.6E+02	4.1E-01	1.5E+01	5.8E+01	1	2.7E+00	0	2.6E-01
MU-6	INORG	Antimony	233	21	1.4E-04	8.5E-04	6.9E-03	1.1E-04	3.0E-02	2.3E-02	0	3.0E-01	28	1.3E+00
MU-6	INORG	Arsenic	233	85	2.0E-03	2.9E-02	2.0E-01	4.4E-03	1.5E-01	8.7E-01	0	2.3E-01	0	1.7E-01
MU-6	INORG	Barium	233	83	1.0E-02	2.0E-01	6.9E-01	1.1E-02	1.5E+00	1.2E+01	0	5.9E-02	0	1.3E-01
MU-6	INORG	Beryllium	233	0	NA	NA	NA	5.8E-04	6.0E-03	1.2E-01	0	NA	0	5.2E-02
MU-6	INORG	Boron	233	16	1.8E-02	5.1E-02	1.5E-01	1.5E-02	1.5E+01	1.0E+00	0	1.5E-01	54	1.5E+01
MU-6	INORG	Cadmium	233	19	2.5E-04	1.6E-03	1.3E-02	2.8E-04	6.0E-03	5.8E-02	0	2.2E-01	0	1.0E-01
MU-6	INORG	Chromium	233	44	1.1E-02	5.1E-01	1.1E+01	1.0E-02	1.5E+00	5.8E-02	67	1.9E+02	53	2.6E+01
MU-6	INORG	Cobalt	233	63	7.6E-04	5.6E-03	4.3E-02	2.0E-03	1.5E+00	1.7E-02	10	2.5E+00	54	8.7E+01
MU-6	INORG	Copper	233	85	1.4E-01	3.6E-01	1.0E+00	2.2E-02	1.5E+00	8.1E+00	0	1.3E-01	0	1.8E-01
MU-6	INORG	Iron	233	86	1.4E+00	6.1E+00	1.6E+02	1.1E+00	1.5E+01	4.0E+01	1	4.0E+00	0	3.7E-01
MU-6	INORG	Lead	233	48	5.0E-04	1.5E-02	7.8E-01	2.0E-03	1.5E-01	7.5E-02	1	1.0E+01	34	2.0E+00
MU-6	INORG	Lithium	59	86	1.4E-03	1.6E-02	8.4E-02	2.0E-03	2.2E-03	1.2E-01	0	7.2E-01	0	1.9E-02
MU-6	INORG	Manganese	233	85	2.2E-02	2.4E-01	1.5E+00	4.4E-02	1.5E+00	9.0E+00	0	1.7E-01	0	1.7E-01
MU-6	INORG	Mercury	233	100	1.2E-02	3.2E-01	2.2E+00	2.2E-03	2.2E-03	1.2E-02	232	1.9E+02	0	1.9E-01
MU-6	INORG	Molybdenum	233	26	3.3E-04	3.0E-03	1.3E-02	4.0E-03	1.5E-01	1.6E+03	0	7.8E-06	0	9.3E-05
MU-6	INORG	Nickel	233	34	1.9E-03	4.0E-02	3.1E-01	1.0E-02	1.5E+00	6.3E-01	0	4.9E-01	35	2.4E+00
MU-6	INORG	Selenium	233	100	4.4E-03	5.4E-01	1.9E+00	NA	NA	3.3E-01	202	5.9E+00	0	NA
MU-6	INORG	Silver	233	10	7.3E-05	3.0E-04	2.2E-03	6.5E-05	6.0E-03	2.9E-01	0	7.8E-03	0	2.1E-02
MU-6	INORG	Strontium	233	88	9.2E-03	6.3E-01	2.0E+00	2.2E-02	2.9E-01	3.5E+01	0	5.8E-02	0	8.3E-03
MU-6	INORG	Thallium	233	82	5.7E-04	5.3E-03	4.2E-02	1.0E-03	3.0E-02	4.0E-03	76	1.0E+01	31	7.4E+00
MU-6	INORG	Tin	233	25	1.9E-04	1.4E-03	1.0E-02	1.0E-02	6.0E-01	1.7E+01	0	5.8E-04	0	3.5E-02
MU-6	INORG	Vanadium	233	25	6.1E-04	4.3E-03	2.9E-02	2.0E-02	3.0E-01	2.9E-01	0	1.0E-01	1	1.0E+00
MU-6	INORG	Zinc	233	87	3.0E+00	7.2E+00	4.5E+01	2.2E-01	1.5E+01	3.3E+01	2	1.4E+00	0	4.6E-01
MU-6	RADIO	Uranium	233	26	2.7E-05	5.4E-03	1.7E-01	1.0E-03	3.0E-02	3.5E-02	2	4.9E+00	0	8.7E-01

Notes:
INORG - inorganic
RADIO - radionuclide
mg/kg ww – milligrams per kilogram, wet weight
MU – management unit
NA – not applicable
Reference concentrations (95th percentiles) not available for screening.

Table C-5. Surface water screening results for agriculture

MU	Chem Group	CASRN	Constituent	Fraction	Sample Count	% Detected	Minimum Detected Concentration (mg/L)	Maximum Detected Concentration (mg/L)	BC WQG, Irrigation (mg/L)	Count Detected Result Exceed BC WQG, Irrigation	Ratio of Max Detected to BC WQG, Irrigation	BC WQG, Livestock (mg/L)	Count Detected Result Exceed BC WQG, Livestock	Ratio to Max Detected to BC WQG, Livestock
MU-1	INORG	7429-90-5	Aluminum	D	1641	22	1.0E-03	2.7E-01	5.0E+00	361	5.5E-02	5.0E+00	0	5.5E-02
MU-1	INORG	7429-90-5	Aluminum	T	1642	88	3.0E-03	3.4E+00	5.0E+00	1642	6.8E-01	5.0E+00	0	6.8E-01
MU-1	INORG	7440-36-0	Antimony	D	1641	70	1.0E-04	1.7E-03	NA	0	NA	NA	0	NA
MU-1	INORG	7440-36-0	Antimony	T	1642	76	1.0E-04	1.6E-03	NA	0	NA	NA	0	NA
MU-1	INORG	7440-38-2	Arsenic	D	1641	48	1.0E-04	6.1E-04	1.0E-01	780	6.1E-03	2.5E-02	0	2.4E-02
MU-1	INORG	7440-38-2	Arsenic	T	1642	83	1.0E-04	2.2E-03	1.0E-01	1642	2.2E-02	2.5E-02	0	9.0E-02
MU-1	INORG	7440-39-3	Barium	D	1640	100	1.3E-02	3.0E-01	NA	0	NA	NA	0	NA
MU-1	INORG	7440-39-3	Barium	T	1642	100	1.0E-04	2.9E-01	NA	0	NA	NA	0	NA
MU-1	INORG	7440-41-7	Beryllium	D	1640	0	2.1E-05	4.3E-05	NA	0	NA	NA	0	NA
MU-1	INORG	7440-41-7	Beryllium	T	1641	3	2.0E-05	5.0E-04	NA	0	NA	NA	0	NA
MU-1	INORG	7440-42-8	Boron	D	1641	22	1.0E-02	6.1E-02	NA	0	NA	NA	0	NA
MU-1	INORG	7440-42-8	Boron	T	1642	28	1.0E-02	5.7E-02	NA	0	NA	NA	0	NA
MU-1	INORG	7440-43-9	Cadmium	D	1641	96	5.0E-06	2.1E-04	5.1E-03	1575	4.1E-02	8.0E-02	0	2.6E-03
MU-1	INORG	7440-43-9	Cadmium	T	1642	99	5.0E-06	4.6E-04	5.1E-03	1642	9.0E-02	8.0E-02	0	5.7E-03
MU-1	INORG	7440-47-3	Chromium	D	1641	39	1.0E-04	5.5E-04	4.9E-03	640	1.1E-01	5.0E-02	0	1.1E-02
MU-1	INORG	7440-47-3	Chromium	T	1642	86	1.00E-04	5.57E-03	4.90E-03	1642	1.14E+00	0.05	0	1.11E-01
MU-1	INORG	7440-48-4	Cobalt	D	1641	19	1.0E-04	1.1E-03	5.0E-02	316	2.2E-02	1.0E+00	0	1.1E-03
MU-1	INORG	7440-48-4	Cobalt	T	1642	36	1.0E-04	2.6E-03	5.0E-02	1642	5.1E-02	1.0E+00	0	2.6E-03
MU-1	INORG	7440-50-8	Copper	D	1641	14	2.0E-04	1.9E-03	NA	0	NA	NA	0	NA
MU-1	INORG	7440-50-8	Copper	T	1642	14	5.0E-04	2.4E-02	NA	0	NA	NA	0	NA
MU-1	INORG	7439-89-6	Iron	D	1641	7	1.0E-02	5.1E-01	NA	0	NA	NA	0	NA
MU-1	INORG	7439-89-6	Iron	T	1642	76	1.0E-02	5.9E+00	NA	0	NA	NA	0	NA
MU-1	INORG	7439-92-1	Lead	D	1641	1	5.0E-05	5.0E-04	2.0E-01	18	2.5E-03	1.0E-01	0	5.0E-03
MU-1	INORG	7439-92-1	Lead	T	1642	23	5.0E-05	4.1E-03	2.0E-01	1642	2.1E-02	1.0E-01	0	4.1E-02
MU-1	INORG	7439-93-2	Lithium	D	1641	99	1.0E-03	2.7E-01	2.5E+00	1620	1.1E-01	NA	0	NA
MU-1	INORG	7439-93-2	Lithium	T	1642	99	1.0E-03	2.8E-01	2.5E+00	1642	1.1E-01	NA	0	NA
MU-1	INORG	7439-96-5	Manganese	D	1640	95	5.4E-05	4.1E-02	2.0E-01	1554	2.1E-01	NA	0	NA
MU-1	INORG	7439-96-5	Manganese	T	1642	100	1.0E-04	2.9E-01	2.0E-01	1642	1.4E+00	NA	0	NA
MU-1	INORG	7439-97-6	Mercury	D	1616	0	5.1E-06	2.3E-05	2.0E-03	8	1.2E-02	3.0E-03	0	7.7E-03
MU-1	INORG	7439-97-6	Mercury	T	1632	38	5.0E-07	2.5E-05	2.0E-03	1632	1.3E-02	3.0E-03	0	8.3E-03
MU-1	INORG	7439-98-7	Molybdenum	D	1641	100	3.7E-04	1.6E-02	NA	0	NA	NA	0	NA
MU-1	INORG	7439-98-7	Molybdenum	T	1642	100	5.0E-05	1.5E-02	NA	0	NA	NA	0	NA
MU-1	INORG	7440-02-0	Nickel	D	1641	75	5.0E-04	4.4E-02	2.0E-01	1230	2.2E-01	1.0E+00	0	4.4E-02
MU-1	INORG	7440-02-0	Nickel	T	1642	79	5.0E-04	4.6E-02	2.0E-01	1642	2.3E-01	1.0E+00	0	4.6E-02
MU-1	INORG	14797-55-8	Nitrate Nitrogen (NO3), AS N	N	1646	98	5.0E-03	1.1E+02	NA	0	NA	1.0E+02	1	1.1E+00
MU-1	INORG	7782-49-2	Selenium	D	1663	100	3.9E-04	8.0E-01	1.0E-02	1661	8.0E+01	3.0E-02	1022	2.7E+01
MU-1	INORG	7782-49-2	Selenium	T	1664	100	5.0E-05	6.9E-01	1.0E-02	1664	6.9E+01	3.0E-02	1018	2.3E+01
MU-1	INORG	7440-22-4	Silver	D	1641	0	1.2E-05	1.7E-05	NA	0	NA	NA	0	NA
MU-1	INORG	7440-22-4	Silver	T	1642	5	1.0E-05	1.6E-04	NA	0	NA	NA	0	NA
MU-1	INORG	7440-28-0	Thallium	D	1641	16	1.0E-05	4.8E-05	NA	0	NA	NA	0	NA
MU-1	INORG	7440-28-0	Thallium	T	1642	27	1.0E-05	1.5E-04	NA	0	NA	NA	0	NA
MU-1	INORG	7440-31-5	Tin	D	1641	1	1.0E-04	2.0E-04	NA	0	NA	NA	0	NA
MU-1	INORG	7440-31-5	Tin	T	1642	2	1.0E-04	1.1E-03	NA	0	NA	NA	0	NA
MU-1	INORG	7440-61-1	Uranium	D	1641	100	1.5E-04	2.3E-02	1.0E-02	1639	2.3E+00	2.0E-01	0	1.2E-01
MU-1	INORG	7440-61-1	Uranium	T	1642	100	1.0E-05	2.5E-02	1.0E-02	1642	2.5E+00	2.0E-01	0	1.2E-01
MU-1	INORG	7440-62-2	Vanadium	D	1641	21	5.1E-04	2.4E-03	1.0E-01	337	2.4E-02	1.0E-01	0	2.4E-02
MU-1	INORG	7440-62-2	Vanadium	T	1642	38	5.0E-04	1.3E-02	1.0E-01	1642	1.3E-01	1.0E-01	0	1.3E-01
MU-1	INORG	7440-66-6	Zinc	D	1641	30	1.0E-03	6.4E-02	NA	0	NA	NA	0	NA
MU-1	INORG	7440-66-6	Zinc	T	1642	28	3.0E-03	4.1E-02	NA	0	NA	NA	0	NA
MU-1	SVOC	91-57-6	2-METHYLNAPHTHALENE	N	2	0	NA	NA	NA	0	NA	NA	0	NA
MU-1	SVOC	83-32-9	ACENAPHTHENE	N	41	0	NA	NA	NA	0	NA	NA	0	NA
MU-1	SVOC	208-96-8	ACENAPHTHYLENE	N	41	0	NA	NA	NA	0	NA	NA	0	NA
MU-1	SVOC	120-12-7	ANTHRACENE	N	41	0	NA	NA	NA	0	NA	NA	0	NA
MU-1	SVOC	56-55-3	BENZO(A)ANTHRACENE	N	41	0	NA	NA	NA	0	NA	NA	0	NA
MU-1	SVOC	50-32-8	BENZO(A)PYRENE	N	41	0	NA	NA	NA	0	NA	NA	0	NA
MU-1	SVOC	56832-73-6-B_J	BENZO(B&J)FLUORANTHENE	N	2	0	NA	NA	NA	0	NA	NA	0	NA

Table C-5. Surface water screening results for agriculture

MU	Chem Group	CASRN	Constituent	Fraction	Sample Count	% Detected	Minimum Detected Concentration (mg/L)	Maximum Detected Concentration (mg/L)	BC WQG, Irrigation (mg/L)	Count Detected Result Exceed BC WQG, Irrigation	Ratio of Max Detected to BC WQG, Irrigation	BC WQG, Livestock (mg/L)	Count Detected Result Exceed BC WQG, Livestock	Ratio to Max Detected to BC WQG, Livestock
MU-1	SVOC	205-99-2	BENZO(B)FLUORANTHENE	N	39	0	NA	NA	NA	0	NA	NA	0	NA
MU-1	SVOC	191-24-2	BENZO(G,H,I)PERYLENE	N	41	0	NA	NA	NA	0	NA	NA	0	NA
MU-1	SVOC	207-08-9	BENZO(K)FLUORANTHENE	N	41	0	NA	NA	NA	0	NA	NA	0	NA
MU-1	SVOC	218-01-9	CHRYSENE	N	41	0	NA	NA	NA	0	NA	NA	0	NA
MU-1	SVOC	53-70-3	DIBENZ(A,H)ANTHRACENE	N	41	0	NA	NA	NA	0	NA	NA	0	NA
MU-1	SVOC	206-44-0	FLUORANTHENE	N	41	0	NA	NA	NA	0	NA	NA	0	NA
MU-1	SVOC	86-73-7	FLUORENE	N	41	0	NA	NA	NA	0	NA	NA	0	NA
MU-1	SVOC	193-39-5	INDENO(1,2,3-C,D)PYRENE	N	41	0	NA	NA	NA	0	NA	NA	0	NA
MU-1	SVOC	91-20-3	NAPHTHALENE	N	41	0	NA	NA	NA	0	NA	NA	0	NA
MU-1	SVOC	90-12-0	Naphthalene, 1-methyl- (1-METHYLNAPHTHALENE)	N	2	0	NA	NA	NA	0	NA	NA	0	NA
MU-1	SVOC	85-01-8	PHENANTHRENE	N	41	10	2.4E-05	4.4E-05	NA	0	NA	NA	0	NA
MU-1	SVOC	129-00-0	PYRENE	N	41	0	NA	NA	NA	0	NA	NA	0	NA
MU-1	SVOC	91-22-5	QUINOLINE	N	41	0	NA	NA	NA	0	NA	NA	0	NA
MU-2	INORG	7429-90-5	Aluminum	D	535	12	1.0E-03	1.2E-01	5.0E+00	63	2.4E-02	5.0E+00	0	2.4E-02
MU-2	INORG	7429-90-5	Aluminum	T	536	93	3.0E-03	2.6E+00	5.0E+00	536	5.2E-01	5.0E+00	0	5.2E-01
MU-2	INORG	7440-36-0	Antimony	D	535	73	1.0E-04	2.7E-04	NA	0	NA	NA	0	NA
MU-2	INORG	7440-36-0	Antimony	T	536	79	1.0E-04	1.3E-03	NA	0	NA	NA	0	NA
MU-2	INORG	7440-38-2	Arsenic	D	535	44	1.0E-04	2.4E-04	1.0E-01	233	2.4E-03	2.5E-02	0	9.6E-03
MU-2	INORG	7440-38-2	Arsenic	T	536	84	1.0E-04	2.2E-03	1.0E-01	536	2.2E-02	2.5E-02	0	8.6E-02
MU-2	INORG	7440-39-3	Barium	D	535	100	3.0E-02	1.3E-01	NA	0	NA	NA	0	NA
MU-2	INORG	7440-39-3	Barium	T	536	100	1.0E-04	1.4E-01	NA	0	NA	NA	0	NA
MU-2	INORG	7440-41-7	Beryllium	D	535	0	NA	NA	NA	0	NA	NA	0	NA
MU-2	INORG	7440-41-7	Beryllium	T	535	4	2.0E-05	5.0E-04	NA	0	NA	NA	0	NA
MU-2	INORG	7440-42-8	Boron	D	535	48	1.0E-02	1.7E-02	NA	0	NA	NA	0	NA
MU-2	INORG	7440-42-8	Boron	T	536	54	1.0E-02	5.0E-02	NA	0	NA	NA	0	NA
MU-2	INORG	7440-43-9	Cadmium	D	535	88	5.0E-06	1.7E-04	5.1E-03	472	3.3E-02	8.0E-02	0	2.1E-03
MU-2	INORG	7440-43-9	Cadmium	T	536	96	5.0E-06	6.1E-04	5.1E-03	536	1.2E-01	8.0E-02	0	7.6E-03
MU-2	INORG	7440-47-3	Chromium	D	535	78	1.0E-04	3.4E-03	4.9E-03	417	6.9E-01	5.0E-02	0	6.8E-02
MU-2	INORG	7440-47-3	Chromium	T	536	94	1.0E-04	8.5E-03	4.9E-03	536	1.7E+00	5.0E-02	0	1.7E-01
MU-2	INORG	7440-48-4	Cobalt	D	535	1	1.0E-04	3.1E-04	5.0E-02	6	6.2E-03	1.0E+00	0	3.1E-04
MU-2	INORG	7440-48-4	Cobalt	T	536	13	1.0E-04	1.8E-03	5.0E-02	536	3.6E-02	1.0E+00	0	1.8E-03
MU-2	INORG	7440-50-8	Copper	D	535	9	2.0E-04	1.4E-03	NA	0	NA	NA	0	NA
MU-2	INORG	7440-50-8	Copper	T	536	11	5.0E-04	2.4E-02	NA	0	NA	NA	0	NA
MU-2	INORG	7439-89-6	Iron	D	535	1	1.1E-02	3.4E-01	NA	0	NA	NA	0	NA
MU-2	INORG	7439-89-6	Iron	T	536	63	1.0E-02	3.4E+00	NA	0	NA	NA	0	NA
MU-2	INORG	7439-92-1	Lead	D	535	1	5.0E-05	3.7E-04	2.0E-01	5	1.8E-03	1.0E-01	0	3.7E-03
MU-2	INORG	7439-92-1	Lead	T	536	21	5.0E-05	2.8E-03	2.0E-01	536	1.4E-02	1.0E-01	0	2.8E-02
MU-2	INORG	7439-93-2	Lithium	D	535	100	3.5E-03	4.6E-02	2.5E+00	534	1.8E-02	NA	0	NA
MU-2	INORG	7439-93-2	Lithium	T	536	100	1.0E-03	7.0E-02	2.5E+00	536	2.8E-02	NA	0	NA
MU-2	INORG	7439-96-5	Manganese	D	535	91	9.4E-05	4.7E-02	2.0E-01	488	2.3E-01	NA	0	NA
MU-2	INORG	7439-96-5	Manganese	T	536	99	1.0E-04	2.5E-01	2.0E-01	536	1.2E+00	NA	0	NA
MU-2	INORG	7439-97-6	Mercury	D	535	0	1.3E-05	1.3E-05	2.0E-03	1	6.4E-03	3.0E-03	0	4.3E-03
MU-2	INORG	7439-97-6	Mercury	T	537	25	5.0E-07	3.3E-05	2.0E-03	537	1.6E-02	3.0E-03	0	1.1E-02
MU-2	INORG	7439-98-7	Molybdenum	D	535	100	7.9E-04	8.3E-03	NA	0	NA	NA	0	NA
MU-2	INORG	7439-98-7	Molybdenum	T	536	100	5.0E-05	1.4E-02	NA	0	NA	NA	0	NA
MU-2	INORG	7440-02-0	Nickel	D	535	85	5.0E-04	5.0E-03	2.0E-01	455	2.5E-02	1.0E+00	0	5.0E-03
MU-2	INORG	7440-02-0	Nickel	T	536	86	5.0E-04	1.2E-02	2.0E-01	536	6.0E-02	1.0E+00	0	1.2E-02
MU-2	INORG	14797-55-8	Nitrate Nitrogen (NO3), AS N	N	538	100	1.0E-02	1.5E+01	NA	0	NA	1.0E+02	0	1.5E-01
MU-2	INORG	7782-49-2	Selenium	D	541	100	9.3E-04	6.1E-02	1.0E-02	540	6.1E+00	3.0E-02	283	2.0E+00
MU-2	INORG	7782-49-2	Selenium	T	542	100	5.0E-05	6.0E-02	1.0E-02	542	6.0E+00	3.0E-02	260	2.0E+00
MU-2	INORG	7440-22-4	Silver	D	535	0	NA	NA	NA	0	NA	NA	0	NA
MU-2	INORG	7440-22-4	Silver	T	536	2	1.0E-05	7.4E-05	NA	0	NA	NA	0	NA
MU-2	INORG	7440-28-0	Thallium	D	535	1	1.1E-05	1.8E-05	NA	0	NA	NA	0	NA
MU-2	INORG	7440-28-0	Thallium	T	536	11	1.0E-05	1.5E-04	NA	0	NA	NA	0	NA
MU-2	INORG	7440-31-5	Tin	D	535	1	1.3E-04	4.4E-04	NA	0	NA	NA	0	NA
MU-2	INORG	7440-31-5	Tin	T	536	2	1.0E-04	8.1E-04	NA	0	NA	NA	0	NA

Table C-5. Surface water screening results for agriculture

MU	Chem Group	CASRN	Constituent	Fraction	Sample Count	% Detected	Minimum Detected Concentration (mg/L)	Maximum Detected Concentration (mg/L)	BC WQG, Irrigation (mg/L)	Count Detected Result Exceed BC WQG, Irrigation	Ratio of Max Detected to BC WQG, Irrigation	BC WQG, Livestock (mg/L)	Count Detected Result Exceed BC WQG, Livestock	Ratio to Max Detected to BC WQG, Livestock
MU-2	INORG	7440-61-1	Uranium	D	535	100	5.4E-04	4.1E-03	1.0E-02	534	4.1E-01	2.0E-01	0	2.1E-02
MU-2	INORG	7440-61-1	Uranium	T	536	100	1.0E-05	4.0E-03	1.0E-02	536	4.0E-01	2.0E-01	0	2.0E-02
MU-2	INORG	7440-62-2	Vanadium	D	535	0	NA	NA	1.0E-01	0	NA	1.0E-01	0	NA
MU-2	INORG	7440-62-2	Vanadium	T	536	12	5.0E-04	8.1E-03	1.0E-01	536	8.1E-02	1.0E-01	0	8.1E-02
MU-2	INORG	7440-66-6	Zinc	D	535	50	1.0E-03	1.3E-01	NA	0	NA	NA	0	NA
MU-2	INORG	7440-66-6	Zinc	T	536	53	3.0E-03	5.6E-02	NA	0	NA	NA	0	NA
MU-3	INORG	7429-90-5	Aluminum	D	1561	32	1.1E-03	4.0E-01	5.0E+00	506	8.0E-02	5.0E+00	0	8.0E-02
MU-3	INORG	7429-90-5	Aluminum	T	1561	92	3.0E-03	2.7E+01	5.0E+00	1561	5.3E+00	5.0E+00	4	5.3E+00
MU-3	INORG	7440-36-0	Antimony	D	1561	54	1.0E-04	7.4E-03	NA	0	NA	NA	0	NA
MU-3	INORG	7440-36-0	Antimony	T	1561	62	1.0E-04	7.0E-03	NA	0	NA	NA	0	NA
MU-3	INORG	7440-38-2	Arsenic	D	1561	80	1.0E-04	8.9E-04	1.0E-01	1243	8.9E-03	2.5E-02	0	3.6E-02
MU-3	INORG	7440-38-2	Arsenic	T	1561	93	1.0E-04	2.1E-02	1.0E-01	1561	2.1E-01	2.5E-02	0	8.6E-01
MU-3	INORG	7440-39-3	Barium	D	1561	100	3.2E-02	3.4E-01	NA	0	NA	NA	0	NA
MU-3	INORG	7440-39-3	Barium	T	1561	100	3.1E-02	1.6E+00	NA	0	NA	NA	0	NA
MU-3	INORG	7440-41-7	Beryllium	D	1561	0	2.1E-05	4.5E-05	NA	0	NA	NA	0	NA
MU-3	INORG	7440-41-7	Beryllium	T	1561	10	2.0E-05	2.0E-03	NA	0	NA	NA	0	NA
MU-3	INORG	7440-42-8	Boron	D	1561	61	1.0E-02	7.2E-02	NA	0	NA	NA	0	NA
MU-3	INORG	7440-42-8	Boron	T	1561	62	1.0E-02	7.2E-02	NA	0	NA	NA	0	NA
MU-3	INORG	7440-43-9	Cadmium	D	1561	84	5.0E-06	5.2E-04	5.1E-03	1308	1.0E-01	8.0E-02	0	6.5E-03
MU-3	INORG	7440-43-9	Cadmium	T	1561	95	5.0E-06	9.3E-03	5.1E-03	1561	1.8E+00	8.0E-02	0	1.2E-01
MU-3	INORG	7440-47-3	Chromium	D	1560	37	1.0E-04	9.9E-04	4.9E-03	573	2.0E-01	5.0E-02	0	2.0E-02
MU-3	INORG	7440-47-3	Chromium	T	1561	66	1.0E-04	3.2E-02	4.9E-03	1561	6.6E+00	5.0E-02	0	6.4E-01
MU-3	INORG	7440-48-4	Cobalt	D	1561	27	1.0E-04	1.3E-02	5.0E-02	414	2.6E-01	1.0E+00	0	1.3E-02
MU-3	INORG	7440-48-4	Cobalt	T	1561	44	1.0E-04	6.2E-02	5.0E-02	1561	1.2E+00	1.0E+00	0	6.2E-02
MU-3	INORG	7440-50-8	Copper	D	1561	39	2.0E-04	3.4E-03	NA	0	NA	NA	0	NA
MU-3	INORG	7440-50-8	Copper	T	1561	50	5.0E-04	7.7E-02	NA	0	NA	NA	0	NA
MU-3	INORG	7439-89-6	Iron	D	1560	11	1.0E-02	4.1E-01	NA	0	NA	NA	0	NA
MU-3	INORG	7439-89-6	Iron	T	1561	75	1.0E-02	5.5E+01	NA	0	NA	NA	0	NA
MU-3	INORG	7439-92-1	Lead	D	1561	2	5.2E-05	4.0E-04	2.0E-01	28	2.0E-03	1.0E-01	0	4.0E-03
MU-3	INORG	7439-92-1	Lead	T	1561	40	5.0E-05	3.4E-02	2.0E-01	1561	1.7E-01	1.0E-01	0	3.4E-01
MU-3	INORG	7439-93-2	Lithium	D	1561	100	1.1E-03	2.9E-01	2.5E+00	1557	1.2E-01	NA	0	NA
MU-3	INORG	7439-93-2	Lithium	T	1561	100	1.1E-03	2.9E-01	2.5E+00	1561	1.1E-01	NA	0	NA
MU-3	INORG	7439-96-5	Manganese	D	1561	96	5.4E-05	1.7E-01	2.0E-01	1501	8.3E-01	NA	0	NA
MU-3	INORG	7439-96-5	Manganese	T	1561	100	7.1E-05	1.7E+00	2.0E-01	1561	8.4E+00	NA	0	NA
MU-3	INORG	7439-97-6	Mercury	D	1557	1	5.2E-06	1.1E-05	2.0E-03	13	5.7E-03	3.0E-03	0	3.8E-03
MU-3	INORG	7439-97-6	Mercury	T	1557	56	5.0E-07	1.8E-04	2.0E-03	1557	9.1E-02	3.0E-03	0	6.0E-02
MU-3	INORG	7439-98-7	Molybdenum	D	1561	100	2.6E-04	4.1E-02	NA	0	NA	NA	0	NA
MU-3	INORG	7439-98-7	Molybdenum	T	1561	100	3.1E-04	4.0E-02	NA	0	NA	NA	0	NA
MU-3	INORG	7440-02-0	Nickel	D	1561	60	5.1E-04	1.9E-01	2.0E-01	935	9.5E-01	1.0E+00	0	1.9E-01
MU-3	INORG	7440-02-0	Nickel	T	1561	72	5.0E-04	2.8E-01	2.0E-01	1561	1.4E+00	1.0E+00	0	2.8E-01
MU-3	INORG	14797-55-8	Nitrate Nitrogen (NO3), AS N	N	1586	100	5.5E-03	8.6E+01	NA	0	NA	1.0E+02	0	8.6E-01
MU-3	INORG	7782-49-2	Selenium	D	1572	100	8.8E-05	4.0E-01	1.0E-02	1571	4.0E+01	3.0E-02	581	1.3E+01
MU-3	INORG	7782-49-2	Selenium	T	1572	100	1.0E-04	4.0E-01	1.0E-02	1572	4.0E+01	3.0E-02	578	1.3E+01
MU-3	INORG	7440-22-4	Silver	D	1560	0	1.1E-05	2.6E-05	NA	0	NA	NA	0	NA
MU-3	INORG	7440-22-4	Silver	T	1561	14	1.0E-05	8.1E-04	NA	0	NA	NA	0	NA
MU-3	INORG	7440-28-0	Thallium	D	1559	29	1.0E-05	8.1E-05	NA	0	NA	NA	0	NA
MU-3	INORG	7440-28-0	Thallium	T	1561	46	1.0E-05	1.3E-03	NA	0	NA	NA	0	NA
MU-3	INORG	7440-31-5	Tin	D	1560	1	1.1E-04	9.1E-04	NA	0	NA	NA	0	NA
MU-3	INORG	7440-31-5	Tin	T	1561	3	1.0E-04	5.0E-04	NA	0	NA	NA	0	NA
MU-3	INORG	7440-61-1	Uranium	D	1560	100	9.4E-05	2.3E-02	1.0E-02	1560	2.3E+00	2.0E-01	0	1.2E-01
MU-3	INORG	7440-61-1	Uranium	T	1561	100	8.9E-05	2.2E-02	1.0E-02	1561	2.2E+00	2.0E-01	0	1.1E-01
MU-3	INORG	7440-62-2	Vanadium	D	1560	1	5.7E-04	1.2E-03	1.0E-01	10	1.2E-02	1.0E-01	0	1.2E-02
MU-3	INORG	7440-62-2	Vanadium	T	1561	35	5.0E-04	7.3E-02	1.0E-01	1561	7.3E-01	1.0E-01	0	7.3E-01
MU-3	INORG	7440-66-6	Zinc	D	1560	16	1.0E-03	3.7E-02	NA	0	NA	NA	0	NA
MU-3	INORG	7440-66-6	Zinc	T	1561	29	3.0E-03	7.4E-01	NA	0	NA	NA	0	NA
MU-3	SVOC	91-57-6	2-METHYLNAPHTHALENE	N	103	4	3.3E-05	4.8E-03	NA	0	NA	NA	0	NA

Table C-5. Surface water screening results for agriculture

MU	Chem Group	CASRN	Constituent	Fraction	Sample Count	% Detected	Minimum Detected Concentration (mg/L)	Maximum Detected Concentration (mg/L)	BC WQG, Irrigation (mg/L)	Count Detected Result Exceed BC WQG, Irrigation	Ratio of Max Detected to BC WQG, Irrigation	BC WQG, Livestock (mg/L)	Count Detected Result Exceed BC WQG, Livestock	Ratio to Max Detected to BC WQG, Livestock
MU-3	SVOC	83-32-9	ACENAPHTHENE	N	251	0	NA	NA	NA	0	NA	NA	0	NA
MU-3	SVOC	208-96-8	ACENAPHTHYLENE	N	251	0	NA	NA	NA	0	NA	NA	0	NA
MU-3	SVOC	120-12-7	ANTHRACENE	N	251	0	NA	NA	NA	0	NA	NA	0	NA
MU-3	SVOC	56-55-3	BENZO(A)ANTHRACENE	N	251	0	NA	NA	NA	0	NA	NA	0	NA
MU-3	SVOC	50-32-8	BENZO(A)PYRENE	N	251	1	1.3E-05	4.1E-05	NA	0	NA	NA	0	NA
MU-3	SVOC	56832-73-6-B_J	BENZO(B&J)FLUORANTHENE	N	103	0	NA	NA	NA	0	NA	NA	0	NA
MU-3	SVOC	205-99-2	BENZO(B)FLUORANTHENE	N	148	3	1.7E-05	1.4E-04	NA	0	NA	NA	0	NA
MU-3	SVOC	56832-73-6-BJK	BENZO(B,J,K)FLUORANTHENE	N	3	0	NA	NA	NA	0	NA	NA	0	NA
MU-3	SVOC	191-24-2	BENZO(G,H,I)PERYLENE	N	251	1	1.1E-05	5.9E-05	NA	0	NA	NA	0	NA
MU-3	SVOC	207-08-9	BENZO(K)FLUORANTHENE	N	251	0	NA	NA	NA	0	NA	NA	0	NA
MU-3	SVOC	218-01-9	CHRYSENE	N	251	0	4.1E-05	4.1E-05	NA	0	NA	NA	0	NA
MU-3	SVOC	53-70-3	DIBENZ(A,H)ANTHRACENE	N	251	0	5.6E-06	5.6E-06	NA	0	NA	NA	0	NA
MU-3	SVOC	206-44-0	FLUORANTHENE	N	251	0	1.7E-05	1.7E-05	NA	0	NA	NA	0	NA
MU-3	SVOC	86-73-7	FLUORENE	N	251	8	1.1E-05	6.2E-04	NA	0	NA	NA	0	NA
MU-3	SVOC	193-39-5	INDENO(1,2,3-C,D)PYRENE	N	251	0	1.7E-05	1.7E-05	NA	0	NA	NA	0	NA
MU-3	SVOC	91-20-3	NAPHTHALENE	N	251	8	5.2E-05	1.6E-03	NA	0	NA	NA	0	NA
MU-3	SVOC	90-12-0	Naphthalene, 1-methyl- (1-METHYLNAPHTHALENE)	N	95	3	6.5E-05	2.2E-03	NA	0	NA	NA	0	NA
MU-3	SVOC	85-01-8	PHENANTHRENE	N	251	16	2.1E-05	2.0E-03	NA	0	NA	NA	0	NA
MU-3	SVOC	129-00-0	PYRENE	N	251	4	1.0E-05	1.4E-04	NA	0	NA	NA	0	NA
MU-3	SVOC	91-22-5	QUINOLINE	N	251	0	NA	NA	NA	0	NA	NA	0	NA
MU-4	INORG	7429-90-5	Aluminum	D	2387	28	1.0E-03	5.3E-01	5.0E+00	677	1.1E-01	5.0E+00	0	1.1E-01
MU-4	INORG	7429-90-5	Aluminum	T	2394	92	3.0E-03	5.0E+00	5.0E+00	2394	1.0E+00	5.0E+00	0	1.0E+00
MU-4	INORG	7440-36-0	Antimony	D	2387	49	1.0E-04	1.2E-03	NA	0	NA	NA	0	NA
MU-4	INORG	7440-36-0	Antimony	T	2394	66	1.0E-04	1.2E-03	NA	0	NA	NA	0	NA
MU-4	INORG	7440-38-2	Arsenic	D	2387	94	1.0E-04	9.4E-04	1.0E-01	2243	9.4E-03	2.5E-02	0	3.8E-02
MU-4	INORG	7440-38-2	Arsenic	T	2394	96	1.0E-04	3.6E-03	1.0E-01	2394	3.6E-02	2.5E-02	0	1.4E-01
MU-4	INORG	7440-39-3	Barium	D	2387	100	9.7E-03	6.5E-01	NA	0	NA	NA	0	NA
MU-4	INORG	7440-39-3	Barium	T	2394	100	1.0E-04	5.9E-01	NA	0	NA	NA	0	NA
MU-4	INORG	7440-41-7	Beryllium	D	2387	0	2.5E-05	4.9E-05	NA	0	NA	NA	0	NA
MU-4	INORG	7440-41-7	Beryllium	T	2393	7	2.0E-05	5.0E-04	NA	0	NA	NA	0	NA
MU-4	INORG	7440-42-8	Boron	D	2387	56	1.0E-02	1.1E-01	NA	0	NA	NA	0	NA
MU-4	INORG	7440-42-8	Boron	T	2394	60	1.0E-02	1.2E-01	NA	0	NA	NA	0	NA
MU-4	INORG	7440-43-9	Cadmium	D	2387	88	5.0E-06	1.6E-03	5.1E-03	2107	3.1E-01	8.0E-02	0	2.0E-02
MU-4	INORG	7440-43-9	Cadmium	T	2394	97	5.0E-06	1.9E-03	5.1E-03	2394	3.7E-01	8.0E-02	0	2.3E-02
MU-4	INORG	7440-47-3	Chromium	D	2387	68	1.0E-04	3.1E-03	4.9E-03	1615	6.3E-01	5.0E-02	0	6.2E-02
MU-4	INORG	7440-47-3	Chromium	T	2394	86	1.0E-04	9.3E-03	4.9E-03	2394	1.9E+00	5.0E-02	0	1.9E-01
MU-4	INORG	7440-48-4	Cobalt	D	2387	26	1.0E-04	2.6E-02	5.0E-02	615	5.1E-01	1.0E+00	0	2.6E-02
MU-4	INORG	7440-48-4	Cobalt	T	2394	43	1.0E-04	2.9E-02	5.0E-02	2394	5.8E-01	1.0E+00	0	2.9E-02
MU-4	INORG	7440-50-8	Copper	D	2387	18	2.0E-04	2.0E-03	NA	0	NA	NA	0	NA
MU-4	INORG	7440-50-8	Copper	T	2394	23	5.0E-04	1.4E-02	NA	0	NA	NA	0	NA
MU-4	INORG	7439-89-6	Iron	D	2387	10	1.0E-02	6.4E-01	NA	0	NA	NA	0	NA
MU-4	INORG	7439-89-6	Iron	T	2394	79	1.0E-02	7.7E+00	NA	0	NA	NA	0	NA
MU-4	INORG	7439-92-1	Lead	D	2387	1	5.0E-05	6.7E-04	2.0E-01	25	3.4E-03	1.0E-01	0	6.7E-03
MU-4	INORG	7439-92-1	Lead	T	2394	33	5.0E-05	5.8E-03	2.0E-01	2394	2.9E-02	1.0E-01	0	5.8E-02
MU-4	INORG	7439-93-2	Lithium	D	2387	99	1.0E-03	1.4E-01	2.5E+00	2365	5.7E-02	NA	0	NA
MU-4	INORG	7439-93-2	Lithium	T	2394	99	1.0E-03	1.4E-01	2.5E+00	2394	5.6E-02	NA	0	NA
MU-4	INORG	7439-96-5	Manganese	D	2387	93	5.9E-05	4.6E-01	2.0E-01	2216	2.3E+00	NA	0	NA
MU-4	INORG	7439-96-5	Manganese	T	2394	96	5.0E-05	5.0E-01	2.0E-01	2394	2.5E+00	NA	0	NA
MU-4	INORG	7439-97-6	Mercury	D	2258	6	5.1E-07	2.1E-05	2.0E-03	136	1.0E-02	3.0E-03	0	6.9E-03
MU-4	INORG	7439-97-6	Mercury	T	2298	40	5.0E-07	3.4E-05	2.0E-03	2298	1.7E-02	3.0E-03	0	1.1E-02
MU-4	INORG	7439-98-7	Molybdenum	D	2387	100	3.1E-04	9.4E-03	NA	0	NA	NA	0	NA
MU-4	INORG	7439-98-7	Molybdenum	T	2394	100	5.0E-05	9.3E-03	NA	0	NA	NA	0	NA
MU-4	INORG	7440-02-0	Nickel	D	2387	76	5.0E-04	1.5E-01	2.0E-01	1808	7.6E-01	1.0E+00	0	1.5E-01
MU-4	INORG	7440-02-0	Nickel	T	2394	84	5.0E-04	1.6E-01	2.0E-01	2394	7.8E-01	1.0E+00	0	1.6E-01
MU-4	INORG	14797-55-8	Nitrate Nitrogen (NO3), AS N	N	2307	98	6.0E-03	1.6E+01	NA	0	NA	1.0E+02	0	1.6E-01
MU-4	INORG	7782-49-2	Selenium	D	2486	100	1.5E-04	2.7E-01	1.0E-02	2480	2.7E+01	3.0E-02	341	9.1E+00

Table C-5. Surface water screening results for agriculture

MU	Chem Group	CASRN	Constituent	Fraction	Sample Count	% Detected	Minimum Detected Concentration (mg/L)	Maximum Detected Concentration (mg/L)	BC WQG, Irrigation (mg/L)	Count Detected Result Exceed BC WQG, Irrigation	Ratio of Max Detected to BC WQG, Irrigation	BC WQG, Livestock (mg/L)	Count Detected Result Exceed BC WQG, Livestock	Ratio to Max Detected to BC WQG, Livestock
MU-4	INORG	7782-49-2	Selenium	T	2510	100	5.0E-05	2.6E-01	1.0E-02	2510	2.6E+01	3.0E-02	338	8.6E+00
MU-4	INORG	7440-22-4	Silver	D	2387	0	1.2E-05	1.3E-05	NA	0	NA	NA	0	NA
MU-4	INORG	7440-22-4	Silver	T	2394	9	1.0E-05	2.0E-04	NA	0	NA	NA	0	NA
MU-4	INORG	7440-28-0	Thallium	D	2387	27	1.0E-05	2.1E-04	NA	0	NA	NA	0	NA
MU-4	INORG	7440-28-0	Thallium	T	2394	45	1.0E-05	2.5E-04	NA	0	NA	NA	0	NA
MU-4	INORG	7440-31-5	Tin	D	2387	2	1.0E-04	7.7E-04	NA	0	NA	NA	0	NA
MU-4	INORG	7440-31-5	Tin	T	2394	3	1.0E-04	1.9E-02	NA	0	NA	NA	0	NA
MU-4	INORG	7440-61-1	Uranium	D	2387	100	1.4E-04	1.4E-02	1.0E-02	2381	1.4E+00	2.0E-01	0	6.8E-02
MU-4	INORG	7440-61-1	Uranium	T	2394	100	1.0E-05	1.4E-02	1.0E-02	2394	1.4E+00	2.0E-01	0	7.1E-02
MU-4	INORG	7440-62-2	Vanadium	D	2387	1	5.0E-04	1.8E-03	1.0E-01	16	1.8E-02	1.0E-01	0	1.8E-02
MU-4	INORG	7440-62-2	Vanadium	T	2394	27	5.0E-04	2.1E-02	1.0E-01	2394	2.1E-01	1.0E-01	0	2.1E-01
MU-4	INORG	7440-66-6	Zinc	D	2387	31	1.0E-03	2.1E-01	NA	0	NA	NA	0	NA
MU-4	INORG	7440-66-6	Zinc	T	2394	33	3.0E-03	7.7E-02	NA	0	NA	NA	0	NA
MU-5	INORG	7429-90-5	Aluminum	D	612	46	1.8E-03	1.1E-01	5.0E+00	282	2.1E-02	5.0E+00	0	2.1E-02
MU-5	INORG	7429-90-5	Aluminum	T	613	100	3.0E-03	6.0E+00	5.0E+00	613	1.2E+00	5.0E+00	2	1.2E+00
MU-5	INORG	7440-36-0	Antimony	D	612	19	5.0E-05	1.5E-04	NA	0	NA	NA	0	NA
MU-5	INORG	7440-36-0	Antimony	T	613	56	5.0E-05	5.0E-04	NA	0	NA	NA	0	NA
MU-5	INORG	7440-38-2	Arsenic	D	612	99	1.1E-04	3.5E-04	1.0E-01	606	3.5E-03	2.5E-02	0	1.4E-02
MU-5	INORG	7440-38-2	Arsenic	T	613	99	1.0E-04	5.1E-03	1.0E-01	613	5.1E-02	2.5E-02	0	2.0E-01
MU-5	INORG	7440-39-3	Barium	D	612	100	1.2E-04	1.2E-01	NA	0	NA	NA	0	NA
MU-5	INORG	7440-39-3	Barium	T	613	100	5.0E-05	2.3E-01	NA	0	NA	NA	0	NA
MU-5	INORG	7440-41-7	Beryllium	D	612	0	3.8E-05	5.0E-05	NA	0	NA	NA	0	NA
MU-5	INORG	7440-41-7	Beryllium	T	613	16	2.0E-05	5.3E-04	NA	0	NA	NA	0	NA
MU-5	INORG	7440-42-8	Boron	D	612	9	5.0E-03	1.3E-02	NA	0	NA	NA	0	NA
MU-5	INORG	7440-42-8	Boron	T	613	21	5.0E-03	5.0E-02	NA	0	NA	NA	0	NA
MU-5	INORG	7440-43-9	Cadmium	D	612	99	3.0E-06	1.3E-04	5.1E-03	603	2.6E-02	8.0E-02	0	1.7E-03
MU-5	INORG	7440-43-9	Cadmium	T	613	99	5.0E-06	1.2E-03	5.1E-03	613	2.3E-01	8.0E-02	0	1.5E-02
MU-5	INORG	7440-47-3	Chromium	D	612	97	5.0E-05	1.6E-03	4.9E-03	595	3.2E-01	5.0E-02	0	3.1E-02
MU-5	INORG	7440-47-3	Chromium	T	613	95	1.0E-04	1.2E-02	4.9E-03	613	2.3E+00	5.0E-02	0	2.3E-01
MU-5	INORG	7440-48-4	Cobalt	D	612	0	5.0E-05	3.6E-04	5.0E-02	3	7.2E-03	1.0E+00	0	3.6E-04
MU-5	INORG	7440-48-4	Cobalt	T	613	31	1.0E-04	4.8E-03	5.0E-02	613	9.7E-02	1.0E+00	0	4.8E-03
MU-5	INORG	7440-50-8	Copper	D	612	15	2.0E-04	1.8E-03	NA	0	NA	NA	0	NA
MU-5	INORG	7440-50-8	Copper	T	613	31	5.0E-04	1.4E-02	NA	0	NA	NA	0	NA
MU-5	INORG	7439-89-6	Iron	D	612	16	5.0E-03	2.0E-01	NA	0	NA	NA	0	NA
MU-5	INORG	7439-89-6	Iron	T	613	92	1.0E-02	1.1E+01	NA	0	NA	NA	0	NA
MU-5	INORG	7439-92-1	Lead	D	612	3	2.5E-05	5.4E-04	2.0E-01	19	2.7E-03	1.0E-01	0	5.4E-03
MU-5	INORG	7439-92-1	Lead	T	613	55	5.0E-05	8.6E-03	2.0E-01	613	4.3E-02	1.0E-01	0	8.6E-02
MU-5	INORG	7439-93-2	Lithium	D	612	100	1.6E-03	1.5E-02	2.5E+00	610	6.1E-03	NA	0	NA
MU-5	INORG	7439-93-2	Lithium	T	613	100	1.0E-03	1.5E-02	2.5E+00	613	5.9E-03	NA	0	NA
MU-5	INORG	7439-96-5	Manganese	D	612	98	1.0E-04	5.2E-02	2.0E-01	602	2.6E-01	NA	0	NA
MU-5	INORG	7439-96-5	Manganese	T	613	100	1.0E-04	5.2E-01	2.0E-01	613	2.6E+00	NA	0	NA
MU-5	INORG	7439-97-6	Mercury	D	611	3	5.1E-07	5.6E-06	2.0E-03	17	2.8E-03	3.0E-03	0	1.9E-03
MU-5	INORG	7439-97-6	Mercury	T	614	44	5.0E-07	3.5E-05	2.0E-03	614	1.8E-02	3.0E-03	0	1.2E-02
MU-5	INORG	7439-98-7	Molybdenum	D	612	100	5.5E-04	1.7E-03	NA	0	NA	NA	0	NA
MU-5	INORG	7439-98-7	Molybdenum	T	613	100	5.0E-05	1.7E-03	NA	0	NA	NA	0	NA
MU-5	INORG	7440-02-0	Nickel	D	612	67	2.5E-04	2.1E-03	2.0E-01	411	1.1E-02	1.0E+00	0	2.1E-03
MU-5	INORG	7440-02-0	Nickel	T	613	85	2.5E-04	1.9E-02	2.0E-01	613	9.6E-02	1.0E+00	0	1.9E-02
MU-5	INORG	14797-55-8	Nitrate Nitrogen (NO3), AS N	N	612	100	2.4E-01	3.3E+00	NA	0	NA	1.0E+02	0	3.3E-02
MU-5	INORG	7782-49-2	Selenium	D	612	100	7.6E-04	2.1E-02	1.0E-02	611	2.1E+00	3.0E-02	0	6.9E-01
MU-5	INORG	7782-49-2	Selenium	T	613	100	5.0E-05	1.8E-02	1.0E-02	613	1.8E+00	3.0E-02	0	6.1E-01
MU-5	INORG	7440-22-4	Silver	D	612	0	5.0E-06	5.0E-06	NA	0	NA	NA	0	NA
MU-5	INORG	7440-22-4	Silver	T	613	16	1.0E-05	2.2E-04	NA	0	NA	NA	0	NA
MU-5	INORG	7440-28-0	Thallium	D	612	1	5.0E-06	1.1E-05	NA	0	NA	NA	0	NA
MU-5	INORG	7440-28-0	Thallium	T	613	28	5.0E-06	2.9E-04	NA	0	NA	NA	0	NA
MU-5	INORG	7440-31-5	Tin	D	612	8	5.0E-05	1.4E-02	NA	0	NA	NA	0	NA
MU-5	INORG	7440-31-5	Tin	T	613	3	5.0E-05	5.0E-04	NA	0	NA	NA	0	NA

Table C-5. Surface water screening results for agriculture

MU	Chem Group	CASRN	Constituent	Fraction	Sample Count	% Detected	Minimum Detected Concentration (mg/L)	Maximum Detected Concentration (mg/L)	BC WQG, Irrigation (mg/L)	Count Detected Result Exceed BC WQG, Irrigation	Ratio of Max Detected to BC WQG, Irrigation	BC WQG, Livestock (mg/L)	Count Detected Result Exceed BC WQG, Livestock	Ratio to Max Detected to BC WQG, Livestock
MU-5	INORG	7440-61-1	Uranium	D	612	100	4.7E-04	1.9E-03	1.0E-02	611	1.9E-01	2.0E-01	0	9.4E-03
MU-5	INORG	7440-61-1	Uranium	T	613	100	1.0E-05	2.1E-03	1.0E-02	613	2.1E-01	2.0E-01	0	1.0E-02
MU-5	INORG	7440-62-2	Vanadium	D	612	1	2.5E-04	7.4E-04	1.0E-01	5	7.4E-03	1.0E-01	0	7.4E-03
MU-5	INORG	7440-62-2	Vanadium	T	613	46	2.5E-04	2.3E-02	1.0E-01	613	2.3E-01	1.0E-01	0	2.3E-01
MU-5	INORG	7440-66-6	Zinc	D	612	24	1.0E-03	8.7E-02	NA	0	NA	NA	0	NA
MU-5	INORG	7440-66-6	Zinc	T	613	26	1.5E-03	9.1E-02	NA	0	NA	NA	0	NA
MU-6	INORG	7429-90-5	Aluminum	D	720	93	1.5E-03	2.0E-01	5.0E+00	668	4.0E-02	5.0E+00	0	4.0E-02
MU-6	INORG	7429-90-5	Aluminum	T	720	100	3.0E-03	1.0E+01	5.0E+00	720	2.0E+00	5.0E+00	5	2.0E+00
MU-6	INORG	7440-36-0	Antimony	D	720	71	5.0E-05	1.2E-04	NA	0	NA	NA	0	NA
MU-6	INORG	7440-36-0	Antimony	T	720	83	5.0E-05	4.1E-04	NA	0	NA	NA	0	NA
MU-6	INORG	7440-38-2	Arsenic	D	720	100	1.7E-04	9.1E-04	1.0E-01	718	9.1E-03	2.5E-02	0	3.6E-02
MU-6	INORG	7440-38-2	Arsenic	T	720	100	1.0E-04	7.1E-03	1.0E-01	720	7.1E-02	2.5E-02	0	2.8E-01
MU-6	INORG	7440-39-3	Barium	D	720	100	2.0E-02	1.2E-01	NA	0	NA	NA	0	NA
MU-6	INORG	7440-39-3	Barium	T	720	100	1.0E-04	3.4E-01	NA	0	NA	NA	0	NA
MU-6	INORG	7440-41-7	Beryllium	D	720	71	1.0E-05	5.5E-05	NA	0	NA	NA	0	NA
MU-6	INORG	7440-41-7	Beryllium	T	720	81	1.0E-05	8.1E-04	NA	0	NA	NA	0	NA
MU-6	INORG	7440-42-8	Boron	D	720	74	5.0E-03	2.0E-02	NA	0	NA	NA	0	NA
MU-6	INORG	7440-42-8	Boron	T	720	76	5.0E-03	2.0E-02	NA	0	NA	NA	0	NA
MU-6	INORG	7440-43-9	Cadmium	D	720	94	3.0E-06	6.2E-05	5.1E-03	674	1.2E-02	8.0E-02	0	7.7E-04
MU-6	INORG	7440-43-9	Cadmium	T	720	100	3.0E-06	1.0E-03	5.1E-03	720	2.0E-01	8.0E-02	0	1.3E-02
MU-6	INORG	7440-47-3	Chromium	D	720	92	5.0E-05	1.1E-03	4.9E-03	662	2.3E-01	5.0E-02	0	2.2E-02
MU-6	INORG	7440-47-3	Chromium	T	720	98	5.0E-05	1.2E-02	4.9E-03	720	2.5E+00	5.0E-02	0	2.5E-01
MU-6	INORG	7440-48-4	Cobalt	D	720	73	5.0E-05	7.6E-04	5.0E-02	522	1.5E-02	1.0E+00	0	7.6E-04
MU-6	INORG	7440-48-4	Cobalt	T	720	86	5.0E-05	7.5E-03	5.0E-02	720	1.5E-01	1.0E+00	0	7.5E-03
MU-6	INORG	7440-50-8	Copper	D	720	74	1.0E-04	2.1E-03	NA	0	NA	NA	0	NA
MU-6	INORG	7440-50-8	Copper	T	720	86	2.5E-04	1.8E-02	NA	0	NA	NA	0	NA
MU-6	INORG	7439-89-6	Iron	D	720	82	5.0E-03	8.3E-01	NA	0	NA	NA	0	NA
MU-6	INORG	7439-89-6	Iron	T	720	99	5.0E-03	1.6E+01	NA	0	NA	NA	0	NA
MU-6	INORG	7439-92-1	Lead	D	720	74	2.5E-05	2.8E-03	2.0E-01	534	1.4E-02	1.0E-01	0	2.8E-02
MU-6	INORG	7439-92-1	Lead	T	720	94	2.5E-05	1.5E-02	2.0E-01	720	7.4E-02	1.0E-01	0	1.5E-01
MU-6	INORG	7439-93-2	Lithium	D	720	99	5.0E-04	8.2E-03	2.5E+00	711	3.3E-03	NA	0	NA
MU-6	INORG	7439-93-2	Lithium	T	720	100	5.0E-04	2.0E-02	2.5E+00	720	7.8E-03	NA	0	NA
MU-6	INORG	7439-96-5	Manganese	D	720	99	5.0E-05	1.0E-01	2.0E-01	713	5.2E-01	NA	0	NA
MU-6	INORG	7439-96-5	Manganese	T	720	100	1.0E-04	6.7E-01	2.0E-01	720	3.4E+00	NA	0	NA
MU-6	INORG	7439-97-6	Mercury	D	720	71	3.0E-06	1.7E-05	2.0E-03	509	8.3E-03	3.0E-03	0	5.5E-03
MU-6	INORG	7439-97-6	Mercury	T	722	89	2.5E-07	5.6E-05	2.0E-03	722	2.8E-02	3.0E-03	0	1.9E-02
MU-6	INORG	7439-98-7	Molybdenum	D	720	100	3.9E-04	1.3E-03	NA	0	NA	NA	0	NA
MU-6	INORG	7439-98-7	Molybdenum	T	720	100	5.0E-05	1.2E-03	NA	0	NA	NA	0	NA
MU-6	INORG	7440-02-0	Nickel	D	720	72	2.5E-04	9.9E-04	2.0E-01	521	5.0E-03	1.0E+00	0	9.9E-04
MU-6	INORG	7440-02-0	Nickel	T	720	92	2.5E-04	2.0E-02	2.0E-01	720	1.0E-01	1.0E+00	0	2.0E-02
MU-6	INORG	14797-55-8	Nitrate Nitrogen (NO3), AS N	N	720	100	3.4E-02	1.7E+00	NA	0	NA	1.0E+02	0	1.7E-02
MU-6	INORG	7782-49-2	Selenium	D	720	100	7.0E-05	8.3E-03	1.0E-02	718	8.3E-01	3.0E-02	0	2.8E-01
MU-6	INORG	7782-49-2	Selenium	T	720	100	5.0E-05	8.4E-03	1.0E-02	720	8.4E-01	3.0E-02	0	2.8E-01
MU-6	INORG	7440-22-4	Silver	D	720	71	5.0E-06	5.0E-06	NA	0	NA	NA	0	NA
MU-6	INORG	7440-22-4	Silver	T	720	78	5.0E-06	1.7E-04	NA	0	NA	NA	0	NA
MU-6	INORG	7440-28-0	Thallium	D	720	71	5.0E-06	1.0E-05	NA	0	NA	NA	0	NA
MU-6	INORG	7440-28-0	Thallium	T	720	84	5.0E-06	2.9E-04	NA	0	NA	NA	0	NA
MU-6	INORG	7440-31-5	Tin	D	720	76	5.0E-05	4.1E-03	NA	0	NA	NA	0	NA
MU-6	INORG	7440-31-5	Tin	T	720	73	5.0E-05	4.0E-04	NA	0	NA	NA	0	NA
MU-6	INORG	7440-61-1	Uranium	D	720	100	4.0E-04	1.1E-03	1.0E-02	718	1.1E-01	2.0E-01	0	5.6E-03
MU-6	INORG	7440-61-1	Uranium	T	720	100	1.0E-05	1.3E-03	1.0E-02	720	1.3E-01	2.0E-01	0	6.7E-03
MU-6	INORG	7440-62-2	Vanadium	D	720	71	2.5E-04	7.8E-04	1.0E-01	510	7.8E-03	1.0E-01	0	7.8E-03
MU-6	INORG	7440-62-2	Vanadium	T	720	89	2.5E-04	2.1E-02	1.0E-01	720	2.1E-01	1.0E-01	0	2.1E-01
MU-6	INORG	7440-66-6	Zinc	D	720	73	5.0E-04	2.5E-02	NA	0	NA	NA	0	NA
MU-6	INORG	7440-66-6	Zinc	T	720	83	1.5E-03	8.4E-02	NA	0	NA	NA	0	NA

Notes:

1. Data screening conducted for the uncertainty assessment only.

BC WQG - British Columbia Water Quality Guideline
INORG - inorganic
mg/L – milligrams per liter
MU – management unit
NA – not applicable
SVOC - semi-volatile organic compound
D - dissolved fraction
N - no fraction

Table C-6. Groundwater screening results for agriculture

MU	Chem Group	Constituent	Fraction	Sample Count	% Detected	Minimum Detected Concentration (mg/L)	Maximum Detected Concentration (mg/L)	BC WQG, Irrigation (mg/L)	Count Detected Result Exceed BC WQG, Irrigation	Ratio of Max Detected to BC WQG, Irrigation	BC WQG, Livestock (mg/L)	Count Detected Result Exceed BC WQG, Livestock	Ratio of Max Detected to BC WQG, Livestock
MU-3	INORG	Aluminum	D	30	3	3.8E-03	3.8E-03	5.0E+00	0	7.6E-04	5.0E+00	0	7.6E-04
MU-3	INORG	Arsenic	D	30	0	NA	NA	1.0E-01	0	NA	2.5E-02	0	NA
MU-3	INORG	Cadmium	D	30	90	5.4E-06	5.5E-05	5.1E-03	0	1.1E-02	8.0E-02	0	6.8E-04
MU-3	INORG	Chromium	D	60	90	1.4E-04	3.4E-04	4.9E-03	0	6.9E-02	5.0E-02	0	6.8E-03
MU-3	INORG	Cobalt	D	30	0	NA	NA	5.0E-02	0	NA	1.0E+00	0	NA
MU-3	INORG	Lead	D	30	83	5.3E-05	1.0E-03	2.0E-01	0	5.2E-03	1.0E-01	0	1.0E-02
MU-3	INORG	Lithium	D	30	100	2.2E-03	7.7E-03	2.5E+00	0	3.1E-03	NA	0	NA
MU-3	INORG	Manganese	D	30	53	1.1E-04	6.5E-04	2.0E-01	0	3.3E-03	NA	0	NA
MU-3	INORG	Mercury	D	30	0	NA	NA	2.0E-03	0	NA	3.0E-03	0	NA
MU-3	INORG	Nickel	D	30	10	5.1E-04	7.2E-04	2.0E-01	0	3.6E-03	1.0E+00	0	7.2E-04
MU-3	INORG	Nitrate Nitrogen (No3), As N	N	46	100	2.3E-01	1.6E+00	NA	0	NA	1.0E+02	0	1.6E-02
MU-3	INORG	Selenium	D	46	100	1.5E-03	5.6E-03	1.0E-02	0	5.6E-01	3.0E-02	0	1.9E-01
MU-3	INORG	Uranium	D	30	100	7.3E-04	2.0E-03	1.0E-02	0	2.0E-01	2.0E-01	0	1.0E-02
MU-3	INORG	Vanadium	D	30	0	NA	NA	1.0E-01	0	NA	1.0E-01	0	NA
MU-4	INORG	Aluminum	D	109	3	1.6E-03	1.7E-02	5.0E+00	0	3.4E-03	5.0E+00	0	3.4E-03
MU-4	INORG	Arsenic	D	109	26	1.1E-04	8.0E-04	1.0E-01	0	8.0E-03	2.5E-02	0	3.2E-02
MU-4	INORG	Cadmium	D	109	94	5.1E-06	9.1E-05	5.1E-03	0	1.8E-02	8.0E-02	0	1.1E-03
MU-4	INORG	Chromium	D	218	83	1.2E-04	4.0E-03	4.9E-03	0	8.2E-01	5.0E-02	0	8.0E-02
MU-4	INORG	Cobalt	D	109	8	1.0E-04	4.3E-04	5.0E-02	0	8.6E-03	1.0E+00	0	4.3E-04
MU-4	INORG	Lead	D	109	75	5.4E-05	2.8E-03	2.0E-01	0	1.4E-02	1.0E-01	0	2.8E-02
MU-4	INORG	Lithium	D	109	99	1.3E-03	3.3E-02	2.5E+00	0	1.3E-02	NA	0	NA
MU-4	INORG	Manganese	D	109	63	1.1E-04	2.0E-01	2.0E-01	2	1.0E+00	NA	0	NA
MU-4	INORG	Mercury	D	109	0	NA	NA	2.0E-03	0	NA	3.0E-03	0	NA
MU-4	INORG	Nickel	D	109	32	5.3E-04	3.2E-03	2.0E-01	0	1.6E-02	1.0E+00	0	3.2E-03
MU-4	INORG	Nitrate Nitrogen (No3), As N	N	153	96	1.1E-02	5.9E+00	NA	0	NA	1.0E+02	0	5.9E-02
MU-4	INORG	Selenium	D	153	98	5.6E-05	1.5E-02	1.0E-02	50	1.5E+00	3.0E-02	0	5.1E-01
MU-4	INORG	Uranium	D	109	100	1.5E-05	4.3E-03	1.0E-02	0	4.3E-01	2.0E-01	0	2.1E-02
MU-4	INORG	Vanadium	D	109	0	NA	NA	1.0E-01	0	NA	1.0E-01	0	NA
MU-5	INORG	Aluminum	D	66	5	3.6E-03	1.3E-02	5.0E+00	0	2.7E-03	5.0E+00	0	2.7E-03
MU-5	INORG	Arsenic	D	66	20	1.0E-04	5.8E-04	1.0E-01	0	5.8E-03	2.5E-02	0	2.3E-02
MU-5	INORG	Cadmium	D	66	95	7.7E-06	1.3E-04	5.1E-03	0	2.5E-02	8.0E-02	0	1.6E-03
MU-5	INORG	Chromium	D	132	73	1.0E-04	5.5E-04	4.9E-03	0	1.1E-01	5.0E-02	0	1.1E-02
MU-5	INORG	Cobalt	D	66	3	4.1E-04	8.3E-04	5.0E-02	0	1.7E-02	1.0E+00	0	8.3E-04
MU-5	INORG	Lead	D	66	67	5.0E-05	1.6E-03	2.0E-01	0	8.1E-03	1.0E-01	0	1.6E-02
MU-5	INORG	Lithium	D	66	98	1.2E-03	1.2E-01	2.5E+00	0	4.6E-02	NA	0	NA
MU-5	INORG	Manganese	D	66	86	1.2E-04	1.2E+00	2.0E-01	2	5.8E+00	NA	0	NA
MU-5	INORG	Mercury	D	66	0	NA	NA	2.0E-03	0	NA	3.0E-03	0	NA
MU-5	INORG	Nickel	D	66	20	5.8E-04	1.2E-02	2.0E-01	0	6.0E-02	1.0E+00	0	1.2E-02
MU-5	INORG	Nitrate Nitrogen (No3), As N	N	91	98	5.7E-03	2.3E+00	NA	0	NA	1.0E+02	0	2.3E-02

Table C-6. Groundwater screening results for agriculture

MU	Chem Group	Constituent	Fraction	Sample Count	% Detected	Minimum Detected Concentration (mg/L)	Maximum Detected Concentration (mg/L)	BC WQG, Irrigation (mg/L)	Count Detected Result Exceed BC WQG, Irrigation	Ratio of Max Detected to BC WQG, Irrigation	BC WQG, Livestock (mg/L)	Count Detected Result Exceed BC WQG, Livestock	Ratio of Max Detected to BC WQG, Livestock
MU-5	INORG	Selenium	D	91	96	1.4E-04	1.6E-02	1.0E-02	19	1.6E+00	3.0E-02	0	5.3E-01
MU-5	INORG	Uranium	D	66	100	6.4E-05	1.5E-03	1.0E-02	0	1.5E-01	2.0E-01	0	7.3E-03
MU-5	INORG	Vanadium	D	66	0	NA	NA	1.0E-01	0	NA	1.0E-01	0	NA

Notes:

1. Data screening conducted for the uncertainty assessment only.

BC WQG - British Columbia Water Quality Guideline
INORG - inorganic
mg/L – milligrams per liter
MU – management unit
NA – not applicable
D - dissolved fraction
N - no fraction
T – total fraction

Table C-7. Fish and Wild Food Selenium Summary Statistics in Elk Valley and Reference

Area	Media	Sample Count	Minimum Concentration (mg/kg ww)	Maximum Concentration (mg/kg ww)	Mean Concentration (mg/kg ww)	HHRA EPC (mg/kg ww)	EPC Type
Valley-wide	Fish tissue	408	0.63	30	3.14	3.939	95% Chebyshev (Mean, Sd) UCL
Valley-wide	Fish eggs	150	1.643	27.92	9.119	9.861	95% Approximate Gamma UCL
Reference	Fish tissue	79	0.103	2.852	0.843	1.16	95% KM (Chebyshev) UCL
Valley-wide	Berries	201	0.00842	0.707	0.0955	0.0643	95% KM Approximate Gamma UCL
Reference	Berries	34	0.0111	0.109	0.0521	0.0172	95% KM (t) UCL
Valley-wide	Rose hips	14	0.031	0.585	0.13	0.301	95% KM (Chebyshev) UCL
Reference	Rose hips	8	0.0255	0.192	0.0787	0.107	95% KM (t) UCL
Valley-wide	Game muscle	61	0.0617	0.872	0.49	0.604	95% Chebyshev (Mean, Sd) UCL
Reference	Game muscle	19	0.0271	0.677	0.157	0.218	95% Adjusted Gamma UCL
Valley-wide	Game organ	17	0.281	3.959	1.401	1.794	95% Student's-t UCL
Reference	Game organ	12	0.123	1.132	0.382	0.575	95% Adjusted Gamma UCL

Notes:

mg/kg ww – milligrams per kilogram wet weight HHRA - human health risk assessment
EPC - exposure point concentration
UCL - upper confidence limit

Reference concentrations (95th percentiles) not available for fish eggs.

APPENDIX D
ESTIMATION OF BERRY CONSUMPTION RATES USING NHANES DATA

Estimation of Berry Consumption Rates Using NHANES Data

In review of berry consumption rates for use in the HHRA, it was determined that additional analysis might be needed to consider current consumption rates for berries in Canada. The readily available data from Health Canada (2005) are based on outdated consumption rates. Consequently, additional analyses were conducted using data from United States consumers as collected by the National Health and Nutrition Examination Survey (NHANES) for the years 2013 to 2016 to provide additional consideration of potential consumption rates for residential consumers in Elk Valley.

NHANES data are available online[1]. Data from years 2013 to 2016 were researched to summarize data on consumption of all berries for consumers only. In conducting these analyses, decisions about which foods to include were intended to be highly inclusive to avoid any potential for underestimating consumption rates. Table D-1 provides a summary of all foods included in the analysis based on the entire consumption rate.

Appendix D Table D-1: Foods and food codes in NHANEs included in analysis of berry consumption

Food Code	Food Long Description
62105000	Blueberries, dried
63126010	Juneberry, raw
63200100	Berries, raw, NFS
63200200	Berries, frozen, NFS
63201010	Blackberries, raw
63201600	Blackberries, frozen
63201800	Blackberries, frozen, sweetened, NS as to type of sweetener
63203010	Blueberries, raw
63203120	Blueberries, cooked or canned, unsweetened, water pack
63203550	Blueberries, frozen, sweetened
63203570	Blueberries, frozen, NS as to sweetened or unsweetened
63203600	Blueberries, frozen, unsweetened
63205010	Boysenberries, raw
63205600	Boysenberries, frozen
63208000	Dewberries, raw
63214000	Huckleberries, raw
63215010	Loganberries, raw

63215600	Loganberries, frozen
63217010	Mulberries, raw
63219000	Raspberries, raw, NS as to color
63219010	Raspberries, black, raw
63219020	Raspberries, red, raw
63219120	Raspberries, cooked or canned, unsweetened, water pack
63219600	Raspberries, frozen, NS as to added sweetener
63219610	Raspberries, frozen, unsweetened
63219620	Raspberries, frozen, with sugar
63223020	Strawberries, raw
63223030	Strawberries, raw, with sugar
63223120	Strawberries, cooked or canned, unsweetened, water pack
63223600	Strawberries, frozen, NS as to added sweetener
63223610	Strawberries, frozen, unsweetened
63223620	Strawberries, frozen, with sugar
63224000	Youngberries, raw

In addition to the foods summarized in Table D-1, which were included at the full rate consumed, Table D-2 provides a summary of foods that had berries as an ingredient. Foods in Table D-2 are also included in the estimate of berries consumed by applying data from NHANES on the fraction of these foods that is comprised of berries to include these foods in the estimates.

Appendix D Table D-2: Foods and food codes in NHANES included in analysis of berry consumption: foods with berries as an ingredient

Food Code	Food Long Description
11551050	Licuado or Batido
11553100	Fruit smoothie, NFS
11553110	Fruit smoothie, with whole fruit and dairy
11553120	Fruit smoothie, with whole fruit and dairy, added protein
13120400	Ice cream bar or stick with fruit
13250100	Mousse, not chocolate
51180080	Bagel, with fruit other than raisins

51186160	Muffin, English, with fruit other than raisins
53101250	Cake, angel food, with fruit and icing or filling
53104550	Cheesecake with fruit
53118500	Cake, torte
53122070	Cake, shortcake, biscuit type, with whipped cream and fruit
53122080	Cake, shortcake, biscuit type, with fruit
53123070	Cake, shortcake, sponge type, with whipped cream and fruit
53123080	Cake, shortcake, sponge type, with fruit
53123500	Cake, shortcake, with whipped topping and fruit, diet
53303000	Pie, blackberry, two crust
53303070	Pie, blackberry, individual size or tart
53304070	Pie, blueberry, individual size or tart
53310000	Pie, raspberry, one crust
53310050	Pie, raspberry, two crust
53312000	Pie, strawberry, one crust
53313000	Pie, strawberry-rhubarb, two crust
53314000	Pie, strawberry, individual size or tart
53344200	Mixed fruit tart filled with custard or cream cheese
53344300	Dessert pizza
53348000	Pie, strawberry cream
53348070	Pie, strawberry cream, individual size or tart
53366000	Pie, yogurt, frozen
53390100	Pie, tofu with fruit
53410300	Cobbler, berry
53415220	Fritter, berry
53415300	Crisp, blueberry
53430000	Crepe, NS as to filling
53430200	Crepe, fruit filled
53440300	Strudel, berry
53450300	Turnover or dumpling, berry
55100020	Pancakes, with fruit, from frozen
55100055	Pancakes, with fruit, from fast food / restaurant

55103000	Pancakes, with fruit
55200040	Waffle, fruit, from frozen
55200080	Waffle, whole grain, fruit, from frozen
55200120	Waffle, fruit, from fast food / restaurant
55203000	Waffle, fruit
56205200	Rice, frozen dessert, nondairy, flavors other than chocolate
63307100	Cranberry-raspberry Sauce
63311000	Fruit salad, fresh or raw, excluding citrus fruits, no dressing
63311050	Fruit salad, fresh or raw, including citrus fruits, no dressing
63311080	Fruit cocktail or mix, frozen
63401070	Fruit, chocolate covered
64134015	Fruit smoothie, with whole fruit, no dairy
64134020	Fruit smoothie, with whole fruit, no dairy, added protein
64134030	Fruit smoothie juice drink, no dairy
64134100	Fruit smoothie, light
91361020	Fruit sauce
91501070	Gelatin dessert with fruit and sour cream
91511070	Gelatin dessert, dietetic, with fruit and sour cream, sweetened with low calorie sweetener

Appendix D Table D-3, provides a summary of the 95th percentile and 50th percentile berry consumption rates for consumers only as reported in The Firelight Study (2015) and in the NHANES analysis described here though inclusion of the foods identified in Tables D-1 and D-2. As indicated in Table D-3, consumption rates identified in the analysis of NHANES data for the US population were similar to those reported by The Firelight Study (2015). These analyses support the use of data for Ktunaxa consumers to evaluate exposures for all berry consumers.

Appendix D Table D-3. Berry consumption rates identified in The Firelight Study (2015) and in NHANES 2013-2016

Populations	Units	Toddler	Child	Adolescent	Adult	Source
Ktunaxa heavy Consumers	g/day	198	227	206	206	95th%tile consumers only Firelight (2015)
Ktunaxa average Consumers	g/day	81	94	85	85	Average consumers only Firelight (2015)
US NHANES** (2013-2016)	g/day	73	85	77	77	50th percentile consumers only
US NHANES (2013-2016)	g/day	222	257	233.4	233.4	95th percentile consumers only

Notes:

All values are in grams per day, wet weight

Adult life stage is from Firelight Group (2015), other life stages are derived based the ratio of fruit ingestion rates across life stages in Richardson (1997).

APPENDIX E
HEALTH EVALUATION FOR CONSUMPTION OF LAKE KOOCANUSA BURBOT

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HEALTH EVALUATION FOR CONSUMPTION OF LAKE KOOCANUSA BURBOT [PERMIT 107517 CONDITION 9.7]

RAMBOLL ENVIRON

HEALTH EVALUATION FOR CONSUMPTION OF LAKE KOOCANUSA BURBOT [PERMIT 107517 CONDITION 9.7]

CONTENTS

TABLES

1. HEALTH EVALUATION FOR CONSUMPTION OF LAKE KOOCANUSA BURBOT

Potential health risks from consumption of burbot harvested from Lake Koocanusa by a Ktunaxa member were evaluated in a two-step process. Initially the maximum reported concentration for each constituent was compared to its respective screening guideline value. Next, for each constituent exceeding a guideline value, potential health risks were calculated.

1.1 Comparison to Guideline Values

During 2014 and 2015, a total of 21 burbot tissue samples were collected from five locations within Lake Koocanusa (at Sand Creek, Elk River, Oestreich Road, Gold Creek, and Big Springs). In 2014, 13 muscle plug samples were collected from Sand Creek (n=10), Elk River (n=2), and Oestreich Road (n=1). In 2015, seven muscle plug samples were collected from Sand Creek (n=4), Elk River (n=2), and Gold Creek (n=1), and one fillet sample was collected from Big Springs. An additional ten muscle plug samples were collected from Moyie Lake in 2014; these samples were not included in this evaluation. All samples were analyzed for 39 constituents. The data were reported as dry weight. Most human health guideline values are derived on a wet weight basis. Consequently, the percent moisture measured in each sample was used to convert each value from a dry weight to wet weight tissue concentration[1].

The maximum detected constituent concentrations in 2014-2015 Lake Koocanusa burbot tissue were compared to guideline values established for protection of fish consumption by people. Guideline values were available for 23 of the 39 constituents. The BC Ministry of Environment (BC MoE) provides fish tissue guideline values for selenium and mercury (BC MoE 2012a). Selenium guidelines are based on three levels of fish consumption, i.e., "high" (220 g/day), "moderate" (110 g/day) and "average" (30 g/day) fish consumers (Table 1). These guidelines were derived from Health Canada's equation for fish ingestion and the dietary tolerable upper intake for selenium. The guideline based on moderate fish consumption was applied in this screening.

Table 1: BC Ministry of Environment fish tissue selenium guidelines

Fish Tissue Consumption Level	Selenium Guideline (wet weight)
High (220 g/day)	1.8 mg/kg
Moderate (110 g/day)	3.6 mg/kg
Low (30 g/day)	18.7 mg/kg

For mercury, BC MoE provides a "not to exceed" value of 0.5 mg/kg wet weight that is consistent with the Health Canada maximum standard value designated in retail fish (BC MoE 2001; Health Canada 2007). BC MoE has not developed fish tissue guidelines for constituents other than selenium and mercury.

[1] Dry weight tissue concentrations were converted to wet weight concentrations for each sample using the following equation: *Concentration in wet weight = Concentration in dry weight x [1 – (percent sample moisture/100)]*.

U.S. Environmental Protection Agency (USEPA; 2014) Region 3 provides the most comprehensive list of constituent screening levels for edible fish tissue[2]. These values were modified to be consistent with BC MoE and Health Canada risk management levels (i.e., cancer risk=1 in 100,000 and hazard quotient=0.2). This approach is consistent with assumptions applied in the Environmental Assessments prepared for extension of Teck operations in Elk Valley. The fish consumption rate used to derive the USEPA Region 3 values is 54 g/day. Fish consumption rates are discussed further in Section 1.2.

The USEPA Region 3 screening level for arsenic was also modified to account for the low proportion of inorganic arsenic to total arsenic in fish tissue. There is strong evidence demonstrating that arsenic in fish is primarily found in organic forms that exhibit low toxicity to people, instead of the more toxic inorganic forms (de Rosemond et al. 2008; Idaho DEQ 2008; Oregon DEQ 2011; Schoof and Yager 2007). An adjustment factor of 0.1, or 10 percent, is often applied to total arsenic concentrations in freshwater fish to estimate the fraction of arsenic present as the more toxic inorganic form. The assumption that 10 percent of total arsenic is inorganic represents an upper-bound estimate of average tissue concentration for a long-time consumer. Schoof and Yager (2007) recommended using the 75th percentile (10 percent) to represent an upper-bound estimate of average exposures for a long-time consumer. More recent studies support the finding that total inorganic arsenic in freshwater fish tissue comprises less than 10 percent of total arsenic (Idaho DEQ 2008; de Rosemond et al. 2008; Oregon DEQ 2011).

Results from tissue screening are provided in Table 2 for the constituents with screening guidelines. The only constituents to exceed a guideline value were aluminum, cobalt, and iron. The exceedances were all from the same individual burbot sample collected from near the mouth of the Elk River in 2014, there were no other exceedances of guideline values among the 2014-2015 burbot tissue samples. For the three constituents with exceedances, potential risks of fish consumption were calculated.

The maximum selenium concentration was below the BC MoE guidelines for the low (30 grams of fish per day) and moderate consumers (110 grams of fish per day) and equal to the guideline for the highest consumer (220 grams per day). Even though it did not exceed guideline values, selenium was retained for further evaluation because it is a constituent of concern associated with mining activities. Mercury was also retained for further evaluation due to general concerns about mercury levels in all freshwater fish.

[2] The BC MoE process for deriving fish tissue guidelines, which is generally consistent with USEPA Region 3 screening level methodology, but uses of different fish ingestion rates and target risk management levels (BC Ministry of the Environment, 2014). Because the USEPA Region 3 values are already calculated and are based on higher fish consumption rates, these values were adjusted to provide consistency with BC MoE and Health Canada risk management levels.

Table 2: Screening results for burbot tissue

Analyte	Guideline Value [a] (mg/kg ww)	Minimum Tissue Concentration (mg/kg ww)	Mean Tissue Concentration (mg/kg ww)	Maximum Tissue Concentration (mg/kg ww)
Aluminum	300	0.21	38	**352** [d]
Antimony	0.12	0.00044	0.0026	0.0081
Arsenic	0.28	0.025	0.053	0.14
Barium	62	0.0076	0.54	3.6
Beryllium	0.62	0.00050	0.0064	0.020
Boron	62	0.011	0.15	0.44
Cadmium	0.3	0.00020	0.0042	0.034
Chromium	394	0.016	0.29	0.72
Cobalt	0.092	0.0018	0.018	**0.097** [e]
Copper	12	0.16	0.41	0.74
Iron	220	1.5	34	**281** [f]
Lithium	0.62	0.0011	0.034	0.26
Manganese	44	0.10	1.1	9.5
Mercury	0.5 [b]	0.038	0.17	0.39
Molybdenum	1.5	0.0012	0.0086	0.035
Nickel	5.4	0.0026	0.24	1.2
Selenium	3.6 [c]	0.43	0.76	1.8
Silver	1.5	7.9E-05	0.0041	0.065
Strontium	186	0.057	0.60	2.8
Tin	186	0.00061	0.012	0.070
Uranium	0.92	2.6E-05	0.0016	0.015
Vanadium	1.6	0.00059	0.070	0.88
Zinc	92	3.2	7.6	16

Notes:
Summary statistics are from a sample size of 21 fish. Bold font indicates tissue concentration exceeds guideline value. All exceedances found in one fish tissue sample collected in 2014 from Lake Koocanusa at Elk River. There were no other exceedances in 2014 or 2015.
[a.] All constituent guidelines from USEPA Region 3, except for mercury and selenium
[b.] (BC MoE 2001)
[c.] (BC MoE 2012a); Value is based on moderate fish consumption rate
[d.] Second highest concentration is 212 mg/kg ww
[e.] Second highest concentration is 0.067 mg/kg ww
[f.] Second highest concentration is 168 mg/kg ww

Screening guideline values are unavailable for 16 constituents, bismuth, calcium, caesium, gallium, lead, magnesium, sodium, phosphorus, potassium, rhenium, rubidium, thallium, thorium, titanium, yttrium, and zirconium. Table 3 provides the maximum concentration for each constituent. A description explaining why a screening value was not available is also included. None of these constituents will be carried forward except for lead, which lacks a screening guideline but does have a toxicity reference value available for use in risk calculations.

Table 3: Constituents lacking screening guideline values

Analyte	Minimum Concentration (mg/kg ww)	Mean Concentration (mg/kg ww)	Maximum Concentration (mg/kg ww)	Description
Bismuth	0.00022	0.00087	0.0034	Limited oral bioavailability in people, used in laxatives, will not be evaluated in the risk characterization.
Caesium	0.011	0.044	0.13	Trace element for which no toxicity reference values have been established.
Calcium	68	421	1649	Essential macronutrient, not included in health risk assessments.
Gallium	0.0014	0.017	0.13	Trace element for which no toxicity reference values have been established.
Lead	0.0027	0.056	0.22	No screening value, but toxicity reference value is available. Will be evaluated in the risk characterization.
Magnesium	195	309	646	Essential macronutrient, not included in health risk assessments.
Phosphorus	1572	2407	4757	Essential macronutrient, not included in health risk assessments.
Potassium	2360	4066	8237	Essential macronutrient, not included in health risk assessments.
Rhenium	0.000012	0.00043	0.0018	Trace element for which no toxicity reference values have been established.
Rubidium	2.5	5.8	11	Trace element for which no toxicity reference values have been established.
Sodium	383	883	2491	Essential macronutrient, not included in health risk assessments.
Thallium	0.0019	0.0044	0.0095	Animal toxicity studies reported hair loss, generally reversible following cessation of exposure, but similar symptoms have not been reported in humans. USEPA (2009) concluded that weaknesses in the underlying database do not support quantitative toxicity assessment. Will not be evaluated in the risk characterization.
Thorium	0.000036	0.0088	0.071	Trace element for which no toxicity reference values have been established.
Titanium	0.023	0.56	3.5	Limited oral bioavailability in people, used as whitener in toothpaste, will not be evaluated in the risk characterization.
Yttrium	0.00024	0.016	0.18	Trace element for which no toxicity reference values have been established.
Zirconium	0.0011	0.024	0.19	Zirconium generally exhibits low toxicity and is often used in skin ointments and antiperspirants. USEPA (2012) determined that the available database is inadequate and does not support development of a zirconium toxicity reference values. Will not be evaluated in the risk characterization.

Notes:
Summary statistics are from a sample size of 21 fish.

1.2 Exposure Assessment

Exposures were calculated for the three constituents that exceeded screening values: aluminum, cobalt, and iron. Risks were also calculated for lead, for which a screening value was unavailable, and for selenium and mercury, which are constituents of interest to the community.

Exposure to constituents in burbot tissue was estimated for a Ktunaxa First Nations resident, including a toddler (seven months to four years), child (5 to 11 years), teenager (12 to 19 years), and adult (≥20 years). The average daily exposure rate for each of these life stages was calculated using exposure parameters from Table 4 and the following equation:

$$ADER = \frac{IR_f \times ED}{BW \times AP \times CF}$$

Where:

ADER = average daily exposure rate (kg_{fish}/kg_{BW}-day)
IR_f = fish ingestion rate (g/day wet weight)
ED = exposure duration (years)
BW = body weight (kg)
AP = averaging period (years)
CF = unit conversion factor (1000 g/kg)

Table 4: Fish ingestion exposure parameters for Ktunaxa resident

Exposure Factors	Units	Toddler	Child	Teenager	Adult
Fish Ingestion Rate (IR)	g_{fish}/day	13.4	23	31	43
Duration of Exposure (ED)	years	4.5	7	8	60
Body Weight (BW)	kg_{BW}	16.5	32.9	59.7	70.7
Averaging Period (AP)	years	4.5	7	8	60
Average Daily Fish Ingestion Exposure Rate (ADER)	kg_{fish}/kg_{BW}/day	8.1E-04	7.0E-04	5.1E-04	6.1E-04

For a Ktunaxa resident, the 95th percentile fish consumption rate for consumers (43 g/day) reported in the Ktunaxa Diet Study (The Firelight Group 2013) was applied to estimate the adult exposure rate. The consumer-only fish consumption rate was selected because this evaluation focuses on one pathway only; intakes via other media are not included (e.g., air, soil, dust, water). When multiple exposure pathways are assessed, use of a consumer-only value may not be appropriate. This consumption rate is conservative when compared to the Health Canada published fish consumption rates, as well as consumption rates for the larger Ktunaxa population that includes residents who do not consume fish, summarized in Table 5.

Table 5: Fish consumption estimates and sources

Source	Population	Consumption Rate[a] (g/day, ww)
Ktunaxa Diet Study, Firelight Group (2013)	Ktunaxa Adult Consumer (95th percentile)	43
	Ktunaxa Adult Consumer (Average)	10
	Ktunaxa Adult Consumer & Non-consumers (95th percentile)	22
	Ktunaxa Adult Consumer & Non-consumers (Average)	4.6
Health Canada (2007)	General Canadian Adult	21
	Canadian Adult High Fish Consumer	40
USEPA (2014)	General US Adult	54

Notes:
g/day, ww = grams of fish tissue per day, as wet weight

a. Fish consumption rates are derived by dividing the total amount of fish consumed in a year by the number of days per year. Because most people do not consume fish every day, the consumption rates listed are less than a single meal size portion of fish. The listed values are for fish all species combined.

The fish consumption rates provided in Table 5 represent all fish, which would include burbot among many other fish species consumed by Ktunaxa Nation members and other Elk Valley residents. The consumption rate for burbot only is 11.4 grams per day for the 95th percentile of Ktunaxa burbot consumers, which is roughly one-fourth that of the total fish consumption rate. Use of the consumption rate for all fish is a conservative initial assessment of Lake Koocanusa burbot consumption. In addition to assuming that all fish consumed are burbot, this analysis also assumes that all burbot consumed are from Lake Koocanusa. These assumptions will over-represent exposure to constituents from Lake Koocanusa burbot for most individuals who consume a variety of fish species harvested from multiple locations throughout Elk Valley.

Because the Ktunaxa diet study examined only rates of ingestion for adults, the adult ingestion rate was adjusted using the relative ingestion rates for different life stages, following Richardson (1997). The maximum average daily exposure rate estimated from among the toddler, child, teenager, and adult residents was selected for risk characterization because the life stage with the maximum exposure is protective of all other life stages. As shown in Table 4, the toddler has the highest calculated average daily exposure rate.

The fish tissue concentrations, referred to as exposure point concentrations, are the 95% upper confidence limit of the mean (UCLM) concentrations. U.S. EPA software, ProUCL, (2013, version 5.0) calculates the UCLM for a constituent and requires adequate sample size (>10 samples), distinct observations, and some detected concentrations, i.e., 100% of the samples cannot be below the detection limit. ProUCL was configured to generate all UCLM types (parametric and non-parametric) with 10,000 bootstrap operations. All tissue data collected from Lake Koocanusa were combined to estimate exposure point concentrations because people are assumed to harvest fish from multiple locations within the Lake and also, fish are mobile and are not confined to a fixed location. Data for years 2014 and 2015 were combined to create a sample size that would support UCLM calculations (i.e., minimum sample size should be at least 10 samples). UCLM concentrations recommended by ProUCL are listed in Table 6.

Table 6: Exposure point concentrations

Constituent	N	Minimum (mg/kg)	Maximum (mg/kg)	Mean (mg/kg)	UCLM[a] (mg/kg)
Aluminum	21	0.21	352	38	120
Cobalt	21	0.0018	0.097	0.018	0.041
Iron	21	1.5	281	34	98
Lead	21	0.0027	0.22	0.056	0.088
Mercury	21	0.038	0.39	0.17	0.22
Selenium	21	0.43	1.8	0.76	0.86

Notes:
[a.] For aluminum, cobalt, and iron, the recommended UCLM is the 95 percent Chebyshev. For lead, mercury, and selenium, the UCLM is the 95 percent adjusted gamma.

1.3 Risk Estimates

Risks were calculated for aluminum, cobalt, iron, lead, selenium, and mercury. As none of these constituents are known to cause cancer, only noncancer health risks were calculated. This calculation requires multiplying the average daily exposure rate by the exposure point concentration and dividing by a toxicity reference value. This yields a noncancer hazard quotient (HQ). An HQ equal to or less than one indicates that no adverse health effects are expected from exposure to the constituent. A hazard quotient greater than one does not mean that adverse health effects will occur, but indicates that further evaluation is needed.

The toxicity reference values applied in the HQ calculations were selected based on a hierarchy of sources outlined in BC MoE risk assessment guidance (BC MoE 2012b). See Table 7 for each toxicity reference value along with the target organ or critical effect associated with each constituent.

Table 7: Chronic toxicity reference values (TRV)

Constituent	Chronic Oral TRV (mg/kg-day)	Target Organ/Critical Effect (Source)
Aluminum	1	Neurological (USEPA 2006a)
Cobalt	0.0003	Thyroid (USEPA 2008)
Iron	0.7	GI tract (USEPA 2006b)
Lead	0.0013	Developmental, decreased IQ (SNC-Lavalin 2012)
Mercury	0.0003	Nephrotoxicity (Health Canada 2010)
Selenium	0.0057	Skin (clinical selenosis) (Health Canada 2010)

Results show that for a Ktunaxa toddler, assuming a 95th percentile total fish consumption rate, HQs are all below 1 and the potential for noncancer health effects is low (see Table 8). HQs for the three constituents for which the screening guidelines were exceeded, aluminum, cobalt, and iron, and for lead, for which a screening guideline was not available, are below BC MoE's noncancer threshold of 0.2. The threshold of 0.2 is applied by BC MoE when risks are evaluated for only one exposure pathway and the magnitude of exposure via other pathways (e.g., soil and water ingestion, dermal contact, and inhalation) is unknown. The HQ for selenium, which did not exceed the screening guideline, also is below BC MoE's noncancer threshold of 0.2 when evaluating a single exposure pathway.

Table 8: Hazard quotients for Ktunaxa toddler resident (7 months to 4 years)

Constituent	Hazard Quotient
Aluminum	0.1
Cobalt	0.1
Iron	0.1
Lead	0.05
Mercury	0.6
Selenium	0.1

Although the maximum tissue concentration of mercury did not exceed the screening guideline, risks were calculated for mercury because it is of interest to the community. The HQ calculated for mercury exceeds BC MoE's noncancer threshold of 0.2, but is below the target HQ of 1.0 used to assess risks for multiple pathways. For mercury consumption from fish, an HQ of 1.0 is the most appropriate threshold for evaluating risks because fish consumption is the dominant pathway for mercury intake. Mercury intake via other pathways, such as soil and water ingestion and inhalation, is negligible (Health Canada 2007).

The burbot tissue HQs listed in Table 8 indicate a low potential for noncancer health effects when assuming all fish consumed by Ktunaxa toddlers is burbot harvested from Lake Koocanusa. If other local fish do not exceed the concentrations of constituents reported in burbot, risks for all fish would be lower than those reported above. If the estimated 95th percentile fish consumption rate for burbot-only were employed (which is approximately one-fourth of the total fish consumption rate), the HQs associated with consumption of burbot only by Ktunaxa toddlers would be approximately one-fourth those shown above (0.01 for lead, 0.2 for mercury, and 0.03 for all other constituents).

1.4 Conclusions

Consumption of burbot from Lake Koocanusa does not pose a risk of adverse health effects for high fish consuming Ktunaxa or for other fish consumers. The maximum concentration of three constituents (aluminum, cobalt, iron) exceeded screening guideline values protective of fish consumption; however, risks calculated for these three constituents did not exceed BC MoE's noncancer threshold of 0.2 for assessment of a single exposure pathway. Risk estimates were also calculated for lead, selenium, and mercury. Risks for lead and selenium also did not exceed BC MoE's noncancer threshold of 0.2. The noncancer risk for mercury was 0.6, which is below the threshold of 1.0, used when evaluating risks via multiple exposure pathways. Consideration of this threshold is appropriate when evaluating mercury intake via fish consumption because intake via other pathways is negligible. Additionally, when using a Ktunaxa burbot-only fish consumption rate mercury risks do not exceed the BC MoE noncancer threshold of 0.2.

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APPENDIX F
SELECTION OF MARKET BASKET DATA FOR SELENIUM

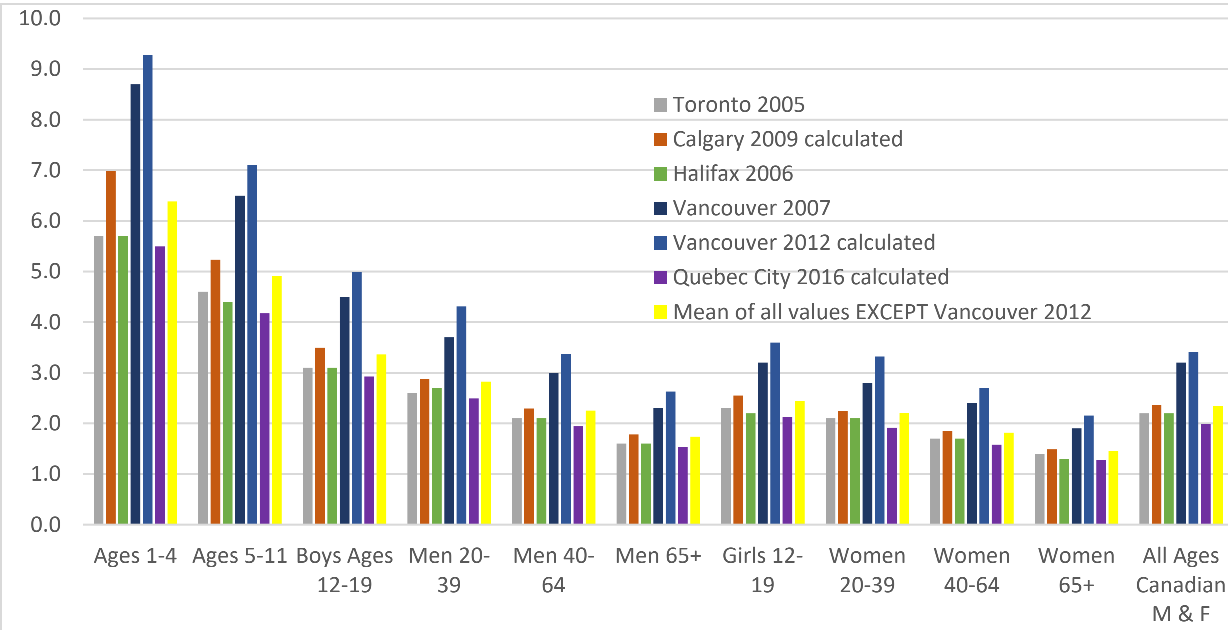
Selection of Market Basket Data for Selenium

Commercial foods and consumer products can lead to exposures of COPCs in addition to those associated with mining activity. Quantifying background exposures is important to understanding the context of mine-related exposures. The 2016 HHRA (Ramboll Environ 2016) included consideration of market basket foods based on the average daily intakes for selenium as provided in the Canadian Total Diet Study. The Canadian Total Diet Study provides consumption rates as micrograms of selenium per kilogram of bod weight per day (µg/kg-day) for residents of various inland and coastal cities, by gender and age groupings. Available information for BC First Nations diets rely heavily on coastal populations which consume much higher quantities of marine fish and shellfish, which would not be relevant to interior populations. The 2016 HHRA incorporated market basket intake data for Toronto, which was selected to reflect an inland diet rather than a coastal diet. This approach was consistent with advice received from the Elk Valley Water Quality Plan Technical Advisory Committee. The 2016 HHRA identified a hazard index of 1 associated with exposure to selenium in market basket foods. In addition, there were concerns regarding the representativeness of the Toronto dietary data to represent Elk Valley resident or Ktunaxa exposures. Due to concerns regarding representativeness of the Toronto data and the finding that the hazard index for market basket foods was 1, selenium intake from the market basket is explored further here.

Market basket intake of selenium was further explored in HHRA Workgroup discussions on HHRA Workgroup calls in 2019. This appendix provides the details regarding analyses and discussions conducted during those calls that led to the decision to base market basket exposures on an average from all Canadian cities except the 2012 data for Vancouver. This appendix provides detail on the decision to exclude the Vancouver 2012 data and why a nationwide estimate was identified as most representative of market basket foods. Figure F-1 shows total selenium intake in µg/kg by age group for Canadian cities with selenium market basket data and an average concentration for all Canadian cities excluding the Vancouver 2012 data.

Market basket estimates will be included in the HHRA to provide context for site related exposure estimates and to more fully evaluate selenium exposure. The Canadian Diet Study intake rates account for consumption of foods from all food categories, grains, dairy, meat products, processed foods, fruits, vegetables, and more. To avoid double-counting intakes from store-bought foods in the market basket study that may instead be harvested locally by Elk Valley residents, trace element intakes associated with meat, freshwater fish, and berries will be removed from total market basket intakes.

The first section here provides detail regarding the selection of Canadian cities for use in evaluating market basket intake. The next section discuses work done to better understand the degree to which foods in Elk Valley Markets are locally sourced. The final section of this appendix provides conclusions.



Note: The intakes for Toronto, Halifax and Vancouver 2007 are from the Health Canada website, while the intakes for Calgary, Quebec City and Vancouver 2012 were calculated from the individual food data using the same method used by Health Canada.

Figure F-1: Selenium Intake in µg/kg-day by age group in Canadian Cities

Determination of the appropriate cities for use in estimating market basket selenium intake

Data from the Canadian Diet Study (Health Canada 2009, 2011) was collected and intake data for selenium was compiled for Toronto (2005), Calgary (2009), Halifax (2006), Vancouver (2007, 2012), Quebec City (2016). For some cities, intake by food and by age was available, in other cases the selenium concentrations in the foods were available and the total intake by age group in µg/kg-day was calculated using dietary intakes of foods (Toronto 2005, Calgary 2009, Vancouver 2012, Quebec City 2016). Data were also evaluated to determine which foods made the greatest contribution to dietary selenium and it was determined that bread, eggs, milk, poultry, pork, and beef were primary contributors in all groups and were the top contributors for children ages 1 to 4. In reviewing the data, it was apparent that data from Vancouver (2007 and 2012) were consistently higher than data from other cities. This was discussed during Workgroup calls and it was determined that Lisa Yost from Ramboll would reach out to Dr. Dabeka, a senior research scientist at Health Canada with extensive experience in the analysis of metals in foods. The following is a summary of the email interactions with Dr. Dabeka.

Lisa Yost provided Figure F-2 to Dr. Dabeka by email 25 March 2019 with this question:

> *"In particular, we note that data from Vancouver are consistently higher across food groups in both the 2007 dataset and the 2012 dataset. We are wondering if you might have any ideas about why this is so and how a community in SE BC may be best represented by the existing datasets. I have attached a graphic showing what we have found looking into the different datasets. "*

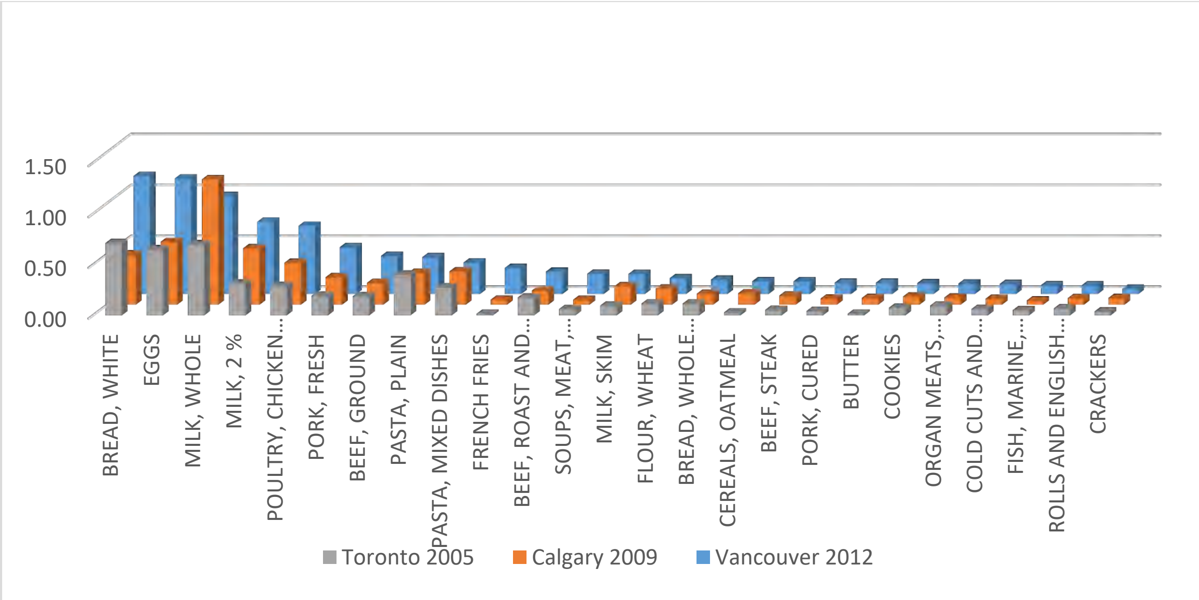


Figure F-2 Top Foods Contributing to Selenium Intake (µg/kg-day) in Children Ages 1-4 Years (Ranking Based on Vancouver)

Dr. Dabeka's response follows:

> *"Hi Lisa. The selenium levels in Vancouver TDS milk from 2007 and 2012 are higher than most other cities. While this could easily be due to both the regular diet of BC cattle and the supplements given them, there is also the possibility of analytical variance due to set-up of the ICPMS instrument (Se is extremely sensitive to this), and it is not easily identified in quality control results. Based on the graph you provided me, there appears to be general increase in the levels of Se in 2012 compared with 2007 and other years, which extend beyond dairy products. For this reason I would treat the 2012 Se data with scepticism."*
>
> *"In answer to your question about how to deal with this in terms of a specific community in BC, I would use either the 2007 data alone, or I would even use an average of the 2005-2011 data to give you a baseline dietary Se. If you need a more accurate estimate of dietary intake, you would need to conduct additional analysis of local Se-rich foods, including milk. The TDS was designed to give only approximate dietary intake values. If these point to a possible health hazard, then additional data are needed to refine the intake (using for example local food consumption values and additional surveys of local products."*

In discussion within the HHRA Workgroup regarding this feedback, the question came up about whether the selenium analyses were from single or multiple labs. Lisa Yost sent an additional email to Dr. Dabeka on 19 April 2019, which is reproduced here:

> *"Dear Dr. Dabeka;*
>
> *We are still working through questions of dietary intake of selenium and trying to determine which dataset(s) might best represent an inland BC population. I have attached the figure I sent with my prior email and a second figure that shows total intake by age groups in various cities (now including Quebec City). One*

question that came up in our discussion, was whether the selenium analysis for samples collected from various cities are all analyzed in the same lab, or whether selenium analyses are sent off to more than one lab. What I have gleaned so far from the Health Canada web site suggests that all analyses go off first to Kemptville college for preparation and then to Health Canada laboratories for analysis. So here's our question:

1. *Are selenium analyses in the total diet study conducted in a single lab or multiple labs?*
2. *If analyses are conducted in multiple labs might that account for higher concentrations seen across food groups in Vancouver in 2012 (or, lower concentrations across food groups in other cities)? If so, is there a good way to know whether the Vancouver 2012 outcomes are over-representing true concentrations, or the other city results are under-representing true selenium concentrations?*

Any advice or thoughts are welcome."

"Here is the background for my assumptions regarding Kemptville College and Health Canada laboratories in Ottawa.

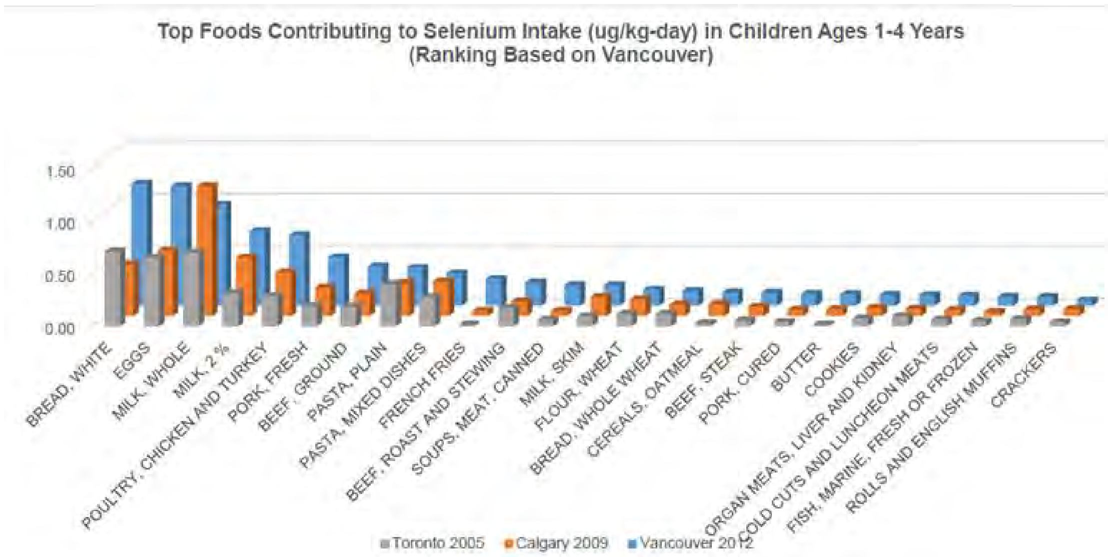
I see from the Health Canada web site that foods from all collection locations are sent to Kemptville College for preparation. (see link and quote 1)."

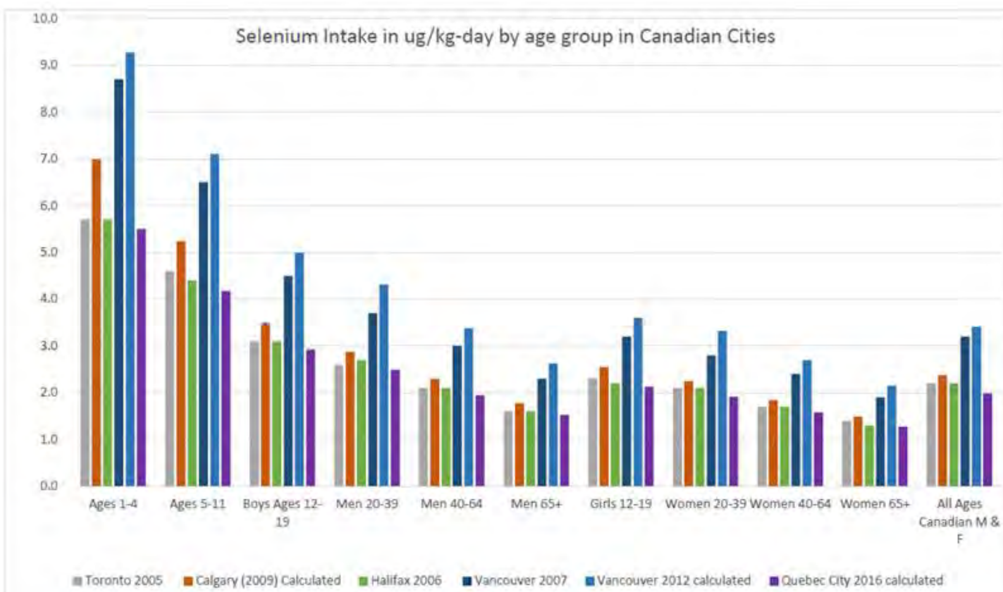
> *"For each city, each individual food item tested (there are about 210 individual food items for the current Canadian Total Diet Study) is purchased from three to four different supermarkets. Food samples are sent to Kemptville College where they are prepared and processed as they 'would be consumed' in the average household kitchen (i.e., raw meats are cooked; fresh vegetables cooked or properly peeled, trimmed or otherwise cleaned for serving if not cooked). These processed foods are then mixed according to each category to make composites (there are over 140 different food composites in the current study). All food composites are analysed for the presence of toxic and nutritionally important chemicals." [Emphasis added]*
>
> https://www.canada.ca/en/health-canada/services/food-nutrition/food-nutrition-surveillance/canadian-total-diet-study.html

Looking at the website for Kemptville campus, it appears that after preparation samples are sent on the Health Canada laboratories in Ottawa for analysis.

> *"Purchased foods are shipped to Forbes at the Kemptville campus. Her staff prepare the food, anything from roast beef to raisin pies, as it would normally be prepared in a household. Composite samples are then bottled, labeled and catalogued before being packed and sent to Health Canada laboratories in Ottawa to be analyzed for contaminants. "[Emphasis added]*
>
> https://news.uoguelph.ca/2010/07/she-knows-what-you-put-in-your-grocery-cart/

Here are the two figures I mentioned:





Note: The intakes for Toronto, Halifax and Vancouver 2007 are from the Health Canada website, while the intakes for Calgary, Quebec City and Vancouver 2012 were calculated from the individual food data using the same method used by Health Canada.

"Are selenium analyses in the total diet study conducted in a single lab or multiple labs?"

"If analyses are conducted in multiple labs might that account for higher concentrations seen across food groups in Vancouver in 2012 (or, lower concentrations across food groups in other cities)?"

> *"If so, is there a good way to know whether the Vancouver 2012 outcomes are over-representing true concentrations, or the other city results are under-representing true selenium concentrations?"*

Lisa Yost received a reply from Dr. Dabeka on 21 April 2019 as follows:

> *"In answer to your questions the 2000-2012 results were all analysed for trace elements in our Quebec regional laboratory in Longueuil.*
>
> - *They used the same highly competent analysts over that period, so I wouldn't expect any changes due to analysts.*
> - *After 2012, the TDS samples have been analysed in our own Food Research Division laboratory in Ottawa."*
>
> *"Any differences in concentrations found between 2000 and 2012 years can be due to 2 factors.*
>
> 1. *Real differences.*
> 2. *Improper set-up of the ICPMS collision cell gas. This would result in consistently high levels of Se found for all the samples, but they would be most apparent in foods which have typically low Se concentrations. The error would not be picked up using standard quality control measures. In other words, it is possible to periodically get unusually high concentrations for this reason, but also it would be extremely unusual for any laboratory to produce Se concentrations consistently below the true concentrations. I can also affirm that the method applied to the analysis of the samples was accredited by the Standards Council of Canada, and one of the procedural steps includes, when setting up the instrument for analysis each day, specific collision cell gas adjustments and response criteria which must be met which would eliminate this specific error."*

Thus, the reply from Dr. Dabeka ruled out laboratory inconsistencies as a basis for observed differences in the analytical results.

Evaluations regarding how much of Elk Valley market basket foods are locally sourced

Further analyses were also carried out to evaluate the degree to which Elk Valley market basket foods are locally sourced. Lisa Yost contacted local grocery stores introducing herself as a public health specialist helping Teck understand the sources of foods in local groceries. Lisa asked questions regarding whether food was distributed form warehouses or from local sources and asked specific questions regarding sourcing of meats, eggs, breads and fish. A number of groceries were contacted and three were interviewed. Table F-1 summarizes the discussions with the following grocers:

- Save-On Foods managers in Sparwood and Fernie
- Kootenay Market in Elkford

Appendix Table F-1: Sourcing of Foods in Three Elk Valley Groceries

Question:	Grocery 1	Grocery 2	Grocery 3

How much of your food comes from Elk Valley?	Almost None	Almost None	Almost None
Where is your primary distribution center located?	Kruger, Purex, Western Family Products distribution facilities- not in Elk Valley.	Edmonton, Alberta	Associated Grocers or Sobees (depending on varying prices) in Calgary, Alberta
Foods from Primary Distribution Center	Meats, eggs, breads, from Alberta	'All products'	Meats, eggs, breads, fruits, vegetables
Other Distribution Center?	Indicated milk was from a 'large distribution center with many farms contributing'	None noted	• Milk from Kootenay Meadows • Fish from Canadian Fisheries in Vancouver* • 180 suppliers, Canada, Europe, US and elsewhere

Based on interviews from primary grocers in Elk Valley, it was concluded that food is not sourced from Elk Valley and instead comes primarily from large distribution centers in Alberta, which obtain food from Alberta and from other Canadian and international sources. Sources of food change over time and season with availability and price.

Conclusions

Based on the finding that few if any foods are sourced locally and instead foods are sourced federally and internationally, Total Diet Study data from across Canada best represent market basket foods. It was determined by the HHRA Workgroup that market basket analyses for selenium will be based on an average of data from 2005 to 2016. Data from Vancouver 2012 will be excluded from the average, but data from Vancouver 2007 will be included.

APPENDIX G
EXPOSURE POINT CONCENTRATIONS

Table G-1a. Groundwater exposure point concentrations by MU

MU	Constituent	Sample Size	Percent Detect	Method for Calculating Exposure Point Concentration	Exposure Point Concentration (mg/L)
MU-3	Iron	30	7%	95% KM (t) UCL	1.06E-02
MU-3	Lithium	30	100%	95% Chebyshev (Mean, Sd) UCL	6.19E-03
MU-3	Manganese	30	53%	95% KM (t) UCL	2.35E-04
MU-3	Selenium	46	100%	95% Student's-t UCL	2.90E-03
MU-4	Iron	109	25%	95% KM (Chebyshev) UCL	4.11E-01
MU-4	Lithium	109	99%	95% KM (Chebyshev) UCL	1.39E-02
MU-4	Manganese	109	63%	95% KM (Chebyshev) UCL	4.45E-02
MU-4	Selenium	153	98%	95% KM (Chebyshev) UCL	9.14E-03
MU-5	Iron	66	29%	95% KM (Chebyshev) UCL	9.38E-02
MU-5	Lithium	66	98%	95% KM (t) UCL	1.14E-02
MU-5	Manganese	66	86%	KM H-UCL	1.37E-02
MU-5	Selenium	91	96%	95% KM (t) UCL	7.24E-03
Valley Wide (MU 3-5)	Iron	36	23%	95% KM (Chebyshev) UCL	2.32E-01
Valley Wide (MU 3-5)	Lithium	94	99%	95% KM (Chebyshev) UCL	1.20E-02
Valley Wide (MU 3-5)	Manganese	113	69%	95% KM (Chebyshev) UCL	4.75E-02
Valley Wide (MU 3-5)	Selenium	227	98%	95% KM (Chebyshev) UCL	7.57E-03

Notes:

mg/L – milligrams per liter
MU – management unit
UCL - upper confidence limit

Concentrations reported are for dissolved fraction.

The HHRA dataset does not include wells located in MUs 1, 2, or 6.

Table G-1b. Groundwater exposure point concentrations by well (Uncertainty Analysis)

MU	Deidentified Well ID	Constituent	Sample Size	Percent Detect	Method for Calculating Exposure Point Concentration	Exposure Point Concentration (mg/L)
MU-4	Well-01	Lithium	1	100%	Maximum detected concentration	4.80E-03
MU-4	Well-01	Manganese	1	100%	Maximum detected concentration	6.80E-04
MU-4	Well-01	Selenium	2	100%	Maximum detected concentration	6.36E-03
MU-4	Well-02	Lithium	17	94%	95% KM (t) UCL	5.36E-03
MU-4	Well-02	Manganese	17	35%	95% KM Adjusted Gamma UCL	1.90E-04
MU-4	Well-02	Selenium	19	100%	95% Chebyshev (Mean, Sd) UCL	1.21E-02
MU-4	Well-03	Selenium	4	100%	Maximum detected concentration	1.22E-02
MU-4	Well-04	Selenium	1	100%	Maximum detected concentration	1.12E-02
MU-4	Well-05	Iron	15	7%	Maximum detected concentration	1.74E-01
MU-4	Well-05	Lithium	15	100%	95% Modified-t UCL	1.16E-02
MU-4	Well-05	Manganese	15	100%	95% Chebyshev (Mean, Sd) UCL	1.84E-02
MU-4	Well-05	Selenium	23	100%	95% Student's-t UCL	1.17E-02
MU-4	Well-06	Lithium	29	100%	95% Student's-t UCL	5.98E-03
MU-4	Well-06	Manganese	29	17%	95% KM (t) UCL	1.47E-04
MU-4	Well-06	Selenium	35	100%	95% Student's-t UCL	9.67E-03
MU-4	Well-07	Lithium	2	100%	Maximum detected concentration	5.60E-03
MU-4	Well-07	Manganese	2	50%	Maximum detected concentration	1.73E-03
MU-4	Well-07	Selenium	8	100%	95% Student's-t UCL	8.77E-03
MU-4	Well-08	Selenium	2	50%	Maximum detected concentration	5.60E-05
MU-4	Well-09	Lithium	1	100%	Maximum detected concentration	2.70E-03
MU-4	Well-09	Manganese	1	100%	Maximum detected concentration	4.60E-04
MU-4	Well-09	Selenium	1	100%	Maximum detected concentration	9.68E-04
MU-4	Well-10	Lithium	1	100%	Maximum detected concentration	4.10E-03
MU-4	Well-10	Manganese	1	100%	Maximum detected concentration	1.30E-04
MU-4	Well-10	Selenium	1	100%	Maximum detected concentration	9.97E-04
MU-4	Well-11	Lithium	2	100%	Maximum detected concentration	3.00E-03
MU-4	Well-11	Selenium	2	100%	Maximum detected concentration	2.60E-03
MU-4	Well-12	Lithium	1	100%	Maximum detected concentration	1.30E-03
MU-4	Well-12	Manganese	1	100%	Maximum detected concentration	1.24E-02
MU-4	Well-12	Selenium	1	100%	Maximum detected concentration	4.38E-04
MU-4	Well-13	Lithium	1	100%	Maximum detected concentration	3.40E-03
MU-4	Well-13	Manganese	1	100%	Maximum detected concentration	5.00E-04
MU-4	Well-13	Selenium	1	100%	Maximum detected concentration	1.51E-03
MU-4	Well-14	Lithium	1	100%	Maximum detected concentration	3.40E-03
MU-4	Well-14	Manganese	1	100%	Maximum detected concentration	3.87E-03
MU-4	Well-14	Selenium	1	100%	Maximum detected concentration	1.74E-03

Table G-1b. Groundwater exposure point concentrations by well (Uncertainty Analysis)

MU	Deidentified Well ID	Constituent	Sample Size	Percent Detect	Method for Calculating Exposure Point Concentration	Exposure Point Concentration (mg/L)
MU-4	Well-15	Lithium	1	100%	Maximum detected concentration	2.60E-03
MU-4	Well-15	Selenium	1	100%	Maximum detected concentration	1.62E-03
MU-4	Well-16	Lithium	1	100%	Maximum detected concentration	4.30E-03
MU-4	Well-16	Manganese	1	100%	Maximum detected concentration	2.01E-01
MU-4	Well-16	Selenium	1	100%	Maximum detected concentration	3.29E-04
MU-4	Well-17	Lithium	1	100%	Maximum detected concentration	3.60E-03
MU-4	Well-17	Selenium	1	100%	Maximum detected concentration	1.42E-03
MU-4	Well-18	Iron	1	100%	Maximum detected concentration	1.54E-01
MU-4	Well-18	Lithium	1	100%	Maximum detected concentration	4.50E-03
MU-4	Well-18	Manganese	1	100%	Maximum detected concentration	7.27E-02
MU-4	Well-19	Iron	1	100%	Maximum detected concentration	7.58E+00
MU-4	Well-19	Lithium	1	100%	Maximum detected concentration	5.70E-03
MU-4	Well-19	Manganese	1	100%	Maximum detected concentration	1.22E-01
MU-4	Well-20	Iron	12	100%	95% Student's-t UCL	9.36E-02
MU-4	Well-20	Lithium	12	100%	95% Student's-t UCL	2.08E-02
MU-4	Well-20	Manganese	12	100%	95% Student's-t UCL	1.64E-01
MU-4	Well-20	Selenium	18	100%	95% Student's-t UCL	1.83E-04
MU-4	Well-21	Lithium	1	100%	Maximum detected concentration	6.60E-03
MU-4	Well-21	Manganese	1	100%	Maximum detected concentration	1.10E-04
MU-4	Well-21	Selenium	1	100%	Maximum detected concentration	1.51E-03
MU-4	Well-22	Lithium	1	100%	Maximum detected concentration	7.50E-03
MU-4	Well-22	Manganese	1	100%	Maximum detected concentration	2.00E-04
MU-4	Well-22	Selenium	1	100%	Maximum detected concentration	1.11E-03
MU-4	Well-23	Iron	13	85%	95% KM (t) UCL	1.74E-01
MU-4	Well-23	Lithium	13	100%	95% Student's-t UCL	2.61E-02
MU-4	Well-23	Manganese	13	100%	95% Student's-t UCL	1.45E-02
MU-4	Well-23	Selenium	21	100%	95% Student's-t UCL	9.97E-03
MU-4	Well-24	Iron	3	33%	Maximum detected concentration	1.50E-02
MU-4	Well-24	Lithium	3	100%	Maximum detected concentration	2.38E-02
MU-4	Well-24	Manganese	3	100%	Maximum detected concentration	2.46E-03
MU-4	Well-24	Selenium	3	100%	Maximum detected concentration	1.37E-02
MU-4	Well-25	Lithium	3	100%	Maximum detected concentration	2.53E-02
MU-4	Well-25	Manganese	3	100%	Maximum detected concentration	8.69E-03
MU-4	Well-25	Selenium	3	100%	Maximum detected concentration	1.52E-02
MU-5	Well-26	Lithium	13	100%	95% Student's-t UCL	9.58E-03
MU-5	Well-26	Manganese	13	46%	95% KM (t) UCL	2.43E-04

Table G-1b. Groundwater exposure point concentrations by well (Uncertainty Analysis)

MU	Deidentified Well ID	Constituent	Sample Size	Percent Detect	Method for Calculating Exposure Point Concentration	Exposure Point Concentration (mg/L)
MU-5	Well-26	Selenium	15	100%	95% Student's-t UCL	1.20E-02
MU-5	Well-27	Lithium	1	100%	Maximum detected concentration	1.24E-02
MU-5	Well-27	Manganese	1	100%	Maximum detected concentration	1.15E+00
MU-5	Well-27	Selenium	1	100%	Maximum detected concentration	1.47E-03
MU-5	Well-28	Iron	11	27%	95% KM (t) UCL	1.29E-02
MU-5	Well-28	Lithium	11	100%	95% Modified-t UCL	9.27E-03
MU-5	Well-28	Manganese	11	82%	95% KM (Chebyshev) UCL	3.94E-03
MU-5	Well-28	Selenium	15	100%	95% Student's-t UCL	1.03E-02
MU-5	Well-29	Selenium	2	100%	Maximum detected concentration	1.60E-03
MU-5	Well-30	Selenium	1	100%	Maximum detected concentration	4.51E-03
MU-5	Well-31	Iron	1	100%	Maximum detected concentration	6.46E-01
MU-5	Well-31	Lithium	1	100%	Maximum detected concentration	1.11E-02
MU-5	Well-31	Manganese	1	100%	Maximum detected concentration	2.79E-01
MU-5	Well-32	Iron	3	33%	Maximum detected concentration	1.10E-02
MU-5	Well-32	Lithium	3	100%	Maximum detected concentration	6.60E-03
MU-5	Well-32	Manganese	3	100%	Maximum detected concentration	1.63E-03
MU-5	Well-32	Selenium	6	100%	95% Student's-t UCL	7.27E-03
MU-5	Well-33	Selenium	2	100%	Maximum detected concentration	8.30E-04
MU-5	Well-34	Iron	1	100%	Maximum detected concentration	2.89E-01
MU-5	Well-34	Lithium	1	100%	Maximum detected concentration	1.15E-01
MU-5	Well-34	Manganese	1	100%	Maximum detected concentration	1.46E-02
MU-5	Well-35	Iron	1	100%	Maximum detected concentration	2.80E-02
MU-5	Well-35	Lithium	1	100%	Maximum detected concentration	5.90E-03
MU-5	Well-35	Manganese	1	100%	Maximum detected concentration	1.68E-02
MU-5	Well-35	Selenium	1	100%	Maximum detected concentration	6.60E-03
MU-5	Well-36	Lithium	1	100%	Maximum detected concentration	6.10E-03
MU-5	Well-36	Manganese	1	100%	Maximum detected concentration	4.72E-03
MU-5	Well-36	Selenium	1	100%	Maximum detected concentration	6.47E-03
MU-5	Well-37	Selenium	2	100%	Maximum detected concentration	7.70E-04
MU-5	Well-38	Selenium	1	100%	Maximum detected concentration	7.60E-04
MU-5	Well-39	Iron	12	33%	95% KM (t) UCL	1.05E-02
MU-5	Well-39	Lithium	12	100%	95% Student's-t UCL	6.80E-03
MU-5	Well-39	Manganese	12	100%	95% Student's-t UCL	1.16E-03
MU-5	Well-39	Selenium	15	100%	95% Student's-t UCL	7.91E-03
MU-5	Well-40	Selenium	3	100%	Maximum detected concentration	3.56E-03
MU-5	Well-41	Iron	2	50%	Maximum detected concentration	1.20E-02

Table G-1b. Groundwater exposure point concentrations by well (Uncertainty Analysis)

MU	Deidentified Well ID	Constituent	Sample Size	Percent Detect	Method for Calculating Exposure Point Concentration	Exposure Point Concentration (mg/L)
MU-5	Well-41	Lithium	2	100%	Maximum detected concentration	5.70E-03
MU-5	Well-41	Manganese	2	100%	Maximum detected concentration	6.30E-04
MU-5	Well-41	Selenium	2	100%	Maximum detected concentration	1.34E-03
MU-5	Well-42	Iron	10	20%	95% KM (Chebyshev) UCL	2.49E-02
MU-5	Well-42	Lithium	10	100%	95% Student's-t UCL	6.60E-03
MU-5	Well-42	Manganese	10	100%	95% Student's-t UCL	8.17E-03
MU-5	Well-42	Selenium	10	100%	95% Student's-t UCL	9.79E-03
MU-5	Well-43	Lithium	1	100%	Maximum detected concentration	1.20E-03
MU-5	Well-43	Manganese	1	100%	Maximum detected concentration	3.90E-04
MU-5	Well-43	Selenium	1	100%	Maximum detected concentration	6.60E-04
MU-5	Well-44	Lithium	1	100%	Maximum detected concentration	5.70E-03
MU-5	Well-44	Manganese	1	100%	Maximum detected concentration	1.46E-03
MU-5	Well-44	Selenium	1	100%	Maximum detected concentration	4.11E-03
MU-5	Well-45	Iron	1	100%	Maximum detected concentration	4.71E-01
MU-5	Well-45	Lithium	1	100%	Maximum detected concentration	4.60E-03
MU-5	Well-45	Manganese	1	100%	Maximum detected concentration	1.62E-02
MU-5	Well-45	Selenium	1	100%	Maximum detected concentration	2.36E-03
MU-5	Well-46	Iron	1	100%	Maximum detected concentration	2.81E-01
MU-5	Well-46	Manganese	1	100%	Maximum detected concentration	1.83E-02
MU-5	Well-46	Selenium	1	100%	Maximum detected concentration	1.62E-04
MU-5	Well-47	Iron	2	100%	Maximum detected concentration	1.60E-02
MU-5	Well-47	Lithium	2	100%	Maximum detected concentration	6.80E-03
MU-5	Well-47	Manganese	2	100%	Maximum detected concentration	2.16E-03
MU-5	Well-47	Selenium	2	100%	Maximum detected concentration	5.61E-03
MU-5	Well-48	Iron	2	50%	Maximum detected concentration	1.30E-02
MU-5	Well-48	Lithium	2	100%	Maximum detected concentration	4.80E-03
MU-5	Well-48	Manganese	2	100%	Maximum detected concentration	1.33E-03
MU-5	Well-48	Selenium	2	100%	Maximum detected concentration	4.56E-03
MU-5	Well-49	Lithium	2	100%	Maximum detected concentration	4.70E-03

Table G-1b. Groundwater exposure point concentrations by well (Uncertainty Analysis)

MU	Deidentified Well ID	Constituent	Sample Size	Percent Detect	Method for Calculating Exposure Point Concentration	Exposure Point Concentration (mg/L)
MU-5	Well-49	Manganese	2	100%	Maximum detected concentration	2.01E-03
MU-5	Well-49	Selenium	2	100%	Maximum detected concentration	6.75E-03

Notes:

mg/L – milligrams per liter
MU – management unit
UCL - upper confidence limit

Concentrations reported are for dissolved fraction.

The dataset does not include wells located in MUs 1, 2, 3, or 6.

The maximum detected concentration was used as the exposure point concentration if the calculated 95% UCL was greater than the maximum detected concentration or if a 95% UCL could not be calculated due to limited detections.

Table G-2. Surface water exposure point concentrations

MU	Constituent	Sample Size	Percent Detect	Method for Calculating Exposure Point Concentration	Exposure Point Concentration (mg/L)
MU1-5	Aluminum	6746	92%	95% KM (Chebyshev) UCL	1.6E-01
MU1-5	Antimony	6746	68%	95% KM (Chebyshev) UCL	3.4E-04
MU1-5	Arsenic	6746	91%	95% KM (Chebyshev) UCL	2.9E-04
MU1-5	Barium	6746	100%	95% KM (t) UCL	9.3E-02
MU1-5	Cadmium	6746	97%	95% KM (Chebyshev) UCL	7.5E-05
MU1-5	Cobalt	6746	38%	95% KM (Chebyshev) UCL	7.8E-04
MU1-5	Iron	6746	77%	95% KM (Chebyshev) UCL	2.3E-01
MU1-5	Lead	6746	33%	95% KM (Chebyshev) UCL	1.9E-04
MU1-5	Lithium	6746	99%	95% KM (Chebyshev) UCL	2.5E-02
MU1-5	Manganese	6746	99%	95% KM (Chebyshev) UCL	1.4E-02
MU1-5	Nickel	6746	80%	95% KM (Chebyshev) UCL	1.1E-02
MU1-5	Selenium	6901	100%	95% KM (Chebyshev) UCL	3.6E-02
MU1-5	Uranium	6746	100%	95% KM (Chebyshev) UCL	2.8E-03
MU1-5	Vanadium	6746	32%	95% KM (Chebyshev) UCL	8.3E-04
MU-1	Aluminum	1642	88%	95% KM (Chebyshev) UCL	6.6E-02
MU-1	Antimony	1642	76%	95% KM (t) UCL	2.1E-04
MU-1	Arsenic	1642	83%	95% KM (t) UCL	1.9E-04
MU-1	Barium	1642	100%	95% KM (t) UCL	1.1E-01
MU-1	Cadmium	1642	99%	95% KM (Chebyshev) UCL	5.4E-05
MU-1	Cobalt	1642	36%	95% KM (Chebyshev) UCL	1.5E-04
MU-1	Iron	1642	76%	95% KM (Chebyshev) UCL	9.3E-02
MU-1	Lead	1642	23%	95% KM (Chebyshev) UCL	1.0E-04
MU-1	Lithium	1642	99%	95% KM (Chebyshev) UCL	2.2E-02
MU-1	Manganese	1642	100%	95% KM (Chebyshev) UCL	6.5E-03
MU-1	Nickel	1642	79%	95% KM (Chebyshev) UCL	3.5E-03
MU-1	Selenium	1664	100%	95% KM (Chebyshev) UCL	5.9E-02
MU-1	Uranium	1642	100%	95% KM (Chebyshev) UCL	2.7E-03
MU-1	Vanadium	1642	38%	95% KM (Chebyshev) UCL	8.7E-04
MU-2	Aluminum	536	93%	95% KM (Chebyshev) UCL	7.6E-02
MU-2	Antimony	536	79%	95% KM (t) UCL	1.6E-04
MU-2	Arsenic	536	84%	95% KM (t) UCL	1.6E-04
MU-2	Barium	536	100%	95% KM (t) UCL	7.7E-02
MU-2	Cadmium	536	96%	95% KM Approximate Gamma UCL	7.9E-05
MU-2	Cobalt	536	13%	95% KM (Chebyshev) UCL	1.4E-04
MU-2	Iron	536	63%	95% KM (Chebyshev) UCL	1.2E-01
MU-2	Lead	536	21%	95% KM (Chebyshev) UCL	1.2E-04
MU-2	Lithium	536	100%	95% KM (Chebyshev) UCL	2.2E-02
MU-2	Manganese	536	99%	95% KM (Chebyshev) UCL	7.3E-03
MU-2	Nickel	536	86%	95% KM (Chebyshev) UCL	2.4E-03
MU-2	Selenium	542	100%	95% KM (Chebyshev) UCL	3.1E-02
MU-2	Uranium	536	100%	95% KM (t) UCL	2.2E-03
MU-2	Vanadium	536	12%	95% KM (Chebyshev) UCL	6.8E-04
MU-3	Aluminum	1561	92%	95% KM (Chebyshev) UCL	3.1E-01
MU-3	Antimony	1561	62%	95% KM (Chebyshev) UCL	9.0E-04
MU-3	Arsenic	1561	93%	95% KM (Chebyshev) UCL	4.1E-04
MU-3	Barium	1561	100%	95% Student's-t UCL	8.6E-02
MU-3	Cadmium	1561	95%	95% KM (Chebyshev) UCL	9.4E-05
MU-3	Cobalt	1561	44%	95% KM (Chebyshev) UCL	7.5E-04
MU-3	Iron	1561	75%	95% KM (Chebyshev) UCL	4.7E-01
MU-3	Lead	1561	40%	95% KM (Chebyshev) UCL	3.6E-04
MU-3	Lithium	1561	100%	95% KM (Chebyshev) UCL	5.0E-02

Table G-2. Surface water exposure point concentrations

MU	Constituent	Sample Size	Percent Detect	Method for Calculating Exposure Point Concentration	Exposure Point Concentration (mg/L)
MU-3	Manganese	1561	100%	95% KM (Chebyshev) UCL	1.8E-02
MU-3	Nickel	1561	72%	95% KM (Chebyshev) UCL	2.5E-02
MU-3	Selenium	1572	100%	95% Chebyshev (Mean, Sd) UCL	5.3E-02
MU-3	Uranium	1561	100%	95% Chebyshev (Mean, Sd) UCL	4.8E-03
MU-3	Vanadium	1561	35%	95% KM (Chebyshev) UCL	1.4E-03
MU-4	Aluminum	2394	92%	95% KM (Chebyshev) UCL	1.6E-01
MU-4	Antimony	2394	66%	95% KM (Chebyshev) UCL	2.3E-04
MU-4	Arsenic	2394	96%	95% KM (t) UCL	3.0E-04
MU-4	Barium	2394	100%	95% KM (Chebyshev) UCL	9.9E-02
MU-4	Cadmium	2394	97%	95% KM (Chebyshev) UCL	9.4E-05
MU-4	Cobalt	2394	43%	95% KM (Chebyshev) UCL	1.6E-03
MU-4	Iron	2394	79%	95% KM (Chebyshev) UCL	2.2E-01
MU-4	Lead	2394	33%	95% KM (Chebyshev) UCL	1.7E-04
MU-4	Lithium	2394	99%	95% KM (Chebyshev) UCL	1.7E-02
MU-4	Manganese	2394	96%	95% KM (Chebyshev) UCL	2.1E-02
MU-4	Nickel	2394	84%	95% KM (Chebyshev) UCL	1.2E-02
MU-4	Selenium	2510	100%	95% KM (Chebyshev) UCL	2.5E-02
MU-4	Uranium	2394	100%	95% KM (Chebyshev) UCL	2.5E-03
MU-4	Vanadium	2394	27%	95% KM (Chebyshev) UCL	9.6E-04
MU-5	Aluminum	613	100%	95% KM (Chebyshev) UCL	3.6E-01
MU-5	Antimony	613	56%	95% KM (t) UCL	1.0E-04
MU-5	Arsenic	613	99%	95% KM (Chebyshev) UCL	4.2E-04
MU-5	Barium	613	100%	95% KM (t) UCL	8.2E-02
MU-5	Cadmium	613	99%	95% KM (Chebyshev) UCL	6.8E-05
MU-5	Cobalt	613	31%	95% KM (Chebyshev) UCL	2.9E-04
MU-5	Iron	613	92%	95% KM (Chebyshev) UCL	4.9E-01
MU-5	Lead	613	55%	95% KM (Chebyshev) UCL	3.7E-04
MU-5	Lithium	613	100%	KM Student's t	7.6E-03
MU-5	Manganese	613	100%	95% KM (Chebyshev) UCL	2.3E-02
MU-5	Nickel	613	85%	95% KM (Chebyshev) UCL	1.5E-03
MU-5	Selenium	613	100%	95% KM (t) UCL	8.5E-03
MU-5	Uranium	613	100%	KM Student's t	1.0E-03
MU-5	Vanadium	613	46%	95% KM (Chebyshev) UCL	1.5E-03
MU-6	Aluminum	720	100%	95% KM (t) UCL	4.3E-01
MU-6	Antimony	720	83%	95% KM (t) UCL	6.9E-05
MU-6	Arsenic	720	100%	95% KM (t) UCL	5.7E-04
MU-6	Barium	720	100%	95% KM (t) UCL	5.7E-02
MU-6	Cadmium	720	100%	95% KM (t) UCL	2.7E-05
MU-6	Cobalt	720	86%	95% KM (t) UCL	3.1E-04
MU-6	Iron	720	99%	95% KM (t) UCL	6.2E-01
MU-6	Lead	720	94%	95% KM (t) UCL	5.7E-04
MU-6	Lithium	720	100%	95% KM (t) UCL	3.4E-03
MU-6	Manganese	720	100%	95% KM (t) UCL	2.4E-02
MU-6	Nickel	720	92%	95% KM (t) UCL	9.1E-04
MU-6	Selenium	720	100%	95% KM (t) UCL	2.0E-03
MU-6	Uranium	720	100%	95% KM (t) UCL	7.2E-04
MU-6	Vanadium	720	89%	95% KM (t) UCL	9.4E-04

*All surface water is total fraction

Table G-3. Nitrate Surfacewater exposure point concentrations

MU	Quarter	Sample Size	Percent Detect	Method for Calculating Exposure Point Concentration	Exposure Point Concentration (mg/L)
MU-1	1	396	100%	95% KM (Chebyshev) UCL	1.69E+01
MU-1	2	600	99%	95% KM (Chebyshev) UCL	8.81E+00
MU-1	3	356	96%	95% KM (Chebyshev) UCL	9.83E+00
MU-1	4	294	99%	95% KM (Chebyshev) UCL	1.35E+01
MU-2	1	136	99%	95% KM (Chebyshev) UCL	9.35E+00
MU-2	2	190	100%	95% Chebyshev (Mean, Sd) UCL	7.29E+00
MU-2	3	114	100%	95% Chebyshev (Mean, Sd) UCL	7.36E+00
MU-2	4	98	100%	95% Chebyshev (Mean, Sd) UCL	8.78E+00
MU-3	1	330	100%	95% Chebyshev (Mean, Sd) UCL	2.61E+01
MU-3	2	783	99%	95% KM (Chebyshev) UCL	1.31E+01
MU-3	3	287	100%	95% KM (Chebyshev) UCL	1.76E+01
MU-3	4	186	100%	95% Chebyshev (Mean, Sd) UCL	2.06E+01
MU-4	1	583	99%	95% KM (Chebyshev) UCL	3.39E+00
MU-4	2	842	98%	95% KM (Chebyshev) UCL	2.41E+00
MU-4	3	461	95%	95% KM Approximate Gamma UCL	2.75E+00
MU-4	4	421	97%	95% KM (Chebyshev) UCL	3.40E+00
MU-5	1	151	99%	95% KM (t) UCL	2.16E+00
MU-5	2	281	100%	95% Student's-t UCL	1.48E+00
MU-5	3	108	100%	95% Approximate Gamma UCL	1.60E+00
MU-5	4	72	100%	95% Student's-t UCL	1.98E+00
MU-6	1	50	100%	95% Chebyshev (Mean, Sd) UCL	1.22E+00
MU-6	2	382	100%	95% Student's-t UCL	4.49E-01
MU-6	3	121	98%	95% KM (Chebyshev) UCL	5.75E-01
MU-6	4	76	100%	95% Chebyshev (Mean, Sd) UCL	6.04E-01

Notes:
mg/L - milligrams per liter
MU – management unit.
Concentrations reported are for total fraction.

Table G-4. Sediment exposure point concentrations

MU	Constituent	Sample Size	Percent Detect	Method for Calculating Exposure Point Concentration	Exposure Point Concentration (mg/kg ww)
MU-1	Benzo(a)pyrene	85	72%	95% KM (Chebyshev) UCL	4.59E-02
MU-1	Cobalt	185	93%	95% KM (Chebyshev) UCL	5.09E+00
MU-1	Iron	165	88%	95% KM (Chebyshev) UCL	1.19E+04
MU-1	Lithium	120	83%	95% KM (t) UCL	9.56E+00
MU-1	Selenium	165	92%	95% KM (Chebyshev) UCL	9.60E+00
MU-2	Benzo(a)pyrene	20	30%	95% KM (t) UCL	1.30E-02
MU-2	Cobalt	20	100%	95% Student's-t UCL	7.13E+00
MU-2	Iron	20	100%	95% Student's-t UCL	1.61E+04
MU-2	Lithium	20	100%	95% Student's-t UCL	1.02E+01
MU-2	Selenium	20	100%	95% Student's-t UCL	6.02E+00
MU-3	Benzo(a)pyrene	80	15%	95% KM (t) UCL	1.07E-02
MU-3	Cobalt	80	99%	KM Student's t	5.20E+00
MU-3	Iron	80	99%	95% KM (t) UCL	1.36E+04
MU-3	Lithium	80	99%	95% KM Approximate Gamma UCL	1.21E+01
MU-3	Selenium	80	99%	95% KM (t) UCL	1.51E+00
MU-4	Benzo(a)pyrene	214	44%	95% KM (Chebyshev) UCL	6.03E-02
MU-4	Cobalt	214	100%	95% Chebyshev (Mean, Sd) UCL	5.18E+01
MU-4	Iron	214	100%	95% Chebyshev (Mean, Sd) UCL	1.49E+04
MU-4	Lithium	214	100%	95% KM (t) UCL	1.13E+01
MU-4	Selenium	214	100%	95% Chebyshev (Mean, Sd) UCL	1.20E+01
MU-5	Benzo(a)pyrene	90	72%	95% KM (Chebyshev) UCL	1.05E+00
MU-5	Cobalt	90	100%	95% Student's-t UCL	4.45E+00
MU-5	Iron	90	100%	95% Student's-t UCL	1.24E+04
MU-5	Lithium	90	100%	95% Student's-t UCL	1.02E+01
MU-5	Selenium	90	100%	95% Chebyshev (Mean, Sd) UCL	5.74E+00
MU-6	Benzo(a)pyrene	25	12%	95% KM (t) UCL	1.03E-02
MU-6	Cobalt	35	100%	95% Student's-t UCL	9.76E+00
MU-6	Iron	35	100%	95% Student's-t UCL	2.31E+04

Table G-4. Sediment exposure point concentrations

MU	Constituent	Sample Size	Percent Detect	Method for Calculating Exposure Point Concentration	Exposure Point Concentration (mg/kg ww)
MU-6	Lithium	35	100%	95% Student's-t UCL	2.56E+01
MU-6	Selenium	35	100%	95% Student's-t UCL	6.64E-01
Valley Wide (MU 1-5)	Benzo(a)pyrene	514	47%	95% KM (Chebyshev) UCL	2.22E-01
Valley Wide (MU 1-5)	Cobalt	624	98%	95% KM (Chebyshev) UCL	2.19E+01
Valley Wide (MU 1-5)	Iron	604	97%	95% KM (Chebyshev) UCL	1.29E+04
Valley Wide (MU 1-5)	Lithium	559	96%	95% KM (t) UCL	1.05E+01
Valley Wide (MU 1-5)	Selenium	604	98%	95% KM (Chebyshev) UCL	7.73E+00

Notes:

mg/kg ww – milligrams per kilogram, wet weight
MU – management unit.

Table G-5. Fish tissue exposure point concentrations

MU	Constituent	Sample Size	Percent Detect	Method for Calculating Exposure Point Concentration	Exposure Point Concentration (mg/kg ww)
MU-1	Aluminum	53	57%	KM H-UCL	3.39E+00
MU-1	Antimony	53	45%	95% KM (t) UCL	2.91E-03
MU-1	Arsenic	53	55%	KM H-UCL	2.81E-02
MU-1	Cadmium	53	53%	95% KM (t) UCL	1.59E-03
MU-1	Chromium (III)	53	55%	95% KM (t) UCL	8.43E-02
MU-1	Cobalt	53	60%	95% KM (t) UCL	3.02E-02
MU-1	Iron	53	62%	95% KM (t) UCL	7.74E+00
MU-1	Lead	53	55%	KM H-UCL	1.41E-02
MU-1	Lithium	29	100%	95% Student's-t UCL	2.08E-02
MU-1	Mercury	53	60%	KM H-UCL	5.18E-03
MU-1	Nickel	53	55%	95% KM Approximate Gamma UCL	6.14E-02
MU-1	Selenium	53	100%	95% Student's-t UCL	3.14E+00
MU-1	Thallium	53	55%	95% KM (t) UCL	7.44E-03
MU-1	Uranium	53	55%	KM H-UCL	6.87E-04
MU-1	Vanadium	53	55%	95% KM (t) UCL	1.53E-02
MU-1	Zinc	53	70%	95% KM (t) UCL	5.48E+00
MU-2	Aluminum	75	37%	KM H-UCL	3.51E+00
MU-2	Antimony	75	19%	KM H-UCL	1.54E-03
MU-2	Arsenic	75	37%	95% Adjusted Gamma UCL	2.23E-02
MU-2	Cadmium	75	25%	KM H-UCL	2.46E-03
MU-2	Chromium (III)	75	25%	KM H-UCL	7.49E-02
MU-2	Cobalt	75	35%	95% KM Adjusted Gamma UCL	1.39E-02
MU-2	Iron	75	40%	95% Chebyshev (Mean, Sd) UCL	9.91E+00
MU-2	Lead	75	28%	KM H-UCL	1.56E-02
MU-2	Lithium	18	83%	95% KM (t) UCL	3.70E-02
MU-2	Mercury	73	93%	95% Chebyshev (Mean, Sd) UCL	3.53E-02
MU-2	Nickel	75	27%	95% KM (Chebyshev) UCL	9.91E-02
MU-2	Selenium	96	100%	95% Chebyshev (Mean, Sd) UCL	3.90E+00
MU-2	Thallium	75	37%	95% Adjusted Gamma UCL	1.22E-02
MU-2	Uranium	75	23%	KM H-UCL	7.03E-04
MU-2	Vanadium	75	21%	KM H-UCL	1.11E-02
MU-2	Zinc	75	37%	95% Student's-t UCL	4.63E+00
MU-3	Aluminum	45	69%	KM H-UCL	4.42E+00
MU-3	Antimony	45	31%	95% KM (t) UCL	9.69E-04
MU-3	Arsenic	45	80%	95% KM Adjusted Gamma UCL	3.97E-02
MU-3	Cadmium	45	42%	KM H-UCL	2.25E-03

Table G-5. Fish tissue exposure point concentrations

MU	Constituent	Sample Size	Percent Detect	Method for Calculating Exposure Point Concentration	Exposure Point Concentration (mg/kg ww)
MU-3	Chromium (III)	45	53%	95% KM (Chebyshev) UCL	1.42E-01
MU-3	Cobalt	45	73%	95% KM Adjusted Gamma UCL	1.40E-02
MU-3	Iron	45	87%	95% Chebyshev (Mean, Sd) UCL	7.89E+00
MU-3	Lead	45	42%	Gamma Adjusted KM-UCL (use when k<=1 and 15 < n < 50 but k<=1)	1.66E-02
MU-3	Lithium	15	93%	KM Student's t	1.02E-02
MU-3	Mercury	49	100%	95% Chebyshev (Mean, Sd) UCL	3.97E-02
MU-3	Nickel	45	40%	95% KM (t) UCL	2.98E-02
MU-3	Selenium	48	100%	95% Student's-t UCL	1.34E+00
MU-3	Thallium	45	64%	95% KM Adjusted Gamma UCL	1.45E-02
MU-3	Uranium	45	36%	95% KM (Chebyshev) UCL	4.55E-03
MU-3	Vanadium	45	33%	KM H-UCL	1.00E-02
MU-3	Zinc	45	82%	95% Student's-t UCL	5.54E+00
MU-4	Aluminum	135	57%	KM H-UCL	3.49E+00
MU-4	Antimony	135	27%	95% KM Approximate Gamma UCL	1.69E-03
MU-4	Arsenic	135	64%	KM H-UCL	2.85E-02
MU-4	Cadmium	135	29%	95% KM Approximate Gamma UCL	1.99E-03
MU-4	Chromium (III)	135	41%	95% KM Approximate Gamma UCL	6.74E-02
MU-4	Cobalt	135	50%	95% KM Approximate Gamma UCL	1.58E-02
MU-4	Iron	135	73%	95% KM (t) UCL	1.13E+01
MU-4	Lead	135	39%	KM H-UCL	9.30E-03
MU-4	Lithium	37	84%	95% KM Adjusted Gamma UCL	1.15E-02
MU-4	Mercury	142	87%	KM H-UCL	1.47E-02
MU-4	Nickel	135	36%	95% KM Approximate Gamma UCL	4.02E-02
MU-4	Selenium	140	100%	95% Student's-t UCL	5.28E+00
MU-4	Thallium	135	69%	95% KM Approximate Gamma UCL	1.46E-02
MU-4	Uranium	135	28%	95% KM (t) UCL	5.13E-04
MU-4	Vanadium	135	29%	95% KM (t) UCL	1.86E-02
MU-4	Zinc	135	76%	95% KM (t) UCL	6.64E+00
MU-5	Aluminum	81	35%	KM H-UCL	3.55E+00
MU-5	Antimony	81	17%	KM H-UCL	1.45E-03
MU-5	Arsenic	81	73%	KM H-UCL	1.93E-02
MU-5	Cadmium	81	25%	95% KM (Chebyshev) UCL	2.92E-03
MU-5	Chromium (III)	81	38%	95% KM (Chebyshev) UCL	7.02E-02
MU-5	Cobalt	81	56%	95% KM Approximate Gamma UCL	1.21E-02
MU-5	Iron	81	81%	95% Chebyshev (Mean, Sd) UCL	1.06E+01
MU-5	Lead	81	27%	95% KM Approximate Gamma UCL	1.21E-02

Table G-5. Fish tissue exposure point concentrations

MU	Constituent	Sample Size	Percent Detect	Method for Calculating Exposure Point Concentration	Exposure Point Concentration (mg/kg ww)
MU-5	Lithium	14	100%	95% Adjusted Gamma UCL	2.49E-02
MU-5	Mercury	81	99%	95% Approximate Gamma UCL	2.81E-02
MU-5	Nickel	81	23%	95% KM Approximate Gamma UCL	2.80E-02
MU-5	Selenium	85	100%	95% Approximate Gamma UCL	2.39E+00
MU-5	Thallium	81	54%	95% KM Approximate Gamma UCL	8.88E-03
MU-5	Uranium	81	17%	KM H-UCL	6.66E-04
MU-5	Vanadium	81	17%	KM H-UCL	1.88E-02
MU-5	Zinc	81	80%	95% Chebyshev (Mean, Sd) UCL	8.74E+00
MU-6	Aluminum	228	43%	95% KM (Chebyshev) UCL	4.62E+00
MU-6	Antimony	233	21%	95% KM (Chebyshev) UCL	7.97E-04
MU-6	Arsenic	233	85%	KM H-UCL	3.22E-02
MU-6	Cadmium	233	19%	95% KM (Chebyshev) UCL	1.13E-03
MU-6	Chromium (III)	233	44%	95% KM (Chebyshev) UCL	5.45E-01
MU-6	Cobalt	233	63%	95% KM (Chebyshev) UCL	6.86E-03
MU-6	Iron	233	86%	95% KM (Chebyshev) UCL	8.97E+00
MU-6	Lead	233	49%	95% KM (Chebyshev) UCL	2.34E-02
MU-6	Lithium	59	86%	95% KM (Chebyshev) UCL	2.29E-02
MU-6	Mercury	233	100%	95% KM (Chebyshev) UCL	4.52E-01
MU-6	Nickel	233	34%	95% KM (Chebyshev) UCL	3.33E-02
MU-6	Selenium	233	100%	95% Chebyshev (Mean, Sd) UCL	6.21E-01
MU-6	Thallium	233	82%	95% KM (Chebyshev) UCL	6.63E-03
MU-6	Uranium	233	26%	95% KM (Chebyshev) UCL	5.18E-03
MU-6	Vanadium	233	25%	95% KM (Chebyshev) UCL	6.18E-03
MU-6	Zinc	233	87%	95% KM (t) UCL	7.51E+00
Valley-Wide	Aluminum	389	50%	95% KM (t) UCL	4.25E+00
Valley-Wide	Antimony	389	26%	95% KM (t) UCL	1.83E-03
Valley-Wide	Arsenic	389	61%	95% KM (t) UCL	2.50E-02
Valley-Wide	Cadmium	389	32%	95% KM (t) UCL	2.10E-03
Valley-Wide	Chromium (III)	389	41%	95% KM (t) UCL	6.21E-02
Valley-Wide	Cobalt	389	52%	KM H-UCL	1.58E-02
Valley-Wide	Iron	389	69%	95% KM (t) UCL	7.70E+00
Valley-Wide	Lead	389	37%	KM H-UCL	9.23E-03
Valley-Wide	Lithium	113	91%	95% KM Approximate Gamma UCL	1.73E-02
Valley-Wide	Mercury	398	89%	KM H-UCL	1.90E-02
Valley-Wide	Nickel	389	34%	KM H-UCL	3.67E-02
Valley-Wide	Selenium	422	100%	95% Student's-t UCL	3.39E+00

Table G-5. Fish tissue exposure point concentrations

MU	Constituent	Sample Size	Percent Detect	Method for Calculating Exposure Point Concentration	Exposure Point Concentration (mg/kg ww)
Valley-Wide	Thallium	389	57%	95% KM (t) UCL	1.11E-02
Valley-Wide	Uranium	389	29%	95% KM (t) UCL	7.78E-04
Valley-Wide	Vanadium	389	29%	95% KM (t) UCL	1.48E-02
Valley-Wide	Zinc	389	69%	95% KM (t) UCL	5.84E+00
Reference	Aluminum	61	49%	95% KM Approximate Gamma UCL	5.58E-01
Reference	Antimony	61	8%	95% KM (t) UCL	3.96E-04
Reference	Arsenic	61	74%	KM H-UCL	3.45E-02
Reference	Cadmium	61	38%	95% KM (t) UCL	1.41E-03
Reference	Chromium (III)	61	43%	95% KM (t) UCL	2.75E-02
Reference	Cobalt	61	66%	95% KM (t) UCL	7.75E-03
Reference	Iron	61	75%	95% KM (t) UCL	3.85E+00
Reference	Lead	61	48%	KM H-UCL	7.76E-03
Reference	Lithium	20	100%	95% Student's-t UCL	5.92E-03
Reference	Mercury	61	100%	95% Approximate Gamma UCL	5.22E-02
Reference	Nickel	61	34%	95% KM (t) UCL	5.88E-03
Reference	Selenium	65	98%	95% KM (t) UCL	6.87E-01
Reference	Thallium	61	69%	95% KM (t) UCL	1.53E-02
Reference	Uranium	61	31%	KM H-UCL	4.60E-04
Reference	Vanadium	61	33%	95% KM Approximate Gamma UCL	1.76E-03
Reference	Zinc	61	77%	95% KM (t) UCL	4.72E+00

Notes:

Exposure point concentrations (EPCs) for the following MUs or locations were calculated using ProUCL version 5.2: MUs 1 and 4, Valley-wide, and reference. Remaining EPCs were calculated using version 5.1.002 of ProUCL.

mg/kg ww – milligrams per kilogram, wet weight
MU – management unit.

Table G-6. Fish ovary (egg) exposure point concentrations

MU	Constituent	Sample Size	Percent Detect	Method for Calculating Exposure Point Concentration	Exposure Point Concentration (mg/kg ww)
MU-1	Aluminum	1	100%	Maximum Detect	1.50E-01
MU-1	Antimony	1	100%	Maximum Detect	4.19E-04
MU-1	Arsenic	1	100%	Maximum Detect	1.41E-02
MU-1	Cadmium	1	100%	Maximum Detect	1.75E-03
MU-1	Chromium (III)	1	100%	Maximum Detect	2.14E-02
MU-1	Cobalt	1	100%	Maximum Detect	8.25E-02
MU-1	Iron	1	100%	Maximum Detect	1.18E+01
MU-1	Lead	1	100%	Maximum Detect	1.29E-03
MU-1	Lithium	1	100%	Maximum Detect	1.53E-02
MU-1	Mercury	1	100%	Maximum Detect	9.74E-04
MU-1	Nickel	1	100%	Maximum Detect	1.76E-02
MU-1	Selenium	1	100%	Maximum Detect	9.08E+00
MU-1	Thallium	1	100%	Maximum Detect	1.46E-03
MU-1	Uranium	1	100%	Maximum Detect	1.40E-03
MU-1	Vanadium	1	100%	Maximum Detect	5.94E-03
MU-1	Zinc	1	100%	Maximum Detect	2.00E+01
MU-2	Aluminum	14	43%	95% KM (t) UCL	5.36E-01
MU-2	Arsenic	14	100%	95% Student's-t UCL	1.33E-02
MU-2	Cadmium	14	71%	95% KM (t) UCL	7.47E-03
MU-2	Chromium (III)	14	36%	95% KM (t) UCL	2.28E-02
MU-2	Cobalt	14	100%	95% Adjusted Gamma UCL	4.77E-02
MU-2	Iron	14	100%	95% Student's-t UCL	1.21E+01
MU-2	Lead	14	43%	95% KM (Chebyshev) UCL	4.93E-03
MU-2	Lithium	5	100%	95% Student's-t UCL	4.97E-02
MU-2	Mercury	17	53%	95% KM (t) UCL	2.08E-03
MU-2	Nickel	14	43%	95% KM (t) UCL	2.22E-02
MU-2	Selenium	19	100%	95% Student's-t UCL	9.67E+00
MU-2	Thallium	14	36%	95% KM (t) UCL	1.97E-03

Table G-6. Fish ovary (egg) exposure point concentrations

MU	Constituent	Sample Size	Percent Detect	Method for Calculating Exposure Point Concentration	Exposure Point Concentration (mg/kg ww)
MU-2	Uranium	14	36%	95% KM Adjusted Gamma UCL	9.45E-04
MU-2	Vanadium	14	36%	95% KM (t) UCL	6.77E-03
MU-2	Zinc	14	100%	95% Student's-t UCL	2.50E+01
MU-3	Aluminum	22	64%	Gamma Adjusted KM-UCL (use wher	5.18E+00
MU-3	Arsenic	22	100%	95% Student's-t UCL	4.88E-02
MU-3	Cadmium	22	59%	KM H-UCL	2.02E-02
MU-3	Chromium (III)	22	41%	95% KM (t) UCL	2.35E-02
MU-3	Cobalt	22	100%	95% Chebyshev (Mean, Sd) UCL	1.55E-01
MU-3	Iron	22	100%	95% Chebyshev (Mean, Sd) UCL	5.03E+01
MU-3	Lead	22	32%	95% KM (t) UCL	2.85E-03
MU-3	Lithium	5	100%	95% Student's-t UCL	1.55E-02
MU-3	Mercury	22	86%	95% KM Adjusted Gamma UCL	5.04E-03
MU-3	Nickel	22	27%	95% KM (t) UCL	1.41E-02
MU-3	Selenium	24	100%	95% H-UCL	8.85E+00
MU-3	Thallium	22	45%	95% KM (Chebyshev) UCL	1.52E-02
MU-3	Uranium	22	23%	95% KM (t) UCL	1.30E-03
MU-3	Vanadium	22	27%	95% KM (t) UCL	2.18E-02
MU-3	Zinc	22	100%	95% Student's-t UCL	4.24E+01
MU-4	Aluminum	57	47%	95% KM (Chebyshev) UCL	3.64E+00
MU-4	Arsenic	57	91%	95% KM (Chebyshev) UCL	5.70E-02
MU-4	Cadmium	57	68%	95% KM Approximate Gamma UCL	7.86E-03
MU-4	Chromium (III)	57	21%	95% KM Approximate Gamma UCL	2.06E-02
MU-4	Cobalt	57	96%	95% KM (t) UCL	5.83E-02
MU-4	Iron	57	100%	95% Student's-t UCL	1.90E+01
MU-4	Lead	57	19%	95% KM (t) UCL	4.91E-03
MU-4	Mercury	57	16%	95% KM (t) UCL	1.63E-03
MU-4	Nickel	57	61%	95% KM Approximate Gamma UCL	3.55E-02
MU-4	Selenium	64	100%	95% Approximate Gamma UCL	1.20E+01

Table G-6. Fish ovary (egg) exposure point concentrations

MU	Constituent	Sample Size	Percent Detect	Method for Calculating Exposure Point Concentration	Exposure Point Concentration (mg/kg ww)
MU-4	Thallium	57	65%	95% KM Approximate Gamma UCL	4.54E-03
MU-4	Uranium	57	4%	95% KM (t) UCL	1.39E-03
MU-4	Vanadium	57	4%	95% KM (t) UCL	2.94E-02
MU-4	Zinc	57	100%	95% Approximate Gamma UCL	4.23E+01
MU-5	Aluminum	35	31%	95% KM (t) UCL	7.99E-01
MU-5	Arsenic	36	97%	95% KM (t) UCL	2.88E-02
MU-5	Cadmium	36	58%	KM H-UCL	1.55E-02
MU-5	Chromium (III)	36	14%	95% KM (t) UCL	1.61E-02
MU-5	Cobalt	36	97%	KM H-UCL	1.03E-01
MU-5	Iron	36	100%	95% Chebyshev (Mean, Sd) UCL	3.78E+01
MU-5	Lead	36	17%	KM H-UCL	9.80E-04
MU-5	Lithium	5	100%	95% Student's-t UCL	1.86E-02
MU-5	Mercury	37	65%	KM H-UCL	3.18E-03
MU-5	Nickel	36	28%	95% KM (t) UCL	1.61E-02
MU-5	Selenium	42	100%	95% Chebyshev (Mean, Sd) UCL	1.22E+01
MU-5	Thallium	36	50%	95% KM (Chebyshev) UCL	1.69E-02
MU-5	Uranium	36	17%	95% KM (t) UCL	1.26E-03
MU-5	Vanadium	36	17%	KM H-UCL	6.21E-03
MU-5	Zinc	36	100%	95% Chebyshev (Mean, Sd) UCL	5.79E+01
MU-6	Aluminum	146	47%	95% KM (Chebyshev) UCL	5.45E+00
MU-6	Antimony	146	5%	95% KM (t) UCL	2.94E-03
MU-6	Arsenic	146	99%	KM H-UCL	6.57E-02
MU-6	Cadmium	146	37%	95% KM (Chebyshev) UCL	7.99E-03
MU-6	Chromium (III)	146	27%	95% KM (Chebyshev) UCL	6.92E-02
MU-6	Cobalt	146	74%	95% KM Approximate Gamma UCL	1.67E-02
MU-6	Iron	146	100%	95% H-UCL	3.02E+01
MU-6	Lead	146	38%	KM H-UCL	8.99E-03
MU-6	Mercury	146	100%	95% Chebyshev (Mean, Sd) UCL	3.09E-02
MU-6	Nickel	146	16%	95% KM (Chebyshev) UCL	3.50E-02

Table G-6. Fish ovary (egg) exposure point concentrations

MU	Constituent	Sample Size	Percent Detect	Method for Calculating Exposure Point Concentration	Exposure Point Concentration (mg/kg ww)
MU-6	Selenium	146	100%	95% Approximate Gamma UCL	3.72E+00
MU-6	Thallium	146	90%	95% KM Approximate Gamma UCL	6.34E-03
MU-6	Uranium	146	3%	95% KM (t) UCL	1.35E-03
MU-6	Vanadium	146	6%	95% KM (t) UCL	2.87E-02
MU-6	Zinc	146	100%	95% Student's-t UCL	6.07E+01
Valley Wide (MU 1-5)	Aluminum	274	46%	KM H-UCL	1.42E+00
Valley Wide (MU 1-5)	Antimony	275	3%	95% KM (t) UCL	6.67E-04
Valley Wide (MU 1-5)	Arsenic	275	97%	KM H-UCL	3.50E-02
Valley Wide (MU 1-5)	Cadmium	275	50%	95% KM (Chebyshev) UCL	1.39E-02
Valley Wide (MU 1-5)	Chromium (III)	275	25%	95% KM Approximate Gamma UCL	1.85E-02
Valley Wide (MU 1-5)	Cobalt	275	85%	95% KM (Chebyshev) UCL	9.49E-02
Valley Wide (MU 1-5)	Iron	275	100%	95% Student's-t UCL	2.13E+01
Valley Wide (MU 1-5)	Lead	275	31%	95% KM Approximate Gamma UCL	2.67E-03
Valley Wide (MU 1-5)	Lithium	218	78%	95% H-UCL	3.27E-02
Valley Wide (MU 1-5)	Mercury	279	39%	95% KM (Chebyshev) UCL	2.93E-03
Valley Wide (MU 1-5)	Nickel	282	82%	95% KM Approximate Gamma UCL	2.32E-02
Valley Wide (MU 1-5)	Selenium	288	88%	95% Approximate Gamma UCL	9.86E+00
Valley Wide (MU 1-5)	Thallium	275	14%	95% KM (Chebyshev) UCL	7.91E-03
Valley Wide (MU 1-5)	Uranium	275	10%	95% KM (t) UCL	1.02E-03
Valley Wide (MU 1-5)	Vanadium	275	80%	KM H-UCL	8.25E-03
Valley Wide (MU 1-5)	Zinc	381	55%	95% Student's-t UCL	3.86E+01

Notes:
mg/kg ww – milligrams per kilogram, wet weight
MU – management unit.

Fish ovary samples are used as a surrogate for fish eggs in the HHRA.

Exposure point concentrations (EPCs) were not calculated for constituents that had one or zero detected results by management unit. These constituents are not included in the table or risk results.

MU 4 and MU 6 samples were not analyzed for lithium.

Table G-7. Berry exposure point concentrations

MU	Constituent	Sample Size	Percent Detect	Method for Calculating Exposure Point Concentration	Exposure Point Concentration (mg/kg ww)
MU-1	Aluminum	43	100%	95% H-UCL	3.98E+00
MU-1	Antimony	43	12%	95% KM (t) UCL	1.87E-03
MU-1	Arsenic	43	21%	95% KM (t) UCL	4.32E-03
MU-1	Barium	43	100%	95% H-UCL	2.10E+00
MU-1	Cadmium	43	81%	95% KM Adjusted Gamma UCL	9.78E-03
MU-1	Cobalt	43	60%	95% KM (Chebyshev) UCL	1.66E-02
MU-1	Iron	43	100%	95% Student's-t UCL	9.74E+00
MU-1	Lead	43	49%	KM Student's t	5.63E-03
MU-1	Manganese	43	100%	95% Chebyshev (Mean, Sd) UCL	1.28E+01
MU-1	Nickel	43	100%	95% Adjusted Gamma UCL	7.82E-01
MU-1	Selenium	43	60%	95% KM Adjusted Gamma UCL	6.94E-02
MU-1	Uranium	43	21%	KM H-UCL	4.50E-04
MU-1	Vanadium	43	33%	95% KM (t) UCL	2.22E-02
MU-2	Aluminum	4	100%	95% Student's-t UCL	2.06E+01
MU-2	Barium	4	100%	Maximum Detect	7.78E+00
MU-2	Cadmium	4	50%	Maximum Detect	8.81E-03
MU-2	Cobalt	4	100%	95% Student's-t UCL	9.33E-03
MU-2	Iron	4	100%	95% Student's-t UCL	1.97E+01
MU-2	Lead	4	75%	Maximum Detect	7.50E-03
MU-2	Manganese	4	100%	Maximum Detect	4.75E+00
MU-2	Nickel	4	100%	Maximum Detect	9.48E-01
MU-2	Selenium	4	75%	95% KM (t) UCL	3.73E-01
MU-3	Aluminum	35	100%	95% Adjusted Gamma UCL	4.50E+00
MU-3	Arsenic	35	9%	95% KM (t) UCL	3.02E-03
MU-3	Barium	35	100%	95% Adjusted Gamma UCL	7.42E+00
MU-3	Cadmium	35	86%	KM H-UCL	1.99E-02
MU-3	Cobalt	35	37%	95% KM Adjusted Gamma UCL	9.07E-03
MU-3	Iron	35	100%	95% H-UCL	7.69E+00

Table G-7. Berry exposure point concentrations

MU	Constituent	Sample Size	Percent Detect	Method for Calculating Exposure Point Concentration	Exposure Point Concentration (mg/kg ww)
MU-3	Lead	35	17%	95% KM (t) UCL	3.98E-03
MU-3	Manganese	35	100%	95% Adjusted Gamma UCL	8.84E+00
MU-3	Nickel	35	100%	95% Adjusted Gamma UCL	3.06E-01
MU-3	Selenium	35	46%	95% KM Adjusted Gamma UCL	8.12E-02
MU-3	Uranium	35	9%	95% KM (t) UCL	3.02E-04
MU-3	Vanadium	35	37%	KM H-UCL	1.27E-02
MU-4	Aluminum	52	100%	95% Chebyshev (Mean, Sd) UCL	7.97E+01
MU-4	Antimony	52	6%	95% KM (t) UCL	2.45E-03
MU-4	Arsenic	52	10%	KM H-UCL	4.13E-03
MU-4	Barium	52	100%	95% Approximate Gamma UCL	7.87E+00
MU-4	Cadmium	52	77%	95% KM Approximate Gamma UCL	3.25E-02
MU-4	Cobalt	52	54%	95% KM (Chebyshev) UCL	2.26E-02
MU-4	Iron	52	100%	95% Chebyshev (Mean, Sd) UCL	4.01E+01
MU-4	Lead	52	40%	95% KM (Chebyshev) UCL	4.04E-02
MU-4	Manganese	52	100%	95% H-UCL	1.82E+01
MU-4	Nickel	52	100%	95% Approximate Gamma UCL	4.97E-01
MU-4	Selenium	52	52%	95% KM (t) UCL	8.14E-02
MU-4	Uranium	52	15%	95% KM (Chebyshev) UCL	7.20E-03
MU-4	Vanadium	52	63%	95% KM (Chebyshev) UCL	4.69E-01
MU-5	Aluminum	52	100%	95% H-UCL	2.22E+01
MU-5	Antimony	52	4%	95% KM (t) UCL	1.60E-03
MU-5	Arsenic	52	17%	95% KM (t) UCL	5.21E-03
MU-5	Barium	52	100%	95% Student's-t UCL	1.01E+01
MU-5	Cadmium	52	88%	KM H-UCL	2.87E-02
MU-5	Cobalt	52	73%	95% KM Approximate Gamma UCL	1.18E-02
MU-5	Iron	52	100%	95% Chebyshev (Mean, Sd) UCL	2.37E+01
MU-5	Lead	52	40%	95% KM (t) UCL	1.06E-02
MU-5	Lithium	44	9%	95% KM (t) UCL	3.48E-02

Table G-7. Berry exposure point concentrations

MU	Constituent	Sample Size	Percent Detect	Method for Calculating Exposure Point Concentration	Exposure Point Concentration (mg/kg ww)
MU-5	Manganese	52	100%	95% Adjusted Gamma UCL	1.24E+01
MU-5	Nickel	52	100%	95% Adjusted Gamma UCL	4.09E-01
MU-5	Selenium	52	50%	95% KM (t) UCL	4.93E-02
MU-5	Uranium	52	23%	95% KM Adjusted Gamma UCL	8.59E-04
MU-5	Vanadium	52	31%	95% KM Approximate Gamma UCL	7.41E-02
MU-6	Aluminum	15	100%	95% Adjusted Gamma UCL	3.48E+00
MU-6	Arsenic	15	20%	95% KM (t) UCL	5.19E-03
MU-6	Barium	15	100%	95% Adjusted Gamma UCL	1.68E+01
MU-6	Cadmium	15	40%	95% KM (t) UCL	1.74E-03
MU-6	Cobalt	15	47%	95% KM (t) UCL	6.75E-03
MU-6	Iron	15	100%	95% Student's-t UCL	9.05E+00
MU-6	Manganese	15	100%	95% H-UCL	1.35E+01
MU-6	Nickel	15	47%	95% KM Adjusted Gamma UCL	1.85E-01
MU-6	Selenium	15	40%	95% KM (t) UCL	1.73E-01
Reference	Aluminum	34	100%	95% H-UCL	1.34E+01
Reference	Barium	34	100%	95% Adjusted Gamma UCL	7.01E+00
Reference	Cadmium	34	50%	95% KM (Chebyshev) UCL	3.22E-02
Reference	Cobalt	34	82%	95% KM Adjusted Gamma UCL	1.46E-02
Reference	Iron	34	100%	95% H-UCL	1.47E+01
Reference	Lead	34	41%	Gamma Adjusted KM-UCL (use wher	1.27E-02
Reference	Manganese	34	100%	95% Adjusted Gamma UCL	1.08E+01
Reference	Nickel	34	100%	95% Adjusted Gamma UCL	2.98E-01
Reference	Selenium	34	9%	95% KM (t) UCL	1.72E-02
Reference	Uranium	34	12%	95% KM (t) UCL	1.14E-03
Reference	Vanadium	34	9%	95% KM (t) UCL	2.84E-02
Valley Wide (MU 1-6)	Aluminum	201	100%	95% Chebyshev (Mean, Sd) UCL	2.68E+01
Valley Wide (MU 1-6)	Antimony	201	5%	95% KM Approximate Gamma UCL	1.53E-03
Valley Wide (MU 1-6)	Arsenic	201	14%	KM H-UCL	3.38E-03

Table G-7. Berry exposure point concentrations

MU	Constituent	Sample Size	Percent Detect	Method for Calculating Exposure Point Concentration	Exposure Point Concentration (mg/kg ww)
Valley Wide (MU 1-6)	Barium	201	100%	95% Chebyshev (Mean, Sd) UCL	7.88E+00
Valley Wide (MU 1-6)	Cadmium	201	79%	KM H-UCL	1.95E-02
Valley Wide (MU 1-6)	Cobalt	201	58%	95% KM (Chebyshev) UCL	1.24E-02
Valley Wide (MU 1-6)	Iron	201	100%	95% Chebyshev (Mean, Sd) UCL	1.82E+01
Valley Wide (MU 1-6)	Lead	201	36%	95% KM (Chebyshev) UCL	1.43E-02
Valley Wide (MU 1-6)	Lithium	190	3%	95% KM Approximate Gamma UCL	2.26E-02
Valley Wide (MU 1-6)	Manganese	201	100%	95% H-UCL	1.04E+01
Valley Wide (MU 1-6)	Nickel	201	96%	KM H-UCL	4.33E-01
Valley Wide (MU 1-6)	Selenium	201	52%	95% KM Approximate Gamma UCL	6.43E-02
Valley Wide (MU 1-6)	Uranium	201	17%	95% KM (Chebyshev) UCL	2.11E-03
Valley Wide (MU 1-6)	Vanadium	201	39%	KM H-UCL	2.37E-02

Notes:

mg/kg ww – milligrams per kilogram, wet weight
MU – management unit.

Exposure point concentrations (EPCs) were not calculated for constituents that had one or zero detected results by management unit. These constituents are not included in the table or risk results.

Table G-8. Rosehip exposure point concentrations

MU	Constituent	Sample Size	Percent Detect	Method for Calculating Exposure Point Concentration	Exposure Point Concentration (mg/kg ww)
MU-1	Aluminum	1	100%	Maximum Detect	6.26E+01
MU-1	Barium	1	100%	Maximum Detect	5.01E+00
MU-1	Cadmium	1	100%	Maximum Detect	4.18E-03
MU-1	Cobalt	1	100%	Maximum Detect	3.34E-02
MU-1	Iron	1	100%	Maximum Detect	2.88E+01
MU-1	Lead	1	100%	Maximum Detect	2.51E-02
MU-1	Manganese	1	100%	Maximum Detect	1.63E+01
MU-1	Nickel	1	100%	Maximum Detect	3.17E-01
MU-1	Selenium	1	100%	Maximum Detect	5.85E-01
MU-1	Vanadium	1	100%	Maximum Detect	1.67E-01
MU-2	Aluminum	1	100%	Maximum Detect	1.35E+01
MU-2	Barium	1	100%	Maximum Detect	9.00E+00
MU-2	Cobalt	1	100%	Maximum Detect	1.29E-02
MU-2	Iron	1	100%	Maximum Detect	1.35E+01
MU-2	Lead	1	100%	Maximum Detect	6.43E-03
MU-2	Manganese	1	100%	Maximum Detect	1.93E+01
MU-2	Nickel	1	100%	Maximum Detect	1.22E-01
MU-2	Selenium	1	100%	Maximum Detect	5.78E-02
MU-3	Aluminum	6	100%	95% Student's-t UCL	7.11E+00
MU-3	Barium	6	100%	95% Student's-t UCL	9.37E+00
MU-3	Cadmium	6	83%	95% KM (t) UCL	9.70E-03
MU-3	Cobalt	6	67%	95% KM (t) UCL	9.27E-03
MU-3	Iron	6	100%	95% Student's-t UCL	1.06E+01
MU-3	Lead	6	83%	95% KM (t) UCL	7.43E-03
MU-3	Manganese	6	100%	95% Student's-t UCL	1.65E+01
MU-3	Nickel	6	100%	95% Student's-t UCL	2.39E-01
MU-3	Selenium	6	67%	95% KM (t) UCL	6.40E-02
MU-3	Vanadium	6	100%	95% Student's-t UCL	2.63E-02

Table G-8. Rosehip exposure point concentrations

MU	Constituent	Sample Size	Percent Detect	Method for Calculating Exposure Point Concentration	Exposure Point Concentration (mg/kg ww)
MU-4	Aluminum	1	100%	Maximum Detect	6.60E+00
MU-4	Barium	1	100%	Maximum Detect	1.17E+01
MU-4	Cadmium	1	100%	Maximum Detect	2.73E-02
MU-4	Iron	1	100%	Maximum Detect	8.97E+00
MU-4	Lead	1	100%	Maximum Detect	4.70E-03
MU-4	Manganese	1	100%	Maximum Detect	3.21E+01
MU-4	Nickel	1	100%	Maximum Detect	1.57E-01
MU-4	Selenium	1	100%	Maximum Detect	3.10E-02
MU-4	Vanadium	1	100%	Maximum Detect	1.76E-02
MU-5	Aluminum	3	100%	Maximum Detect	3.12E+01
MU-5	Barium	3	100%	Maximum Detect	2.36E+01
MU-5	Cadmium	3	67%	Maximum Detect	3.24E-02
MU-5	Cobalt	3	67%	Maximum Detect	2.31E-02
MU-5	Iron	3	100%	Maximum Detect	2.66E+01
MU-5	Lead	3	100%	Maximum Detect	1.50E-02
MU-5	Manganese	3	100%	Maximum Detect	1.96E+01
MU-5	Nickel	3	100%	Maximum Detect	5.14E-01
MU-5	Selenium	3	100%	Maximum Detect	3.46E-01
MU-5	Uranium	3	33%	Maximum Detect	4.30E-04
MU-5	Vanadium	3	100%	Maximum Detect	1.15E-01
Reference	Aluminum	8	100%	Maximum Detect	5.10E+01
Reference	Barium	8	100%	95% Student's-t UCL	7.17E+00
Reference	Cobalt	8	100%	95% Student's-t UCL	3.00E-02
Reference	Iron	8	100%	Maximum Detect	5.52E+01
Reference	Lead	8	63%	95% KM (t) UCL	2.24E-02
Reference	Manganese	8	100%	95% Student's-t UCL	1.57E+01
Reference	Nickel	8	100%	95% Student's-t UCL	2.44E-01
Reference	Selenium	8	75%	95% KM (t) UCL	1.07E-01

Table G-8. Rosehip exposure point concentrations

MU	Constituent	Sample Size	Percent Detect	Method for Calculating Exposure Point Concentration	Exposure Point Concentration (mg/kg ww)
Reference	Vanadium	8	25%	95% KM (Chebyshev) UCL	1.15E-01
Valley Wide (MU 1-5)	Aluminum	12	100%	95% Adjusted Gamma UCL	2.84E+01
Valley Wide (MU 1-5)	Barium	12	100%	95% Student's-t UCL	1.12E+01
Valley Wide (MU 1-5)	Cadmium	12	75%	95% KM (t) UCL	1.60E-02
Valley Wide (MU 1-5)	Cobalt	12	67%	95% KM (t) UCL	1.58E-02
Valley Wide (MU 1-5)	Iron	12	100%	95% Adjusted Gamma UCL	1.93E+01
Valley Wide (MU 1-5)	Lead	12	92%	95% KM (t) UCL	1.19E-02
Valley Wide (MU 1-5)	Manganese	12	100%	95% Student's-t UCL	1.89E+01
Valley Wide (MU 1-5)	Nickel	12	100%	95% Adjusted Gamma UCL	2.94E-01
Valley Wide (MU 1-5)	Selenium	12	83%	95% KM (Chebyshev) UCL	3.41E-01
Valley Wide (MU 1-5)	Uranium	12	17%	95% KM (t) UCL	4.46E-04
Valley Wide (MU 1-5)	Vanadium	12	92%	95% KM Adjusted Gamma UCL	9.46E-02

Notes:

mg/kg ww – milligrams per kilogram, wet weight
MU – management unit.

Rose hips were not sampled in MU 6.

Exposure point concentrations (EPCs) were not calculated for constituents that had one or zero detected results by management unit. These constituents are not included in the table or risk results.

Reference samples were not analyzed for lithium.

Table G-9. Game muscle exposure point concentrations

MU	Constituent	Sample Size	Percent Detect	Method for Calculating Exposure Point Concentration	Exposure Point Concentration (mg/kg ww)
MU-1	Aluminum	8	100%	95% Adjusted Gamma UCL	2.56E+01
MU-1	Arsenic	8	38%	95% KM (t) UCL	5.13E-03
MU-1	Barium	8	75%	95% KM (t) UCL	2.98E-01
MU-1	Cadmium	8	50%	95% KM (t) UCL	2.85E-03
MU-1	Cobalt	8	63%	95% KM (t) UCL	8.12E-03
MU-1	Iron	8	100%	95% Student's-t UCL	6.31E+01
MU-1	Lead	8	63%	95% KM (t) UCL	5.32E-02
MU-1	Lithium	8	88%	95% KM (t) UCL	9.86E-02
MU-1	Manganese	8	100%	95% Student's-t UCL	2.33E-01
MU-1	Selenium	8	100%	95% Student's-t UCL	5.01E-01
MU-1	Uranium	8	50%	95% KM (t) UCL	8.15E-04
MU-1	Vanadium	8	75%	95% KM (t) UCL	6.37E-02
MU-2	Aluminum	4	100%	Maximum Detect	3.42E+00
MU-2	Arsenic	4	100%	95% Student's-t UCL	7.65E-03
MU-2	Barium	4	100%	Maximum Detect	1.84E-01
MU-2	Cadmium	4	100%	95% Student's-t UCL	6.43E-03
MU-2	Cobalt	4	100%	Maximum Detect	1.57E-02
MU-2	Iron	4	100%	Maximum Detect	4.57E+01
MU-2	Manganese	4	100%	95% Student's-t UCL	3.06E-01
MU-2	Nickel	4	100%	Maximum Detect	6.26E-01
MU-2	Selenium	4	100%	Maximum Detect	5.30E-01
MU-2	Vanadium	4	100%	Maximum Detect	1.48E-02
MU-4	Aluminum	41	56%	95% KM (Chebyshev) UCL	5.26E+01
MU-4	Antimony	41	17%	95% KM (t) UCL	2.90E-03
MU-4	Arsenic	41	24%	KM H-UCL	1.90E-02
MU-4	Barium	41	100%	95% Chebyshev (Mean, Sd) UCL	2.48E+00
MU-4	Cadmium	41	73%	KM H-UCL	9.04E-03
MU-4	Cobalt	41	39%	95% KM (Chebyshev) UCL	2.53E-02

Table G-9. Game muscle exposure point concentrations

MU	Constituent	Sample Size	Percent Detect	Method for Calculating Exposure Point Concentration	Exposure Point Concentration (mg/kg ww)
MU-4	Iron	41	100%	95% H-UCL	5.61E+01
MU-4	Lead	41	22%	Gamma Adjusted KM-UCL (use wher	3.98E-02
MU-4	Lithium	37	16%	KM Student's t	3.40E-02
MU-4	Manganese	41	100%	95% Chebyshev (Mean, Sd) UCL	1.08E+00
MU-4	Nickel	41	29%	KM H-UCL	4.52E-02
MU-4	Selenium	41	100%	95% Student's-t UCL	6.07E-01
MU-4	Uranium	41	12%	95% KM (t) UCL	3.31E-03
MU-4	Vanadium	41	34%	KM H-UCL	1.01E-01
MU-5	Aluminum	6	33%	Maximum Detect	8.09E+00
MU-5	Arsenic	6	83%	95% KM (t) UCL	1.84E-02
MU-5	Barium	6	100%	Maximum Detect	1.91E+00
MU-5	Cadmium	6	67%	95% KM (t) UCL	5.27E-03
MU-5	Iron	6	100%	95% Student's-t UCL	3.59E+01
MU-5	Lead	6	50%	95% KM (t) UCL	7.05E-02
MU-5	Manganese	6	100%	95% Student's-t UCL	3.35E-01
MU-5	Selenium	6	100%	95% Student's-t UCL	2.22E-01
MU-6	Aluminum	2	50%	Maximum Detect	1.06E+00
MU-6	Arsenic	2	100%	Maximum Detect	1.59E-02
MU-6	Barium	2	100%	Maximum Detect	1.89E-01
MU-6	Cadmium	2	50%	Maximum Detect	5.67E-03
MU-6	Cobalt	2	50%	Maximum Detect	1.42E-02
MU-6	Iron	2	100%	Maximum Detect	6.81E+01
MU-6	Lead	2	50%	Maximum Detect	5.67E-03
MU-6	Manganese	2	100%	Maximum Detect	3.97E-01
MU-6	Selenium	2	100%	Maximum Detect	3.97E-01
Reference	Aluminum	19	37%	97.5% KM (Chebyshev) UCL	1.52E+01
Reference	Arsenic	19	47%	95% KM (t) UCL	6.67E-03
Reference	Barium	19	100%	95% Chebyshev (Mean, Sd) UCL	2.46E-01

Table G-9. Game muscle exposure point concentrations

MU	Constituent	Sample Size	Percent Detect	Method for Calculating Exposure Point Concentration	Exposure Point Concentration (mg/kg ww)
Reference	Cadmium	19	53%	95% KM (Chebyshev) UCL	3.57E-02
Reference	Cobalt	19	63%	95% KM (t) UCL	1.11E-02
Reference	Iron	19	100%	95% Student's-t UCL	4.71E+01
Reference	Lead	19	37%	95% KM (t) UCL	1.05E-02
Reference	Manganese	19	100%	95% Adjusted Gamma UCL	4.44E-01
Reference	Nickel	19	16%	95% KM (t) UCL	3.24E-02
Reference	Selenium	19	100%	95% Adjusted Gamma UCL	2.18E-01
Reference	Vanadium	19	21%	95% KM (t) UCL	6.77E-02
Valley Wide (MU 1-6)	Aluminum	61	62%	KM H-UCL	9.45E+00
Valley Wide (MU 1-6)	Antimony	61	15%	95% KM (t) UCL	2.67E-03
Valley Wide (MU 1-6)	Arsenic	61	39%	KM H-UCL	1.39E-02
Valley Wide (MU 1-6)	Barium	61	97%	95% KM (Chebyshev) UCL	1.75E+00
Valley Wide (MU 1-6)	Cadmium	61	70%	KM H-UCL	6.82E-03
Valley Wide (MU 1-6)	Cobalt	61	44%	95% KM (Chebyshev) UCL	1.91E-02
Valley Wide (MU 1-6)	Iron	61	100%	95% H-UCL	5.12E+01
Valley Wide (MU 1-6)	Lead	61	31%	KM H-UCL	1.31E-02
Valley Wide (MU 1-6)	Lithium	50	28%	95% KM (t) UCL	4.60E-02
Valley Wide (MU 1-6)	Manganese	61	100%	95% Chebyshev (Mean, Sd) UCL	7.98E-01
Valley Wide (MU 1-6)	Nickel	61	26%	95% KM Approximate Gamma UCL	1.15E-01
Valley Wide (MU 1-6)	Selenium	61	100%	95% Chebyshev (Mean, Sd) UCL	6.04E-01
Valley Wide (MU 1-6)	Uranium	61	15%	95% KM Approximate Gamma UCL	3.27E-03
Valley Wide (MU 1-6)	Vanadium	61	39%	95% KM Approximate Gamma UCL	1.22E-01

Notes:
mg/kg ww – milligrams per kilogram, wet weight
MU – management unit.

Game muscle was not sampled in MU 3.

Exposure point concentrations (EPCs) were not calculated for constituents that had one or zero detected results by management unit. These constituents are not included in the table or risk results.

Table G-10. Game organ exposure point concentrations

MU	Constituent	Sample Size	Percent Detect	Method for Calculating Exposure Point Concentration	Exposure Point Concentration (mg/kg ww)
MU-1	Aluminum	3	100%	Maximum Detect	1.18E+01
MU-1	Antimony	3	33%	Maximum Detect	2.20E-03
MU-1	Arsenic	3	33%	Maximum Detect	4.80E-03
MU-1	Barium	3	100%	Maximum Detect	3.94E-01
MU-1	Cadmium	3	100%	Maximum Detect	1.21E+00
MU-1	Cobalt	3	100%	Maximum Detect	5.20E-02
MU-1	Iron	3	100%	Maximum Detect	7.47E+02
MU-1	Lead	3	100%	Maximum Detect	4.84E-02
MU-1	Lithium	2	50%	Maximum Detect	4.90E-02
MU-1	Manganese	3	100%	Maximum Detect	2.76E+00
MU-1	Nickel	3	67%	Maximum Detect	2.10E-02
MU-1	Selenium	3	100%	Maximum Detect	2.58E+00
MU-1	Uranium	3	33%	Maximum Detect	7.90E-04
MU-1	Vanadium	3	67%	Maximum Detect	9.30E-02
MU-2	Aluminum	1	100%	Maximum Detect	7.46E+00
MU-2	Barium	1	100%	Maximum Detect	2.57E-01
MU-2	Cadmium	1	100%	Maximum Detect	1.82E-02
MU-2	Cobalt	1	100%	Maximum Detect	7.60E-03
MU-2	Iron	1	100%	Maximum Detect	4.56E+02
MU-2	Lead	1	100%	Maximum Detect	5.40E-03
MU-2	Manganese	1	100%	Maximum Detect	1.35E-01
MU-2	Nickel	1	100%	Maximum Detect	1.40E-01
MU-2	Selenium	1	100%	Maximum Detect	5.09E-01
MU-2	Vanadium	1	100%	Maximum Detect	3.08E-02
MU-4	Aluminum	10	20%	95% KM (t) UCL	7.45E-01
MU-4	Arsenic	10	20%	95% KM (Chebyshev) UCL	3.25E-02
MU-4	Barium	10	100%	95% H-UCL	1.13E-01
MU-4	Cadmium	10	100%	95% Student's-t UCL	8.85E-01

Table G-10. Game organ exposure point concentrations

MU	Constituent	Sample Size	Percent Detect	Method for Calculating Exposure Point Concentration	Exposure Point Concentration (mg/kg ww)
MU-4	Cobalt	10	100%	95% Student's-t UCL	5.20E-02
MU-4	Iron	10	100%	95% Adjusted Gamma UCL	2.81E+02
MU-4	Lead	10	80%	97.5% KM (Chebyshev) UCL	1.15E+00
MU-4	Manganese	8	100%	95% Student's-t UCL	3.02E+00
MU-4	Selenium	10	100%	95% Adjusted Gamma UCL	2.45E+00
MU-5	Aluminum	1	100%	Maximum Detect	1.02E+00
MU-5	Arsenic	1	100%	Maximum Detect	2.04E-02
MU-5	Barium	1	100%	Maximum Detect	3.07E-01
MU-5	Cadmium	1	100%	Maximum Detect	1.79E-02
MU-5	Cobalt	1	100%	Maximum Detect	7.67E-03
MU-5	Iron	1	100%	Maximum Detect	2.56E+02
MU-5	Lead	1	100%	Maximum Detect	5.11E-03
MU-5	Manganese	1	100%	Maximum Detect	2.04E-01
MU-5	Selenium	1	100%	Maximum Detect	2.81E-01
MU-6	Arsenic	2	50%	Maximum Detect	2.37E-02
MU-6	Barium	2	100%	Maximum Detect	1.24E-01
MU-6	Cadmium	2	100%	Maximum Detect	8.82E-01
MU-6	Cobalt	2	100%	Maximum Detect	4.88E-02
MU-6	Iron	2	100%	Maximum Detect	2.22E+02
MU-6	Lead	2	100%	Maximum Detect	2.85E-02
MU-6	Manganese	2	100%	Maximum Detect	2.54E+00
MU-6	Nickel	2	0%	Maximum Detect	5.58E-02
MU-6	Selenium	2	1	Maximum Detect	0.97614
MU-6	Uranium	2	0.5	Maximum Detect	0.0006417
Reference	Aluminum	12	17%	95% KM (t) UCL	9.04E-01
Reference	Arsenic	12	67%	95% KM (t) UCL	1.14E-02
Reference	Barium	12	100%	95% Student's-t UCL	1.08E-01
Reference	Cadmium	12	100%	95% Adjusted Gamma UCL	1.87E+00

Table G-10. Game organ exposure point concentrations

MU	Constituent	Sample Size	Percent Detect	Method for Calculating Exposure Point Concentration	Exposure Point Concentration (mg/kg ww)
Reference	Cobalt	12	92%	95% KM (t) UCL	5.34E-02
Reference	Iron	12	100%	95% Adjusted Gamma UCL	2.50E+02
Reference	Lead	12	67%	95% KM Bootstrap t UCL	9.19E-01
Reference	Lithium	12	100%	95% KM (Chebyshev) UCL	4.12E-01
Reference	Manganese	12	0%	95% Student's-t UCL	2.59E+00
Reference	Selenium	12	100%	95% Adjusted Gamma UCL	5.75E-01
Valley Wide (MU 1-6)	Aluminum	17	41%	95% KM (t) UCL	3.23E+00
Valley Wide (MU 1-6)	Antimony	17	12%	95% KM (Chebyshev) UCL	4.77E-03
Valley Wide (MU 1-6)	Arsenic	17	29%	95% KM (t) UCL	1.33E-02
Valley Wide (MU 1-6)	Barium	17	100%	95% Adjusted Gamma UCL	2.07E-01
Valley Wide (MU 1-6)	Cadmium	17	100%	95% Student's-t UCL	7.51E-01
Valley Wide (MU 1-6)	Cobalt	17	100%	95% Student's-t UCL	4.75E-02
Valley Wide (MU 1-6)	Iron	17	100%	95% Adjusted Gamma UCL	3.26E+02
Valley Wide (MU 1-6)	Lead	17	88%	975% KM (Chebyshev) UCL	6.77E-01
Valley Wide (MU 1-6)	Lithium	12	17%	95% KM (t) UCL	3.69E-02
Valley Wide (MU 1-6)	Manganese	17	100%	95% Student's-t UCL	2.61E+00
Valley Wide (MU 1-6)	Nickel	17	18%	95% KM (t) UCL	3.52E-02
Valley Wide (MU 1-6)	Selenium	17	100%	95% Student's-t UCL	1.79E+00
Valley Wide (MU 1-6)	Uranium	17	12%	95% KM (t) UCL	5.39E-04
Valley Wide (MU 1-6)	Vanadium	17	24%	95% KM (t) UCL	5.12E-02

Notes:

mg/kg ww – milligrams per kilogram, wet weight
MU – management unit.

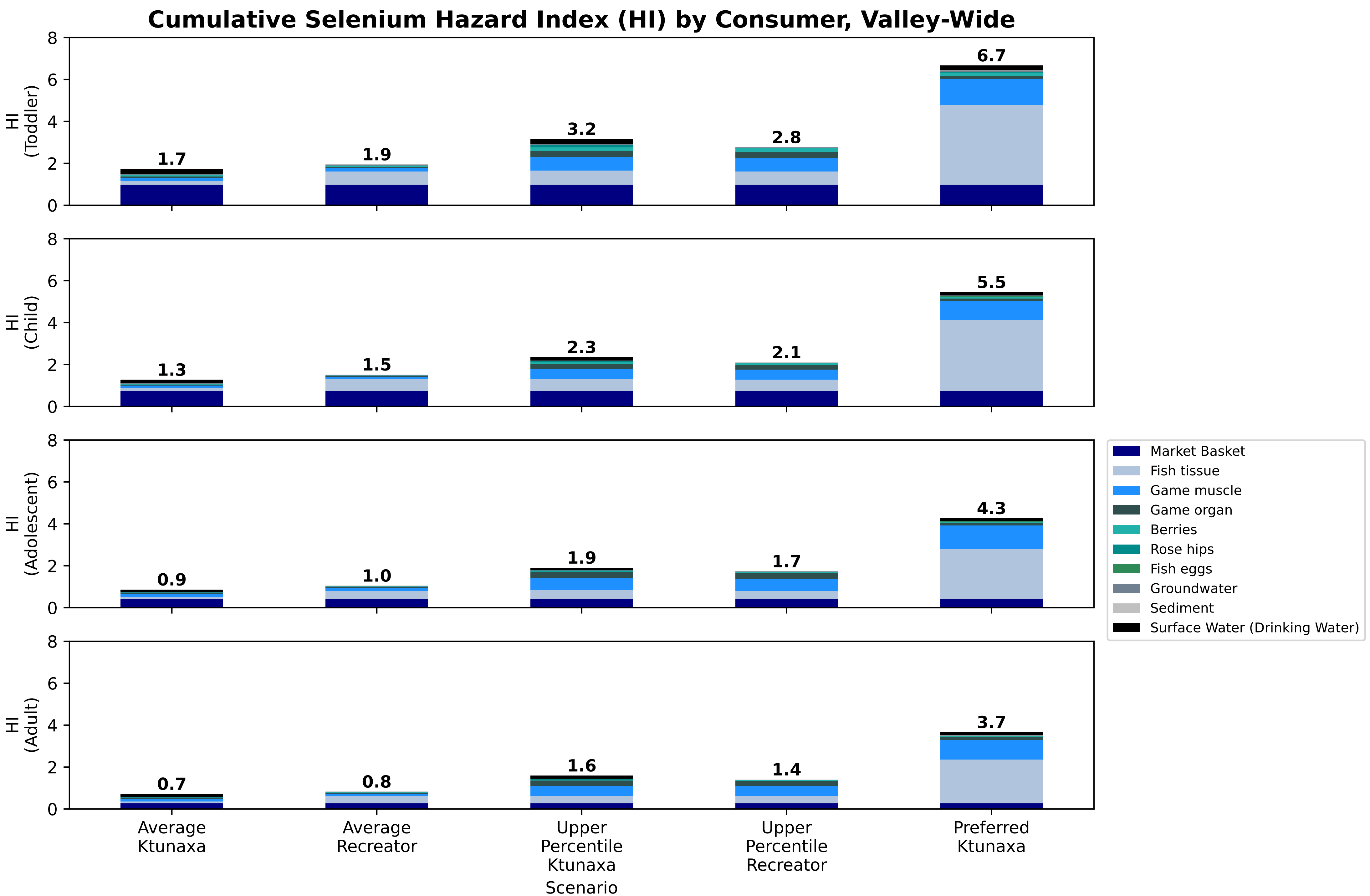
Game organ was not sampled in MU 3.

Exposure point concentrations (EPCs) were not calculated for constituents that had one or zero detected results by management unit. These constituents are not included in the table or risk results.

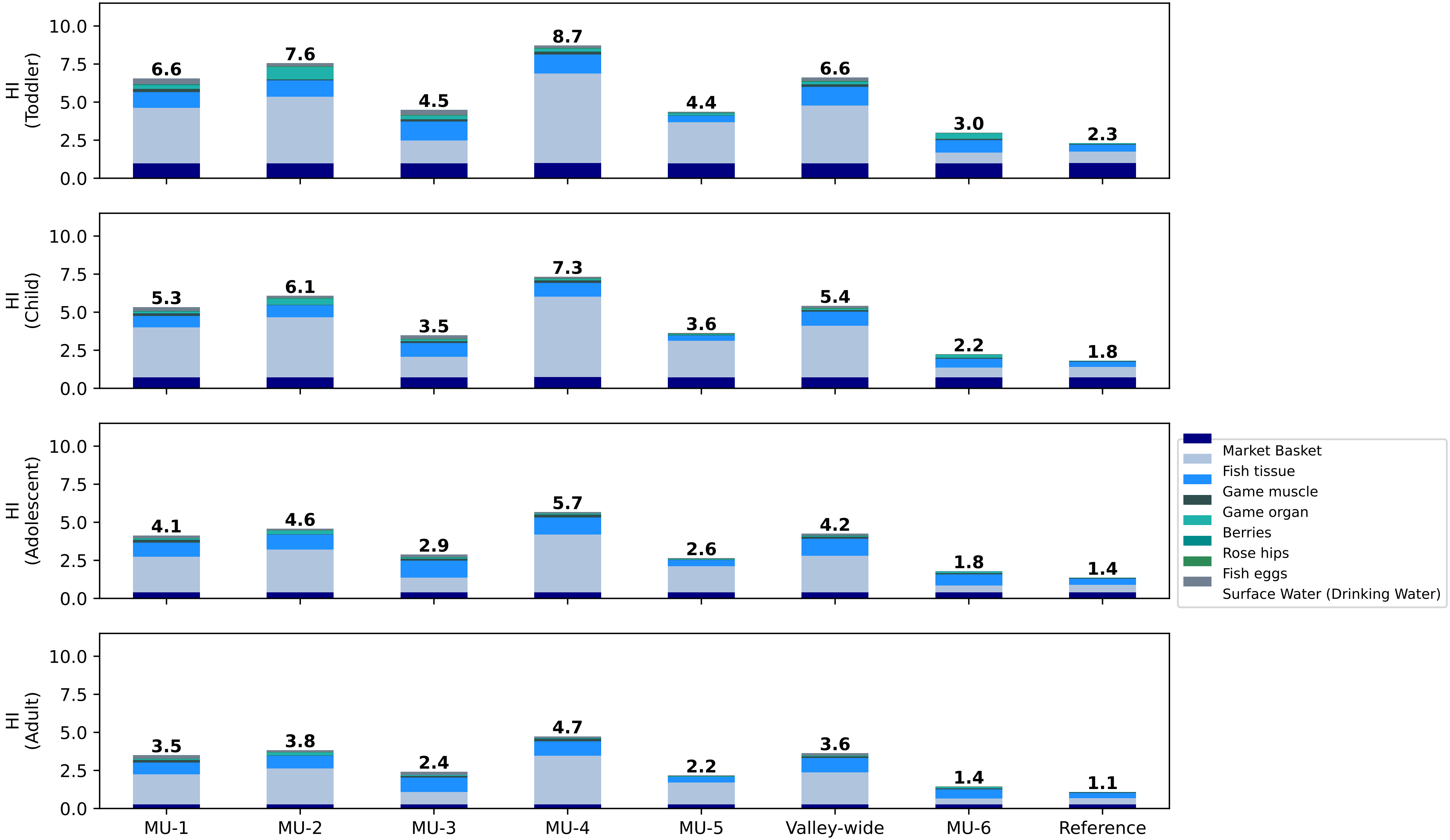
MU 5 samples were not analyzed for lithium.

APPENDIX H
INTAKES AND RISK RESULTS (DIGITAL)

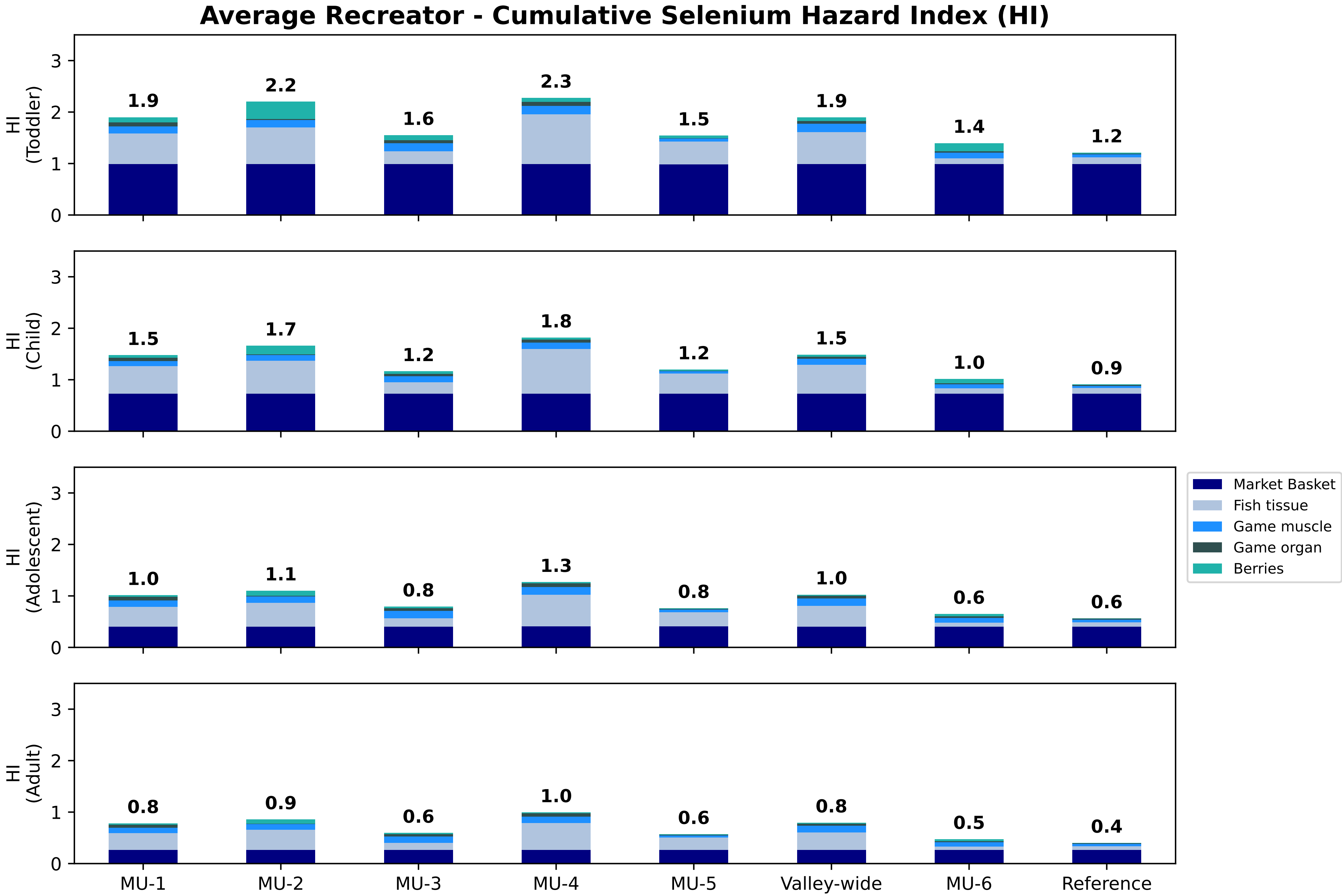
APPENDIX I
CUMLATIVE RISK STACKED BAR CHARTS, ALL LIFESTAGES


Cumulative Selenium Hazard Index (HI) by Consumer, Valley-Wide
HI (Toddler)
HI (Child)
HI (Adolescent)
HI (Adult)
1.7
1.9
3.2
2.8
6.7
1.3
1.5
2.3
2.1
5.5
0.9
1.0
1.9
1.7
4.3
0.7
0.8
1.6
1.4
3.7
Average Ktunaxa
Average Recreator
Upper Percentile Ktunaxa
Upper Percentile Recreator
Preferred Ktunaxa
Scenario
Market Basket
Fish tissue
Game muscle
Game organ
Berries
Rose hips
Fish eggs
Groundwater
Sediment
Surface Water (Drinking Water)

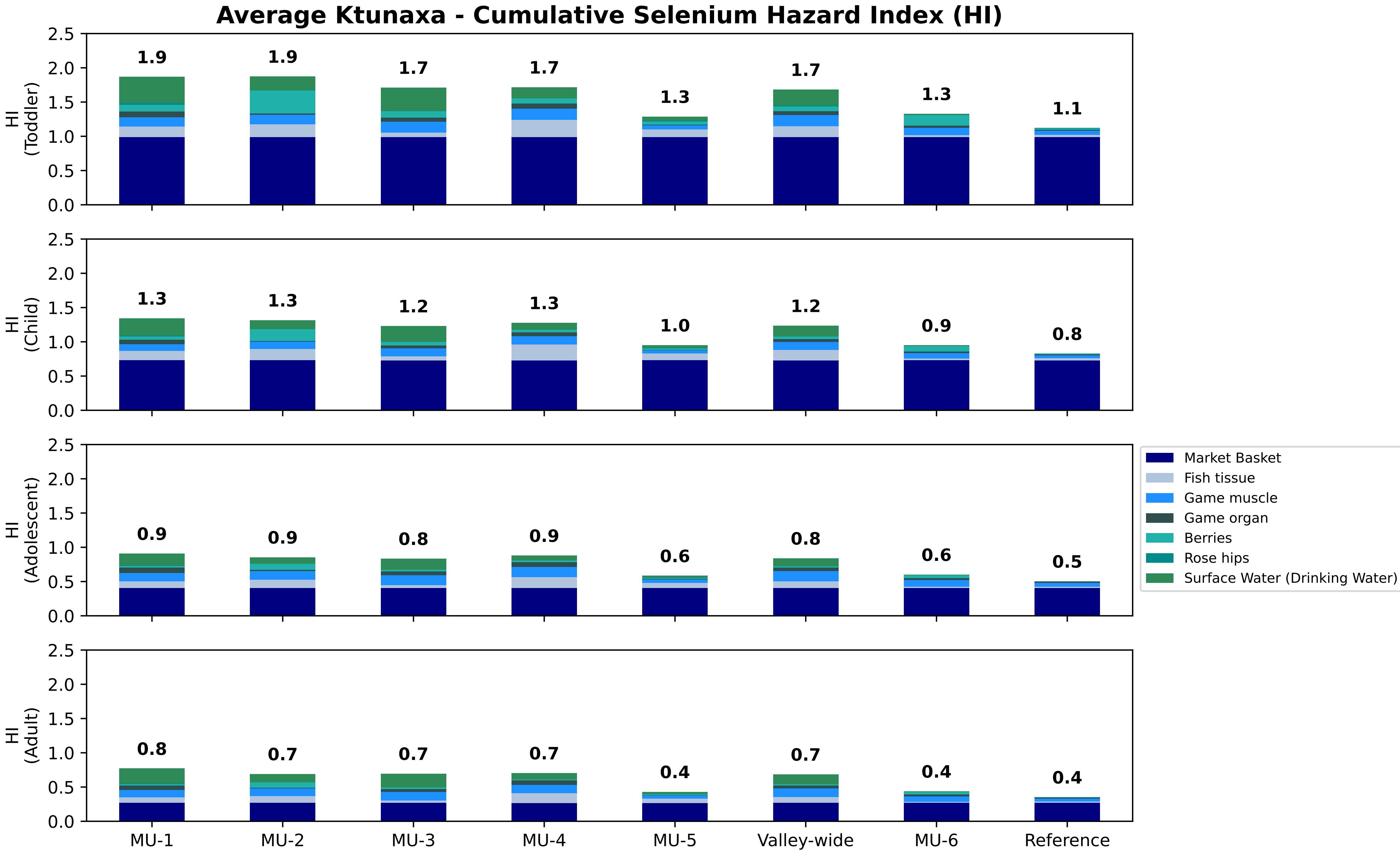
Preferred Ktunaxa - Cumulative Selenium Hazard Index (HI)



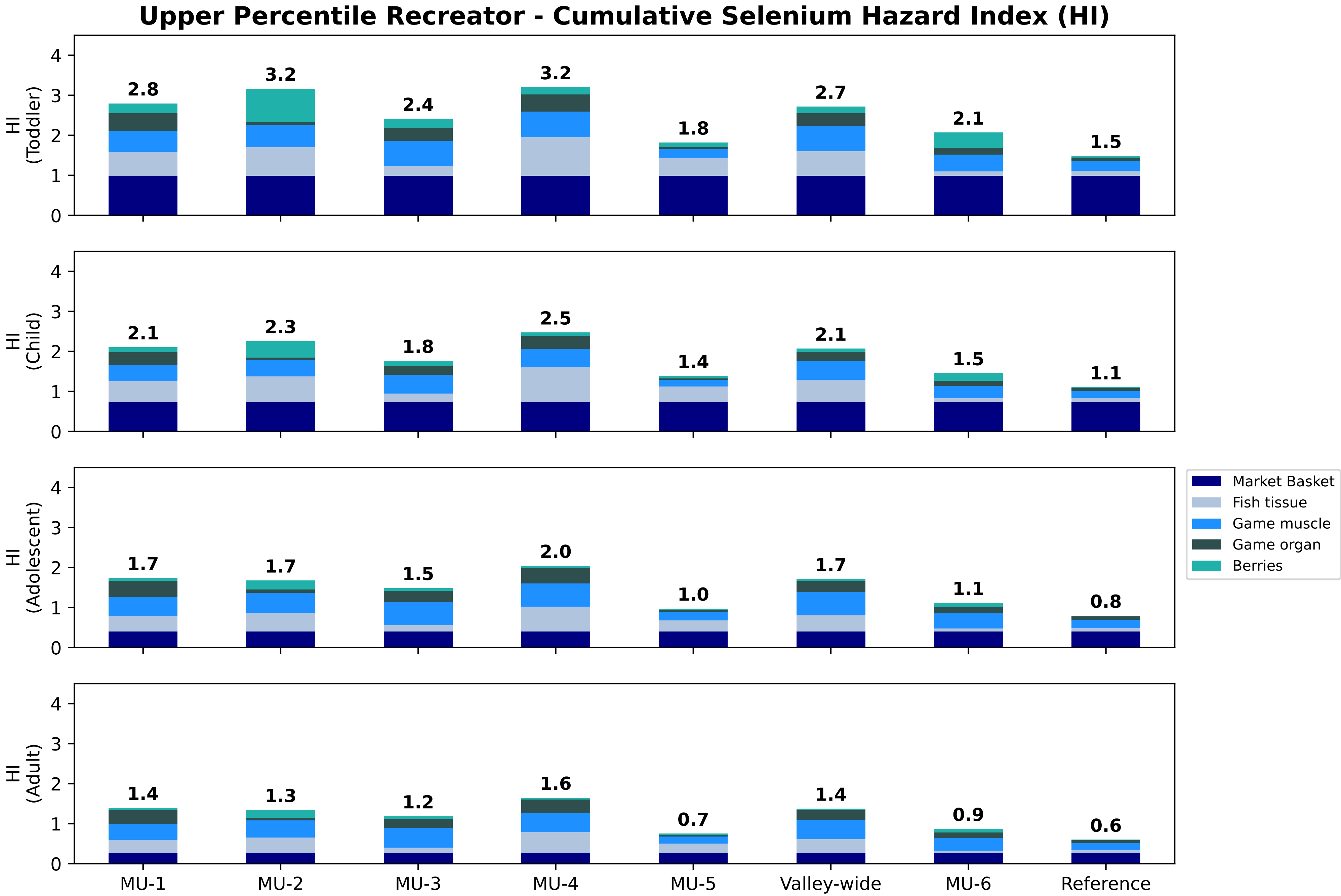
Notes:
1. Risk estimates for MU-4 fish tissue are biased high due to sample composition. A significant proportion of the fish tissue samples collected in MU-4 are longnose sucker in Goddard Marsh, a mine sedimentation pond. Longnose sucker sampled in this location had elevated selenium concentrations, but do not represent a typical source of fish consumption.
2. Game meat and organ were not sampled in MU-3. The valley-wide HIs for game meat and organ are used to approximate exposures in MU-3.
3. Rose hips were not sampled in MU-6. The valley-wide HI for rose hips is used to approximate exposures in MU-6.
4. Valley-wide estimates incorporate all data from MUs 1-5 for fish fillet and fish eggs, and all data from MUs 1-6 for game muscle, game organ, berries, and rose hips, as available.



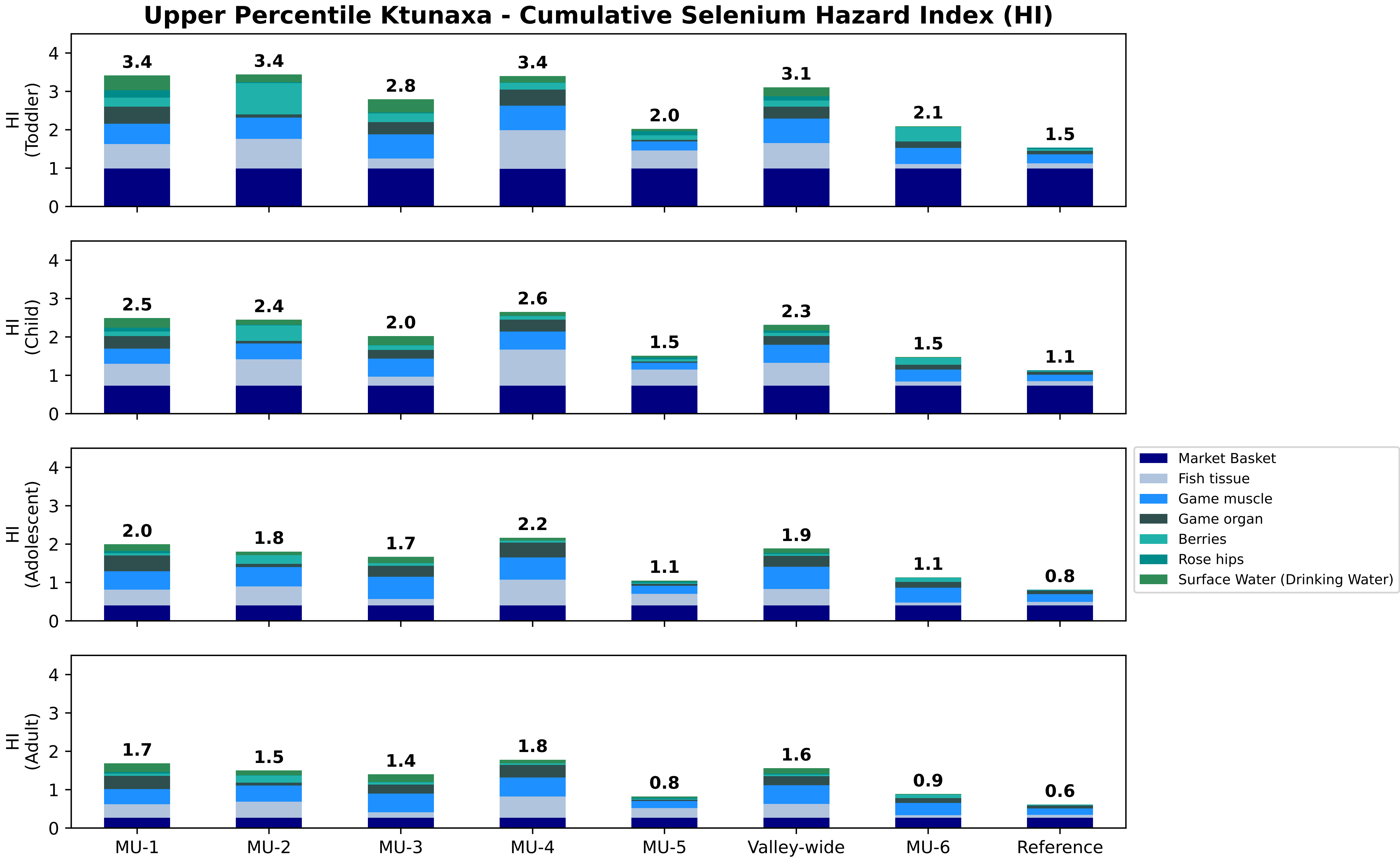
Notes:
1. Risk estimates for MU-4 fish tissue are biased high due to sample composition. A significant proportion of the fish tissue samples collected in MU-4 are longnose sucker in Goddard Marsh, a mine sedimentation pond. Longnose sucker sampled in this location had elevated selenium concentrations, but do not represent a typical source of fish consumption.
2. Game meat and organ were not sampled in MU-3. The valley-wide HIs for game meat and organ are used to approximate exposures in MU-3.
3. Rose hips were not sampled in MU-6. The valley-wide HI for rose hips is used to approximate exposures in MU-6.
4. Valley-wide estimates incorporate all data from MUs 1-5 for fish fillet and fish eggs, and all data from MUs 1-6 for game muscle, game organ, berries, and rose hips, as available.



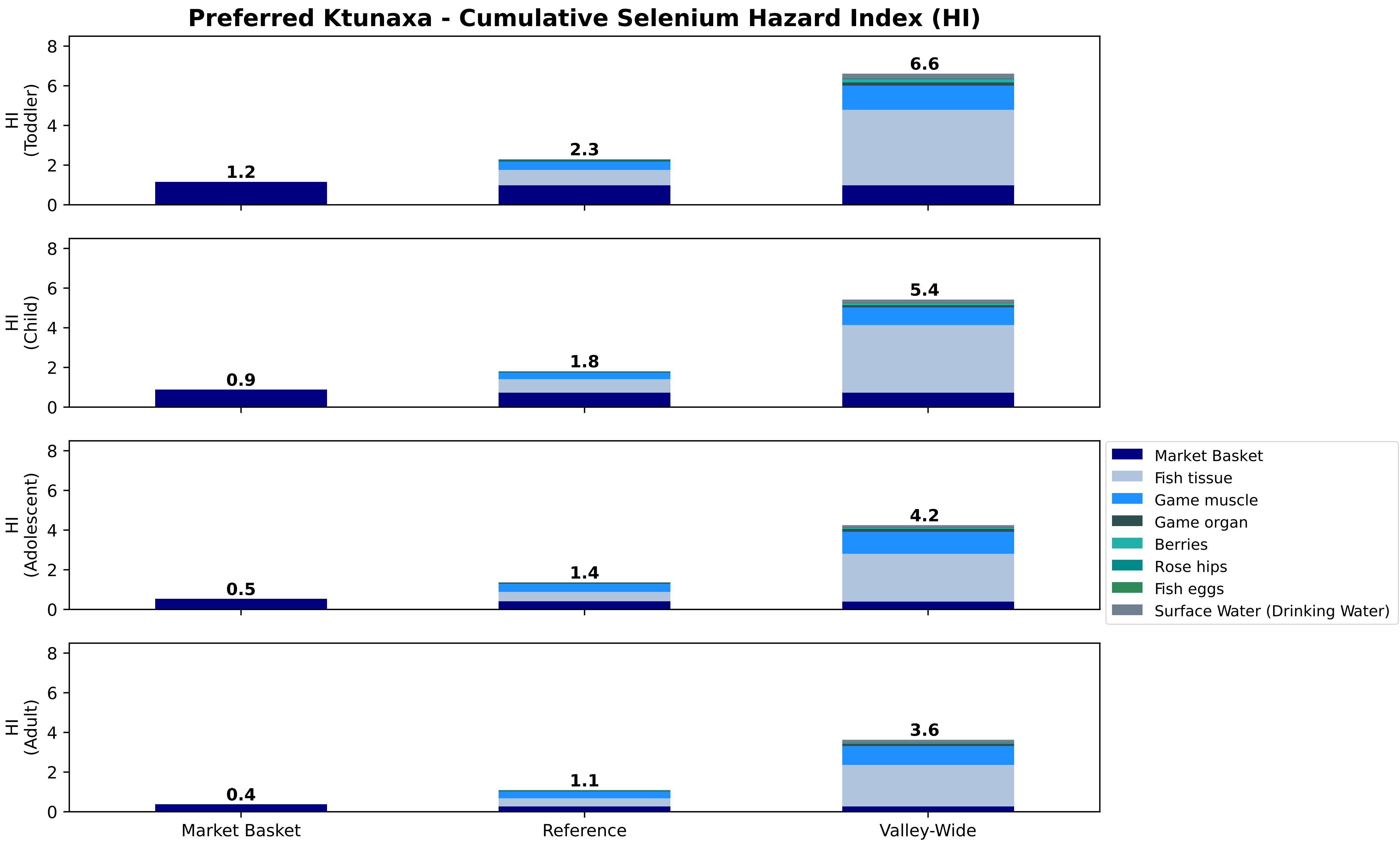
Notes:
1. Risk estimates for MU-4 fish tissue are biased high due to sample composition. A significant proportion of the fish tissue samples collected in MU-4 are longnose sucker in Goddard Marsh, a mine sedimentation pond. Longnose sucker sampled in this location had elevated selenium concentrations, but do not represent a typical source of fish consumption.
2. Game meat and organ were not sampled in MU-3. The valley-wide HIs for game meat and organ are used to approximate exposures in MU-3.
3. Rose hips were not sampled in MU-6. The valley-wide HI for rose hips is used to approximate exposures in MU-6.
4. Valley-wide estimates incorporate all data from MUs 1-5 for fish fillet and fish eggs, and all data from MUs 1-6 for game muscle, game organ, berries, and rose hips, as available.



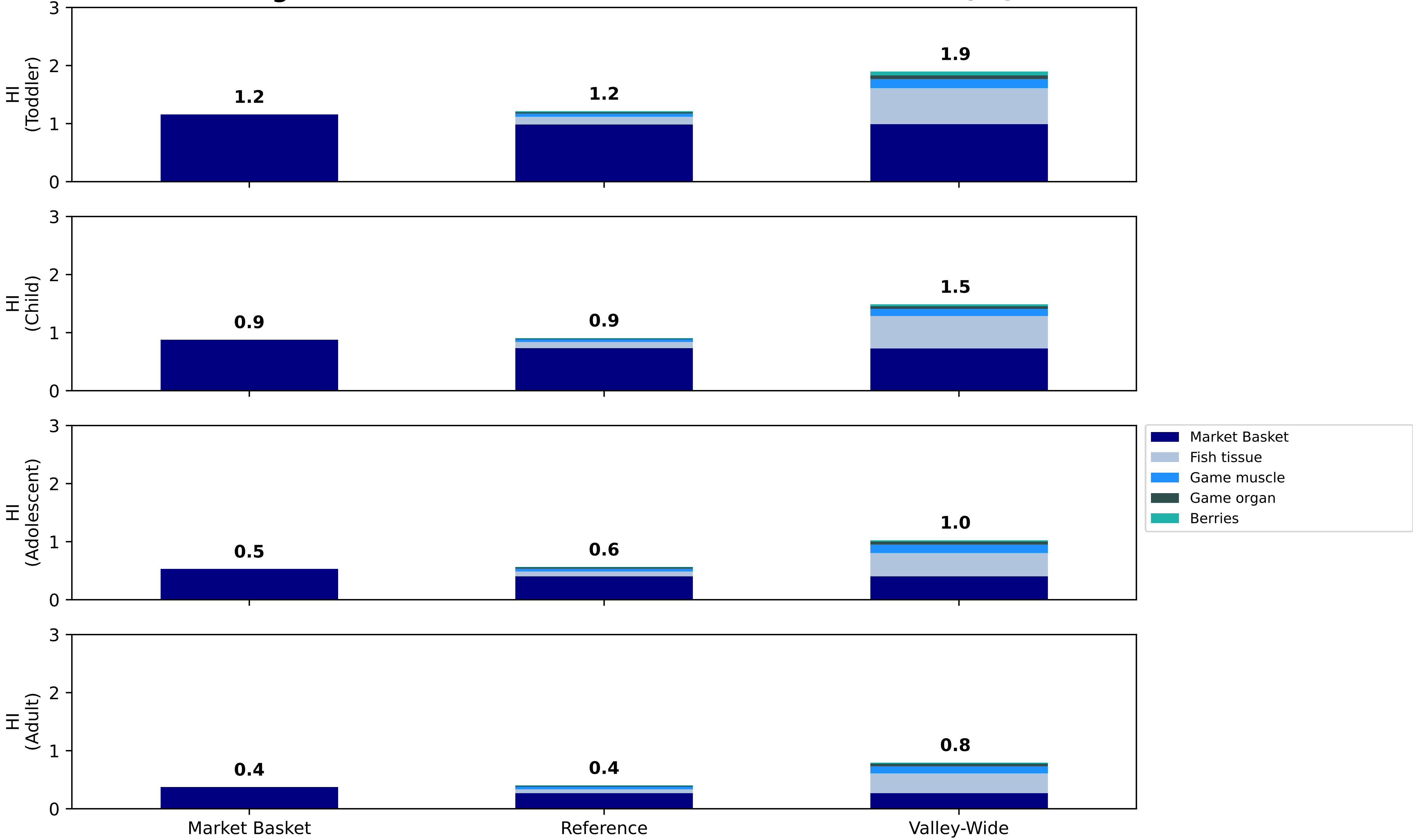
Notes:
1. Risk estimates for MU-4 fish tissue are biased high due to sample composition. A significant proportion of the fish tissue samples collected in MU-4 are longnose sucker in Goddard Marsh, a mine sedimentation pond. Longnose sucker sampled in this location had elevated selenium concentrations, but do not represent a typical source of fish consumption.
2. Game meat and organ were not sampled in MU-3. The valley-wide HIs for game meat and organ are used to approximate exposures in MU-3.
3. Rose hips were not sampled in MU-6. The valley-wide HI for rose hips is used to approximate exposures in MU-6.
4. Valley-wide estimates incorporate all data from MUs 1-5 for fish fillet and fish eggs, and all data from MUs 1-6 for game muscle, game organ, berries, and rose hips, as available.

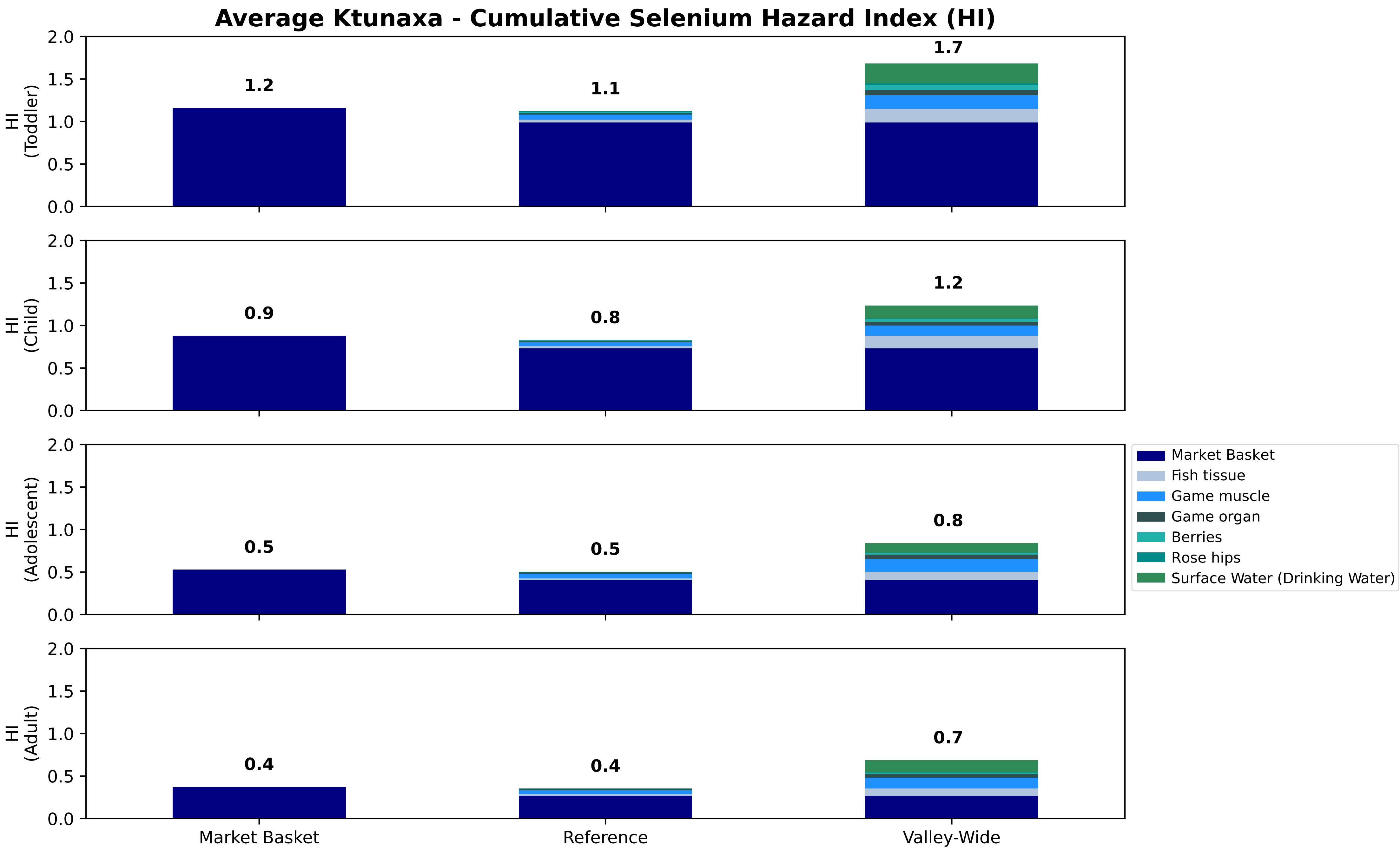


Notes:
1. Risk estimates for MU-4 fish tissue are biased high due to sample composition. A significant proportion of the fish tissue samples collected in MU-4 are longnose sucker in Goddard Marsh, a mine sedimentation pond. Longnose sucker sampled in this location had elevated selenium concentrations, but do not represent a typical source of fish consumption.
2. Game meat and organ were not sampled in MU-3. The valley-wide HIs for game meat and organ are used to approximate exposures in MU-3.
3. Rose hips were not sampled in MU-6. The valley-wide HI for rose hips is used to approximate exposures in MU-6.
4. Valley-wide estimates incorporate all data from MUs 1-5 for fish fillet and fish eggs, and all data from MUs 1-6 for game muscle, game organ, berries, and rose hips, as available.

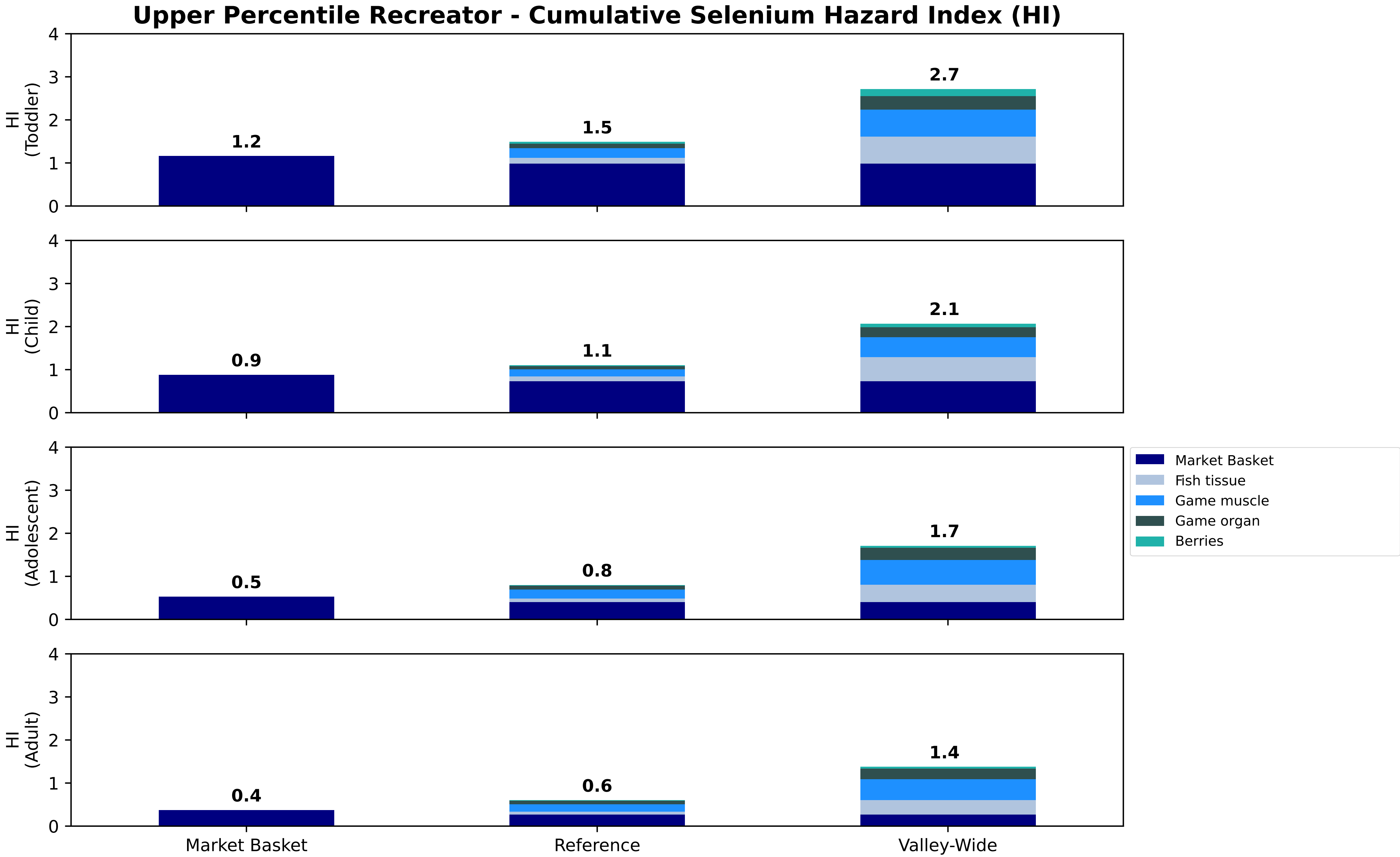

Preferred Ktunaxa - Cumulative Selenium Hazard Index (HI)
HI (Toddler)
HI (Child)
HI (Adolescent)
HI (Adult)
0
2
4
6
8
1.2
2.3
6.6
0.9
1.8
5.4
0.5
1.4
4.2
0.4
1.1
3.6
Market Basket
Reference
Valley-Wide
Market Basket
Fish tissue
Game muscle
Game organ
Berries
Rose hips
Fish eggs
Surface Water (Drinking Water)

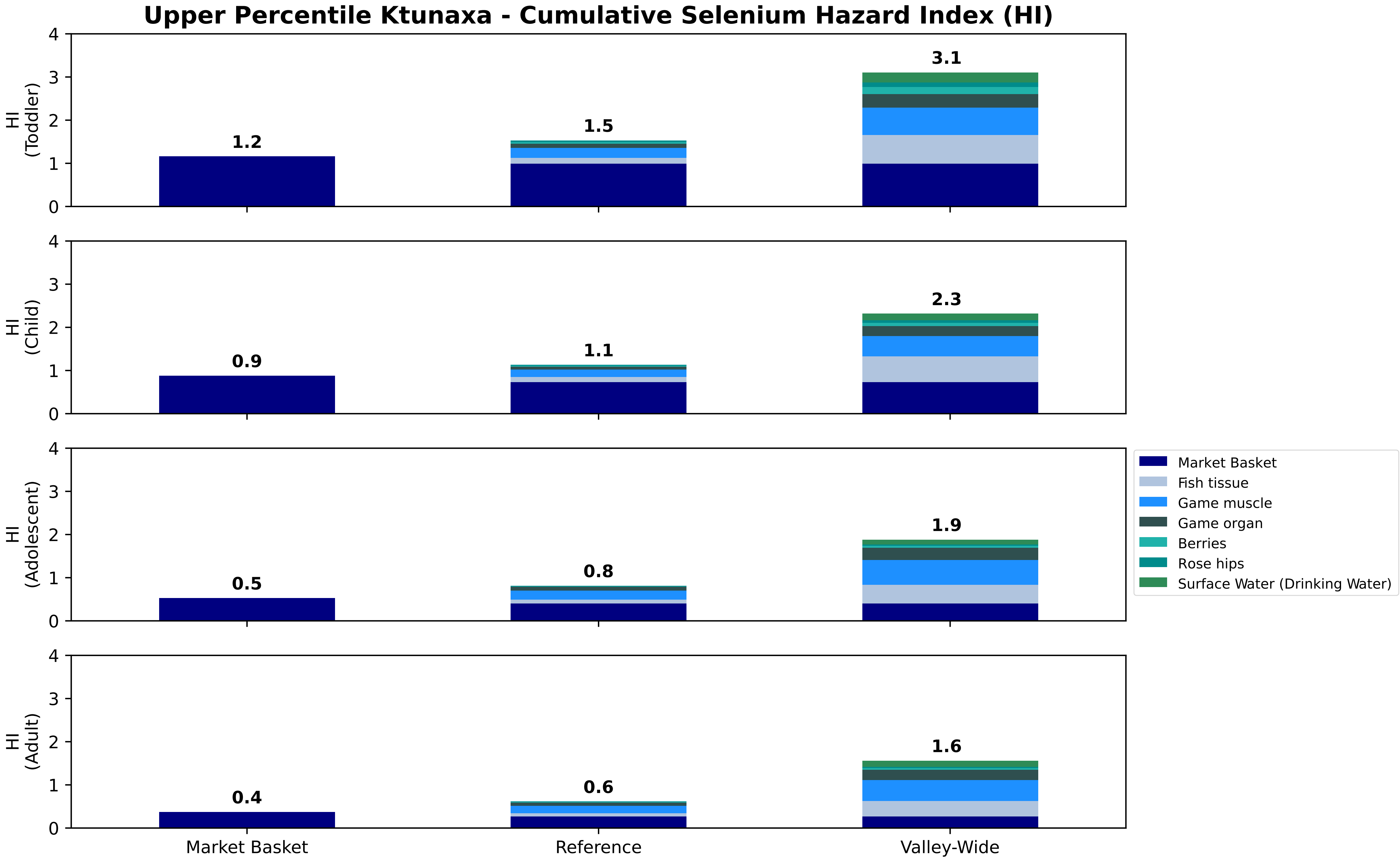
Average Recreator - Cumulative Selenium Hazard Index (HI)





Average Ktunaxa - Cumulative Selenium Hazard Index (HI)
HI (Toddler)
HI (Child)
HI (Adolescent)
HI (Adult)
2.0
1.5
1.0
0.5
0.0
1.2
1.1
1.7
0.9
0.8
1.2
0.5
0.5
0.8
0.4
0.4
0.7
Market Basket
Reference
Valley-Wide
Market Basket
Fish tissue
Game muscle
Game organ
Berries
Rose hips
Surface Water (Drinking Water)


Upper Percentile Recreator - Cumulative Selenium Hazard Index (HI)
HI (Toddler)
HI (Child)
HI (Adolescent)
HI (Adult)
1.2
1.5
2.7
0.9
1.1
2.1
0.5
0.8
1.7
0.4
0.6
1.4
Market Basket
Reference
Valley-Wide
Market Basket
Fish tissue
Game muscle
Game organ
Berries


Upper Percentile Ktunaxa - Cumulative Selenium Hazard Index (HI)
HI (Toddler)
HI (Child)
HI (Adolescent)
HI (Adult)
0
1
2
3
4
1.2
1.5
3.1
0.9
1.1
2.3
0.5
0.8
1.9
0.4
0.6
1.6
Market Basket
Reference
Valley-Wide
Market Basket
Fish tissue
Game muscle
Game organ
Berries
Rose hips
Surface Water (Drinking Water)

APPENDIX J
CONSIDERATION OF NON-WATER QUALITY PATHWAYS NOT EVALUATED IN PERMIT 107517 HHRA

In addition to this HHRA performed to comply with Permit 107517, an HHRA supporting the Baldy Ridge Extension (BRE) Project of the existing Elkview Operations was completed in November 2015. Each HHRA addresses specific requirements outlined by BC ENV, with each serving different purposes in environmental assessment and management processes. The BRE HHRA answers the question, "*What changes in human health risk will the BRE Project elicit relative to existing conditions?*" The HHRA also estimates what changes the BRE Project will affect in combination with other reasonably foreseeable developments, whereas the Permit 107517 HHRA answers the question, "*Is water quality being managed to remain protective of human health*?"

KNC has raised concerns that the Permit 107517 HHRA does not address potential mine-influenced exposure pathways unrelated to water quality, such as exposure to constituents in dust, soil, and air. This analysis utilizes the Permit 107517 and BRE HHRAs to respond to KNC concerns to the extent possible.

1.1.1 BRE HHRA Overview and Relationship to Permit 107517 HHRA

The BRE HHRA focused on human health risks in areas where people are known to be present and included various intake patterns based on the populations in those areas. Daily exposures were calculated based on exposures via multiple, combined pathways. Specifically the BRE HHRA examined risks associated with changes to the environment (soil, air, surface water, groundwater, sediment, fish, wild game, and vegetation) as the result of the BRE Project. The BRE HHRA utilized predicted concentrations for Base, Application, and Reasonably Foreseeable Development cases for COPCs associated with the BRE Project. The Base case represented existing conditions in the Elk Valley. Predicted concentrations incorporated measured baseline data for air, water, fish, soil, wild game, and berries.

Daily intakes and risks were calculated at specific locations throughout the study area for each COPC for the following exposure pathways: incidental ingestion of soil, dermal contact with soil, inhalation of dust from soil (referred to as inhalation of soil), ingestion of surface water, dermal contact with surface water, incidental ingestion of sediment, dermal contact with sediment, consumption of food (berries, fish, wild game and market basket foods), and inhalation of air (Table J-1). Risk estimates were provided for community residents, temporary residents of seasonal hunting/harvesting camps, and people spending time in recreational areas (e.g., recreational/ commercial cabins or camps), by location within the Elk Valley. Risk estimates were also provided for KNC members who consume high quantities of traditional foods.

Table J-1. Exposure pathways evaluated in the BRE HHRA and Permit HHRA

Exposure Pathway	BRE HHRA	Permit HHRA
Groundwater ingestion	●	●
Soil incidental ingestion	●	
Soil dermal contact	●	
Soil inhalation	●	
Sediment incidental ingestion	●	●
Sediment dermal contact	●	●
Surface water dermal contact	●	●
Surface water incidental ingestion	●	●
Air inhalation (particulates & vapours from mine operations)	●	
Fish ingestion	●	●
Berry ingestion	●	●
Wild game ingestion	●	●
Market basket food intake	●	●

1.1.2 Comparison of BRE and Permit 107517 HHRA Intakes

To respond to the concerns identified by KNC, the Base case First Nations high-consumer resident toddler intakes were selected to compare with intakes from this HHRA. The Base case was selected because it is representative of current conditions for First Nations residents in Elk Valley and is more directly comparable to the Permit 107517 HHRA. The BRE HHRA First Nations high-consumer, based on 95th percentile consumption rates of traditional foods (i.e., berries, elk, deer, and fish) assessed among members of the Ktunaxa Nation community, was selected to adequately address concerns about high-intake exposures within the community. A toddler represents the most sensitive residential population evaluated in an HHRA because toddlers are considered to be more susceptible to non-cancer health effects and certain chemicals and because certain behavioural activities may result in greater exposures on a body-weight basis than other life stages. As presented in the BRE HHRA, no significant residual adverse effects as a result of the BRE Project were identified for the Base case First Nations high-consumer toddler for any of the assessed COPCs or for any of the other populations.

The BRE and Permit HHRA were first compared for those exposure pathways quantified in both HHRAs. These shared exposure pathways include fish ingestion, surface water ingestion, sediment and groundwater ingestion, wild game and berry ingestion, and skin contact with surface water and sediment, as shown in Table J-1.

The exposure parameters used in the BRE HHRA for the soil and air pathways are presented in Table J-2.

In the BRE HHRA, concentration data was modeled for specific locations in the study area and represented a point estimate of the concentration at that location. Intake values that incorporated that concentration data were then calculated for each location by exposure pathway[1]. In the Permit HHRA, concentration data was based on monitoring sample data collected within each management unit and was representative of the general concentration for the entire management unit; one exposure intake value was then calculated for each management unit[2].

Table J-2: Exposure parameters for soil and air pathways used in the BRE HHRA

Exposure Factor	Units	Toddler	Adult	Source
Soil Contact Pathways				
Soil ingestion rate	mg/day	80	20	Health Canada 2012
Skin surface area exposed for soil contact-hands	cm^2	430	890	Health Canada 2012
Skin surface area exposed for soil contact-arms and legs	cm^2	2,580	8,220	Health Canada 2012
Soil loading rate-hands	mg/cm^2/event	0.10		Health Canada 2012
Soil loading rate-arms and legs	mg/cm^2/event	0.01		Health Canada 2012
Exposure frequency	days/week	7		Health Canada 2012
Exposure frequency	weeks/year	39		Assumed [a]
Air Inhalation Pathway				
Particulate concentration in air	mg/m^3	0.00076		Health Canada 2012
Exposure time (time spent outdoors)	hours	1.5		Health Canada 2012
Inhalation rate	m^3/day	8.3	16.6	Health Canada 2012
Exposure frequency	days/week	7		Health Canada 2012
Exposure frequency	weeks/year	52		Health Canada 2012

Notes:
mg = milligrams; cm^2 = square centimeters
[a] Assumed 39 weeks per year when the ground is not snow covered based on closeest Environment Canada monitoring station reporting snow cover (Government of Canada 2014).
From: Teck 2015b. Elkview Operations Baldy Ridge Extension Project. Prepared by Golder Associates for Teck Coal Ltd

Daily intake values for the First Nations high consumer resident toddler (Base case intakes from the BRE HHRA) for each exposure pathway calculated in each HHRA were compared as

[1] Certain exposure pathways in the BRE HHRA were not location-specific, including sediment dermal contact and sediment ingestion, berry ingestion, and wild game ingestion.

[2] MU-1 and MU-2 were not considered in this analysis because there are no permanent residents in those areas; the BRE HHRA evaluated only seasonal receptors within these management units. The management units evaluated here will be reflective of the pattern of exposure if seasonal receptors were to be present year-round in MU-1 and MU-2.

an assessment of the methodological approach of each HHRA and to allow for later evaluation of the impact of quantitatively evaluating only certain exposure pathways. To facilitate this comparison, selenium was selected as the COPC-specific intake for evaluation because it was the only COPC evaluated across all exposure pathways in all management units and receptor locations in both HHRAs. BRE HHRA location-specific intake values were assigned to the Permit HHRA management unit into which they fell and then the maximum BRE intake for each management unit was compared to the Permit HHRA intake for that management unit. BRE HHRA receptor locations for Elkford, Whispering Winds Trailer Park, Sparwood, and Grasmere were selected to represent management units 3, 4, 5, and 6, respectively. Locations evaluated in the BRE HHRA are shown in Figure 2 with overlapping management unit boundaries.

As shown in Table J-3, the intakes by management unit are generally within one order of magnitude for each exposure pathway. This suggests that there is reasonable agreement in the modeled and sampled concentrations utilized in each HHRA and the intakes calculated are relatively comparable. Sediment dermal contact intake is much lower for the Permit HHRA than the BRE HHRA, which may be due to differences in assumptions for sediment-to-skin adherence.

Table J-3. Comparison of BRE and Permit 107517 HHRA selenium intakes by media and management unit

Exposure Pathway	MU-3		MU-4		MU-5		MU-6	
	BRE HHRA	Permit HHRA	BRE HHRA	Permit HHRA	BRE HHRA	Permit HHRA	BRE HHRA	Permit HHRA
Tap Water Ingestion	1E-04	1E-04	5E-05	3E-04	2E-04	3E-04	3E-04	--[a]
Surface Water Dermal Contact	2E-07	3E-06	2E-06	1E-06	1E-06	4E-07	5E-07	5E-07
Surface Water Incidental Ingestion	2E-06	2E-05	1E-05	1E-05	1E-05	4E-07	4E-06	4E-06
Sediment Dermal Contact	6E-06	1E-08	6E-06	1E-07	6E-06	5E-08	6E-06	6E-09
Sediment Ingestion	1E-06	5E-06	1E-06	4E-05	1E-06	2E-05	1E-06	2E-06
Berry Ingestion	2E-03	1E-03	2E-03	1E-03	2E-03	6E-04	2E-03	2E-03
Fish Ingestion	2E-03	2E-03	2E-03	7E-03	2E-03	3E-03	2E-03	7E-04
Wild Game Ingestion	3E-03	5E-03[b]	3E-03	6E-03	3E-03	2E-03	3E-03	3E-03
Total	7E-03	3E-03	7E-03	1E-02	7E-03	6E-03	7E-03	6E-03

Notes:

All units are provided in mg/kg-day.
Gray shading indicates an intake that is not MU- or location-specific.
For Permit HHRA, surface water selenium intakes represent swimming/tubing exposures, sediment intakes are for wading/foraging, and berry, fish, and wild game ingestion is for the upper percentile Ktunaxa consumer.

[a] Value not calculated because the Permit HHRA assumed that tap water is groundwater and no groundwater wells were sampled in MU-6.
[b] Valley-wide intake used because no wild game data available in MU-3.
BRE = Baldy Ridge Extension; HHRA = human health risk assessment

Despite variation in individual pathways, the total intake by management unit for the BRE and Permit HHRAs are approximately the same. As discussed previously, it is important to consider that the input concentration data, i.e., EPCs, used to calculate daily intakes for each HHRA was different, thus impacting the resulting calculated intakes. Monitoring data such as that used in the Permit HHRA provides valuable measurements of the concentrations present in various exposure media at sampling locations across an area of interest (in this case, each management unit). Modeled data such as that used in the BRE HHRA also provides valuable estimations of concentrations in exposure media to assist in the characterization of specific exposures that may occur at varying time periods in the future related to projects not yet constructed or in operation.

1.1.3 Combined BRE and Permit 107517 HHRA Evaluation

To fully address KNC concerns about exposure via multiple, combined pathways, this analysis evaluated the potential additional impact of pathways quantified in the BRE HHRA but not the Permit HHRA. These pathways include inhalation of particulates and gases and incidental ingestion of and skin contact with soil. To evaluate the potential impact, the Base case First Nations high consumer resident toddler selenium intakes for these pathways as calculated in the BRE HHRA (for those BRE HHRA discrete locations previously matched to a management unit) were added to the Ktunaxa upper percentile consumer toddler intakes for pathways calculated in the Permit HHRA by management unit, as shown in Table J-4.

The additional pathways quantified only in the BRE HHRA are minor contributors to exposure, and the total intakes for pathways quantified in the Permit HHRA are almost the same as the BRE HHRA calculated total intake including the additional pathways. If the Ktunaxa preferred consumption rates for fish, berry, and game were used in this evaluation, the contribution from the air and soil pathways would be even smaller due to the overwhelming contribution of the food pathways to total intake. As discussed previously, the intakes for the pathways quantified in both the Permit and BRE HHRAs are generally within a reasonable range, given the differences in calculation methodology utilized. Based on this comparison, there is low uncertainty that the water quality-focused exposure pathways evaluated in the Permit HHRA are underestimating total exposures from environmental media within the Designated Area. The inclusion of the additional exposure pathways quantified in the BRE HHRA would not result in a significant difference in the Permit HHRA results.

Table J-4. Selenium intakes by media and management unit for Permit and BRE HHRAs combined

Pathway		Units	MU-3	MU-4	MU-5	MU-6
BRE HHRA	Air Inhalation	mg/m³	4E-07	4E-07	4E-07	4E-07
		mg/kg-d[a]	1E-07	1E-07	1E-07	1E-07
	Soil Dermal Contact	mg/kg-d	8E-08	8E-08	8E-08	8E-08
	Soil Ingestion	mg/kg-d	9E-06	9E-06	9E-06	9E-06
	Soil Particulate Inhalation	mg/m³	9E-11	9E-11	9E-11	9E-11
		mg/kg-d[a]	3E-11	3E-11	3E-11	3E-11
Permit HHRA	Tap Water Ingestion	mg/kg-d	1E-04	3E-04	3E-04	--[b]
	Surface Water Dermal Contact	mg/kg-d	3E-06	1E-06	4E-07	5E-07
	Surface Water Incidental Ingestion	mg/kg-d	2E-05	1E-05	4E-07	4E-06
	Sediment Dermal Contact	mg/kg-d	1E-08	1E-07	5E-08	6E-09
	Sediment Ingestion	mg/kg-d	5E-06	4E-05	2E-05	2E-06
	Berry Ingestion	mg/kg-d	1E-03	1E-03	6E-04	2E-03
	Fish Ingestion	mg/kg-d	2E-03	7E-03	3E-03	7E-04
	Wild Game Ingestion	mg/kg-d	5E-03[b]	6E-03	2E-03	3E-03
Permit HHRA Total		mg/kg-d	8E-03	1E-02	6E-03	6E-03
All Pathways Total		mg/kg-d	8E-03	1E-02	6E-03	6E-03
Permit HHRA Percent of All Pathways Total			99.9%	99.9%	99.8%	99.8%

Notes:
Gray shading indicates an intake that is not MU- or location-specific.
[a] Inhalation intake rates were converted from mg/m³ to mg/kg-day by assuming a 20 m³/day breathing rate and a 70 kilogram body weight.
[b] Value not calculated because the Permit HHRA assumed that tap water is groundwater and no groundwater wells were sampled in MU-6.
[c] Valley-wide intake used because no wild game data available in MU-3.
BRE = Baldy Ridge Extension; HHRA = Human Health Risk Assessment; MU = Management Unit; -- = Not calculated; mg = milligram; m3 = cubic meter; kg = kilogram; d = day

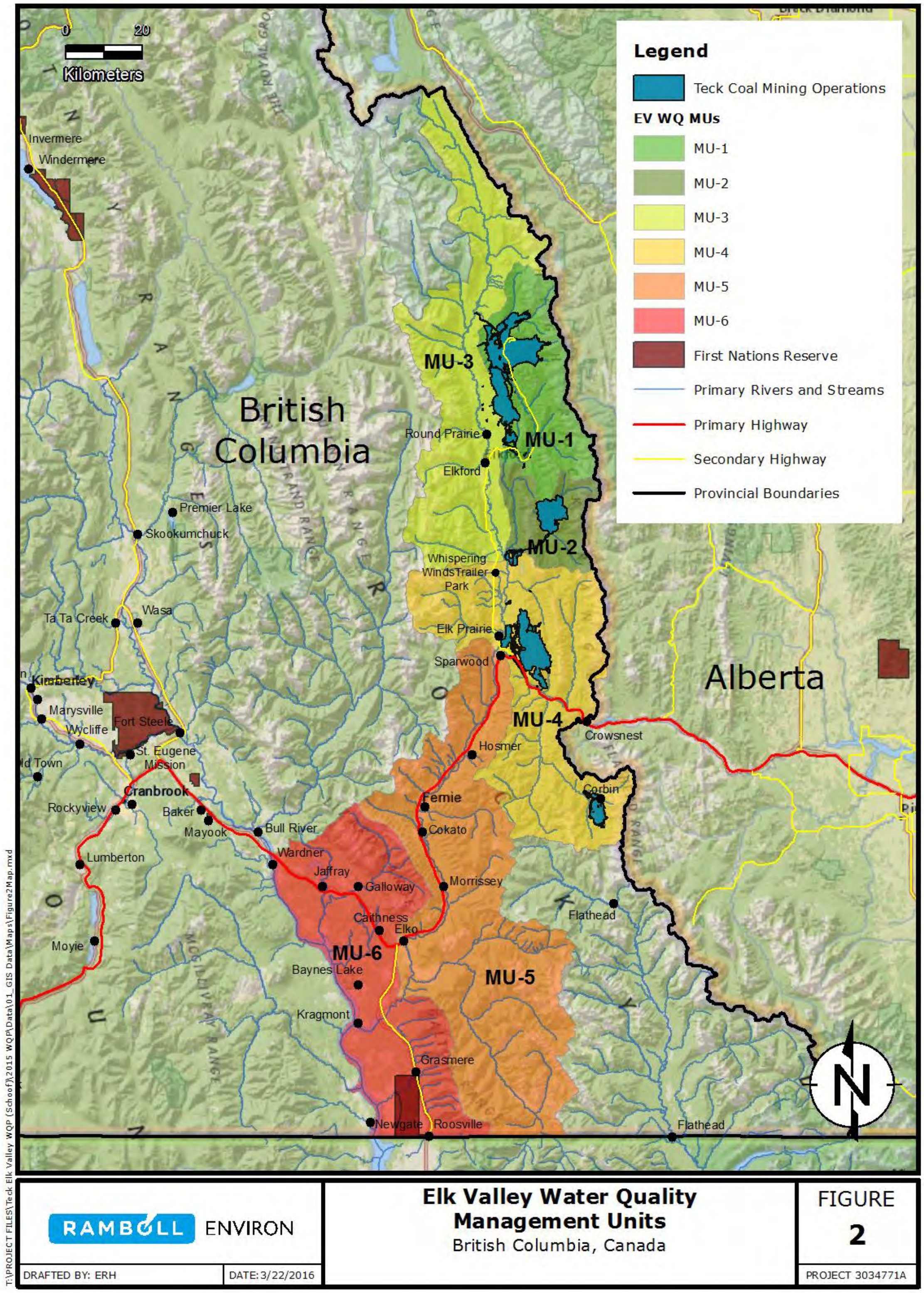


Figure 2: Elk Valley Water Quality Management Units

APPENDIX K
EMC Advice and Teck Response Table

Final Human Health Risk Assessment Supporting the Elk Valley Water Quality Plan (Submitted July 2022) Advice & Input To Support Decision Making						
#	Report Page & Section	Comment	Rationale	Date	Reviewer	Response to Comments
1		Page numbering appears off in ES. Looks like pages were re-ordered but pagination update not completed. Ex. Figure ES-11 is on ES-14 but page 30. wherease page ES-15 is on page 28 of the pdf and then again on page 31		Nov 7 2022	KF	Thanks for pointing this out. This has been corrected.
2	ES-1; ES-14	Recommend Ramboll introduce how HQ of 0.2 is used in the HHRA within the ES. Ramboll introduces the BC ENV preliminary risk threshold on ES-14 but do not explain. Table ES-1 includes description of HQ >1. Within Appendix K, there were several instances when clarification was sought by reviewers around the HQ. In response to comment IH-23 Ramboll responded in that 'Ramboll discussed this comment on a call with IH on 3/3/22, and it was agreed that the preliminary comparison to a HQ of 0.2 helps identify potential contributors to cumulative risks, but the subsequent target organ analysis and focus on HQs>1 should be the primary focus of the discussion and risk recommendations.' The response to comment KNC-28 in Appendix K, was 'Consistent with Health Canada DQRA guidance, the ENV risk management threshold of HQ>1 is used to determine if there are elevated risks. This is because exposure from background sources are quantified in the HHRA. HQ>0.2 is used as a preliminary risk threshold to identify primary media that may contribute to risk, but is not an indicator of elevated risk. '	Risk communication. Clarity for readers of how risk is quantified and the value/use of both these thresholds	Nov 7 2022	KF	The second bullet in the Text Table under Non-Cancer Risks now reads: Initial screening was conducted based on a comparison with an HQ of 0.2 to identify constituents and pathways of most importance. HQ values less than 0.2 have negligible risks. In risk calculations including consideration of background, where if the HQ is less than or equal to 1, no adverse health effects are expected (i.e., low risk). If an HQ is greater than 1, additional assessment may be needed.
3	ES-1; p16	Identify in ES that local food is included in the HHRA to 1) identify background exposure and parse out potential differences in COPC levels from foods obtained in reference areas . As diet is a significant background source of exposure for many minerals, this HHRA also evaluated the contribution from locally harvested foods (fish, elk, deer, berries) and purchased food and beverages.	Risk communication. Additional text helps explain rationale for looking at contributions from diet/local food	Nov 7 2022	KF	This point is included in an edit to the "What Was Evaluated" section of the Executive Summary and in the first bullet of the Conclusions of the Executive Summary.
4	ES-1; p16	Suggest that the text be included from Section 7.2 that "Influences from dust / air emissions from the mines were not the subject of the HHRA and were not characterized. The focus of the HHRA was on risks associated with exposures to water and water-related or -associated media to inform water quality management practices. However, it is possible that airborne deposition has influenced concentrations in berries and on forage consumed by game."	Risk communication. Exposure for Ktunaxa and others harvesting locally may be elevated from people who just eat market foods b/c of mining influences that were not examined.	Nov 7 2022	KF	The following text was added to the Ex. Sum under the heading "What Was Evaluated?" at the end of the first paragraph "Influences from dust / air emissions from the mines were not the subject of the HHRA and were not characterized. However, it is possible that airborne deposition has influenced concentrations in berries and on forage consumed by game."
5	ES-5; p.20	Consumption levels were used to **evaluate exposure to COPCS in** foods sourced from the Elk Valley	Risk communication. Evaluting the background exposure from consuming these foods at different levels, not the consumption of these foods	Nov 7 2022	KF	Edit made thank you.
6	ES-6; p21	Section. What Health Effects were evaluated? Place this sentence in following section on What are the results of the HHRA. 'Among the many COPCs evaluated in the HHRA, selenium contributed to higher risks than other COPCs across all exposure media and populations' Then join the remainder of this paragraph to the one above it where example of selenium is provided.	Risk communication. Provides greater clarity as to what was evaluated rather than introducing findings here	Nov 7 2022	KF	Edit has been made as requested
7	ES-6; p21	Section. What are the results of the HHRA. Suggest 'The HHRA presents health risks for 1) Ktunaxa who have land-and water-based relationships in the Elk Valley HHRA study area, 2) residents in the Elk Valley study area and visitors and 3) groundwater consumers who may be full-time or seasonal residents and visitors.'	Risk communication. provides greater clarity as to the 3 populatiions that are looked at	Nov 7 2022	KF	The suggested sentence has been added after the first sentence in the "What are the results of the risk assessment?" section with the text in red added as a modification: "The HHRA presents health risks for 1) Ktunaxa who have land-and water-based relationships in the Elk Valley HHRA study area, 2) residents in the Elk Valley study area and visitors and 3) people who consume groundwater as residential drinking water who may be full-time or seasonal residents and visitors."
8	ES-7	Do not remove the symptoms of selenium overexposure		Nov 7 2022	LC	The text now reads: "Some amount of selenium is essential to life but chronic overexposure to selenium at concentrations much higher than the TRV (e.g., over 800 µg/day) may cause a health condition called selenosis. Symptoms observed in individuals exposed to chronically high levels of dietary selenium include loss of hair and nails, skin lesions, tooth decay, and abnormalities of the nervous system (ENV 2014). These effects typically resolve themselves once the exposure route is eliminated. Selenium is not known to cause cancer."
9	ES-7; p22	On this page, Ramboll indicates an HQ of 1 or less is a strong indicator that adverse effects are unlikely but describes an HQ above 1 **for each exposure medium** not as a predictor of actual health risk but rather a potential elevated health risk. Furthermore, it's stated a HQ >1 indicates further refinement of assumptions or additional data collection is needed. Does this mean no immediate actions are needed to current management?	Risk communication. This seems odd and will be confusing for most folk. Suggest remove words such as predictor of actual health risk and used phrases 'likely adverse effect or elevated risk? If an HQ > 1 requires no mitigation, it's prudent to clarify to a reviewer what the threshold value for action is.	Nov 7 2022	KF	The following sentence is added to the end of the last paragraph in the section entitled "What Are the Results of the HHRA": "Section 7 of this HHRA describes recommendations for next steps and adaptive management for human health. "
10	ES-7; p22	Ramboll indicates an HQ above 1 **for each exposure medium** not as a predictor of actual health risk but rather a potential elevated health risk due to the nature of the methodoloyg. I'm not clear as to how the local health conditions of the residents of the local health area are factored into this. What if they are already at a heightened vulnerability. Does it matter?	Risk communication. Suggest there be some presentation of current health and vulnerability for the populations included (esidents of Elk Valley, Ktunaxa) when assessing the potential for adverse effects. As it stands, local residents seem concerned about dust and there is evidence from sampling that there are some elevated levels of minerals within the reference area, which points to a background exposure at or above 1. Fish and wildlife population declines also suggest concerns with the local environment. LHA Fernie 2020 profile reported that the Standardized Mortality Rate (SMR) over the period of 2011-2015 had more deaths than expected from cancer, respiratory disease. there are much greater food insecurity rates for Ktunaxa than general population which increases likelihood of hospital admissions and disease.. It seems prudent to share what is known re: baseline health of population relative to reference areas to establish if there is elevated health risks.	Nov 7 2022	KF	Analysis of site-specific risks based on specific vulnerabilities of the local population is beyond the scope of the HHRA. However, the HHRA does incorporate many aspects that tend to overestimate risks including the use of toxicity values intended to focus on the most sensitive members of society, application of upper-end exposure values, and the selection of data for the risks assessment from areas more likely to be affected by mining. These factors provide a protective means to consider risk assessment findings. In addition, Table ES-1 has been updated to include a column summarizing hazard quotients greater than 0.2.
11	ES-8 and 9	Table ES-3, HQ calculated for each source/medium should use a threshold of 0.2 instead of 1.		Nov 7 2022	LC	Table ES-3 has been updated to include a column summarizing hazard quotients greater than 0.2.

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#	Report Page & Section	Comment	Rationale	Date	Reviewer	Response to Comments
12	ES-8 and 9	Add a paragraph to describe clearly what source/medium showed a HQ>0.2		Nov 7 2022	LC	The summary Table ES-1 has been updated to summarize where HQ >0.2 and additional text has been added to refer the reader to detailed summaries of HQs.
13	ES-8; p23	Game Meat: Negligible Risks 'for all COPCs and consumer groups except preferred consumers in MU-5. Should this be: 'negligible risks for most COPCS and most human receptor groups evaluated' as lead appears to be a likely issue?	Risk communication. clarify confusion.	Nov 7 2022	KF	Lead was already mentioned in the 4th column of this table and has also been added to the second column.
14	ES-8; p23	Suggest text re: elevated risk for mercury (above 1) appear in 4th column , be carried into that column of elevated risk , instead of just in background exposure? Not completely sure that there is strong evidence that levels of mercury are comparable to other regional lakes (b/c of paucity of data. See 1 local lake: Moyie lake had some data but others are further away.)		Nov 7 2022	KF	The same text that was in the column regarding background was added to the column regarding elevated risks stating: "HQs are greater than 1 for mercury in Koocanusa Reservoir for upper percentile and preferred consumers. However, concentrations are comparable to concentrations in regional lakes."
15	ES-8; p23	Ramboll identifies 5 exposure medium in Table ES-3 and uses an HQ of 1 for each exposure medium to define if there is a potential elevated risk. Would it not be HQ of 1 when all food and water is combined?	Clarity needed	Nov 7 2022	KF	Additional detail has been added in the Executive Summary text and tables regarding risks elevated over 0.2 by pathway.
16	ES-9; 24	If this is section is about cumulative risks and a 'hazard index' that takes into account combined roles of various COPCS, suggest this section include additional discussion of how the other COPCs (mercury, cadmium, lead) contribute to HI here before focus on selenium.	Clarity needed	Nov 7 2022	KF	Section 6.3.2 of the HHRA and Table 6.2 provide cumulative hazard indices by target organ for pathways directly related to water quality. As indicated there selenium has the primary contribution to hazard indicies greater than 1 in MU-1 through MU-5 and mercury, a global pollutant, has the primary contribution to hazard indicies greater than 1 in MU-6.
17	ES-10; 25	Why not include water in this cumulative risk summary as 'drinking water' is considered part of diet. Or if negligible contributor then include this somewhere in text on ES-9 and footnote to figures on ES-10. (ie refer to figure 6.6 section 6.10)	Water is a large part of diet. Water should be included as part of the total contribution to exposure?	Nov 7 2022	KF	Surface water as drinking water has been added to the figures in the main text and in appendix for Ktunaxa receptors and the text has been revised accordingly.
18	ES-9 to 10; p. 24-25	It is stated that average consumer Hazard Index is +.3 from background while preferred diet consumer has +4 from background. Can you be more specific as to how you were calculating these? In the figure Es-4. I see difference of .7 (valley wide) from reference for toddler whereas this is .4 for adult. For prefered Ktunaxa, figure Es-8, I see + 4.2 for toddler and +3.4 for adult. Can the risks to each	Confirm numbers and greater description of risk for each of the groups is warranted	Nov 7 2022	KF	The text has been revised to clarify what risks are being referred to.
19	ES-9/ Appendix K (comment IH-8)	The text suggests risks increase as local food use increases, especially food harvested in Mu-4. This seems alarming but there is an overall suggestion to not worry as many are not eating that much fish or game or berries but instead their intake is similar to market basket. Clarify if it's not a concern b/c reference area intakes would be generally the same for the different groups evaluated at the various intake levels? or if changes to water quality management would have negligible effects on levels of mercury, lead, selenium in fish and land animals? We did not assess commercially grown foods in the Elk Valley and their potential levels of selenium or other COPCs. Thinking of whose risk may be underestimated and thinking about an economic transition in the future, a 2011 report (https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/agricultural-land-and-environment/strengthening-farming/land-use-inventories/rdek2011_elkluireport.pdf) describes current ALR use in the Elk Valley. Of the areas in use, much is used for grazing land for horses and beef cattle. At the time, they recorded 572 beef cattle. Perhaps, it is important to consider whether there is a potential that intakes may be higher among different sub sets of the population, such as ranchers or those purchasing local beef.	Risk communication. Add additional sentences around the seemingly minimal concern and point that most of the COPCs are coming from local food. Are further changes in surface water quality management expected to have limited impact on changing the magnitude of levels in fish and game? If so, describe where focus needs to be	Nov 7 2022	KF	This comment appears to predominantly refer to Appendix K text (responses to comments). The Executive Summary text cited does not minimize concerns and instead notes risks are most elevated in MU-4 and that they are predominantly related to selenium in fish.
20	ES-11	Add a paragraph to describe clearly where and who elevated risks (HI>1) were observed. For example, Toddlers of groups (average recreator, average Ktunaxa, upper percentile of recreator, upper percentile of Ktunaxa, and preferred Ktunaxa) showed cumulative HI higher than 1. Adults of upper percentile Ktunaxa and preferred Ktunaxa also had HI higher than 1 (Table 6-10). Average recreator who eat berries, fish, game muscle, game organ and rosehips in the Elk Valley will have HI of 2.0 compared to 1.3 for those from the reference site and 1.2 for those who eat market food only (Figure ? p.128). In comparison, the high end consumer of these traditional foods (upper percentile of Ktunaxa) will be HI of 3.0 compared to 1.6 from the reference site and 1.2 for the average market food only (p.132). Ktunaxa eating traditional foods at the preferred consumption rate will have an HI of 7, compared to the reference of 2.8 and market foods of 1.2 p.133). The highest risk was found in MU-4, where the HI is 3.6 compared to the valley-wide average of 3.0 (p.135)		Nov 7 2022	LC	More detail has been added to this section.
21	ES-11	Add a sentence describing Se concentrations (EPC) in fish in MU-4 compared to those in the other MUs		Nov 7 2022	LC	Text has been edited to include a footnote about selenium concentrations in Goddard Marsh Long-nose Suckers.
22		Generally consumption of local water has been separated from consumption of local food in preceding sections of the ES. Suggest that consideration be given to presenting local water separately or including its contribution to exposure in the earlier figures		Nov 7 2022	KF	Consumption of surface water as drinking water for Ktunaxa receptors has been added to the stacked bar charts in the Executive Summary and appendix and to the text discussing cumulative risks. These risk estimates focus on selenium as it is the main constituent of concern and do not address any biological risks associated with consumption of surface water, or risks associated with nitrate for infants consuming surface water.
23	ES14	Why only Goddard Marsh is mentioned in MU-4? Only 1/3 of longnose sucker samples came from this site. The EPC for all fish combined in MU-4 is 6.8 mg/kg and the HQ is greater than 1. Elaborate what are the waters receiving untreated mine effluents		Nov 7 2022	LC	Please see response to comment on row 23. Data from Goddard Marsh were particularly high and caused the UCL to be elevated.
24	ES14	The threshold for HQ is 0.2 for one source, i.e. fish consumption. Justification is needed for changing the threshold from 0.2 to 1 in the last paragraph.		Nov 7 2022	LC	Text and Executive Summary Table ES-3 have been modified to clarify the 0.2 versus 1 HQ findings.

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25	Figure ES-9	The three panels for Elk Valley Recreator, Ktunaxa upper percentile consumer, and Ktunaxa preferred consumer all show the HQs are higher than 0.2 for both toddlers and adults consuming fish in MUs 1-5. Note that in p.105, the description for the same figure (Figure 6-1), The majority of selenium HQs were below 0.2 for average Ktunaxa consumers but were greater than an HQ of 0.2 for Ktunaxa and recreator upper percentile consumers and preferred diet Ktunaxa consumers.		Nov 7 2022	LC	Comment noted.
26	Fig ES-10	The legend should provide information on the fish Se concentration, TRV, and HQ used to generate the estimate. The results do not agree with Figure ES-4 to 9.		Nov 7 2022	LC	Comment noted.
27	ES-15; 28	Figure Es-9. There are 4 groups displayed in the figure but 5 groups in Table Es-2. Is the Elk Valley Recreator shown an 'upper percentile recreator' ? If so, label accordingly. You may want to label first figure as Average Ktunaxa/Recreator		Nov 7 2022	KF	Figure will be revised to indicate that average is KTN and recreator and what is now recreator is upper percentile recreator.
28	ES-16; 29 Figure ES-10	Figure ES-10. Suggest this figure reflect the risk estimates for all chemicals (lead, mercury, selenium), combined to make it more understandable and useful for recreators. People will not make an assessment based on 1 mineral.		Nov 7 2022	KF	Additional detail has been added regarding other chemicals that have a HQ greater than 0.2.
29	ES-14; 30	Figure ES-11. There are 4 groups displayed in the figure but 5 groups in Table Es-2. Is the Elk Valley Recreator shown an 'upper percentile recreator' ? If so, label accordingly. You may want to label first figure as Average Ktunaxa/Recreator		Nov 7 2022	KF	We will make this edit as requested.
30	ES-14; 30	Figure ES-9. Data presented by MU 1 to 5 combine and then MU-6 is highlighted (why?) Why not highlight MU-4 specifically	consistency	Nov 7 2022	KF	MUs 1-5 represent Elk Valley, MU6 is Koocanusa. Figure not intended to show all MU-specific risks, but those are shown in detail in tables and text in the report.
31	ES-14; 30	Discussion of wells. Recommend that include estimate of coverage of elk valley residents that would likely be included in estimate of risk from groundwater based on the wells tested. Did this not include main community wells? And/or , can there be some understanding of the proportion of wells included in the current dataset?		Nov 7 2022	KF	Text in Section 2.1.3 has been revised to include an estimate of the percentage of the population accounted for in the groundwater data used in the risk assessment and the Executive Summary section on groundwater has been updated to include the following red sentences : Groundwater use as drinking water has negligible risks for all COPCs when evaluated by MU and by individual well in all but two wells. In well-by-well analysis two wells in MU-5 had elevated risk, one for lithium and one for manganese. However, data were not available for all wells in the Elk Valley. Private well owners in the Elk Valley are encouraged to have their water tested either through Teck or privately. The groundwater dataset included municipal wells in Elkford, Sparwood, and Fernie, the community well in Elko, and 49 private wells. On a population basis, the groundwater data in the HHRA represent more than 80 percent of the population of the Elk Valley (See Section 2.1.4). Agricultural uses of groundwater and surface water are only evaluated in the uncertainty assessment but are not expected to result in elevated risk.
32	ES-15; 31	The last paragraph in the fish section and in the game/berry section seems better suited to being in an uncertainty section or in the conclusions.		Nov 7 2022	KF	Comment noted.
33	ES-15; 31	In the conclusions, there is no statement regarding whether water quality if being managed to be protective of human health. Given that the 1) HHRA was focused on the water-related exposures that may be influenced by current and historic mining practices ans 2) Elk Valley foods have higher levels of selenium than non-mining influenced areas and 3) there are other COPCS of concern in surface water (nitrates) and in fish (lead, mercury), why is there not a sentence that states. No, water influenced pathways are not yet being managed to be protective of human health.	Need a conclusion that answers the reason why the HHRA was undertaken. That is to evaluate whether any changes are needed in water quality management to address potential human health risks. Clearly, there are potential human health risks for people who eat local Elk Valley food	Nov 7 2022	KF	A subbullet has been added to the first set of bullets in the conclusions stating: -"The elevated risks related to selenium indicate that additional risk management measures should be considered for selenium in MU-1, through MU-5.."
34	ES General	A summary of findings should be extracted from the summary of the main body Chapter 7 should be added. Consider presenting who and where and doing/eating what will increase risk of exposure to COPC in a more layman language. Some suggested points are: 1. Higher levels of Se were found in longnose sucker in MU4. Therefore, consumption longnose sucker in MU-4 may increase Se intake and risk of exposure. 2. Consumers of high amount (the upper percentile amount) of traditional foods (fish, berries, games and rosehips) have increased risk of Se exposure. 3. Ktunaxa preferred rate of traditional food consumption will increase risk over 100 % (HI7 vs HI2.8) across all MUs compared to the reference site.	ES is intended to be for non-technical folk as well. The language should approach grade 9 reading level	Nov 7 2022	LC	Text has been revised to address this comment.
35	ES	In the conclusions, there are 3 recommendations: 1) get greater details re: fish consumption by species 2) continue monitoring drinking water supplies 3) don't'drink surface water. Based on the informaiton that Elk Valley foods have higher levels of selenium that reference areas, there should be 4th recommendation to review adequacy of current soil/sediment, wildlife health and food sampling program (farms, traditional food) to identify what and where greater sampling is needed		Nov 7 2022	KF	Text has been revised based on this comment.
36	Section 1.4	the Ktunaxa Nation diet study report has 2 slightly different titles. Please use title: "*Ktunaxa Nation Diet Study Final Report* ". 2015		Nov 7 2022	KF	Text has been revised in each instance that the study is referenced.
37	Section 2.14 (18/171) and 3.11	In section 2.14, 50 private wells are mentioned but not the municipal wells. Then it states that 50 wells is a small subset but spatially distributed. In 3.1.1. the text is slightly different. Mentioning that 56 wells is a small subset. Suggest include mention of muncipal wells in section 2.14.	consistent informaiton re: wells in both places	Nov 7 2022	KF	Text has been revised to be consistent and to show that there were 49 wells sampled.

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#	**Report Page & Section**	**Comment**	**Rationale**	**Date**	**Reviewer**	**Response to Comments**
38	Section 3.1.1 Groundwater and Surface Water Figure 3-2 Surface Water Sampling Locations, p.38	Koocanusa Reservoir station RG_KERRRD is seasonally mine affected and should not be included in the background data set.	KNC had initially raised the concern that mine affected groundwater reporting to Koocanusa reservoir upstream of RG_KERRRD may be impacting the water quality at that station. Data presented by Teck at the June 2022 Groundwater Working Group meeting suggest that RG_KERRRD is seasonally mine affected however the cause is likely due to backwashing and mixing rather than groundwater. "Temporal and spatial patterns of selenium concentrations in Koocanusa Reservoir indicate that backwashing/lateral mixing of water within the reservoir when forebay elevations are high have a greater influence on concentrations in the upper portion of the reservoir than groundwater bypass" (June 2022, GWG meeting slide 346)	Nov 7 2022	BL	This sampling location has been moved to MU-6. RG_KERRRD coordinates (UTMs) = 11u 626668 E 5454059 N (Koocanusa Reservoir u/s of Elk River and d/s of Kikomun Creek; MU-6)
38	Section 3.13	Add Nation after Ktunaxa		Nov 7 2022	KF	This edit was made as requested.
40	Section 3.14; 46/171	in the 2019 diet expansion study, juniper berries was added to the list of berries		Nov 7 2022	KF	An edit was made indicating that in the 2019 diet expansion study, juniper berries were added to the list of berries consumed.
41	Section 4.2.4.2; p.75/171	add the word in-person before interview (as all interviews were face to face). Delete extra word 'questions' after usual portion sizes. Replace the word 'were' to 'for' in the sentence re: food insecurity and critical importance of Ktunaxa foods		Nov 7 2022	KF	This edit was made as requested.
42	Section 4.2.4.2; p.76/171	change word addition to additional in sentence at top, considered good addition information		Nov 7 2022	KF	This edit was made as requested.
43	Section 4.2.4.3 78/171	sub-bullet required for after 693 grams of land animals (for muscle)		Nov 7 2022	KF	This edit was made as requested.
44	4.2.5	replace 2012 Ktunaxa Diet Study and 2012 Diet Study with Ktunaxa Nation Diet Study Final Report -do this for other instances.		Nov 7 2022	KF	These edits were made as requested.
45	4.2.5; 80/171	When mentioning the 2014 and 2015 Ktunaxa Nation Diet Study documents, please refer to them as the Ktunaxa Nation Diet Study technical memo (2014) and final report (2015). The 2015 final report did provide preliminary minimum preferred consumption rates based on results from 2 focus groups and 95th but as descibed earlier, these were not sufficient.		Nov 7 2022	KF	These edits were made as requested.
46	4.2.5; 80/171	Footnote 18. What is the source of ENV 2014 'Canadian FN fish consumption rate'? Is it HC 2013?		Nov 7 2022	KF	The reference HC 2004 is added to that footnote and to the references. Health Canada. 2004. Federal contaminated site risk assessment in Canada. Part I: Guidance on human health preliminary quantitative risk assessment (PQRA). Ottawa, ON (CA): Health Canada, Contaminated Sites Program, Environmental Health Assessment Services. 40p. Accessed on-line at http://dsp-psd.pwgsc.gc.ca/Collection/H46-2-04-367E.pdf
47	4.2.5; 80/171	It is staged that 40 grams/day is representative of Elk Valley residents who are assumed to represent higher fish consumers and is protective of exposures to elk valley residents. the source is HC 2007. Three sources identified in the literature below, suggest higher consumers have an intake of 100+ grams/day. Therefore, there is some uncertainty around whether this rate is conservative enough for the recreator. A paper published in Nutrients 2021 Jan 13(1): 77 describes average intake among Canadian consumers, based on CCHS 2004 and 2015 data at 100 gram. A paper in Environmental Research (158 (2017):126-136 bu Von Stackelberg et al. , suggests high frequency fish consumers in the U.S, have ~111 grams/day (2013 survey). Table 8a in the EPA Estimated Fish Consumption Rates for the U.S. Population (NHANES 2003-2010) indicates upper end consumption among those described as 'other race' as 102.7 grams /day.		Nov 7 2022		The consumption rates applied in the assessment were discussed at length and were agreed upon. Agreed upon consumption rates range from 15 g/day average to 365 g day. Fish consumers can self identify with the number of fish meals they consume from different areas.
48	6.3. 130 (98/171)	Repeated paragraph starting at sentence Figure 6.1 (98/171).		Nov 7 2022	KF	The duplicate paragraph has been deleted. Thank you.
49	6.3. 130 (98/171)	Figure 6-1 . First sentence states that the figure describes information for preferred, but it shows HQ for all populations.	Clarity	Nov 7 2022	KF	The Figure 6-1 title has been revised with the slight revisions in HQs related to moving reference locations and with a title change from "Elk Valley Recreator" to "Elk Valley Upper Percentile Recreator." The text has been edited to clarify Figure 6-1 shows a range of consumption rates while the text describes HQs for toddlers consuming at the Ktunaxa preferred rate.
50	6.3. 130 (98/171)	There is interesting text re: fish consumption a driver of mercury or selenium and then some explanation of spills likely causing selenium accumulation. It seems prudent to include some of the discussion around changes to water quality management that have occurred during the time this HHRA was undertaken in the ES conclusions.		Nov 7 2022	KF	Ongoing efforts to address releases to surface water are expected to reduce releases of selenium. For example, Teck's Active Water Treatment Facility (AWTF) at the Line Creek Operations released more bioavailable forms of selenium (e.g. selenite and organoselenium species) from 2016 through March 2018, which resulted in increased uptake of selenium in some fish located downstream of the AWTF in MU-2 during this time period. Subsequently advanced oxidation process installed at the AWTF has significantly shifted the selenium species discharged in effluent to a less bioavailable form (e.g., selenate), selenium concentrations in bull trout and westslope cutthroat trout are expected to decrease moving forward.

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51	6.3. 130 (98/171)	What is the HQ=.3 for reference fish based on? In the English Screening Assessment Selenium and its compounds, it says that there are typically very low levels of selenium in fish. Much higher selenium concentrations are seen near coal mines,and agricultural run-off. (ISBN 978-0-660-24255-2). Selenium concentrations in the most common traditional foods consumed in the FNFNES study were up to 0.87 µg/g ww in salmon, up to 0.49 µg/g ww in moose meat and up to 0.38 µg/g ww deer meat. Selenium concentrations were higher in organ meats (e.g., liver, heart) over muscle meats of animals and were particularly high in fish eggs (up to 4.14 µg/g ww). Concentrations of selenium in retail seafood ranges from .4 to 1.5 ug/g. Based on the TRV, this		Nov 7 2022	KF	The text has been edited to include Figure 3-4 which shows reference locations. It appears that the comment ends midsentence - perhaps something got cut off?
52	Section 6.3.2. p. 101	The top paragraph describes the contribution of fish consumption to HI by MU. It needs to be supported by a graph or table.		Nov 7 2022	LC	Table 6-2 referenced in this paragraph and located on the next page provides an overview of the target organ HIs that are above 1 by MU.
53	Section 6.3.3	This is the first time HQ>1 is used as the threshold for fish consumption. What is the justification?		Nov 7 2022	LC	This section provides extensive information about hazard quotients greater than 0.2 and greater than 1 including summaries in figures and tables. Prior sections provided additional text on hazard quotients greater than 0.2.
54	6.5; 107/171	HQ <.2 and HQ <1 are identified. HQ <.2 is explained as low risk. There is no statement as to risk level when HQ > .2 for infants in MU 1-4. and when HQ <1 . The only statement for when HQ> .2 for adults in MU3 is a subsequent statement pointing to uncertainty. Please indicate potential risk for HQ >.2 and below 1 and for HI	Understand relative risk for this surface water pathway exposure	Nov 7 2022	KF	As indicated in the text the comparison to an HQ of 1 is appropriate because in the scenario of an infant consuming formula reconstituted with surface water, this pathway would be the only means of nitrate exposure. The text has been revised to clarify where HQ >0.2 are summarized.
55	6.5.1	It is mentioned that many samples were taken to assess nitrate. What is the frequency of seasonal sampling for nitrate? Can you add a footnote		Nov 7 2022	KF	The following footnote has been added: "Table C-1 provides a summary of nitrate samples by MU in comparison with screening values. A total of 7,318 nitrate samples were available with a range of samples per MU from 2,307 in MU-4 to 538 in MU-2. "
56	6.7.1	Please refine text to add sentence indicating whether there is risk or not when HQ >.2 but below 1 for consumption of berries at various rates. Please indicate when there is risk . Example, is there elevated risk with HQ >2	clarity of relative risk	Nov 7 2022	KF	Text has been revised.
57	6.7.1	Provide comparative information as to levels of COPCS in reference areas for berries?	clarity as there is comparison to reference areas as this is done for other items	Nov 7 2022	KF	Text has been revised to add this sentence: Exposure point concentrations of COPCs in MUs and reference areas are summarized in Appendix Table G-7 for berries and in Appendix Table G-8 for rose hips.
58	Section 6.7.3	An explanation is needed for why an HI is developed to combine the HQs from the consumption of berries, game meat and game organs only. Since this HI was estimated to be 1 in Table 6-8. A typical traditional food user will likely eat all these and also fish will have an HI adding the HQ of fish consumption and higher than 1.		Nov 7 2022	LC	Further text has been added. Please also see response to comment on row 73.
59	6.7.3	Add information re: reference area locations and data sources for reference area for foods		Nov 7 2022	KF	Table 6-8 has been updated to include this note: "See Figure 3-6 and Table 3-4 for further detail on samples outside of the designated area which are used as reference locations."
60	6.7.4	This section is interesting and I appreciate the table and text illustrating that 'safe' is defined at 'average consumption levels' . Can you add in a sentence that states, safe levels of consumption including eating at average rates (ie. Berries at X g/day + fish at X g/day +meat at Xg/day)		Nov 7 2022	KF	The following sentence has been added: Consumption rates are summarized in Table ES-2 and include the following average consumption rates: fish 10 g/day or 15 meals a year; game 82 g/day, or 123 meals per year; game organs 10 g/day or 14 meals per year; berries 85 g/day.
61	6.8	thanks for the additionla text re: efforts to reduce selenium		Nov 7 2022	KF	We are glad it was helpful.
62	Section 6.9	Please clarity if the market basket includes drinking water.		Nov 7 2022	KF	The market basket totals include drinking water and text has been revised to clarify this.
63	Section 6.9	Please identify which dietary dataset is being used in the Canada Diet study. This goes back to our work with Dr. Dabeka who at the time said that the Total Diet study relied on intake estimates from a 1969 data set. In section 4.2.6 there is text speaking of the decision to go with NHANES data instead for berry consumption as the intake rates in the Canadian Total Diet study were much lower. A more recent report, based on a review of the selenium screening assessment (ISBN 978-0-660-24255-2), used "Probabilistic dietary intake estimates for the general population 6 months of age and older were derived by Health Canada's Food Directorate using concentrations of selenium in food commodities collected between 2009 and 2013 (n > 30 000), provincial drinking water data, and food and water consumption rates from the Canadian Community Health Survey (Statistics Canada 2004)'. I am not sure if you chose to rely on CCHS 2004 dietary intakes to estimate selenium intake. This newer report suggests, higher total market basket selenium intakes for all age groups (See table 7.2). When i take the TRV for selenium 5.7 ug/day and look at table 7.2 in the aforementioned document, and apply the 95th percentile intake rate , the HQ is 1.36 for 0-5 months, 1.5 for those 6 months to a year, HQ =1.6 for those aged 1-3, HQ=1.14 for children 4-8, HQ=.74 for those aged 9-13 (males) HQ=.68 for adolescent males and HQ=.54 for adolescent females (14-18), HQ=.59 for 19-30 males; HQ=.46 for females aged 19-30. Lowest level is .42 for adults aged 71+. At the very least, there may need to be some sentences that identify the uncertainty around intakes in the total diet study versus contemporary intakes.. unless you can provide more updated information on what dietary set is being used to assess selenium intake.	uncertainty around estimates of selenium intake, based on dietary patterns. The selenium assessment report indicated that 99% is from food, 1% from water with about 30% from grains, followed by poultry, pork, dair and eggs.	Nov 7 2022	KF	This sentence was added before the last sentence in Section 4.3, where the market basket estimates are described: "The dietary intake estimates are based on consumption rates of different types of foods by Canadians and these consumption rates have changed over time and may not be completely representative of current intake for a given food, which adds uncertainty to the market basket estimates. "
64	Section 6.9, Figure 6.5	fix formatting so figure not orphaned from label	reading	Nov 7 2022	KF	Edit will be made thank you.
65	Section 6.9, Figure 6.5	Can you compare the selenium intake from market fish to that found in the Elk Valley. As I understand it, retail marine fish and seafood range in levels from 0.4 to 1.5 ug/g ww (Rayman 2008) . (ISBN 978-0-660-24255-2)Areas with similar levels to those found in the Elk River watershed include Beaverlodge Lake, near a decommissioned uranium operation.		Nov 7 2022	KF	Data collected within the Canadian diet study include concentration data for freshwater fish, marine fish, and canned fish. Selenium, concentrations in the market basket data used in this analysis ranged from 0.329 to 0.906 mg/kg ww. Mean concentrations were 0.537 mg/kg for marine fish, 0.428 mg/kg for freshwater fish, 0.695 mg/kg for canned fish.

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66	Section 6.9	Would this be defined as the reference market basket data, corresponding to infomraiton in figure 6-7 for adults? If so, indicate for transitioning to the next section. So I will consider that the reference adult has .37 market basket and .27 without fish, game berries,		Nov 7 2022	KF	Yes the market basket inputs are the same for estimates for the reference area and for the MU and Valley- wide estimates. Text has been modified to clarify this.
67	Section 6.10; 148 (116/171)	On this page, elevated risk is attributed largely to food patterns with fish being a key contributor. This is followed by a sentence that says' contribution from water quality related pathways, groundwater, sediment and surface water are negligible. But if we are evaluating water quality pathways, that includes fish. Is it not more correct to re write and state: Contributions from the water quality related pathway, fish is major while other water-quality pathways are negligible.	Restate to recognize relatedness to water quality and that while levels in drinking water are not posing risk, effects through aquatic media (fish)are elevated.	Nov 7 2022	KF	The sentence has been revised to state: "While fish consumption is a primary contributor to risks, contributions from other water quality-related pathways are negligible including: groundwater as drinking water; surface water as drinking water for Ktunaxa receptors; and ingestion of or dermal contact with sediment, and surface water."
68	Section 6.10	Reference area foods are mentioned repeatedly but not pointed to. They are buried in Table C-7, and mentioned in Appendix K. Please help the reader. Can additional informaiton be added re: reference area samples/sources/geographic locations. Are these all from wild food sampling program? or are they from other sources?		Nov 7 2022	KF	A footnote has been added to state: "See Figure 3-6 and Table 3-4 for further detail on samples outside of the designated area which are used as reference locations."
69	Section 6.10 Table 6-10. 118/171	Suggest that another column be introduced, showing clearly the water quality related pathway contributions (separately and total) and the land based contributions for each target population in order to clearly illustrate the relative exposure, then do similarly when comparing to reference areas		Nov 7 2022	KF	An additional row was added to Table 6-10 to show risks for surface water used as drinking water.
70	Section 6.10 ; 124/171	The top paragraph is the "key" finding of the HHRA and needs to be elaborated. For example, state all the scenarios where HIs are higher than the background (reference) by 100%. The last sentence of the top paragraph provides the explanation. It should start with stating that the cumulative risk in MU-4 is higher than the other MUs but it could be due to…..		Nov 7 2022	LC	Please see the response to the next comment
71	Section 6.10 ; 124/171	Some descriptions on what the health risk is associated with the cumulative HI>3 or >7, e.g. compared to the LOEL in other human population studies, should be added either here at the end of the risk characterization section and/or in the conclusion section.		Nov 7 2022	LC	This paragraph has been added at the end of Section 6.10: The finding of HI estimates above the ENV risk management threshold of 1 indicate the need for ongoing monitoring and adaptive management. In interpreting these cumulative risk estimates for selenium, it is helpful to consider that the TRV of 0.0057 mg/kg-day for selenium used in this assessment (see Section 5.1.1) was based on background intake in nursing infants. Specifically, Health Canada (2010c) used a NOAEL of 45 µg/day derived from background intake levels in nursing infants (Shearer and Hadjimarkos 1975). This background level was then adjusted to a range of TRVs based on body weights. No uncertainty factor was applied because no adverse effects were associated with this intake level. Health Canada also identified a NOAEL of 800 µg/day reported in (Yang and Zhou 1994) as the basis of the critical effect of hair and nail brittleness and loss, which are signs and symptoms of selenosis following chronic selenium exposure. Thus, the NOAEL of 45 µg/day used as the basis for the TRV is 17 times lower than the NOAEL for the critical effect of selenosis, which indicates that there is a considerable margin of safety associated with the TRV for selenium. No clear NOAEL has been established for young children, and so the TRV is based on dietary intake rather than a NOAEL. However, the IOM (2000) documentation establishing the upper limit intake for infants, which is equivalent to the TRV, states that "there is no evidence indicating increased sensitivity to selenium toxicity for any age group." Nevertheless, exposures greater than the TRV are considered unacceptable in this HHRA even though the TRV is not based on a NOAEL.
72	6.11.1 (124/171)	Suggestion that likely risks are overestimated using the example of risks overestimated for those exposured during swimming or cultural activities. Given that levels of contaminants, such as nitrate, can vary greatly, is the risk oveestimated for infants and toddlers? engaged in cultural activities?		Nov 7 2022	KF	Concentrations of nitrate are variable, but the risk estimates incorporate the variability though use of the 95 percent upper confidence limit level on the mean consistent with risk assessment guidance. This section discusses uncertainties regarding pathways included in the HHRA indicates the following: "For example, risks associated with COPCs in surface water were evaluated assuming use as a residential drinking water source even though surface water is not currently a primary drinking water source. This may greatly overestimate risks for people who are exposed to COPCs in surface water only during swimming or cultural activities. "
73	Table 6.11 (125/171)	The uncertainties that have impacts on the conclusions are : 1. Sampling bias leading to overestimation of concentrations of COPC in fish. This will affect the conclusion for risk associated with fish consumption, e.g. Se intake from MU4 will be overestimated if people do not consume long nose sucker. However, the impacts on the overall increase in cumulative HI across all MUs among high traditional food consumers will not be moderate. A fish species preference/harvest survey by region will be needed in future study. 2. High consumption rate for 95th leads to overestimation. Disagreed. Most traditional food users tend to eat more of all traditional foods. 3. Co and Li TRV leads to overestimation. Disagreed. Also in p. 165 and 167, **I did not support the development of alternative TRV by the risk assessor and recommended a discussion with the regulating agencies. Health Canada subsequently provided comments and recommendation of using 0.015 mg/kg/d as TRV for Co and justification of the EPA RFD of 0.002 mg/kg/d for Li.** I recommended following the Health Canada recommendations. It is acceptable and a common practice to provide argument for the level of uncertainties associated with the TRV. However, there is no value in proposing an alternative value which is not acceptable by the regulatory agency.		Nov 7 2022	LC	Table has been modified to add a parenthetical that KNC does not agree the use of the TRV for cobalt and lithium may represent an overestimate.
74	6.11.2	Reference is made to the fish tissue screening levels derived from the Ktunaxa preferred diet of 245 grams and states that is a conservative assumption for non-subsistence fish consumers that is 6 times higher than the Bureau's adult high fish consumer value (40 g/day). Include source (HC 2007).		Nov 7 2022		Reference has been added as requested.

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75	6.11.2	Reference is made to the fish tissue screening levels derived from the Ktunaxa preferred diet of 245 grams and states that is a conservative assumption for non-subsistence fish consumers that is 6 times higher than the Bureau's adult high fish consumer value (40 g/day). A recent paper published in Nutrients 2021 Jan 13(1): 77 describes average intake among Canadian consumers, based on 2004 and 2015 data at 100 gram. A paper in Environmental Research (158 (2017):126-136 bu Von Stackelberg et al. , suggests high frequency fish consumers in the U.S, have ~111 grams/day (2013 survey). Table 8a in the EPA Estimated Fish Consumption Rates for the U.S. Population (NHANES 2003-2010) indicates upper end consumption among those described as 'other race' as 102.7 grams /day. These 3 data sources suggest that the adult high fish consumer value of 40g/day from HC 2007 underestimates adult high fish consumer rates. As such, 245 g/day may not be overly conservative.	over stating the conservatism. The Bureau's 2007 rate likely underestimates fish consumption.	Nov 7 2022		A wide range of fish consumption rates are used in the HHRA and were developed with intensive input from the Working Group. Individuals can evaluate risks based on the intake rates that best represent their consumption levels.
76	Table 6-18 page 160	This is a good exercise to add restrictions of fish catch in the risk assessment. How will this result affect the cumulative HI for the average and 95th centile recreators?		Nov 7 2022	LC	The risk estimates provided in the HHRA did not include any adjustment for restrictions on fish consumption and this has been re-iterated in the text in this section. Considering the summary of uncertainty assessment calculations accounting for fishing restrictions in Table 6-18, the location with the biggest change is MU-1, where HQ for fish consumption was reduced from 0.6 to 0.3. The cumulative HQ for MU-1 would still be greater than 1 for the upper percentile toddler.
77	Section 7.1 page 174	This is an important section. The section for fish, berries, rose hips and game. What is the meaning of risk management of threshold HQ of 1? Why calculating a HI for berries, rosehips and game separately and use HQ=1 for fish consumption alone. It makes more sense to calculate the HI by summing the HQs fish, berries, rose hips and game and compare to 1. Again, the results of the cumulative risk compared to market and reference should be expanded.		Nov 7 2022	LC	Risk estimates are evaluated based on an HQ of 1 and an HQ of 0.2 in this section and in prior sections.
78	8. References; 166	Franz 2013 reference needs to be separated out from Firelight 2020		Nov 7 2022	KF	Edit has been made thank you.
79	Appendix C	Table C-7. Are there citations for the source of the values for the reference area foods ?		Nov 7 2022	KF	A footnote has been added to state: "See Figure 3-6 and Table 3-4 for further detail on samples outside of the designated area which are used as reference locations."
80	Executive Summary	Numerous Elk valley residents will be very interested in the findings of the HHRA. In addition to Ktunaxa concerns, Sparwood residents have also been pushing for HHRAs on the dust, because it is so visible. Some of the previous EMC comments speak to the need for clear plain language conclusions(ie good risk communication) and Tecks response is that the Executive Summary is to fit this need. From my perspective the Executive summary in its current form would be very difficult to communicate to laypersons, in terms of persons being able to understand and make well informed choices. As alluded in previous comment KNC 23 and Tecks reference to Marushka et al. 2021, there are both tangible and intangible benefits to wild food harvesting consumption (nutritional quality, food security, cultural/spiritual/lifestyle etc.)- not just fish, but also game and berries, and being able to drink water from a stream. Obviously a key message/outcome is that Tecks mines have impaired wildfood safety due to the selenium, and Teck needs to take action on that. At the same time, risks need to be weighed against benefits, so that persons are not unnecessarily detered from harvesting practice where the risks don't outweigh the benefits. Individuals need to weigh this risk for themselves, but need clear understanding to be able to do so. Clear language risk communication materials need to be developed that considers this context.		Nov 7 2022	MJT	Comment noted.
81	Executive Summary	The report evaluated *"understanding lifetime exposures should surface water be relied on exclusively as a drinking water source"* and concluded *"Negligible risk for consumption of surface water as drinking water for all COPCs except nitrate."* It will confuse people that the selenium in water exceeds drinking water standards (e.g. EPCs of >50 compared to standard of 10 in BC, 50 in canada) and yet the report doesnt really highlight drinking water as an issue because HQs are <1 (calculated max HQ is 0.38). As pointed to in other comments, this is partially because the report does not consistently explain or appopriately compare to an HQ of 1 (for all pathways combined) versus an HQ of 0.2 for individual pathways (i.e. the drinking water standard is based on a HQ of 0.2, not 1) "Being ktunaxa on the land" will include both drinking the water AND eating berries and game..... From a KNC perspective, it is inappropriate to not include the drinking water pathway in the cumulative stacked bar charts in Exec Summ figures ES-4 and 5. Apparently the water pathway is shown in the first chart in Appendix I, but the chart values don't seem to match the calculated HQs (the colours in the charts are so similar it is hard to tell what is what). The key messaging and risk communication needs to align with drinking water standards or the interpretation will be incorrect as well as confusing.		Nov 7 2022	MJT	Surface water as drinking water has been added to stacked bar charts and to Table 6-10 for Ktunaxa receptors. Additional explanation has been added to the Executive Summary and the main text regarding surface water risks.
82	Use of UCLM for Game meat	The EPC for game meat are calculated as UCLMs. Consider that for typical consumers the bag limits of elk and deer are 1 and 2 animals respectively, and that even at Ktunaxa preferrred consumption rates, just a small number of large elk or moose could feed an individual/family for a year. Thus an arithmetic mean does not account for an individual who could by chance harvest an animal or three that have the highest concentrations. A 90th percentile or maximum metric would be more appropriate for non-carcinogenic exposures. (HHRA guidance documents generally point to using max concentrations or percentiles in PQRAs, and UCLMs in DQRAs on a case specific basis only with justification). This will increase the risk calculations somewhat, though per Table 6.16 it wont be huge, UCLMs were quite high anyway since samples sizes were small.		Nov 7 2022	MJT	As noted in the comment, the EPCs were calculated as UCLMs; however, it is worth noting that the maximum concentration was utilized for a selection of samples. In 55 (out of 154) game muscle or game organ samples, the maximum concentration was used as the EPC.

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83	"Exceptions" - Lead in Game meat, Manganese in Berries	There are two notable exceptions to the findings: *Berry ...consumption had a negligible risk for all COPCs except for an elevated risk for manganese for toddlers consuming berries in MU-4 at preferred and upper percentile levels* *Game meat consumption had negligible risks for all COPCs and consumer groups except preferred consumers in MU-5, where toddlers had elevated risk for lead.* These exceptions add confusion in that they beg more questions than answers - what is the source, how risky is it, why those MUs but not the others etc? Without answers it undermines confidence in the report, especially for people already skeptical, it just sounds like it is all bad. More work should be done to truth these two issues - are they real risks? Some prelim comments on this follow, which the report would benefit greatly by addressing:		Nov 7 2022	MJT	Discussion regarding lead in game meat and manganese in berries has been added to the text. Please see Sections 6.11.6.4 and 6.11.5.
84	Bioaccessibility	It is well known that many metals are not fully bioaccessible/bioavailable. For example it is now routine/prescriptive in BC (1) to do PBET tests for Pb and As in Soil. Bioaccessbility was considered in the mercury assessment, but unless this reviewer missed it, it wasnt considered for Se, Pb, Mn. At least one study on bioaccessibility of metals in country foods (2) showed that metals such as Pb and Mn in country foods are partially bioaccessible, depending on the medium. Consideration of these values (or doing PBET tests) would lower the risk estimates, notwithstanding the comment on marinating meat below.	(1)https://www2.gov.bc.ca/assets/gov/environment/research-monitoring-and-reporting/monitoring/emre/methods/in_vitro_bioaccessibility_ivba_for_as_and_pb_in_soil_prescriptive.pdf (2)https://www.fnfnes.ca/docs/Laird_and_Chan_2013.pdf	Nov 7 2022	MJT	Discussion of bioavailability of fish and game has been added to the text. Please see Section 6.11.4.2.
85	Lead in Game Meat	Lead shot, which a majority of hunters still use (other than for waterfowl) is well known to manifest high lead concentration in game meat. Quickly comparing to some literature: - The highest UCLM for lead in meat was 0.071 mg/kg (Appendix G) Notwithstanding max concentrations (see comment on UCLM above), these values are: - lower than USEPA and Alberta standard for lead in meat - 0.1 mg/kg (1) - somewhat higher than market basket values, based on a cursory search: 0.019 ± 0.027 and 0.024 ± 0.034 in Italian beef and pork (2) up to 0.00758 in polish meats (3) - much lower than a quebec study on lead ammunition killed game (4) : Mean lead levels in white-tailed deer and moose killed by lead ammunition were 0.28 and 0.17 mg kg(-1) respectively Meat cooking preparation also an important consideration. Many hunters prefer to marinate game meat in acidic solution and marination significantly increases the bioavailability of lead in game meat shot with lead ammunition (5,6) Tecks 2020 trace metals vegetation uptake monitoring report did not find lead contamination in soil to be associated with the mine areas - values for lead were quite low. Assuming a high proportion of the meat samples were harvested using lead shot, the report conclusions would benefit from some research and discussion on this topic, or as next steps.	(1)https://www.alberta.ca/lead-toxicity.aspx (2) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7359620/ (3)https://www.researchgate.net/publication/269868196_Lead_concentration_in_meat_an_meat_products_of_different_origin (4) https://pubmed.ncbi.nlm.nih.gov/26161681/ (5) https://www.cambridge.org/core/journals/journal-of-nutritional-science/article/marination-increases-the-bioavailability-of-lead-in-game-meat-shot-with-lead-ammunition/F4A0598F966E75AC43CCB576FA1F8591 (6)https://www.researchgate.net/publication/49782948_Bioaccessibility_of_Pb_from_Ammunition_in_Game_Meat_Is_Affected_by_Cooking_Treatment	Nov 7 2022	MJT	Text has been added to address lead bioaccessibility in game meat. See Section 6.11.6.4.
86	Manganese in Berries	A quick check of the berry data indicated 20% of the berry samples were huckleberry or blueberry. Consider that: -The highest UCLM for Mn in berries was 18.2 mg/kg wwt (Appendix G) -Commercially sold Wild blueberrieare touted to be high in manganese, with reported concentrations ranging from ~2.8 to ~6.1 ug/g (1,2,3) -A baseline country foods study near Kamloops found UCLM of 49.5 mg/kg wwt in Huckleberries (4) -A baseline country foods study in Quebec found mean of 120 mg/kg wwt in wild blueberries (5) (concentrations much lower in other berries) -The CSR matrix standards for Mn in soil are 6,000 mg/kg for intake of soil, 2,000 mg/kg for toxicity to plants. However the latter value is corrected to background, which is reported as 2,000 mg/kg for the Kootenays (6) -One study found toxic effects to blueberry plants at concentrations of 350 ppm- apparently this is related to blueberry affinity for acidic soil. (7) -Teck's 2020 trace metals veg uptake monitoring report did not find manganese in soil associated with reclaimed areas. If fact, the only two soil samples with manganese >2,000 were reference samples. This info suggests that the Mn in huckleberries, and likely in similar berry species, is not unique to the elk valley, and not likely to be mine related. The report would benefit from some research and discussion on this topic, or as next steps.	(1) https://www.benefitsofblueberry.com/blueberries-good-source-manganese/ (2) https://fdc.nal.usda.gov/fdc-app.html#/food-details/173949/nutrients (3) https://www.nal.usda.gov/legacy/sites/default/files/manganese_0.pdf (4) https://iaac-aeic.gc.ca/050/documents/p61898/100977E.pdf (5) https://www.gov.nl.ca/ecc/files/env-assessment-projects-y2013-1711-1711-app9-wabush3.pdf (6) https://www2.gov.bc.ca/assets/gov/environment/air-land-water/site-remediation/docs/protocols/p4__jan2021_revisions_final_signed.pdf (7) https://www.ishs.org/ishs-article/810_67	Nov 7 2022	MJT	Text has been added to address manganese in berries. See Section 6.11.5

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[Additional comments from KNC on Appendix K received November 14 2022] The Teck response shown in Appendix K is reasonable except:						
87	KNC-19	A new table, Table 6-3 is included that shows the selenium EPC in different species of fish and the HQ for different receptors in different MUs as well as from the reference sites. There are some mistakes in the colouring where HQ>1 was shown in yellow instead of pink. This is a very useful table, but the description in the text (Section 6.3.3) still needs to fully describe the results. For example, the key results that need to be highlighted can include: 1. All fish species in the Elk Valley (MUs 1-5 combined) have an average of 3.3 times higher selenium (3.9 vs 1.16) than in the reference site. 2. The highest selenium levels are found in fish collected in MU4 (6.8), particularly Longnose Sucker (13.39). 3. Bull Trout in MU2 (6.03) and Longnose Sucker in MU4 (13.39) had the highest selenium concentrations. 4. The risk of selenium is acceptable (HQ=0.2 or less) for average fish consumers (4.5 g/day for toddlers and 10g/day for an adult) in the Elk Valley (MUs 1-5 combined). 5. A higher risk of selenium exposure is identified for average consumers of Bull Trout in MU2 (toddlers only and Longnose Sucker in MU4 (both toddlers and adults). 6. High-end fish consumers (43g/day) catching fish from MU1, 2, 4 and 5 will have a higher risk of selenium intake. 7. The preferred rate of fish consumption of the Ktunaxa will result in a higher risk of selenium exposure even using fish from the Reference site, but the risk will increase by 3-4 times using fish from the Elk Valley		Nov 14 2022	LC	This text has been added after Table 6-3 with some minor edits. Regarding the shading - as indicated in Table 6.3 values are shaded pink where they are greater than one to one significant figure, i.e., >1.49.
88	KNC-22	The new Table 6-10 and Figures 6-6 to 6-12 are very useful in showing the increased cumulative risk of selenium exposure. The text in Section 6.10 is not sufficient to describe the results. It is important to provide the context in the understanding of the hazard Index. The Toxicological Reference Value (TRV) used is 5.7 ug/kg bw/day which is equivalent to 400 ug/day of selenium intake1. This is based on the No Observable Effect Level (NOEL) of 800 ug/day with an uncertainty factor of 2. Therefore, a HI of 2 means that the intake will likely not cause any adverse effect. In comparison, the Lowest Observable Effect was reported to be 913 ug. Therefore, a HI of 2.5 will indicate potential health effects. Table 6-10 shows that toddlers in the upper percentile recreator and Ktunaxa will have increased health risk of selenium exposure (HI=3) and the Preferred Ktunaxa will have a high health risk from selenium exposure (HI=7 and 4 for toddlers and adults, respectively). Figure 6-12 shows that the cumulative selenium intake is about two times higher in the Elk Valley compared to the Reference for both toddlers and Adults. The highest risk of exposure is in MU-4. The new Appendix A2, e.g. Figure A2-1 is very useful in showing the extent of the elevated concentrations of berries in the Elk Valley compared to the Reference.		Nov 14 2022	LC	Please see the response to the comment on row 73.
89	KNC-28	is the issue of using HQ = 0.2 or 1 for the risk characterization of selenium intake for fish consumption.		Nov 14 2022	LC	Additional text has been added in the Executive Summary and in tables to point readers to analyses based on a comparison with an HI of 0.2
[Additional comments from KNC received November 30 2022]						
90	Section 3.3.1	1. In Section 3.3.1, it is stated that for sediments "all reference data were combined and used to derive reference concentrations for all MUs." No rationale is provided for combining the reference data in this way, nor are any analyses presented demonstrating that sediment concentrations in reference areas are suitably comparable to combine into a reference pool despite varied geology across the designated area. We recommend that the authors demonstrate that the reference data can be combined or conduct the evaluation by MU as was done in the 2014 synthesis report.		Nov 30 2022	JS	As described in Section 3.3, sediment data were screened against medium-specific RBSL and if an analyte concentration exceeded the RBSL, that analyte was screened further using reference area concentrations. If the maximum chemical concentration was lower than the reference concentration, it was not evaluated further. ..."If the maximum concentration was greater than the reference concentration, then the constituent was considered a COPC and was retained for further evaluation. This preliminary screening approach provides a health protective means to focus further risk assessment analyses, but the results are not used in risk management decision-making. For example, all constituent concentrations measured over the previous five years are included in the screening, and use of the maximum concentration measured over the previous 5 years ensures that any constituent that may present a potential risk are evaluated in the detailed HHRA. This process was agreed upon by the HHRA Workgroup during development of the HHRA methodology, as it was considered sufficiently protective."
91	Sections 3.3.2.2 and 3.2.2.3 and 6.11.2.5	1. Sections 3.3.2.2 and 3.2.2.3 present the results of the surface and groundwater screening for constituents of potential concern. Sulphate is excluded as a COPC based on rationale provided in section 6.11.2.5. The rationale states that there is a lack of a health-based drinking water guideline (i.e., the drinking water guideline is an aesthetic objective). The rationale for excluding sulphate is not supported for the following reasons: 1) the Health Canada drinking water guideline for sulphate states that health authorities be notified when concentrations exceed 500 mg/L for the potential for adverse physiological effects; 2) within the HHRA, McKee and Wolfe 1963 are cited as stating that ingestion of elevated sulphate may lead to gastrointestinal discomfort, diarrhea, or dehydration; 3) exceedance of an aesthetic objective, affecting taste, may lead to individuals perceiving a risk to health and thereby avoiding the water body, infringing on typical uses and practices; and 4) trends in sulphate concentrations within the designated area are increasing, which will likely lead to greater surface water and groundwater concentrations over time and the potential for risk. Therefore, we recommend that sulphate be included as a COPC. We acknowledge the lack of a health-based risk thresholds and recommend that the drinking water thresholds be adopted as the RSBL for COPC screening.		Nov 30 2022	JS	Text has been added at the comment location to state: "As discussed in Section 3.2.4, sulphate was not retained as a surface water COPC for numerous reasons, including but not limited to the lack of established guidelines and that sulphate is an innocuous water quality parameter. Section 6.11.2.5 provides detail regarding the sulphate concentrations compared to Health Canada's aesthetic objective." As further discussion in response to this comment: As described in Section 6.11.2.5, sulphate concentrations in groundwater were screened against Health Canada's aesthetic objective of less than or equal to 500 mg/L of sulphate in drinking water, which is based on taste considerations and is not risk-based. The text goes on to state: "Groundwater samples were collected in MUs 3 through 5. Sulphate was identified in groundwater samples collected in these three MUs; however, exceedances were observed solely in MU-4. Of the 151 detected samples in this MU, a total of 20 samples exceeded the drinking water guideline (Table 6 12). All exceedances were located in private residential water sources (Well-05, Well-23, Well-24, and Well-25) within MU-4. The highest concentration of sulphate was identified at RG_DW-07-01 (670 mg/L)."

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#	Report Page & Section	Comment	Rationale	Date	Reviewer	Response to Comments
92	Figure 3-4	Figure 3-4 presents a spatial representation of the reference and mine-exposed fish capture locations. The selection of reference locations requires additional information on the suitability of these locations as suitable to characterize reference conditions. In particular, RG_FODCH is included; however, our understanding is that these fish are samples that have also been associated with RG_FODGH, located downstream of GHO in the Fording River (i.e., these represent a mine-exposed area); more detail on these samples is provided in the FRO LAEMP 2021 Report. In addition, it appears that RG_MC is situated on Michel Creek downstream of the Coal Mountain Mine. Finally, rationale for including other reference locations, not typically relied on in the RAEMP (e.g., RG_KR, RG_MR) is needed. We recommend that the authors provide the fish tissue data for all of the reference locations, re-evaluate the suitability for each of the reference locations, and revise the risk characterization accordingly.		Nov 30 2022	JS	Based on this comment, Ramboll and Teck conducted a further review of the reference locations with help from Minnow and we have made the following changes: •RG_FODCH (Fording River d/s of Chauncey Creek) is moved to MU-1 •RC_MC (Michel Creek d/s of CMm) is moved to MU-4 •RG_CBN (Corbin Creek within CMm) is moved to MU-4 All other locations in the HHRA reference dataset are consistent with the reference locations used in the RAEMP: •RG_KR (Kootenay River, near Fort Steele); RG_MR (St Mary's River, near Kimberley); RG_BR (Bull River, near Mayook); and RG_FC (Flathead Creek) were identified as reference locations in the 2015-2016 RAEMP Report (Appendix H Table HMW1) •RG_FLA1 (Flathead Side Channel) was identified as a reference location in the 2015-2016 RAEMP Report (Appendix H Table HLSU1) and in the 2017-2019 RAEMP Report (Appendix K Table 3.12) •RG_BULL (Bull River, near Quinn Creek) and RG_MOYIE (Moyie River, west of Cranbrook) were identified as reference locations in the 2017-2019 RAEMP Report (Appendix F Table F2) •RG_FH (Flathead River) was identified as a reference location in the 2017-2019 RAEMP Report (Appendix F Table F6)
93	6.11.3.1	In Section 6.11.3.1, it is stated that "maximum concentrations in wet weight were greater in fillet than in the whole body" with respect to selenium in fish tissue. Were any data on organ concentrations (e.g., liver) available to understand the risks associated with consuming fish livers?		Nov 30 2022	JS	Comparison of fish muscle with fish organs (liver, muscle, and ovary) has been added. See "Comparison of Selenium Concentrations in Fish Muscle with Concentrations in Organs " of Section 6.11.31 for additional details. As indicated there, fish liver and ovary data indicate higher selenium concentrations than in muscle. These organs are small relative to the entire fish. However, those whom prefer fish liver and eggs may have higher selenium exposure than those who eat only fish muscle.
94	Section 4.2.4.3	typo and update - ʔakisq̓nuk vs. ʔakisq'nuk and Yaq̓it ʔa·knuqⱡi'it for the Nov 13 and Dec 17 focus groups.		Nov 30 2022	HM	Edit has been made as requested.
95	Glossary	Yaq̓it ʔa·knuqⱡi 'it vs. Yaq̓it ʔa·knuqⱡiʔit		Nov 30 2022	HM	Edit has been made as requested.
96	ES-5	add language (two bullets) from page 77 on preferred rates to ES-5 (note spelling mistake below) - prefer the full cultural concept is all presented.		Nov 30 2022	HM	This text has been added at ES-5 (including the edit to remove the extra 'is'): Ktunaxa Preferred rates are premised upon two key Ktunaxa principles: 1. Take what you need, according to your context including, cultural, spiritual, family size etc. as well as recognition of the food needs shared with other species and options for other foods in times of scarcity. 2. ʔa•kpiȼ̓is is the Ktunaxa concept that refers to the favourite and regular foods eaten for both animals, birds, fish, and humans, according to inherent and interdependent relationships of ʔȧkxaṁis q̓api qapsin—all living things—and so governed by Ktunaxa natural law—ʔa•knumuȼtiⱡiⱡ.
97	Page 77	typo - ʔa·kpiȼ̓is vs. ʔa•kpiȼ̓isis		Nov 30 2022	HM	Edit has been made as requested.
98	answer to KNC-39	2020 Regional Groundwater Monitoring Program Update - Table P: states that the 95th percentile of mine affected wells is 1650mg/L. Please compare this with any available data NOELs/LOELs etc. to understand potential health affects at these levels.		Nov 30 2022	ER	The response to comment 39 indicates that the highest sulfate concentration identified was 670 mg/L. No EPC was calculated for sulfate because there is no toxicity value for sulfate. There is no Table P in the report or appendices.
99	Answer to KNC-53	It is not only ENV's perspective that is considered when determining the scope of the HHRA. Teck has an IMBA with Ktunaxa and the Ktunaxa perspective should be respected and considered.		Nov 30 2022	ER	Comment noted.
100	Koocanusa fish tissue	Sampling was limited to the Canadian side of Koocanusa. My understanding is that there areas in the US side of Koocanusa that could have higher fish tissue bioaccumulation of selenium (the forebay). Should discuss this uncertainty - it is possible that the fish sampled are not representative of the full reservoir.		Nov 30 2022	ER	Sampling further from the mine along the 90 mile Lake Koocanusa would not be representative of any potential impact from the mine.
101	7.4	There is extensive site specific data - one would think there is enough to warrent drawing some conclusions. The risk characterization - high HQs/HIs show that consumption at certain levels do pose a potential health risk and adaptive management is required. Section needs to be updated to reflect the evaluation of the dose response data to provide context around the high HQs. There is enough information to know that it would not be advisable for Ktunaxa to live off the land in the designated area and rely on fish from mine impacted waters.		Nov 30 2022	ER	The following text has been revised to re-iterate some key findings of the HHRA and how they will be considered within the Adaptive Management Plan. "A health-protective evaluation of potential human health risks that builds upon both the 2016 and on this final 20232021 HHRA Report can support the adaptive management process. As described in more detail in Section 7.1, this 2023 report indicates that consumption of fish at a Ktunaxa preferred level is associated with unacceptable risks associated with selenium in MU-1 through MU-5 indicating the need for ongoing monitoring and adaptive managment. Consumption of fish at Ktunaxa preferred levels in MU-6 is also associated with elevated risks related to mercury, but mercury concentrations are consistent with regional lakes. This assessment and the 2016 HHRA also identify unacceptable risks associated with nitrate exposures if surface water in MU-1 and MU-3 is used as drinking water for infants. Concentrations of selenium is present in surface water at concentrations greater than the British Columbia screening value of 10 ug/L for drinking water in numerous locations, but HQs for consumption of drinking water do not exceed a threshold of 1. "

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#	Report Page & Section	Comment	Rationale	Date	Reviewer	Response to Comments
[Comments received from Interior Health]						
102		The elevated risks associated with nitrates within the surface drinking water pathway for toddlers identified in MU-3 on page ES-3 is not clearly reflected in Section 6.3 of the main report.		Aug 8 2022	GM	This text was added to the beginning of Section 6.3: "Surface water within the DA is not a current municipal drinking water source, however, to understand the implications of potential use of surface water as drinking water and support future water resource management decisions, noncancer risks were estimated for infant (0-6 months) consumers in addition to the default Health Canada life stages within each MU and this is described in Section 6.5. As indicated in Section 6.5, surface water in MU-1 and MU-3 would have elevated risks if used as drinking water for infants due to nitrates."
103		I know there were some elevated selenium levels in some wells in MU-4 and -5 as part of the RDWMP which I am curious to know if they were specifically factored into this assessment or not? What would be their statistical significance be relatively the overall data set used?		Aug 8 2022	GM	Data from 2015- Q2 2020 was included in HHRA and any elevated Se levels measured in that time frame are included in HHRA dataset. The selenium WQG is derived using different basis than the risk assessment methodology. Specifically the WQG is based on a determined allowable contribution (10-25%) to overall Se intake. When evaluated on well by well basis, 8 wells have EPCs > 10 ug/L (max 15.2 ug/L). The well by well evaluation found Se HQs all <0.1 (max HQ=0.098). The new Figure C-1 shows surface water data relative to the WQG and shows the EPCs for each MU.
104		What was the rationale for not factoring in the drinking water within the cumulative selenium risk HI's tables? What is statistical significance? Despite the indented focus being on mining impact to drinking water the ES seems to have more relatable information or greater emphasis in the ES for the impacts to country foods and general diet.		Aug 8 2022	GM	Figure 6-6 and Table 6-10 include groundwater as drinking water in the cumulative risk presentation. The largest contribution from groundwater to the cumulative selenium risk is 5% (for average Ktunaxa adult, HQ=0.03). The groundwater use as drinking water hazard quotient for selenium was <0.1 for all scenarios including well by well. In response to comments, this final HHRA includes cumulative risk estimates for surface water used as drinking water for Ktunaxa receptors. The highest selenium HQ for this pathway is 0.4 (infant/toddler drinking surface water in MU-1).
105	ES-6/Table ES-2 -	The risks associated with drinking water from the Elk Valley were not clearly and equitably discussed within in the Executive Summary. We request that the details of the non-cancerous risks for both surface water and groundwater for all identified COPCs throughout the Elk Valley be more clearly and equitably included within the executive summary. This would be to rationalize the current and long-term risk of exposure with drinking water relative to other identified exposure pathways.		Jan 17 2023	GM	The ES has been revised to elaborate on the surface and groundwater results of the HHRA and have included surface water as drinking water for Ktunaxa receptors in the cumulative risk stacked bar charts. Edits have been made in numerous locations to describe risks associated with surface water and also to indicate that the HHRA is focused on site-related CoPCs and risk estimates do not account for potential risks related to non-site related biological contaminants.
106		Section 6.11.2.2 must be revised to reflect that surface water is full and complete exposure pathway within the Elk Valley as was previously acknowledge and recognised in Section 2.2.2.		Jan 17 2023	GM	The text has been updated to state that ingestion of surface water is a complete exposure pathway for some people in the Elk Valley, noting that the majority of people obtain their potable water from municipal sources. If IH has information on specific MUs where water is used as drinking water or possible treatment of water withdrawn, we can add that information if this would be helpful to IH. The following sentences were struck from Section 6.11.1: ~~For example, risks associated with COPCs in surface water were evaluated assuming use as a residential drinking water source even though surface water is not currently a primary drinking water source. This may greatly overestimate risks for people who are exposed to COPCs in surface water only during swimming or cultural activities.~~ [Please also see response to prior comment.]
107	ES&Sec.6.4 -T	There is currently no recognition that the BC Source Drinking Water Quality Guideline for Selenium is still regularly exceeded in a large portion of the mine affected area (upper portions of Elk River Watershed) despite the calculated health quotients being relatively low for all COPC's, except for nitrates to the infant/toddler life stage. Therefore a map that shows where selenium exceeds BC drinking water quality guideline of 10ug/L, should be reincorporated into this HHRA within the discussion on non-cancerous risks for consumption of surface water within the Elk Valley, and another that includes the contrasting ambient water quality levels and the relative exposure risk within each management unit.		Jan 17 2023	GM	Together with the Workgroup Ramboll prepared a map showing the frequency and location of exceedances of the BC screening value of 10 ug/L. This sentence has been added to the second section of the Executive Summary entitled "What Was Evaluated in the HHRA?" "While the HHRA evaluated a full range of constituents that could be influenced by mining, at the outset selenium was known to be present in surface water at concentrations greater than the British Columbia screening value of 10 ug/L for drinking water (see Figure C-1 in Appendix C) and selenium is a particular focus of this assessment." Figure C-1 is also identified in Section 3.3.2 which describes the risk-based screening for surface water.
108		Sec. 7.4 pg. 162 - The direct linkage between the 2021 HHRA and the existing Adaptive Management Plan (AMP) should also include for clarity purposes a summary of the current and planned risk management activities, following best available technologies and industry practices (i.e. Active Water Treatment Plants, adopting saturated waste rock piles etc.) towards managing the identified human health risks.		Jan 17 2023	GM	Additional text has been added to Section 7.4 pg. 162 to better link the findings of the HHRA to the existing Adaptive Management Plan. Specifically, the following sentences have been added: "As described in more detail in Section 7.1, this 2023 report indicates that consumption of fish at a Ktunaxa preferred level is associated with unacceptable risks associated with selenium in MU-1 through MU-5 indicating the need for ongoing monitoring and adaptive management. " Consumption of fish at Ktunaxa preferred levels in MU-6 is also associated with elevated risks related to mercury, but mercury concentrations are consistent with regional lakes. This assessment and the 2016 HHRA also identify unacceptable risks associated with nitrate exposures if surface water in MU-1 and MU-3 is used as drinking water for infants. Concentrations of selenium is present in surface water at concentrations greater than the BC water quality guidelines of 10 ug/L in numerous locations, but HQs for consumption of drinking water do not exceed a threshold of 1. "
109		Sec 7.1 pg. 159 - We have strong concerns about current suggestion that consumption of groundwater from all but two of the wells evaluated in the HHRA is "safe to drink" or otherwise acceptable. The rationale being that not all water quality parameters that can adversely affect human health were not evaluated within this HHRA. In addition, source water quality can change overtime either naturally or through anthropogenic land-use activities. We recommend that this statement reflect that the risks of over exposure to the constituents of concerns with consumption of groundwater in the Elk Valley, except from the two identified wells, is low.		Jan 17 2023	GM	The title in Executive Summary table has been changed to include "Mine-related". Discussion has been added to uncertainty column in Executive Summary table. Text describing these issues has been added in Section 6 and 7 where groundwater is discussed. The following edit was made in Section 7.1: "Consumption of groundwater as drinking water has low risks for mining-related CoPCs ~~is safe for current consumers~~ when evaluated on a MU-basis. Groundwater was sampled for mining related CoPCs only: not all water quality parameters that can adversely affect human health were considered. Moreover, water quality can change over time."

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#	Report Page & Section	Comment	Rationale	Date	Reviewer	Response to Comments
110		Page ES-10, pg. 30: Further scientific justification should be provided for the statement "… some fish data used in the HHRA may not be representative of exposure but are unlikely to underestimate risk," to explain why would this lead to an underestimation of risk? The rationale that risks were unlikely to be underestimated is based on the fact that there were some locations near mine operations that are inaccessible to the public but were sampled and included in the HHRA, and in at least one case, this resulted in substantial increases in exposure point concentrations relative to other portions of the MU.		Jan 17 2023	GM	The following sentence was added in the paragraph before Figure ES-11. "Specifically, some fish samples used in the HHRA were from locations near mine operations that are inaccessible to the public. In at least one case, this resulted in substantial increases in exposure point concentrations relative to other portions of the MU, (e.g. station, RG_GO13 in Goddard Marsh). " See also the response to comment on row 23.
111		General Recommendation – The HHRA has identified elevated health risks due to Selenium exposure for Ktunaxa preferred diet consumption rates of fish and to a lesser extent game meats and berries. KNC should be consulted in order to best inform a meaningful and appropriate risk communication strategy for the Ktuxana Nation.		Jan 17 2023	GM	Comment noted. Teck has committed to supporting the Ktunaxa Nation with communication of HHRA results and initiated these efforts during Summer 2022. However, the Ktunaxa Nation and other Workgroup members have stated that the HHRA must be approved by the ENV prior to release of communications to the public.
[Additional comments from KNC received January 25 2023]						
112		Report already makes comparisons to 0.2 for each CoPC and each pathway AND comparisons to 1 for each CoPC and cumulative risks across pathways		Jan 25 2023	LC	Comment noted.
113		I strongly recommend resolving the issue highlighted previously on the appropriateness of using HQ=1 for berries, rosehips and game separately and for fish consumption alone for screening for the risk of local foods.		Jan 25 2023	LC	The report has been revised to provide additional emphasis on risks related to HQs greater than 0.2 or greater than 1.
114		There is a mistake in Slide 10 and 11. The TRV is **NOT** 17 times lower than the NOAEL.		Jan 25 2023	LC	The error on this slide and the corresponding text in the HHRA has been corrected. It should have said that the NOAEL used in deriving the TRVs for infants and children is 17 times lower than the NOAEL (45 ug/day) used in deriving the TRV for adults (800 ug/day). As noted in comment 125, the TRVs derived based on the NOAELs become very similar after accounting for body weight and uncertainty.
115		The HHERA used a TRV of 0.0057 mg/kg/day for both adults and toddlers.		Jan 25 2023	LC	Correct.
116		Health Canada published a set of slightly different TRVs for different age groups 0 to < 6 months 0.0055, 6 months to < 5 years 0.0060, 5 to < 12 years 0.0063, 12 to < 20 years, 0.0062, and ≥ 20 years 0.0057. https://publications.gc.ca/collections/collection_2021/sc-hc/H129-108-2021-eng.pdf		Jan 25 2023	LC	Correct, the TRVs are presented and discussed in Section 5.1.1 of the HHRA text.
117		The adult TRV of 0.0057 mg/kg/day=5.7 ug/kg/day= 5.7x70Kg (adults) or 400 ug/day is based on the NOAEL of 800 ug per day divided by an uncertainty factor of 2. For infants and children, the TRV is based on the NOAEL of 47 ug/day reported by Shearer and Hadjimarkos (1975) in breast milk. https://www.tandfonline.com/doi/epdf/10.1080/00039896.1975.10666686?needAccess=true&role=button		Jan 25 2023	LC	Correct, this had been clarified in Section 5.1.1 of the HHRA text.
118		Health Canada rounded it up to 45 ug/day, used an uncertainty factor of 1, assumed the body weight of 7.5 Kg and developed a TRV of 0.006 mg/kg/day for toddlers <5 years. Since 0.006 and 0.0057 are close enough, it is ok for the HHRA to use 0.0057 mg/kg/day as the TRV for both adults and toddlers. But there is NO extra safety margin.		Jan 25 2023	LC	The described derivation of the infant and child TRVs is correct. We agree no additional safety factor was added by Health Canada in deriving the TRV for infants and children from the dietary intake amount. However, as noted in IOM (2000) an uncertainty factor of 2 was applied to the NOAEL of 800 µg/day when deriving the TRV for adults.
119		For details of the assessment for selenium, please refer to the Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium, and Carotenoids. https://www.ncbi.nlm.nih.gov/books/NBK225470/#ddd0000376		Jan 25 2023	LC	Thank you. This reference (IOM 2000) was reviewed and added to the text.
120		Most agencies, including Health Canada, uses the Upper Limit of Selenium for risk assessment		Jan 25 2023	LC	Thank you. The use of the UL was clarified in the text.
121		As suggested in my previous comment, it is important to explain what the health risk is when the HI is 7 for toddlers and 3 for adults. HI of 7 =7 x 5.7 ug/kg/day=40 ug/kg/day. The HHRA assumes the body weight for toddlers to be 16.5 Kg, and the daily intake would be 40x16.5 or **660 ug/day**. Similarly, for adults, HI of 3 will equal 3x5.7x70 or **1197 ug per day**.		Jan 25 2023	LC	Agreed, however there are uncertainties in applying the intakes estimated in the HHRA to potential health effects. See HHRA Section 6.11.5.1 and response to comment 124.

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#	Report Page & Section	Comment	Rationale	Date	Reviewer	Response to Comments
122		Below, I made a quick comparison between the estimated exposure to those associated with observable health effects. For example, a recent study from Brazil showed that about 10% of children (6-8 years old) with selenium intake of 7-273 ug/day showed selenosis symptoms, such as hair loss, nail deformities, halitosis, and physical fatigue. https://doi.org/10.1007/s10653-020-00672-6		Jan 25 2023	LC	Dos Santos et al. (2021) compared selenium dietary intakes (estimated from dietary surveys), selenium urinary excretion, selenium excretion, and prevalence of selenosis symptoms in a coal mining community and reference community in Brazil. The authors found low prevalence of selenosis symptoms overall. Specifically, 10% of children in the mining community and 7% of children in the control community had symptoms potentially associated with selenosis (hair loss, nail deformities, halitosis, physical fatigue). Selenium dietary intakes were estimated using food frequency questionnaires and average selenium concentrations in food from Brazilian diet studies. Other potential sources of selenium were not accounted for in the intakes. The authors concluded children from both cities had normal levels of selenium intake and urinary excretion, though selenium dietary intake and excretion were higher in children from the mining community. While informative from a selenium exposure perspective, we do not think this study can be used to draw conclusions regarding selenium intake and potential selenosis effects. Selenium intakes were estimated using dietary surveys and selenium concentrations from national diet studies, selenium content in local food sources and non-dietary sources were not accounted for. There was a low prevalence of selenosis symptoms in both communities. The estimated intakes cannot be tied to potential selenosis symptoms.
123		For adults, Yang and Zhou (1994) suggested that 910 µg/day of selenium intake represents an individual marginal toxic daily selenium intake or LOAEL showing overt signs of selenosis: hair loss and nail sloughing. https://pubmed.ncbi.nlm.nih.gov/7599506/		Jan 25 2023	LC	A discussion of the LOAEL from Yang and Zhou (1994) and a discussion regarding the characterization of risk when estimated exposures are above the NOAEL or LOAEL have been added to the text.
124		This suggests these exposure levels will likely result in observable health outcomes.		Jan 25 2023	LC	The text has been revised to more clearly state that hazard quotients greater than 1 are identified as unacceptable and indicate the need for further consideration and potential mitigation. A discussion regarding the characterization of risk when estimated exposures are above the NOAEL or LOAEL has been added to the uncertainty assessment. As described in the text, significant variability in selenium intakes associated with selenosis symptoms was observed in the population studied by Yang and Zhou in a seleniferous region of China. It cannot be concluded that a specific selenium intake, such as the 910 µg/day LOAEL, would result in observable health effects. However it is possible that some individuals could exhibit low level selenium toxicity, such as hair loss, at this level. This is why the TRV is derived using the NOAEL and an additional uncertainty factor of 2 to protect sensitive individuals. The selenium HIs and associated intakes are estimated and intended to be conservative. It is likely that actual selenium intakes, if measured through biomonitoring, would differ. The HHRA is not a health study and is not able to predict levels of selenosis in the Elk Valley community or for a specific individual. However, it identifies environmental media that has unacceptable levels of selenium where further monitoring and potential mitigation is needed.
125		Yes. The two NOAELS for adults and toddlers are derived from two separate studies. One of the main factors for the difference was that they did not account for the difference in body weight. After accounting for the difference (70Kg for adults and 7.5 Kg for toddlers) and the level of uncertainty (there was a higher uncertainty for the estimate of intake for adults, so UF=2, and the toddler intake was all from milk, so UF=1), the TRVs became very similar. The point I raised in KNC-22 is that we need to better characterize the risks when the estimated exposures are several times higher than the NOAEL and even higher than the LOAEL.		Jan 26 2023	LC	Thank you for pointing out that the difference between the NOAELs is primarily due to body weight. This has been added to the text. A discussion regarding the characterization of risk when estimated exposures are above the NOAEL or LOAEL has been added to the uncertainty assessment.

Permit 107517 Environmental Monitoring Committee Advice/Input - Draft Human Health Risk Assessment Supporting the Elk Valley Water Quality Plan (Permit Section 8.10)						
#	Page and Section	Advice	Rationale	Date Received	EMC Member	Teck Response
ADVICE/INPUT						
ENV-1	General	The draft HHRA is thorough and provides valuable recommendations for future evaluations under the AMP. Many of my comments are questions aimed to improve my understanding of the tool and to ensure I'm interpreting the outcomes correctly.		Dec 01 2021	AN-ENV	Comment noted, thank you.
ENV-2	General	ENV is supportive of the recommendation to add an executive summary and recommends this be written in plain language.	It is likely that the public won't read the HHRA, but if the executive summary includes key takeaways, or responses to key questions it would be a valuable communication piece.	Dec 01 2021	AN-ENV	An Executive Summary has been prepared for review by the HHRA Workgroup and has been added to the HHRA report.
ENV-3	Pg. 6, Section 2.1	I recommend including some context to clarify that sampling data was limited to receiving environment monitoring locations and not from samples collected within the mine boundary (or within water management structures).		Dec 01 2021	AN-ENV	Additional context was added to Section 3.1 Overview of Chemical Data for the HHRA.
ENV-4	Pg. 33, Section 4.1	This section indicates that "Sample sizes for some media in some MUs were small and thus may not represent long-term exposures. Consequently, estimates based on valley-wide EPCs may be more representative of site risks." Can this statement specify game, berries and rose hips?		Dec 01 2021	AN-ENV	This section was revised to add the details suggested.
ENV-5	Pg. 35, 4.2.1	ENV understands that while Ktunaxa preferred consumption rates were used in the RA, Ktunaxa body weights were not used. Why were certain Ktunaxa specific components included in the RA and not others?		Dec 01 2021	AN-ENV	Table 5 of the 2015 Firelight report includes body weight data for 83 adults only, including an average weight of 73.6 kg for the 48 women and an average weight of 84.1 kg for the 35 men for whom data were reported. These body weights were higher than the body weights for adults of 70.7 kg used in the HHRA as identified in Health Canada (2019). The lower body weight for adults was applied because it is based on a larger more robust dataset and because the body weights were lower. Use of a lower body weight is a health protective assumption because exposures are considered on a per kg body weight basis and lower body weights result in a higher assumed dose and risk estimate on a per kg basis. For example, for Ktnaxa preferred rate fish tissue ingestion, the valley-wide selenium HQ estimate is 2.4 using a body weight of 70.7 kg used in the HHRA. If an average body weight of 78 kg based on the 2015 Firelight report were used, the HQ would decrease to 2.2. The magnitude of the change in this case is not significant and the HHRA conclusions would be the same, especially given that risks to toddlers are the greatest; however, we preferred a more conservative approach that is also consistent with provincial and federal risk assessment guidance.
ENV-6	Pg. 30, Section 3.3.4.1 Pg. 44, Section 4.2.4	The fish tissue pathway is based on the edible tissue portion. It would be valuable to include a brief discussion on how the risk characterization would change for fish consumption if the whole body results were considered. Alternatively, a statement about why the whole body was not considered could be included.	Through work on the draft Water Quality Objective we understand that whole body concentrations may be more valuable when assessing risk from fish consumption at Ktunaxa preferred diet rates.	Dec 01 2021	AN-ENV	While some populations may consume additional fish tissue besides that which was evaluated in the HHRA, the available data were limited. There were few whole body tissue samples from 2015 for only Longnose Sucker species in MUs 3, 4, and 5. This data was reviewed and selenium concentrations were higher in the fillet tissue data that was used in the HHRA (e.g. the maximum concentration was 1.81 mg/kg ww in MU-3 fillet and 1.41 mg/kg ww in MU-3 whole body). Therefore, assessing fish consumption risks using fillet tissue data is conservative, even for people who may consume whole fish. This discussion and details about the whole body data were added to the Uncertainty Assessment in Section 6.11.3.1.
ENV-7	Pg. 48, Section 4.2.5	What is the rationale for applying the same consumption rate across all life stages for berries and rose hips? Why was this intake not scaled across life stages as with other consumables?		Dec 01 2021	AN-ENV	The KNC Preferred Diet Memo to Teck requested that the berry consumption rate for adults be applied to all life stages. The KNC memo did not include information on rose hips, but in follow up communications between J. Tu (Ramboll) and K. Fediuk (The Firelight Group), K. Fediuk recommended also applying this approach to rose hips. This communication is cited in Section 4.2.5 of the draft report (Section 4.2.6 of the final report).
ENV-8	Pg. 51, Section 4.2.6	Is it a coincidence that the meal size for both game and fish meat averaged out to 245 g?		Dec 01 2021	AN-ENV	Yes, it does appear to be coincidental that average meal sizes are consistent between fish and game.
ENV-9	Pg. 61, Section 6.3	The title of Table 6-1 should indicate that it is in reference to the toddler life stage. Including the HQ in these figures would help understand the magnitude of exceedance of the 0.2.		Dec 01 2021	AN-ENV	Toddler and Infants has been added to the title. The table is intended to provide a general summary of COPCs and pathways that may pose increased risks and the specific HQs > 0.2 are discussed in the text. Because there are different HQs associated with each MU, consumption rate, and lifestage, it is too complex to add HQ values to the table. Detailed information on HQs is provided in tables within the appendices, particularly Appendix H.
ENV-10	Pg. 64, Section 6.3.1 Pg. G-12, Appendix G	Figure 6-1 - I am interpreting this figure to indicate that the HQ for Thallium for any consumption scenario is higher in reference fish than in fish caught anywhere in the Elk Valley. Similarly, with Selenium the HQ in reference fish for all consumption scenarios is higher than the HQ in MU-6 fish. Am I correct to assume this means measured selenium in reference fish was higher than measured selenium in Koocanusa Reservoir fish?	The Exposure Point Concentrations appear to indicate that tissue selenium concentrations in MU-6 fish are 0.621 mg/kg ww, while reference fish are 1.16 mg/kg ww. Figure 3-4 (map) indicates that the reference fish sampling areas include the Moyie, Bull and Flathead Rivers. The EPC calculations for Koocanusa Reservoir fish are lower than I would expect. Please clarify if I'm misinterpreting this data.	Dec 01 2021	AN-ENV	The interpretation of the data and EPCs is correct. Thallium concentrations are higher in reference fish than Elk Valley fish, and Koocanusa Reservoir fish have lower selenium concentrations than reference fish.
ENV-11	Pg. 64, Section 6.3.1	While I understand that the Ktunaxa toddler has been identified as the most sensitive human receptor I am also curious to see the outcomes compared to an adult consumer.	I'd like to understand how risk changes by age classes.	Dec 01 2021	AN-ENV	Adult HQs were added to Figures 6-1 and 6-2 in this section for comparison to toddler HQs. Figures showing cumulative risks across lifestages were added as Appendix I.
ENV-12	Pg. 72, Section 6.5	The first sentence in the second to last paragraph would benefit from some re-wording "exceeded...in any MU" is a bit confusing.		Dec 01 2021	AN-ENV	This sentence was revised to state: Table 6-4 provides an overview of the HQs for surface water COPCs other than nitrate that exceed 0.2 for the 0-6 month infant.
ENV-13	Pg. 74, Section 6.5.1	The seasonal breakdown of nitrate EPCs is really interesting.		Dec 01 2021	AN-ENV	Comment noted, thank you.
ENV-14	Pg. 77, Section 6.7.2	Can reference data be included in these HQ>0.2 tables? The text indicating that many COPCs have similar or higher HQs in reference areas seems critical to the interpretation of these tables.	This links to my comment below.	Dec 01 2021	AN-ENV	We have shaded where background risks have HQs >0.2 in Tables 6-6 and 6-7.
ENV-15	Pg. 30, Section 3.3.4.1 Pg. 77, Section 6.7.2	I'm finding the interpretation of results for a number of media challenging owing to the amount of reference HQs that are higher than those in exposed areas. Is this an artifact of the COPC screening process not considering reference data for some media?	The discussion is thorough, but I'm finding that it may emphasize outcomes that are actually lower than reference. I see the challenge in needing to account for these contributions to the diet, even though they're not necessarily mine related.	Dec 01 2021	AN-ENV	Shading was added to Tables 6-6 and 6-7 that indicates where reference media have HQs>0.2 for the most sensitive lifestage (i.e., toddler). Additional clarifications has been added to the text.

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#	Page and Section	Advice	Rationale	Date Received	EMC Member	Teck Response
ADVICE/INPUT						
ENV-16	Pg. 80, Section 6.10	I interpret these figures to indicate that market basket food alone represents an HQ>1 without consumption of Elk Valley food.		Dec 01 2021	AN-ENV	The interpretation is correct for toddlers. Consumption of market basket food alone results in a selenium HQ of 1.2 for toddlers. For adults, the market basket food HQ is 0.4. Adult HQs have been added to Figure 6-6 through 6-11.
ENV-17	Pg. 86, Section 6.10	Are the figures in this section available for other life stages assessed?	It would provide useful context to see how much more sensitive the toddler life stage is compared to adult, adolescent, etc, similar to how the decline in HQ in market basket food is demonstrated across life stages in Figure 6-5. Specifically, I would like to see Figure 6-12 included for all consumer scenarios to better understand the difference in HQ between life stages.	Dec 01 2021	AN-ENV	The current figures and Table 6-10 were updated to add adult risks for comparison. Figures for other lifestages have been added to a new Appendix I.
ENV-18	Pg. 89, Section 6.11.3.1	Discussion throughout on the potential sampling bias is valuable context. I appreciate that this uncertainty is clearly linked to a recommendation.		Dec 01 2021	AN-ENV	Comment noted, thank you.
ENV-19	Pg. 97, Section 6.11.5.1 Pg. 99, Section 6.11.5.4	ENV comments on Cobalt and Lithium were provided through the Groundwater Working Group.		Dec 01 2021	AN-ENV	Comment noted, thank you.
ENV-20	Pg. 102, Section 7.1	The conclusion indicating "Lake Koocanusa may be a good source of fish for consumption…" could be strengthened. This will be a conclusion of interest and removing ambiguity in this statement is important.		Dec 01 2021	AN-ENV	This conclusion has been revised. Selenium is not a primary contributor to elevated HQs in Lake Koocanusa (MU-6) fish. Elevated HQs in Lake Koocanusa are due to mercury, which is introduced from regional, or perhaps global, sources. A review of fish mercury concentrations in regional lakes (Section 6.11.3.1) indicates mercury concentrations in Lake Koocanusa fish are not dissimilar from fish in other lakes.
ENV-21	Pg. 105, Section 7.5	The recommendation in this section pertaining to utilizing the outcomes of the HHRA via focused evaluations under MQ6 is great.	This type of recommendation is actionable and appreciated.	Dec 01 2021	AN-ENV	Comment noted, thank you.
ENV-22	Pg. 105, Section 7.5	The EMC is discussing reporting cycles for programs within the AMP and can address the concern flagged in #2.		Dec 01 2021	AN-ENV	Comment noted, thank you.
ENV-23	Pg. 105, Section 7.5	#4 indicates that risks for other COPCs (other than selenium and nitrate) were negligible and don't require further evaluation. Can this statement be in the conclusions, or summary above for clarity?	This is a valuable conclusion that could be highlighted.	Dec 01 2021	AN-ENV	Yes. This is an important finding that is now clarified in the conclusions and is now included in the Executive Summary
ENV-24	Pg. 105, Section 7.5	ENV understands that the AMP related recommendation for future human health risk evaluations is to move to a screening based approach, focusing on primary exposure media (fish and water) and the COPCs selenium and nitrate, as others were negligible. The recommendations in section 7.4 would then be implemented within the ongoing screening based evaluation.	I just want to make sure I'm interpreting this recommendation and the linkage between 7.4 and 7.5 correctly.	Dec 01 2021	AN-ENV	This interpretation is correct.
PRIORITY ADVICE/INPUT						
IH-2	3, 1.2	While the focus of the intent of this assessment would be on non-worker populations, workplace exposure pathways should be acknowledged and included as part of the overall risk assessment matrix.	While it is understood that workplace exposures fall under the auspices of different legislative jurisdiction it must acknowledged that exposure pathways and concentrations could potentially be higher at least without explanation or summary of Teck's workplace health and safety and loss control measures implemented to effectively reduce or eliminate the risk of additional exposures which could be seen to further compound the risks for workers whom are also local residents, consumers, and recreates within the CSM.	Feb 18 2022	GM-IH	This section of the report provides a summary of the scope of the HHRA. Following the sentence that states, "The HHRA focuses on non-worker populations who may contact constituents in surface water, sediment, groundwater, fish, berries, rose hips, and game, and relies on exposure assumptions derived from a combination of federal and provincial guidance, studies provided by the KNC, and literature sources, as discussed later in this report", an additional sentence was added to state, "The focus here is not on worker populations because worker safety is regulated by provincial and national regulations. It is acknowledged that workers may also have exposure during mining activities and exposures to the media evaluated in this assessment."
IH-6	11, 2.2	Even as outlined in Fig. 2-3 it is arguably a bold and inaccurate assumption to completely exclude any consumption or exposure to surface water within the Elk Valley within the CSM. As such consideration should be given to recognize and quantify the current surface water usage for drinking/domestic purposes within designated as a complete exposure pathway, however less significant relative to the identified groundwater exposure pathway.	While it may be known anecdotally by local residents "not to drink" from the Elk River directly, there are clearly known domestic surface water licences on it many of it tributaries and at least one in the river in Elko. Furthermore, it was readily acknowledged in this assessment that there may be unknown hydraulic connections to groundwater, and there was no concrete evidence presented to suggest that no one has ever or will ever consume water from the Elk River, or it primary tributaries in the Fording River or Michel Creek. It was also part of the assessment to calculate the worst case scenario of direct consumption of water from the Elk River, so it would stand to reason that Figure 2-3 should be updated to reflect this a complete pathway that was at assessed to some extent for contextual reference.	Feb 18 2022	GM-IH	The text in Section 2.1.3 has been revised as follows "Surface water within the DA is not currently used as a municipal potable source of drinking water. It is acknowledged that some private individuals may divert surface water for potable use; however, little information is publicly available describing specific draw volumes and uses. Surface water uses are dominated by recreational activities, although permits for surface water diversion have been granted for the Elk River, Fording River, Michel Creek, and Koocanusa Reservoir for irrigation and industrial uses. It is possible that some people may use surface water as a drinking water source while exercising Indigenous rights or while camping." Figure 2-3 has been updated to include surface water consumption as a complete pathway. Also, see response to comment W-1.
IH-17	36, 4.2	It would be nice to have included the memo from KNC to teck regarding the preferred consumption rates and methods of preparation in support of the exposure quantifications, or at least include a little more detail within the discussion. This would include a summary of the typical berries included within their preferred consumption diet found within the Elk Valley, along with the typical methods of preparation for consumption etc. comparison and/or validation of the US based market basket values.	For example some comments on whether or not there is a significant difference in risk of exposure based on Selenium or other identified constituent concentration levels within berries between raw versus cooked preparations would be value added contextual insight.	Feb 18 2022	GM-IH	KNC provided additional text to Teck following their review of the Draft HHRA which includes more detail on the Preferred Diet Memo and other Ktunaxa dietary studies including methodology, uncertainties, etc. This text was incorporated into the HHRA as new Section 4.2.4. Inclusion of the memo itself in the HHRA is at the discretion of the KNC. The memo provided to Teck in June of 2020 indicates the information provided is confidential and it should not be publicly shared. A list of berry species identified as consumed by Ktunaxa in the 2015 Ktunaxa First Nation Diet Study has been added to Section 3.1.4 of the HHRA. Food preparation information is not included in any of the Ktunaxa diet studies, however several questions regarding impacts of food preparation methods have been raised in comments on the Draft HHRA (see comments KNC-36, KNC-56, KNC-64). A discussion of potential impacts various food preparation methods can have on COPC concentrations and subsequent risk estimates for food has been added to the uncertainty assessment.
IH-22	62, 6.3	I would be cautious about using the proposed use of alternate TRV for Co and Li without formal approval from the Province (MoH & ENV)	On behalf of IH am not really in a position to formally endorse these proposed alternate screening values, and as such it would be largely up professional developing to these to clearly document the intent of these values specifically for the EVWQMP and outline the limitations of using these values for any other purposes by anyone else.	Feb 18 2022	GM-IH	Section 6.3 notes the alternate TRVs for cobalt and lithium are discussed in the uncertainty assessment and has been revised to more clearly state the current TRVs recommended by ENV guidance are used in the HHRA. The alternative TRVs were discussed and reviewed with the HHRA Workgroup and agreed that the values are acceptable for use in the uncertainty assessment. These values have not been approved for use elsewhere in BC. Text has been added to Section 6.11.5 noting the purpose of discussing the alternate TRVS in the uncertainty assessment is to understand the potential overestimation of risks discussed in the HHRA.
IH-25	80, 6.9	The finding that selenium is present in market basket foods at levels generating an HQ at or greater than the preliminary BC ENV and HC risk management threshold of 0.2 provides a helpful perspective for foods from the elk valley. However, this does not eliminate that fact that the risk of exposure from country foods harvested would often exceed this thresholds and therefore would likely just serve to multiply their risk of exposure. This is evidently supported by data outlined in Figures 6-7 to 6-11.	These finding should consequently reinforce the necessity to further monitoring selenium levels but also for measures to be taken to affectively reduce the contaminant load within the regional CSM. This should be readily acknowledged in this section of the evaluation as well the conclusions.	Feb 18 2022	GM-IH	The text directly before Figure 6-5 ends with the sentence that states: "The finding that selenium is present in market basket foods at levels generating an HQ at or greater than the preliminary BC ENV and Health Canada risk management threshold of 0.2 provides helpful perspective in considering HQs for foods from Elk Valley." A sentence was added stating "Although hazards related to selenium cannot be completely avoided because selenium occurs naturally in a wide range of dietary items, regardless of source, additional measures to reduce contributions of selenium to the environment from mining are likely to reduce total exposures."
IH-26	102, 7.1	What is the true scope of consultation with IH that has occurred in terms of consumption of groundwater as drinking water as being safe for drinking water, as managed under the RDWMP administered by Teck?	There needs to be some very clear qualifiers here regarding the implied safety GW in the region as is suggested by the current wording of this statement, especially with respect to suggesting full endorsement of this matter by IH.	Feb 18 2022	GM-IH	This text in the summary section was revised to be more specific in what was evaluated for groundwater and the resulting risk estimates. Specifically, the text has been revised to state: "Consumption of groundwater as drinking water is safe for current consumers when evaluated on a MU-basis. Drinking water is managed under the RDWMP administered by Teck. Two wells were found to exceed a HQ of 1, for lithium or manganese, when evaluated on a well-by-well basis. These wells were sampled only once; due to the small sample size, HQs for these wells may reflect an over- or underestimate of risk. " References to the RDWMP being managed in consultation with IH were removed, at the request of IH on the 3/3/22 call with Ramboll.

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ADVICE/INPUT						
IH-28	105,7.4	Missing detailed or at least a summary of the corresponding risk communication strategy	Critical step in outlining the necessary interpretation of the numerical results between the proponent, regulator and the affected stakeholders and which is meant to be on-going throughout the process. In other words you need to be able articulate the worst case scenarios and ensure the results and how the current/planned mitigation strategies will effectively be protective of human health. Even if this is not captured throughout this document it should at least be a key next step within the recommendations.	Feb 18 2022	GM-IH	As discussed in calls with the HHRA Workgroup, further risk communication materials will been prepared in consultation with the workgroup. These include an executive summary and if determined to be helpful, can also include simplified brochure summaries of what was evaluated, estimated risks, and recommendations.
IH-30	105, 7.4	In addition to the suggested fish screening I would also recommend that Teck supports the Province in issuing a fish consumption advisory, pending more information to prompt a re-evaluation of the risk assessment.	This would be based on the calculated elevated risks associated with consumption of fish tissue with HQs ≥ 0.2 for at least five separate mine influenced contaminants, including Cobalt, Lead, Mercury, Selenium, and Thallium, in more than one MU. The risk would be particularly high for the Ktunaxa preferred diet consumer.	Feb 18 2022	GM-IH	The HHRA did not determine whether fish consumption advisories are needed and proposals for or development of fish consumption advisories are beyond the scope of the HHRA. Advisories are typically based on specific species and sizes of fish and consider health benefits of consuming fish in addition to potential exposures. Consumption advisories fall under the purview of public health agencies as opposed to private entities.
ADVICE/INPUT						
IH-1	1, Acronyms	Please remove the reference to Authority for the name of my organization	"Authority" was legally dropped from our name before 2008	Feb 18 2022	GM-IH	This edit has been made.
IH-2a	3, 1.2	While the focus of the intent of this assessment would be on non-worker populations, workplace exposure pathways should be acknowledged and included as part of the overall risk assessment matrix.	While it is understood that workplace exposures fall under the auspices of different legislative jurisdiction it must acknowledged that exposure pathways and concentrations could potentially be higher at least without explanation or summary of Teck's workplace health and safety and loss control measures implemented to effectively reduce or eliminate the risk of additional exposures which could be seen to further compound the risks for workers whom are also local residents, consumers, and recreators within the CSM.	Feb 18 2022	GM-IH	See response to comment IH-2.
IH-3	3, 1.2	Clearer rationale should be provided as to specifically why non-chemical and other environmental stressors which could have compounding or synergistic effects with the chemical stressors identified in drinking water, vegetation, fish, wildlife which are use for food or medicinal sources within the Elk Valley were not included within this assessment, besides just limiting the scope of this overall HHRA.		Feb 18 2022	GM-IH	After the sentence stating: "Non-chemical stressors or influences, such as climate change, barriers to access the outdoors or health care services, and other social determinants of health are not evaluated in this HHRA." The following sentence was added: "While many other factors have important influences on health and wellbeing, this assessment is being conducted to evaluate the mining related influences on surface water to assist in determining what, if any, further mitigations are needed to address mining impacts on surface water. It also is recognized that this approach cannot provide a comprehensive evaluation of wellbeing. "
IH-4	4, 1.4	RE: ENV Risk Thresholds - Are all of these thresholds consistent with public health standards and protective of human health? This is not really explored or highlighted with in the discussion of this draft document		Feb 18 2022	GM-IH	This comment appears to refer to a statement regarding a summary of the 2016 HHRA. The 2016 HHRA and this current draft HHRA rely on risk assessment guidance from BC ENV, Health Canada, and from the HHRA Workgroup. In the section on which this comment is based, the following change is made: After the sentence stating: "The 2016 HHRA results were consistent with the 2014 evaluation, which found that recreating in Lake Koocanusa and the Elk River and its tributaries did not result in risks or hazards in excess of ENV risk management thresholds." An additional sentence has been added to state: "Because the risk management thresholds are protective of human health, no adverse effects would be expected." In this current draft document risk management levels from BC ENV are first described in Section 3.3, when the risk based screening levels are described. The text has been revised to better reflect the protectiveness of these thresholds.
IH-5	8, 2.1.3	More than the suggestion that some people may use surface water as drinking water within the Elk Valley, it should at least be acknowledged that surface water is used currently by unquantified number and may be drawn upon further in future.	It is well documented within the provincial registry that there are roughly 200 domestic use surface water licences within the Elk Valley, albeit all are on tributaries of the Elk River and its watershed.	Feb 18 2022	GM-IH	See response to Comment IH-6. Domestic uses of surface water identified in the provincial registry within the Elk Valley was reviewed and acknowledged in the HHRA.
IH-6a	11, 2.2	Even as outlined in Fig. 2-3 it is arguably a bold and inaccurate assumption to completely exclude any consumption or exposure to surface water within the Elk Valley within the CSM. As such consideration should be given to recognize and quantify the current surface water usage for drinking/domestic purposes within designated as a complete exposure pathway, however less significant relative to the identified groundwater exposure pathway.	While it may be known anecdotally by local residents "not to drink" from the Elk River directly, there are clearly known domestic surface water licences on it many of it tributaries and at least one in the river in Elko. Furthermore, it was readily acknowledged in this assessment that there may be unknown hydraulic connections to groundwater, and there was no concrete evidence presented to suggest that no one has ever or will ever consume water from the Elk River, or it primary tributaries in the Fording River or Michel Creek. It was also part of the assessment to calculate the worst case scenario of direct consumption of water from the Elk River, so it would stand to reason that Figure 2-3 should be updated to reflect this a complete pathway that was at assessed to some extent for contextual reference.	Feb 18 2022	GM-IH	See response to Comment IH-6.
IH-7	13,2.2.2	The statements here pertaining to surface water as drinking water and assessing the worst case scenario, which I agree with, does not seem consistent with position outlined within Sec 2.1.3 Surface Water Use above.		Feb 18 2022	GM-IH	See response to Comment IH-6.
IH-8	13, 2.2.2	RE farmed crops or livestock - While the focus would be on wild grown, it may reasonable to presume that farmed crops or livestock irrigated by contaminated surface waters may pose an equal or greater threat to human health given these products could be more widely dispersed and consumed by local residents than say wild foraged country foods and hunted game. Something that should be explored at least within the discussion of the HHRA.	If there are people growing their own produce/farming their own livestock in the area, which I know there is, I would recommend it be adequately included within the risk assessment	Feb 18 2022	GM-IH	In HHRA Workgroup discussions, it was agreed that livestock would not be included because of limited influence from the riparian environment and from Elk River water, and there was greater interest and concern regarding wild game. However, in response to this comment, surface water and groundwater data were compared to agricultural water quality standards for irrigation and livestock that have been established by ENV. The results will be included in the uncertainty assessment, Section 6.11.2.4 of the final HHRA.
IH-9	16, 3.1.1, Fig 3.1	Is it even wise to share the location of the municipal wells for safety and security reasons? Did you consult with the Municipality to see if they were even comfortable with you sharing this information on what will become public record.	Arguably this information does not offer a large value to this accuracy and validity of the overall, HHRA as compared to the historical monitoring data from these sites	Feb 18 2022	GM-IH	The figure does not specifically identify the location of municipal wells, it provides a high level overview of wells (municipal and private) included in the HHRA. Because the figure does not provide specific location information, we propose retaining this figure.
IH-10	25, 3.3.1	Draft document is missing groundwater reference data that likely critical to comprehensiveness of the captured risk assessment.		Feb 18 2022	GM-IH	Comment noted. However, in the absence of reference data, the groundwater hazard identification process is conservative (i.e. all constituents above drinking water RBSLs were retained as COPCs and assumed to be mine-related).
IH-11	26, 3.3.2.1	Whilst there are no specific guidelines established for chemical contaminants by Health Canada for Recreational Water Quality Guidelines it should still be acknowledged that the multiple barrier approach is still the best method to reduce to the risk of exposure. i.e.. minimize or eliminate the contaminant load		Feb 18 2022	GM-IH	We agree that multiple means should be employed to ensure drinking water is safe. The purpose of this assessment is to evaluate risks related to surface water. HHRA findings can be used to determine whether further measures are needed.

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ADVICE/INPUT						
IH-12	34-55, 4.0	I am concerned that despite our recommendation from March 11, 2019 that the focus of the exposure assessment was not focused on the higher consumer data with the highest exposure levels to clearly highlight the worst case scenarios. Rather than averaging out levels across the management units and equally highlighting the average consumer data. While greater emphasis was highlighted in the summary	It is our opinion that inclusion of too many receptors only results in confusion and dilutes the significance of the findings.	Feb 18 2022	GM-IH	The assessment includes a range of risk estimates for multiple receptors developed in consultation with the HHRA Workgroup. The various scenarios are intended to represent a range of user groups to represent the varied practices and activities for people in Elk Valley. If the focus is entirely on the worst case scenario, by definition most users' experience will not be reflected in the HHRA. Ramboll discussed this comment with IH on 2/23/22 and it was agreed there is value in including all receptors in the HHRA.
IH-13	34, 4.1.2	Where is this evidence alluded in terms of inorganic arsenic to substantiate the assumption or assertion that 10% of Total Arsenic is a conservative estimate, given that Elk Valley fish tissue was admittedly not analysed for inorganic arsenic for to cost and logistical reason. Is this assumption based on the data analyzed for total Arsenic within Elk Valley or was reference data utilized.	In either case the rationale was not evidently clear.	Feb 18 2022	GM-IH	The 10% inorganic arsenic assumption applied to fish tissue comes from multiple studies, all located outside of the Elk Valley. All studies referenced can be provided (Schoof and Yager 2007, de Rosemond et al. 2008, Exponent and Parametrix 2013, Idaho DEQ 2008, Oregon DEQ 2011). The 10% inorganic arsenic estimate was the 75th percentile in data from 13 studies summarized in Schoof and Yager (2007). Numerous subsequent studies indicate inorganic arsenic comprises less than 10% of total arsenic in fish fillet. Additional text has been added to document the inorganic arsenic assumption. In addition, as requested by the HHRA Workgroup, a quantitative sensitivity analysis was added to the uncertainty assessment (Section 6.11.3.6) wherein risks were assessed assuming that 20% of the total arsenic is comprised of inorganic arsenic.
IH-14	34, 4.1.2	Is the use of data collected from the Upper Columbia really an acceptable analogue given the dramatic different geology and land-use activities within that watershed as compared to the majority of the Elk River?	Where is the supporting rationale for use of this reference data in lieu of actual site data was not evidently articulated within this HHRA draft document.	Feb 18 2022	GM-IH	The estimate of inorganic arsenic fraction in freshwater fish was derived from 13 studies from a variety of geologic sources, not only the Upper Columbia River. The 10% fraction was the 75th percentile in Schoof and Yager (2007) and is a higher fraction than found in later studies.
IH-15	34, 4.1.2	The use of food specific inorganic arsenic fractions from a market basket study seems reasonable, but how representative of the exposure point concentrations for local resident indigenous populations is this? Where are the appropriate linkages and/or discussion to the preferred diet study and known consumption rates for the local indigenous populations, especially given the limited game and fish tissue testing done within the Elk Valley?	It would seem that as described that this would still likely underestimate the potential risk of exposure for this subset of the population from country foods collected from within the CSM. As such this should be readily acknowledge as not only a data gap but also a potential limitation of the study.	Feb 18 2022	GM-IH	The inorganic arsenic component of foods is unrelated to the consumption rate so the amount of food consumed will not affect the speciation. Uncertainties regarding the inorganic arsenic fractions applied for berries and game are discussed in Section 6.11.3.6 of the final HHRA. This discussion has been expanded to include additional literature sources.
IH-16	34, 4.1.3	Is there any available data available from the CSM to further support the assertion that equating Total Mercury concentrations with the observed methylmercury concentration would overestimate the exposure risks from fish and provide for a conservative health evaluation?	the supporting rationale for use of this reference data in lieu of actual site data was not evidently articulated within this HHRA draft document	Feb 18 2022	GM-IH	This statement was removed from the report
IH-17a	36,4.2	It would be nice to have included the memo from KNC to tack regarding the preferred consumption rates and methods in support of the exposure quantifications, or at least include a little more detail within the discussion. This would include a summary of the typical berries included within their preferred consumption diet found within the Elk Valley, along with the typical methods of preparation for consumption etc. comparison and/or validation of the US based market basket values.	For example some comments on whether or not there is a significant difference in risk of exposure based on Selenium or other identified constituent concentration levels within berries between raw versus cooked preparations would be value added contextual insight.	Feb 18 2022	GM-IH	See response to comment IH-17.
IH-18	49, 4.2.6	What is the volume of livestock raised in the Elk Valley both for commercial and domestic use and how much of this would be consumed by local residents?	Despite mentioning this additional local exposure pathway there was no discussion or calculations made address this route in terms of contribution Ktunaxa preferred diet or local resident market basket. This may be insignificant given the identified greater preference for game meat over locally harvest fish, but I feel would certainly worth discussing a little. If there are people growing their own produce/farming their own livestock in the area I would recommend it be included in the calculation and discussion.	Feb 18 2022	GM-IH	See response to comment IH-8.
IH-19	52, 4.3	Given the available data from the Canadian Market Based study, what is was the rationale for the TAC to recommend using Toronto as the most appropriate surrogate site? as was highlighted by Interior Health in 2019 the data set from Calgary, or even Vancouver would not only be much more proximate to the BC Interior region in question, but also would be much more representative in terms of average consumer diet than the mega city of Toronto.	With the reported values in the Figure 4-3 would suggest an unwarranted bias to a lower and less conservative data set for comparative analysis to the Local Resident and Ktunaxa preferred consumption diets.	Feb 18 2022	GM-IH	The current draft assessment used data from all available Canadian cities except the 2012 data from Vancouver, as recommended by Dr. Dabeka, a Health Canada scientist with extensive knowledge of the Canadian Diet Study. These analyses were carefully considered with the HHRA Workgroup and with Dr. Dabeka. Those communications are detailed in Appendix F. The use of all cities combined was further evaluated by calling local grocery stores to ask about whether food was locally sourced. Store owners indicated food comes from regional or national sources rather than local or nearest metropolitan area sources.
IH-20	52, 4.3	With the Selenium, being on the chief COPCs, it is not clear why foods obtained from the Elk Valley were excluded from the second estimate for selenium? Where is the data set to be able to effectively excluded this contributing source and complete this calculation?	Does this imply just harvested country foods (meats and berries etc.) were eliminated in order to determine the net contribution or risk exposure from these sources or all foods sourced within the Elk Valley not readily available at commercial foods stores in the area?	Feb 18 2022	GM-IH	As described in Section 4.3, two dietary intakes for selenium in Canadian Market Basket for selenium were prepared. The first estimate of intake included all market basket foods and the second estimate excluded foods that might be obtained from Elk Valley. Specifically, the contribution of selenium from meat and berry food items was subtracted out from the market basket analysis by setting the selenium intake values to zero within each study's results (Calgary 2009, Halifax 2006, Quebec City 2016, Toronto 2005, and Vancouver 2007). Both estimates are used to contextualize cumulative risks, such as in figures 6-7 through 6-11. The purpose of the second estimate with the subtractions is to provide the most accurate estimate of cumulative selenium risk for Elk Valley consumers, assuming they consume fish, game and other red meats, and berry products from Elk Valley, and other foods from market basket sources.
IH-22a	62, 6.3	I would be cautious about using the proposed use of alternate TRV for Co and Li without formal approval from the Province (MoH & ENV)	On behalf of IH am not really in a position to formally endorse these proposed alternate screening values, and as such it would be largely up professional developing to these to clearly document the intent of these values specifically for the EVWQMP and outline the limitations of using these values for any other purposes by anyone else.	Feb 18 2022	GM-IH	See response to comment IH-22.
IH-23	63, 6.3.1	With the non cancer risk estimates for fish where some HQs were equal or greater than 0.2 for several COPCs in one or more MU's I am concerned that it not enough to suggest that lead risk appears generally low and that cobalt and thallium risks are not unique to the Elk Valley.	While reportedly not unique, with the focus being on the Elk Valley, these findings should still prompt further discussion and recommendations for plans to reduce and/or eliminate the risk to the elevated HQ's for the identified parameters, where there are ≥ 0.2, and especially where ≥1.0	Feb 18 2022	GM-IH	Ramboll discussed this comment on a call with IH on 3/3/22, and it was agreed that the preliminary comparison to a HQ of 0.2 helps identify potential contributors to cumulative risks, but the subsequent target organ analysis and focus on HQs>1 should be the primary focus of the discussion and risk recommendations.
IH-24	73,6.5.1	I would not suggest or presume that the Ktunaxa would incidentally or intentionally drink more surface water within the Elk Valley than any other identified receptor, especially in terms of the EPCs or overall risk assessment for nitrates or any contaminant constituent.	There is no basis or evidence presented to support this argument	Feb 18 2022	GM-IH	The statement that "Ktunaxa may ingest surface water incidentally or intentionally" was requested to be included in the HHRA by KNC representatives in the HHRA Workgroup.
IH-25a	80, 6.9	The finding that selenium is present in market basket foods at levels generating an HQ at or greater than the preliminary BC ENV and HC risk management threshold of 0.2 provides a helpful perspective for foods from the elk valley. However, this does not eliminate that fact that the risk of exposure from country foods harvested would often exceed this thresholds and therefore would likely just serve to multiply their risk of exposure. This is evidently supported by data outlined in Figures 6-7 to 6-11.	These finding should consequently reinforce the necessity to further monitoring selenium levels but also for measures to be taken to affectively reduce the contaminant load within the regional CSM. This should be readily acknowledged in this section of the evaluation as well the conclusions.	Feb 18 2022	GM-IH	See response to comment IH-25.

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IH-26a	102, 7.1	What is the true scope of consultation with IH that has occurred in terms of consumption of groundwater as drinking water as being safe for drinking water, as managed under the RDWMP administered by Teck?	There needs to be some very clear qualifiers here regarding the implied safety GW in the region as is suggested by the current wording of this statement, especially with respect to suggesting full endorsement of this matter by IH.	Feb 18 2022	GM-IH	See response to comment IH-26.
IH-27	104, 7.2	While it may be currently unclear based on available evidence that there is a direct correlation be mining influence on country foods as compared to the water, it should prompt further investigation as well as discussion to address these uncertainties as much as possible	It is highly unlikely that any excess of Selenium measured above current known reference levels could be attributable to many other sources within CSM study area, other than the legacy mining influence.	Feb 18 2022	GM-IH	Comment noted. Text has been revised to state: "Influences from dust emissions from the mines were not directly evaluated; however, potential impacts from mine dust can be estimated through evaluation of berries, rose hips, and game. COPC concentrations in berries and rose hips will reflect deposition of dust to vegetation and update from soil, if any. Similarly, COPC concentrations in game meat reflect dust deposited on vegetation consumed by wildlife."
IH-28a	105, 70.4	Missing detailed or at least a summary of the corresponding risk communication strategy	Critical step in outlining the necessary interpretation of the numerical results between the proponent, regulator and the affected stakeholders and which is meant to be on-going throughout the process. In other words you need to be able articulate the worst case scenarios and ensure the results and how the current/planned mitigation strategies will effectively be protective of human health.	Feb 18 2022	GM-IH	See response to comment IH-28.
IH-29	105, 7.4	Similar to # 26 I would be curious to determined what the full extent of the relationship IH is reported to have with Teck in jointly managing the selenium in groundwater monitoring program for the Elk Valley.	this needs to be clarified as I believe IH has provided input but is by no means directly parting to management of the existing monitoring program.	Feb 18 2022	GM-IH	See response to comment IH-26.
IH-30a	105, 7.4	In addition to the suggested fish screening I would also recommend that Teck supports the Province in issuing a fish consumption advisory, pending more information to prompt a re-evaluation of the risk assessment.	This would be based on the calculated elevated risks associated with consumption of fish tissue with HQs ≥ 0.2 for at least five separate mine influenced contaminants, including Cobalt, Lead, Mercury, Selenium, and Thallium, in more than one MU. The risk would be particularly high for the Ktunaxa preferred diet consumer.	Feb 18 2022	GM-IH	See response to comment IH-30.
KNC-1		The most recent draft HHRA completed for the Elk Valley Water Quality Plan included an assessment of risk using rates from the earlier Ktunaxa diet study and updated Ktunaxa preferred food category rates developed from 10 focus groups held with 95 citizens from Ktunaxa communities in the East Kootenay region in 2019. Ktunaxa ʔaqⱡsmaknik who are considered to be Ktunaxa lifestyle sustained/supported, along a continuum participated. Each focus group took approximately 3.5 to 4 hours. The preferred daily per capita intake is 1.36 kg 245 grams of fish, 693 grams of meat/organs/marrow/fat from land animals, 208 grams of berries, 169 grams of plants, 11 grams of lichen, 6 grams of mushroom roots). To understand how well these amounts met subsistence needs required by a family to live largely off the land, findings were discussed with knowledge holders in a follow up session and compared to plant:animal subsistence ratios from the literature and evaluated for nutrient contribution. The 2019 values are intended to incorporated into Teck's HHRA to estimate the risk of chemical exposure to Ktunaxa ʔaqⱡsmaknik and how the practice of sukiⱡ ik naⱡsa (eating good) may be impacted in the future from industrial activities. For cultural reasons, KNC did not provide a proportional breakdown of species which may introduce some additional uncertainty in the potential exposure to contaminants.		Feb 21 2022	KF-KNC	The additional text provided by KNC in this comment and in the markup of the text regarding the various dietary studies methodologies, uncertainties, etc. are added to the revised HHRA.
KNC-2	Maps	The maps in the HHRA report provide an interesting visual of sampling location but results and HQ are provided by MU in table form only. Earlier in our meetings this spring, Ramboll shared box plots for deer and elk showing levels of selenium by MU. Including visual displays of locations within Mus where there were higher concentrations of mine related COPC (chromium,selenium, etc) found in FISH , GAME and BERRIES would serve as a quick screen and allow all readers, including Ktunaxa citizens to have a better sense of potential 'hot spots' for selenium or other COPC by smaller areas within the Mus and help inform risk management.		Feb 21 2022	KF-KNC	We agree a map would be an informative risk communication tool, however, the current dataset does not support the development of these figures. As described in the HHRA, the current fish dataset is based on capturing potential aquatic effects from mining operations and may not be representative of areas where people fish. Including samples from known fishing areas in addition to the current samples would provide a more complete visual representation of potential risks. The berry and game data include areas where people actively hunt or forage, however, these data are more limited and location information is not precise. Because berry and game data were submitted on a voluntary basis, many sample locations are approximate and do not include GPS information. Teck can work with the KNC in the future to develop these figures, using data from the HHRA and data from future monitoring efforts.
KNC-3	Section 4.2.4 to 4.2.6.	The traditional and preferred diet of Indigenous Peoples living in Canada tends to be quite different from that of an urban dweller. While undoubtedly not intended, the inclusion of photos highlighting food weight as well as the detailed description of meals per year hints at incredulity that an Indigenous person could eat 873 grams or 30 ounces daily of meat and fish daily. Although uncommon for urban dwellers relying on market food systems, traditional food systems of Indigenous Peoples in Canada have largely been able to until quite recently enjoy a high reliance on animal foods and limited plant intake with per capita intakes of over 1 kg of fish and meat. These rates are similar or lower than other risk assessment, 'subsistence intake levels'		Feb 21 2022	KF-KNC	The photos were intended to provide a visual estimate for readers to help people understand exposure assumptions used in the risk estimates, however, the photos have been removed.
KNC-4	Section 4.2.4 to 4.2.6.	Indigenous communities are working to restore governance and stewardship over territory, including restoration and return to traditional food system practices. In the 1980s, the Alaska Department of Fish and Game, reported a per capita fish use of 104 kg (dressed weight) which was about 18 times more than the general population in the U.S at that time (Wolfe and Walker 1987) . On a per capita basis, preferred per capita intakes would provide for an active adult with caloric needs set to 2,500 calories, 62% of total energy needs, 96% of protein needs, 48% of fat needs, 39% of carbohydrate needs, 370% of iron needs and 250% of vitamin D needs. Animal-based foods would provide 52% of the total energy needs (1,308 calories) and plant-based foods would provide 9% (228 calories). Current rights-based harvest estimates and the limited relative proportion of fish to land animals, reflects changes in use due to large and cumulative impacts on the availability and confidence in the quality of foods from the water. If tunaxa were able to eat at the preferred levels that were estimated during this diet study expansion project, there would still be a significant caloric contribution (38%) from store-bought or locally cultivated foods.		Feb 21 2022	KF-KNC	The additional text provided by KNC in this comment and in the markup of the text regarding the various dietary studies methodologies, uncertainties, etc. are added to the revised HHRA.

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KNC-5	Section 4.2.6	Section 4.2.6. 'Available game data are combined as follows: muscle and heart tissue for all large game species are combined and evaluated as muscle meat, and liver and kidney tissue for all large game species are combined and evaluated as organ meat.' Back in May/June, Ramboll shared a number of box plots showing Se concentrations for deer, elk and berries by MU and then inside and outside DA). We recommended that deer and elk not be combined given their different dietary patterns and what seemed to be fairly good sample counts. However, in Section 6.7 it is stated that 'Although samples of game and berries were collected from most individual MUs, samples sizes were small in some areas making resulting risk estimates less reliable'. It appears that there were no samples taken from MU-3. We suggest that the risk assessors use the individual MU values and by species instead. Values for MU3 could be an average of values from Mu1 to MU4 or the valley-wide estimate. Uncertainties can be described.		Feb 21 2022	KF-KNC	Providing separate risk estimates for elk and deer (of which there are data for two deer species) would add complexity to the HHRA with little benefit to the reader, in our opinion. The main conclusion that valley-wide risks are generally consistent with reference risks (except for selenium) would not change. Additionally, as noted in Section 6.7 and the comment, some MUs (i.e. MUs 1-3) do not contain many animal tissue samples. Elk data are available for MUs 1, 2, 4, and 5 and deer data are available for MUs 4, 5 and 6. The data are not considered robust enough to calculate both large game species-specific and MU-specific EPCs and risk estimates. To provide additional information on selenium concentrations in elk and deer, the referenced box plots have been added to Appendix A. A discussion was added to the uncertainty assessment (Section 6.11.3.5). A table was added showing summary statistics comparing selenium concentrations in elk and deer by MU and in reference areas, when available. A comparison to the game EPCs used in the HHRA is also provided. For MU-3, we will use valley-wide estimates to approximate risks for game as the comment suggests. Summary figures and tables were updated to reflect this change.
KNC-6	Section 4.2.6	Chromium: Chromium is a low in surface and groundwater but high in fish. What is the explanation?		Feb 21 2022	KF-KNC	Although chromium was above screening levels in fish tissue, risks were well below BC ENV risk thresholds. The highest HQ for chromium in fish tissue was 0.002, two orders of magnitude below the preliminary noncancer risk threshold (HQ=0.2).
KNC-7	Section 4.2.6	Cobalt. Should there not be consideration of understanding cumulative risks across all pathways for cobalt as well as selenium? (selenium does not exceed screening guidelines in sediment but is retained. Cobalt does not show up in groundwater but exceeds in for sediment, fish, and surface water.		Feb 21 2022	KF-KNC	A cumulative risk assessment is not included in the HHRA for cobalt for several reasons. First, there is significant uncertainty associated with the cobalt TRV, as described in the uncertainty section of the HHRA. The current TRV is in the range of background dietary estimates. The 2016 HHRA included a cumulative risk evaluation for cobalt, and found the market basket estimate for cobalt was equivalent to an HQ of 2 for toddlers. This was greater than the contribution from all Elk Valley exposures combined. Second, the risk estimates for cobalt in this HHRA are generally consistent with background and do not exceed the BC ENV risk threshold (HQ>1) for the most sensitive receptor, the preferred diet Ktunaxa toddler. The highest HQ for fish consumption is 0.7 (MU-1), and the highest overall HQ is 1, for berries and game muscle in MU-4. Valley-wide risk estimates are lower (HQ=0.3 for fish, 0.5 for berry, and 0.7 for game muscle) and are equivalent or lower than risks from background for fish and berries. Because of the high level of uncertainty associated with the cobalt TRV and the consistency of risk estimates with reference areas, we do not think a cumulative risk assessment for cobalt is warranted.
KNC-8		The draft human health risk assessment (HHRA) for the Elk Valley Water Quality Plan focused on the examination of the potential effects of mine-related water quality constituents (directly or indirectly) on human health. This draft HHRA was completed to satisfy the legal requirement on Teck under the Environmental Management Act. The HHRA must follow the British Columbia (BC) Contaminated Sites Regulation (CSR) approved methodologies and acceptable risk levels and must be developed in consultation with the Environmental Monitoring Committee (EMC), which includes representatives of the Ktunaxa Nation Council (KNC)–Lands and Resources. This draft HHRA is an updated version of the previous versions of HHRA completed in 2014 and 2016. This draft HHRA includes new contaminant (Metals, nitrate, PAHs, and quinolone) data collected between 2015-2020 in groundwater from wells, surface water, sediment, fish fillet tissues, fish ovary tissue, game, berries, and rose hips from six management units (MUs) along the Elk River. It also includes an analysis of both current and preferred consumption of foods harvested within the Elk Valley (e.g., berries, game, fish) by the members of Ktunaxa Nation.		Feb 21 2022	LC-KNC	Comment noted.
KNC-9a		The draft HHRA follows the approaches described by the Ministry of Health of BC Government (Ministry of Health 2021) and Health Canada (Health Canada 2019). It is technically sound, and the results, including the interpretation, are generally of good quality. However, the HHRA has a very defined scope and objective. For example, it only focuses on water-related exposure pathways and is limited to the current situation. Therefore, the draft HHRA cannot be viewed as a comprehensive risk assessment of the health effects of the impacts of the coal mine operations. For example, exposures to constituents in soil and dust and inhalation of particulates released to air are not included in this HHRA because these exposure media are not directly linked to water quality.		Feb 21 2022	LC-KNC	The scope and objective of the HHRA described in the comment is correct. Although the HHRA focuses on water-related exposure pathways and does not evaluate direct exposures to constituents in soil, dust, and air, COPC concentrations in berries, rose hips, and game may reflect potential migration from these media (e.g., dust deposition on berries, consumption of berries by game). Additionally, potential risks associated with direct contact with soil and air are quantified in the Environmental Assessments (EAs) required for mine project extensions. As discussed at the April 2022 HHRA Workgroup meeting, a summary of the soil and air risks for selenium from the Baldy Ridge Extension EA was included in the 2016 HHRA, and a summary has been added as Appendix J to the revised HHRA. Selenium risks associated with soil and air were minimal, and did not change cumulative selenium intakes.
KNC-9b		A lot of information is presented in the report. However, the most important findings are not clearly presented, and the readers will find it difficult to interpret the results of the report. Some key questions that an HHRA should address are: • Which chemical in which media are of major concern for human health in the Elk Valley? • What is the overall level of risk (HI) for the receptors in the Elk Valley for these chemicals? • Which receptors living in which MU have elevated risk and which pathways are the major contributors? • What are the main uncertainties associated with these key findings? How will they affect the characterization of the identified risk? • Are there data gaps that caused these main uncertainties? What data should be collected in future monitoring programs that can increase the confidence of the risk characterization? • Are there any management measures that can be adapted to lower the risk? What are they? The HHRA can be improved by better organization, use of summary tables and figures to highlight the findings related to the questions above. **Recommendations**: Include summary statements with supporting tables and figures in each section to highlight the key findings. Include a detailed executive summary and a conclusion to summarize the key findings.		Feb 21 2022	LC-KNC	An Executive Summary has been prepared for review by the HHRA Workgroup. HHRA conclusions were revised for clarity.

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KNC-10		Also, non-chemical stressors or influences, such as climate change, and other social determinants of health, are not evaluated. The BC guiding document (Ministry of Health 2021) advises that the potential effects of climate change on COPCs should be monitored and considered for long-term risk mitigation and/or management actions. **Recommendation:** *Include a section discussing the potential effects of climate change and suggest further studies to investigate the impacts of climate change as a confounding factor for COPC exposure or as a co-stressor on health in follow-up studies.*		Feb 21 2022	LC-KNC	We recognize that climate change introduces complex and far reaching stresses into all regions and ecosystems, including Elk Valley. The ways in which climate change may influence exposure and risks related to mining-related constituents in Elk Valley surface water are not well understood and a rigorous analysis of such impacts is beyond the scope of this HHRA, and is not anticipated as part of any subsequent analyses. However, the HHRA acknowledges that climate change impacts are likely to impact resource availability in general due to impacts on habitat in Section 1.2.
KNC-11	Problem Formulation and Conceptual Model Sections 6.5 and 6.6	There is some evidence that some local wells may be contaminated by surface water, e.g. Well 3 of Sparrow District is contaminated by surface water. Stakeholders may be concerned about the health effects of using local well water for drinking. **Recommendations**: *Investigate whether there are correlations between groundwater and surface water metal concentrations (e.g. EPCs) by the MUs and add a discussion using results presented in Sections 6.5 and 6.6 on risk estimates for ingestion of surface water as drinking water. Exposures may occur for people using surface water or groundwater for the irrigation of garden produce, agricultural crops, and raising livestock. The fore, consumption of locally grown foods can be a potential exposure pathway, but this is not included in the draft HHRA.*		Feb 21 2022	LC-KNC	Associations between surface water and groundwater in Elk Valley are discussed in the Elk Valley Regional and Site-Specific Groundwater Monitoring Programs Annual Report (SNC-Lavalin 2021) and Teck Adaptive Management Plan (AMP). Additional analysis of surface water impacts on groundwater is outside the scope of the HHRA. An additional screening analysis was performed to compare concentrations in groundwater and surface water to British Columbia's Agricultural Water Quality Guidelines (BC WQGs) for Irrigation and Livestock. The results of this analysis and potential impacts have been added in the Uncertainty Assessment.
KNC-12	4. Data Characterization and Hazard Identification	The quality of the analytical monitoring data appears to be a concern as it will result in a decrease in the confidence of the reliability of the results for the HHRA. For example, a high proportion of samples (about 25 percent of mine-exposed fish and 30 percent of reference fish samples) had elevated detection limits (DLs) for many metals analyzed in fish tissue. Fortunately, selenium and mercury results are not affected by this issue, but most other metals evaluated in the HHRA are affected. In p. 37, it states that duplicate samples were not included in the HHRA to avoid double-counting of results representing a single sample location. Split samples, which are a single sample divided in two parts and analyzed at separate laboratories, were also excluded from the HHRA database to avoid double-counting results. Only the sample result associated with the primary laboratory was retained and used in the HHRA. No raw data f the duplicate samples are presented. It is important to show the precision and accuracy of the data by showing the variability or reproducibility of the results in duplicated samples. **Recommendations:** *The qualification of the laboratory and the methodology used need to be re-assessed. It is a common practice to use 0.5 x DL as a substitute value for statistical analysis. Include a sensitivity analysis using 0.5 x DL as substitute values to evaluate the impacts on the choice of COPCs. Include a discussion on the quality of the data by showing the statistics on the variability of the duplicate samples and inter-lab comparison.*		Feb 21 2022	LC-KNC	As the analytical data used in the HHRA were compiled from different programs, different groups were responsible for QA/QC of the data. A brief discussion and references to the following reports has been added to the text. A Data Quality Review (DQR) was conducted on laboratory data reported in 2017, 2018, and 2019 for samples collected in support of the RAEMP. Reporting limits, data precision (based on field and laboratory duplicates), data accuracy (based on matrix spike recoveries and/or analysis of standards or certified reference materials) were evaluated. Overall, the quality of the data was considered acceptable. (Minnow Environmental, 2020). Golder (2020) completed an interlaboratory fish tissue data validation study which compared selenium analyses from four laboratories. Data were compared against Data Quality Objectives (DQO) for accuracy, precision and sensitivity to evaluate how data quality varied as a function of tissue type and sample weight. The labs met the majority of the DQOs, with TrichAnalytics and ALS recommended as preferred labs. Azimuth (2021) evaluated the precision (degree of reproducibility) of surface water quality measurements in the Elk Valley from 2012 to 2021. Relative percent difference (RPD) was calculated for each sample-duplicate pair and monthly mean RPDs for each constituent were reviewed over time. There were no clear increasing or decreasing trends over time. Despite occasional high magnitude RPDs, median and mean RPDs were typically <10%, demonstrating that concentrations were generally similar between the parent sample and its duplicate. The 2021 Elk Valley Regional and Site-Specific Groundwater Monitoring Programs report provides a QA/QC assessment. SNC-Lavalin summarized RPDs for duplicate samples, summarized detections in field and trip blanks, and reviewed lab quality control reports for each groundwater monitoring program. Data were generally considered reliable. (SNC Lavalin 2021) Ramboll (2020) prepared a data validation report to assess the validity and usability of laboratory analytical data generated from vegetation and animal tissue samples collected during 2017, 2019, and 2020 and determined the data to be usable. (Ramboll 2020) Regarding detection limits, as discussed in Section 3.2.1, the full detection limit rather than 0.5 x DL was conservatively used in the screening assessment to identify COPCs. The only medium where elevated detection limits may be a concern was fish tissue, and Section 3.3.4.2 discussed which fish tissue COPCs were retained as COPCs based on nondetected results. Additionally, constituents with detection limits exceeding the RBSLs was discussed in the uncertainty assessment.
KNC-13	General, but example on page 21	Throughout the draft HHRA, there is a general tone that the risk of mercury exposure from consuming Elk Valley fish should really not be considered as mercury in fish is not related to mining activities. For example, in p 21, there is a footnote stating that "Although mercury is identified as a potential mine-related parameter of concern in Permit 107517 and is evaluated in this HHRA, several evaluations have concluded that mercury concentrations observed in Elk Valley are not due to mining activities (Azimuth 2018, Azimuth 2019, Windward Environmental et al. 2014). Background data collected on the Elk River, Michel Creek, and the Kootenay River indicate that elevated levels of mercury occur naturally during periods of high flow and turbidity and are not the result of mining activity. This is consistent with the evaluation conducted to develop the surface water quality early warning triggers, which did not identify mercury as a parameter for which early warning triggers were warranted (Azimuth 2018). The cumulative distribution plots of fish concentrations in Elk Valley and Reference area fish presented in Appendix A. Assuming the composition of fish species harvested between the two sites is similar, the result clearly shows that the Elk Valley fish had higher mercury concentrations in general and, more importantly, a high number of fish exceeding 1 ug/g. Concentrations of mercury in fish can be determined from a number of factors, e.g. food web structure, age of the fish, DOC, temperature, pH and selenium concentrations in the water etc. The cumulative distribution plot of the reference site shows a sigmoidal shape peaking at 0.1 ug/g with a few outlier at 0.15 ug/g. This is typical of a normal distribution. The cumulative distribution plot of the mine-exposed fish, however, shows the shape of a log-normal distribution with the top 5% reaching between 0.5 to 2 ug/g. This is a good indication of either local pollution or other activities that change the abiotic and biotic conditions of the aquatic system. The relationship between the mining activities with the observed mercury concentrations in Elk Valley fish may need further investigation. **Recommendations**:*Consider mercury as a COPC. Add the source of mercury as an uncertainty in the uncertainty discussion and remove all qualifier statements questioning mercury as a COPC throughout the draft HHRA.*		Feb 21 2022	LC-KNC	Mercury is already included as a COPC in the HHRA. This will be clarified in the text. A brief discussion of potential mercury sources is included in Section 6.11.3.1, *Mercury Concentrations for Lake Koocanusa Fish.* As indicated in Section 6.11.3.1, mercury in Koocanusa Reservoir fish are comparable to concentrations in non-mining areas (Windward Environmental et al. 2014, Ramboll Environ 2017). Mercury impacts are limited to Koocanusa Reservoir (MU-6) fish; fish in other MUs do not have mercury concentrations that result in elevated risks. The cumulative distribution plots referenced in the comment have been revised to present information for MUs 1-5 and MU-6 separately for mine-exposed fish. The revised plots were reviewed to determine the distribution of mercury concentrations in fish, and if there are any potential indicators of local pollution or other impacts to the system.
KNC-14	Page 37	In p. 37, it states that in groundwater and surface water, innocuous water quality parameters (bromide, chloride, fluoride, sulfate, sulfide, sulfur) were also excluded. Coal is known to contain high level of fluoride, and elevated fluoride exposure is a human health risk (Li et al. 2021; Solanki, 2022). **Recommendations**: *Provide a rationale for why fluoride is not included. Or include fluoride in the HHRA if the concentration data are available or include fluoride in future follow-up studies.*		Feb 21 2022	LC-KNC	Fluoride was added to the COPC screening in the revised HHRA. Note that fluoride did not exceed the BC ENV WQG guideline for fluoride in drinking water (1.5. mg/L) in surface water or groundwater, so fluoride was not further assessed in the HHRA.

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KNC-15		Only metals are evaluated in wild foods in this HHRA, organic COPCs identified in sediment were not evaluated in wild foods. There is no rationale provided why PAH intake from food such as fish is not considered. It was reported that traditional food including northern pike, sucker, trout and whitefish collected in northern Alberta contain PAH at 10 to 100 ng/g level (Chan et al. 2016), and fish consumption was reported to be a major source of PAH intake in freshwater media (Obiakor et al. 2014). **Recommendations:** *Provide a rationale for why PAH in fish is not included. Include PAH in fish in the monitoring and in future follow-up studies.*		Feb 21 2022	LC-KNC	PAHs were evaluated in wild foods (i.e., berry and game tissues) in the 2016 HHRA but were rarely or never detected and as a result, risks were below thresholds of concern. In the current HHRA, PAHs were analyzed in sediment and surface water in Elk Valley; concentrations were not elevated and risks were below thresholds of concern. PAHs were not analyzed in wild foods for the current HHRA. Based in part on the results from the 2016 evaluation of PAHs in wild foods, PAHs are not thought to be a concern. Also, because PAHs are readily metabolized in fish they are not routinely analyzed in fish fillet tissue (ATSDR. 1995, ATSDR. 1995, Meador JP, JE Stein, WL Reichert, U Varanasi. 1995, Replinger S, S Katka, J Toll, B Church, L Saban. 2017, Van der Oost R, H Heida, A Opperhuizen, NP Vermeulen. 1991, Van der Oost R, F-J van Schooten, F Ariese, H Heida. 1994). We understand that alkylated PAHs can be detected in fish in some settings (Chan et al, 2016); however, the lack of elevated PAHs in primary media (i.e., sediment, surface water) suggest no need for PAH monitoring in wild foods. In addition, PAHs present in coal are not highly soluble. Furthermore, the lack of accepted toxicity reference values for alkylated PAHs would make interpretation of alkylated PAH data highly uncertain and challenging. Teck has committed to reviewing and possibly revising tissue types, sample locations, and analyte lists in existing monitoring programs with the HHRA Workgroup to inform future data collection efforts such that data are representative of potential human exposures.
KNC-16		Inorganic arsenic is not analyzed in Elk Valley fish tissue because of the relative high cost. The HHRA used an assumption of 10 percent of total arsenic as an estimate for inorganic arsenic in fish tissue and stated that it is a conservative assumption. However, inorganic As % is species-dependent and can be as high as 20% reported in whitefish in Yellowknife (Tanamal et al. 2020). **Recommendations:** *Conduct a sensitive study to study the changes in the risk of As exposure if the assumption for % of inorganic As is increased to 20%. Include As speciation analysis in selected fish samples in the monitoring and in future follow-up studies.*		Feb 21 2022	LC-KNC	See response to IH-13 and IH-14. We reviewed the Tanamal et al. (2021) study and see that it provides a substantial number of fish samples analyzed for both total and inorganic arsenic forms with the single highest % inorganic arsenic of 19.6%. As requested, a sensitivity analysis was conducted on arsenic in fish tissue to compare the hazard quotients and cancer risks when applying an inorganic arsenic correction factor of 20% versus the 10% that was originally used in the HHRA. No hazard quotients were greater than 0.2. The 10 percent inorganic arsenic fraction assumption used in the HHRA resulted in risk estimates for the preferred consumer of up to 2E-05 in reference areas, MU-1, MU-3, MU-4, MU-6, and Valley-wide, while use of a 20 percent inorganic arsenic fraction in the uncertainty assessment yielded risk estimates for preferred consumers of 3E-05 in MU-1, MU-4 and Valley-wide and 4E-05 for the reference location and for MU-3 and MU-6.
KNC-17		There is a high year-to-year variability in the metal concentrations in the fish samples. For example, there was a higher Hg concentration in fish collected in 2016 than those collected in 2019 (Table 6-11). The HHRA also stated that Teck's Active Water Treatment Facility (AWTF) at the Line Creek Operations released more bioavailable forms of selenium (e.g. selenite and organoselenium species) from 2016 through March 2018, which resulted in increased uptake of selenium in some fish located downstream of the AWTF during this time period and they attributed the AWTF release of bioavailable selenium species is likely responsible for the high selenium concentrations observed in bull trout in MU-2 (Table 6-3). The mine operation conditions and/or human activities that can change the concentrations in the water and other media need to be identified and documented. **Recommendations**: *A more detailed investigation on the sources of variations in metal concentrations, particularly those related to the mine operation, should be conducted.*		Feb 21 2022	LC-KNC	The referenced Table 6-11 only shows MU-6 mercury fish data, and Section 6.11.3.1 discussed higher concentrations in northern pikeminnow in 2016 (reason unknown). Concluding there is generally "high year-to-year variability," based on this example of pikeminnow in Koocanusa Reservoir, may not be an accurate statement given that an analysis of variability in all species across all monitoring years was not performed as part of the HHRA and is outside the scope of the HHRA. The requested investigation is outside the scope of the HHRA, but is addressed in other Teck monitoring programs. The Elk River Watershed Regional Aquatic Effects Monitoring Program's (RAEMP) general objective is to, *"...monitor, assess, and interpret indicators of aquatic ecosystem condition related to mine operations, and to inform adaptive management relative to expectations established in approved plans for mine development, Permit 107517, the EVWQP, and the Implementation Plan Adjustment."* The specific RAEMP objectives are focused on monitoring trends in water quality, fish selenium concentrations, sediment quality, and calcite, including identifying changes in condition since the previous monitoring cycle, identifying unexpected changes, and determining if changes are mine-influenced. The most recent version of the RAEMP report (Minnow 2020) is provided for reference.
KNC-18	Risk Characterization	Se is the most important COPC in this HHRA. The result does not provide a clear picture of the risk of Se exposure from each media for all the receptors. Section 6.3.1 Non-cancer Risk Estimates for Fish and Section 6.10 Cumulative Non-cancer Risk are the two sections that show the most important results. However, only results for the toddler life stage only are presented in Figure 6-1 to Figure 6-12 and Table 6-10. There is no rationale why the results for the other age groups are not presented. It will be very useful to see the results for the adults and compare whether they show a similar trend of relative sources. e.g. **Recommendations:** *Add a paragraph with relevant tables and figures discussing specifically the HQs of Se from each exposure pathway and media (groundwater, surface water, sediment, fish egg, fish for each receptor, i.e. Infant, toddler, recreator, adult Ktunaxa (average, high fish and preferred fish consumption). Sum across multiple exposure pathways and media, and comparing the result to the risk management threshold of 1 and showing the percentage of contribution from each pathway.*		Feb 21 2022	LC-KNC	We received a similar comment from ENV. In response to these comments we produced stacked cumulative risk bar charts for all life stages valley-wide and by MU, and shared these figures with the HHRA Workgroup. These figures were added as Appendix I to the HHRA. In addition, we revised the report to include adult risks as well as toddler risks in risk characterization section.
KNC-19	Section 6.10; Page 99	In p. 99, the last sentence in the 6. 10 states that Differences in cumulative selenium risk across MUs are mainly due to differences in fish HQs, which are likely attributable to differences in selenium concentration in the MUs and/or species sampled by MU. This is a very important finding of the HHRA, but the results justifying the statement are not presented clearly. In Section 6.11.3.1, it states that the EPCs for fish are calculated in two ways: • EPCs for all fish species combined within each of the MUs • EPCs by fish species in which the entire consumption rate is applied to a single species of fish. The 'all species combined' EPC assumes that multiple fish species are consumed by the receptors in Elk Valley, and the relative proportion of fish species consumed was the same as the relative proportions of the fish species sampled in each MU. This assumption will likely cause an error in the exposure assessment. In comparison, the "single species" EPC assumes the receptor is only eating one fish species. This assumption would over-estimate the exposure if only the fish species that had the highest Se concentration was used and under-estimate the exposure if only the fish species that had the lowest Se concentrations was used. **Recommendations**: *To conduct a sensitivity analysis to show the range of exposure using the single species EPC approach. It will also be useful to add a new section titled "main drivers for high HI (>1) in toddlers and adults in each MU. For example, what consumption rate for what species of fish in which MU is the main source of Se for toddlers and adults.*		Feb 21 2022	LC-KNC	Uncertainties associated with the 'all species combined' fish tissue EPC were discussed in Section 6.11.3.1. While the EPCs may be biased by the sampling design, this does not necessarily indicate "an error in the exposure assessment" as the comment suggests. Given the nature of the dataset, the EPCs are intended to be a reasonable representation of consumption of various fish species. While not specifically noted as a sensitivity analysis in the HHRA, species-specific selenium EPCs and risk estimates were calculated to provide insight into species and locations that may pose the greatest potential risk. This discussion is in Section 6.3.3. The range of selenium HQs by fish species and MU is shown in Figure 6-3. Species-specific and combined EPCs and HQs, which notes main drivers for high HIs in toddlers, are shown in Table 6-3. Adult HQs are proportionally 1.85x less (roughly half) than the toddler HQs. The adult HQs have been added to Table 6-3.

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ADVICE/INPUT						
KNC-20	Section 6.11.5	In Section 6.11.5, the draft HHRA reviewed the Provisional Cobalt RfD used by the US EPA and argued that it was too conservative. It proposed an alternate TRV derived by Finley et al. 2012 based on thyroid effects (decreased iodine uptake) in children. The alternate TRV proposed used an approach that is consistent with the HC or EPA typically used and is widely accepted. For example, the paper has also been highly cited (113 times). The use of this alternate TRV in this draft HHRA is reasonable and well justified. In comparison, the proposed alternate TRV for lithium by Ramboll is less robust. The use of lower uncertainty factors of 1 and 3 to account for sensitivity and variability in the population and database uncertainties will need more justifications. Further discussion with other experts and stakeholders is needed before a consensus can be reached. **Recommendations**: *Add a discussion in the HHRA to compare how the risk characterization result will differ if the current TRAs are used instead of the alternate TRVs. It may be sufficient to explain the increased risk in the context of the low TRVs used. Hold a small expert and stakeholder workshop to discuss the development and use of alternate TRVs before using them in the final HHRA.*		Feb 21 2022	LC-KNC	Risks based on current TRVs (USEPA PPRTVs) are presented in the main HHRA for cobalt and lithium. Additional analysis was conducted to compare HQ results when the current lithium and cobalt TRVs are applied versus the alternate TRVs. Tables were added to the uncertainty assessment (Section 6.11.5.1 and 6.11.5.2) to showcase the varied HQs for the toddler preferred consumer (fish tissue) scenario when the different TRVs are applied.
KNC-21	Section 6.11.5	Section 6.11 is very comprehensive in listing all the possible uncertainties associated with the HHRA. However, there is no clear or systematic synthesis of the combined effects on the accuracy of the risk characterization. Section 6.11.6 states that "we have high confidence that this risk characterization for water quality-related pathways (i.e., ingestion of groundwater, contact with surface water and sediment, and fish consumption) is protective, and in many instances errs on the side of overestimating risks, rather than underestimating risks. Some sensitivity analyses may be needed to justify that. It will be useful to include a summary table showing the directions (under or over) or even the magnitude of each uncertainty on the risk characterization. I agree that the chance of underestimating risk is likely to be low. However, it is important to estimate how much the identified risk, i.e. cases where HI>0.2 or 1 are due to over-estimation. Would it be possible to estimate the range of error and set a hiher cut off for HI values with higher confidence? **Recommendations:** *Synthesize the uncertainties and present them in a summary table clearly showing how each uncertainty will over- or under- estimate the risk. Discuss how the COMINBED uncertainties will affect the key findings in risk characterization. Add a table showing the key findings for each scenario where receptors have HI>1 and its associated level of certainty. Identify knowledge and data gap based on the results and recommend priorities for follow-up studies.*		Feb 21 2022	LC-KNC	A new table 6-11 was added to synthesize uncertainties, estimate the magnitude of uncertainties, and whether or not the uncertainties impact the conclusions of the HHRA.
KNC-22	Summary and Conclusions Page 116	In p. 116, it states that the cumulative risk results suggest that Elk Valley foods are higher in selenium than market basket and reference area foods. This is a very general statement and unlikely to be true for all foods. Moreover, there is no direct comparison result presented in the previous sections to support it. Also, there is no summary or conclusive statement on what this means. For example, it should be followed by a statement such as: Therefore, high consumers (upper percentile) of Elk Valley foods will result in an increase Se intake of 2.5 times compared to the average market basket and 1.9 times compared to the reference area foods for toddlers (Figure 6-10). A similar statement for adults is needed. **Recommendations**: *Add a table showing the descriptive statistics (mean and range) of Se concentrations for each food type collected in the Elk Valley, market basket and reference areas and a discussion on the differences. Add a similar figure to Figure 6-10 for adults and describe the difference in Se intake among adults.*		Feb 21 2022	LC-KNC	Sections 6.9 and 6.10 discuss selenium risks related to market basket food and cumulative HIs including Elk Valley foods. Direct comparison of HI results are presented on Figures 6-6 through 6-11 and Table 6-10, which were modified to include adult risks in addition to toddler risks. Minimum, maximum, and mean concentrations and EPCs for foods harvested in Elk Valley and reference areas are provided in Appendix C, Table C7 (new table) and Appendix G, Tables G5 through G10. Additional figures have been added as Appendix A2 consisting of box plots for selenium concentrations in wild foods harvested both within the Designated Area and in 'reference areas.' These figures collectively support the statement that foods harvested in Elk Valley are generally higher in selenium than similar foods harvested outside of Elk Valley. Note: Health Canada data does not provide individual datapoints on market basket foods, only mean concentrations are provided. EPCs and other descriptive statistics cannot be provided.
KNC-23	Summary and Conclusions Page 117	In p. 117, Section 7.3, a list of data gaps and data needs are identified, followed by a list of recommendations Section 7.4 presents. As recommended in the previous section, the data gaps and needs need to be related to the main drivers of uncertainties identified in the uncertainty section. The recommendations need to describe how the added data and additional steps/measures/studies can decrease which uncertainty and by how much. The recommendations should be prioritized by the combination of the relative importance of the findings and levels of uncertainties. The draft HHRA found that the risk of selenium exposure will be higher than the acceptable level, if members of Ktunaxa consume fish at their preferred rate. Therefore, it is likely that they will have to or already have limited their rate of consumption. **Recommendations**: *The health effects associated with the loss of traditional diet/lifestyle, including the decline in nutritional quality and increase in food insecurity, should be discussed in the HHRA and addressed in future studies.*		Feb 21 2022	LC-KNC	The text provided by KNC in the markup of the draft HHRA text regarding loss of traditional diet/lifestyle was added to the revised HHRA. In addition, text was added noting the health benefits of fish consumption and the health effects associated with the loss of a traditional diet/lifestyle, citing Marushka et al. 2021. We would welcome references or studies you might recommend regarding these important topics.
KNC-24	Page 42	p.42 cobalt in groundwater was not considered as a COPC in Table 3-6. Are cobalt concentrations in all groundwater samples below 1 ug/L?		Feb 21 2022	LC-KNC	Yes, cobalt is below 1 µg/L in all groundwater samples, as shown in Appendix C Table C-2a. Cobalt was detected infrequently among the 205 analytical results, and the maximum detected cobalt concentration in groundwater was 0.83 µg/L.
KNC-25	Page 69	p. 69 The development of a dermal TRV is trivial as it is not an important source. What are the absorption rate used for oral exposure from different media?		Feb 21 2022	LC-KNC	Dermal contact with surface water and sediment is a complete exposure pathway for Ktunaxa and recreators during wading, foraging, tubing and swimming activities. As noted in Section 5.3, absorption factors were used to derive dermal TRVs for some metals. The following factors from USEPA IRIS were used in the HHRA: 15% for antimony, 7% for barium, 2.5% for cadmium, 4% for manganese, 4% for nickel, and 2.6% for vanadium.
KNC-26		It states that The HHRA will consider the potential for interactions between constituents and will determine whether those interactions increase or decrease potential risks. For example, it is known that the interaction of mercury and selenium is antagonistic, i.e., the toxicity is reduced when both metals are present (Zhang et al. 2014). How?		Feb 21 2022	LC-KNC	Text and supporting references have been added to the uncertainty assessment (Section 6.11.6.1) to describe available data on antagonistic interaction between selenium and mercury in toxicity.
KNC-27	Table 6-3	In Table 6-3 HQ > 0.249 (i.e., 0.2), but does not exceed 1.49 (i.e., 1). Why the decimal places?		Feb 21 2022	LC-KNC	The footnote intends to clarify that rounding to one significant figure was used in the HHRA, per standard risk assessment practice.
KNC-28	Pages 115/116	p. 115/116 It states that MUs 1-5: Risks are generally consistent with background or below the ENV risk management threshold except for selenium when consumed at Ktunaxa preferred rate. Also, Selenium intake is acceptable for those consuming fish at upper percentile and average rates. However, in Figure 6-1. The HQ of both recreator and Ktunaxa Upper Percentile Consumer in MUs 1-5 was higher than 0.2. Why?		Feb 21 2022	LC-KNC	Consistent with Health Canada DQRA guidance, the ENV risk management threshold of HQ>1 is used to determine if there are elevated risks. This is because exposure from background sources are quantified in the HHRA. HQ>0.2 is used as a preliminary risk threshold to identify primary media that may contribute to risk, but is not an indicator of elevated risk.
KNC-29	Appendix C	Appendix C. It will be useful to create a table showing the number of counts of samples exceeding the screening level of Se in each MU for each media? The Table will show the relative level of Se pollution by MU.		Feb 21 2022	LC-KNC	The number of samples that exceed screening levels are already shown in the Appendix C screening tables by media and analyte.
KNC-30	Appendix G	Appendix G The HHRA dataset does not include wells located in MUs 1, 2, or 6. Why?		Feb 21 2022	LC-KNC	No wells were sampled in MUs 1, 2, and 6 through the Regional Groundwater Drinking Water Monitoring Program (RGDWMP) over the 2015-2020 time period.

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ADVICE/INPUT						
KNC-31	Acknowledgement Section	Although I appreciate the intent behind this section, as I think it is coming from a genuine acknowledgement of the challenges faced in the last few years, I'm not sure it is appropriate in a document that will likely be external facing and publically available(?). I specifically do not agree with the last two sentences as it states that the report has addressed our unique needs and "questions and concerns" – which I do not believe is completely true.		Feb 21 2022	ER-KNC	Text has been removed.
KNC-32	Introduction Section	Recommend including the permit language and a concordance table showing how each aspect of the permit has been addressed. Include justification on why the HHRA only assesses risks directly related to water quality – the permit does not explicitly state that only water quality should be assessed. HHRA Methodology Development (1.3) - If this section is to be included I recommend that it speak to how the methodology was informed by the working group discussions – what topics did we discuss and how was it shaped by working group members? What changed between the draft and final methodology? This section implies that consensus was always reached and working group member recommendations were always taken – which was not the case. Please edit the section to reflect this.		Feb 21 2022	ER-KNC	A new Table 1-1 has been added summarizing the permit conditions and concordance of the HHRA with the requirements.
KNC-33	Section 3.1.1	**10. Groundwater Use:** Recommend the GW working group members review sections related to GW. Section 3.1.1 Dissolved may be more bioavailable but that doesn't mean that the undissolved portion is not. Please include rationale of this assumption. Section 3.1.1 – Does this data set include wells that are no longer used b/c they are above drinking guidelines? Also in cases where RO was installed – are the samples from these wells before or after RO installation? (From Bernie) only 50 domestic wells were included in the study---with no acknowledgement of what a small sample that is. Domestic wells do not have to be registered with the Province although it is encouraged and the provincial database does include wells that are not actively being used. There are hundreds in the Fernie Area alone.		Feb 21 2022	ER-KNC	Though the HHRA evaluated dissolved fraction for groundwater, for the purposes of the Regional Drinking Water Monitoring Program (RDWMP), Teck considered both total and dissolved metals and uses the more conservative (i.e. higher) concentration when providing mitigations. The dataset includes wells that are no longer used because they were above drinking water guidelines. For example, Sparwood Well #3 is no longer in use but is included in the dataset. Reverse osmosis filtered/post-treatment water results were used for two wells in the draft HHRA, all other well results were unfiltered/untreated. The untreated results for the two wells are used instead of the post-treatment results in the revised HHRA. When the untreated results are used, no additional COPCs in groundwater are identified, and EPCs and risks by MUs do not significantly change. The HHRA was updated to reflect this change. The groundwater data in the HHRA comes from wells sampled from 2015 - Q2 2020 through Teck's RDWMP. Participation in the RDWMP is voluntary, so the dataset does not include all domestic well users in Elk Valley. Fifty private wells are included in the HHRA dataset. Available drinking water well data was limited to those that participated in the RDWMP at any point from 2015 - Q2 2020. Due to the low concentrations of mine-related constituents, these wells are sampled on a on-request basis only, and this sampling criteria/frequency was presented to and accepted by the GW working group in July 2019. It is understood that fifty wells is a small subset of the total private and municipal wells in Elk Valley, which may also be used for non-potable purposes. However, the HHRA dataset provides good spatial coverage of the Elk Valley. It is not possible to provide an accurate, comprehensive total of private and municipal pumping wells installed in the Elk Valley as it is not a requirement that water wells be registered. These details are added to the report in section 3.1.1.
KNC-34	Section 3.1	**11. Chemical Data for the HHRA** Section 3.1 - One limitation of this HHRA (which should be also discussed in the uncertainty section) is that the data set is largely from permit requirements that require the samples for different reasons other than the HHRA – i.e. environmental management vs. human health risk characterization. One opportunity for improvement would be to collect samples in preferred areas where locals and Ktunaxa are "on the land" in addition to the samples collected for other permit requirements. Would also like to see more Ktunaxa foods collected as the samples (game and berries) are not the only Ktunaxa foods consumed.		Feb 21 2022	ER-KNC	The limitation of the fish dataset in discussed in the HHRA in Sections 6.3.3 (Consideration of Fish EPC Species Composition) and 6.11.3.1 (COPC Concentrations in Fish Tissue). We agree that it would be beneficial to refine monitoring programs going forward to collect more samples in preferred areas where people are "on the land," and support collection of additional Ktunaxa foods for analysis.
KNC-35		Fish Tissue Samples – Table 3-1. I see in the map that reference areas are distinguished. Is it possible to the break down of mine-exposed fish and reference fish?		Feb 21 2022	ER-KNC	Table 3-1 has been updated to show the counts of mine-exposed and reference fish sampled in each MU in separate columns.
KNC-36		Please note that Ktunaxa dry some of their food (including fish) prior to consumption. Does this change the assumptions?		Feb 21 2022	ER-KNC	A discussion of potential impacts various food preparation methods can have on COPC concentrations and subsequent risk estimates for food has been added to the uncertainty assessment (Section 6.11.3.2).
KNC-37		I'd like clarification how MU are evaluated – are they only based on mine influenced samples or based on all samples in the MU (including reference)?		Feb 21 2022	ER-KNC	Reference samples are not included in MU estimates, even if the reference sample was located in that MU. Only mine-influenced samples are included in the MU risk estimates.
KNC-38		Game, berry and rose hip samples collected outside the Designated Area as reference may be impacted by similar COPC – should be identified as an uncertainty.		Feb 21 2022	ER-KNC	The potential impact of anthropogenic and natural COPC sources in reference areas for berry, game, and rose hips has been added as an uncertainty to the HHRA (Section 6.11.3.5, COPC Concentrations in Berries and Wild Game).
KNC-39		Sulfate is extremely high and above effect concentrations in some areas (1600mg/L) and is also an order constituent. Based on these two facts, sulfate should be assessed in this risk assessment		Feb 21 2022	ER-KNC	Although sulfate is an order constituent, there are currently no regulations for sulfate in drinking water. The BC Ministry of Environment recommends the adoption of Health Canada's aesthetic objective of less than or equal to 500 mg/L of sulfate in drinking water. This guideline is based on taste considerations and is not risk-based. Screening against this guideline has been added to the uncertainty assessment (Section 6.11.2.5). The highest sulfate concentration in drinking water is 670 mg/L. Sulfate was identified in MUs -3, -4, and -5; exceedances were observed solely in MU-4. Of the 151 detected samples in this MU, a total of 20 samples exceeded the aesthetic guideline of 500 mg/L.
KNC-40	Exposure Calculation	Should acknowledge that the 245 g/d for Ktunaxa preferred consumption is very close to the "high" intake rate BC uses to assess Selenium risk.		Feb 21 2022	ER-KNC	This information was added as a footnote in Section 4.2.5.
KNC-41	Risk Characterization	Figure 6-1. Although Toddler is the most sensitive for most COPCs it would be nice to show the relative risk difference for a toddler vs. the other life stages for each COPC that has an HQ >0.2 to help justify only showing the toddler. For risk communication purposes it's difficult to just show a toddler. If the risks are low for adults there is benefit in communicating that.		Feb 21 2022	ER-KNC	Yes, we have added adult risks to main report and other lifestages in an appendix, see response to comment KNC-18.
KNC-42		Would like a map to show the "hot spots" for potential exposures this will help inform risk management.		Feb 21 2022	ER-KNC	See response to comment KNC-2.
KNC-43		Section 6.10 – would like to see results presented for all life stages and for each MU (in addition to valley wide).		Feb 21 2022	ER-KNC	See response to comment KNC-18.
KNC-44		Uncertainties – would like to see senstivitiy analysis support some of the discussion to show how it affects the results (over or under estimation of risk).		Feb 21 2022	ER-KNC	Sensitivity analyses were included in the draft HHRA for some uncertainties, and additional sensitivity analyses were added in response to other comments received. A synthesis of uncertainties and their potential impact on risk estimates has been added to Section 6.11.

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KNC-45		The report states that "… the assumption that the indirect exposure pathways are attributable to water quality related exposures and risks is likely an overestimate of actual water quality related exposure and risk." Ktunaxa aren't interested in just direct water exposure pathways – rather the total risk of being Ktunaxa on the land. It's possible that the increases are related to other emissions from the mine (i.e. deposition of air emissions on vegetation etc.). Would be valuable to show how the air emission modelling lines up with increases of COPCs in game, berries, etc.		Feb 21 2022	ER-KNC	See response to comment KNC-9a.
KNC-46	Summary and Conclusions	The introduction implies all concerns and needs were addressed – I don't think we can say this as we have yet to finish this process – that said, I'm certain all of our concerns and needs will not be met.		Feb 21 2022	ER-KNC	The text was revised.
KNC-47		Statement of "Elk River and Lake Koocanusa are safe for recreational and cultural activities (e.g., wading, foraging) including contact with sediments and surface water during these activities" is not necessarily true. Cultural activities include eating fish – so this will have to be reworded.		Feb 21 2022	ER-KNC	The text was revised.
KNC-48		What lakes in the region are worse than Koocanusa for fish consumption?		Feb 21 2022	ER-KNC	Mercury concentrations for fish in regional lakes are discussed in section 6.11.3.1, Mercury Tissue Concentrations for Lake Koocanusa Fish. The summary was revised to include this information.
KNC-49		Report states: "However, it is unclear if selenium concentrations measured in berries and game are attributable to mining influences on water quality." Do the authors believe these increases are not mining related? I assume these increases are from dust/air emissions from the mine… which is relevant.		Feb 21 2022	ER-KNC	The text was intended to be taken literally, and was not intended to imply that selenium in berries or game is or isn't mining related - only that water quality is unlikely to influence berry and game tissue concentrations. The text has been revised.
KNC-50		Recommend future sampling areas that are preferred locations for Ktunaxa cultural practices including hunting and harvesting. Recommend sampling more Ktunaxa foods (beyond fish, game, berries and rose hips).		Feb 21 2022	ER-KNC	We agree that it would be beneficial to refine monitoring programs going forward to collect more samples in preferred areas where locals and Ktunaxa are "on the land," and support collection of additional Ktunaxa foods for analysis. Teck is looking forward to working with KNC to support the development and implementation of this sampling.
KNC-51		Recommend the next HHRA be comprehensive to include all exposure pathways from mining activities.		Feb 21 2022	ER-KNC	Comment noted.
KNC-52		Adaptive Management - What about actions to decrease exposure? Recommendations to avoid "hot spots"? fish consumption advisories? Should also describe near future actions to decrease concentration of COPCs.		Feb 21 2022	ER-KNC	The recommendations and adaptive management sections were revised. As discussed with the HHRA Workgroup, Teck has committed to discussing additional recommendations based on the HHRA results at a future time after finalization of the HHRA Report as assessment timeline should not be extended further as it may impact relevancy given data covers 2015-2020.
KNC-53		No not agree with the recommendation of narrowing future scopes of HHRAs to Nitrate and selenium.		Feb 21 2022	ER-KNC	Teck agrees that a full evaluation of constituents was important, but maintains that the focus of future actions should be on COPCs contributing to the greatest risks. Other mining-related COPCs are likely to be addressed through management of selenium and nitrate. See also comments ENV-21 to ENV-25 which agree with the HHRA recommendations in Section 7.5.
KNC-54		Would like to see screening values calculated and included in this report.		Feb 21 2022	ER-KNC	As discussed at the April 2022 HHRA Workgroup meeting, screening levels for use in future monitoring and risk evaluation will be developed in consultation with the HHRA Workgroup. Screening level development may be initiated prior to the finalization of the HHRA, but will not be included in the final HHRA.
KNC-55	Problem Formulation	Designated Management Units: Line Creek should be noted in MU1 (Dry Creek drainage). There is also a Rod and Gun organization in this MU. Believe Grave Lake Recreation Site is in MU2.		Feb 21 2022	JC-KNC	The specified items were added to the text in Section 2.1.1.
KNC-56	Data Characterization and Hazard Identification	Ktunaxa wind dry fish – should dry weights be evaluated?		Feb 21 2022	JC-KNC	A discussion of potential impacts various food preparation methods can have on COPC concentrations and subsequent risk estimates for food has been added to the uncertainty assessment.
KNC-57	Exposure Assessment	Page 53 - ABSd needs to be defined in equation.		Feb 21 2022	JC-KNC	The definition has been added.
KNC-58	Risk Characterization	6.11.1 – last sentence - This point does not consider the dust coated plants that receive rain, as being the beginning of mine influenced water! Contributing to Tributaries that feed the Elk River.		Feb 21 2022	JC-KNC	This text was added: "Influences from dust or air emissions from the mine were not the subject of the HHRA and were not characterized. However, it is possible that airborne deposition has influenced concentrations in berries and on forage consumed by game." An additional analysis of non-water quality pathways was added as Appendix J.
KNC-59		6.11.3 - Concern that some "reference locations" may be effected by Elk River originating groundwater.		Feb 21 2022	JC-KNC	Surface water reference concentrations come from the Aquatic Environmental Synthesis Report (Windward Environmental et al. 2014; Section 3.1.2.1 and Appendix A). Note that the surface water reference concentrations were not the limiting factor in the screening, the risk-based screening levels (RBSLs) ultimately drove the screening results. Constituents in surface water with concentrations greater than RBSLs were also compared to reference concentrations, and if the max concentration of the constituent exceeding the RBSL was lower than the reference concentration, it would have been excluded from further evaluation in the HHRA. However, in all instances where constituents exceeded RBSLs in surface water, the reference concentration was less than the RBSL, meaning the constituent was included for further evaluation in the HHRA. Thus, the surface water reference concentrations had no impact on the screening results.
KNC-60		6.11.3.3 - This sound like surface area transfer. the lower the # of eggs, the more surface contact with ovarian tissue per individual egg…		Feb 21 2022	JC-KNC	Comment noted.
KNC-61		Lack of data for individual Mus may reflect an active avoidance by harvesters due to assumed potential risk.		Feb 21 2022	JC-KNC	Comment noted.
KNC-62		6.11.4.1 - One uncertainty I have is the effect of consumption of raw kidney meat. It is common for the harvester and helpers to consume the kidney at the time it is removed from the rest of the organs. Also, a significant portion of the game meat is smoke cured… does that effect exposure?		Feb 21 2022	JC-KNC	Meat consumed raw would be represented by the concentrations of metals used in the risk assessment. Kidney tissue data (one sample within DA and three samples outside DA) were included along with liver tissue in the game organ dataset; kidney tissue was not evaluated independently. Uncertainties related to changes in concentration and exposure following cooking, smoking, and drying meat are discussed in the uncertainty assessment.
KNC-63		6.11.4.2 - I question the IR for toddlers because I've seen toddlers at the beach and their hands are always in their mouth.		Feb 21 2022	JC-KNC	Soil ingestion has been intensively studied through investigations using tracers and in studies recording hand to mouth activity. These studies, which are cited in Section 4.2.3.2, have been used to estimate soil ingestion rates and the highest value identified in the studies for children whom do not have pica (deliberate ingestion of non-food items) was used in the HHRA. Also, the soil ingestion rates reflect a daily average and is not intended to represent isolated worst-case events, so there may be periods where someone ingests a greater amount of soil - such as during seasons when a larger period of time is spent outdoors - and periods where less soil is ingested.
KNC-64	Summary and Conclusions	Might need to consider Ktunaxa preparation of foods (smoking, drying and pit cooking), and cultural practices (such as the kidney consumption mentioned earlier).		Feb 21 2022	JC-KNC	A discussion of potential impacts various food preparation methods can have on COPC concentrations and subsequent risk estimates for food has been added to the uncertainty assessment.
W-1	2.1.3 Surface Water Use (p.11)	*"Surface water within the Designated Area is not currently used as a potable source of drinking water."* This needs to be clarified there are numerous (100s) of active surface water point of diversion licences and licensed springs listed as being for domestic purposes in the Designated Area. Most appear to be in non-mine affected tributary catchments and therefore may be out of scope for this study, however that should be verified.		March 11 2022	Waterline-KNC	The text has been revised as follows: "Surface water within the DA is not currently used as a municipal potable source of drinking water. It is acknowledged that some private individuals may divert surface water for potable use; however, little information is publicly available describing specific draw volumes and uses. Surface water uses are dominated by recreational activities, although permits for surface water diversion have been granted for the Elk River, Fording River, Michel Creek, and Koocanusa Reservoir for irrigation and industrial uses. It is possible that some people may use surface water as a drinking water source while exercising Indigenous rights or while camping. " Figure 2-3 was updated to include surface water consumption as a complete pathway. Domestic uses of surface water identified in the provincial registry within the Elk Valley are reviewed and acknowledged in the HHRA.

Permit 107517 Environmental Monitoring Committee Advice/Input - Draft Human Health Risk Assessment Supporting the Elk Valley Water Quality Plan (Permit Section 8.10)

#	Page and Section	Advice	Rationale	Date Received	EMC Member	Teck Response
ADVICE/INPUT						
W-2	2.1.4 Groundwater Use (p.13)	*"Fifty private wells are included in the HHRA dataset."* This report should provide some indication of number of groundwater users in the Designated Area, to illustrate that 50 is a very small subset. In addition, an estimate of the number of domestic and water works groundwater supply wells that are in aquifers that could be mine-affected should be included.		March 11 2022	Waterline-KNC	See response to KNC-33.
W-3	2.1.4 Groundwater Use (p.13)	*"The District of Sparwood owns three wells, two of which are on the west bank of the Elk River (Franz Environmental Inc 2013). The wells numbers 1 and 2, located adjacent to the Elk River, are presently not influenced by surface water under current pumping conditions (SNC-Lavalin 2014)"* This information is 8 years old; it should be confirmed that these wells remain non-mine affected. KNC requests that well installation information, pumping rates and groundwater quality data from these wells be provided for review.		March 11 2022	Waterline-KNC	The SNC-Lavalin reference has been updated to the 2021 Elk Valley Regional and Site-Specific Groundwater Monitoring Programs Annual Report (SNC-Lavalin 2022). This report also contains the requested well installation information, pumping rates, and groundwater quality data. Based on 2021 data, Sparwood wells #1 and #2 are not inferred to be influenced by Elk River surface water.
W-4	2.2.1 Chemical Sources and Chemical Transport (p.15)	*"Constituents in surface water may influence groundwater when a hydraulic connection is present. This is likely limited to locations where groundwater wells are screened in the floodplain and a hydraulic gradient from the Elk River, whether natural or induced through pumping, is present."* This discussion is overly simplified, and does not accurately represent the potential extent of mine-affected groundwater: •The Elk River is not the only mine-affected watercourse where groundwater surface water interaction could lead to mine-affected groundwater supplies. There may also be drinking water supply wells that are influenced by Michel Creek near EVO and Corbin Creek near CMO. •There may also be drinking water supply wells that are influenced by mine-affected groundwater directly, including bedrock wells and licensed springs in provincially mapped Aquifer 1082 near EVO and possibly wells in the Elkford area, including Elkford town well (RG-DW-01-03). •There are mine-affected groundwater wells outside of what would commonly be considered the Elk River flood plain, yet the selenium concentrations observed in these wells confirm recharge from the Elk River. Mine-affected water has been observed in wells in the Elko, Kikomun Creek and Baynes Lake area by the Regional District of the East Kootenay (RDEK) and may be affecting the surface water quality in Kikomun Creek via a groundwater transport pathway.	Information in the local paper highlighted for KNC the potential for mine impacted groundwater to bypass the Elko Dam and Order Station ER4 (RG_ELKORES): Cranbrook Daily Townsman. October 2, 2020. RDEK working with province to address South Country water crisis. The article notes a connection between water levels in the Elko Reservoir and water levels in Baynes Lake area and that "Additional chemical testing completed over the last few weeks shows a relationship between elevated levels of selenium in the Elk River and well tests in the Baynes Lake area, proving that the {ELK} river is the water source". The surficial geology map for the area (attached as Elko Koocanusa.pdf) shows a large glaciofluvial fan that extends from the Elko Reservoir to Koocanusa Reservoir. KNC has contacted the Regional District of the East Kootenay (RDEK) and the preliminary data does suggest that there is elevated selenium in the Kikomun /Baynes Lake area groundwater and surface water.	March 11 2022	Waterline-KNC	It is outside the scope of the HHRA to include a detailed discussion of the extent of mine-affected groundwater. A detailed presentation of the current hydrogeological conceptual site model (CSM), available groundwater and relevant surface water data, and a discussion of data gaps and proposed next steps is provided in the 2020 Regional Groundwater Monitoring Program Update, 2021 Site Specific Groundwater Monitoring Program Update for each operation and Teck Adaptive Management Plan (AMP). In response to the information included in the comment, the second sentence in the highlighted HHRA statement has been removed.
			The selenium levels in the groundwater in the Elk River glaciofluvial fan also appear to be affecting surface water quality in the Kikomun /Baynes Lake area based on the limited publicly available surface water quality data. The KIKOMUN CRK @ JAFFRAY BAYNES LAKE RD BRIDGE site located within the Elk River glaciofluvial fan, 1 km upstream of Koocanusa Reservoir and over 9 km directly down gradient from the Elko Reservoir has selenium levels an order of magnitude higher than the SAND CRK @ MATSON RD BRIDGE site downstream of Jaffray which is outside of the influence of the Elk River glaciofluvial fan. EMS ID: E306185, Location Name: KIKOMUN CRK @ JAFFRAY BAYNES LAKE RD BRIDGE, Sample Date: 2016/08/16 Selenium Total Fresh Water .00194 mg/L (or 1.94 ug/L) EMS ID: E306186, Location Name: SAND CRK @ MATSON RD BRIDGE, Sample Date: 2016/08/16 Selenium Dissolved Fresh Water .000137 mg/L (or 0.137 ug/L) Selenium Total Fresh Water .000157 mg/L (or 0.157 ug/L)	March 11 2022	Waterline-KNC	
W-5	3.1.1 Groundwater (p.22)	*"If Teck installed a reverse osmosis system in a residence and a filtered water sample was available, the filtered water results were used in the HHRA."* To be conservative the unfiltered water sample concentrations should be used in the analysis. Participation in the Regional Drinking Water Monitoring Program (RDWMP) is voluntary. There may be residents using well water from a similar source that exceeds the BC WQG for selenium but are unaware since they have not voluntarily had there well tested.		March 11 2022	Waterline-KNC	Post-Treatment water results were used for two wells in the draft HHRA, all other well results were untreated. The untreated results for the two wells were used instead of the treated -results in the revised HHRA. When the untreated results are included, no additional COPCs in groundwater are identified, and EPC and risks by MUs do not significantly change. The HHRA has been updated to reflect this change.
W-6	Figure 3-1 Drinking Water Well Locations (p.23)	There are no Regional Drinking Water Monitoring Program (RDWMP) located in MU-6. As discussed in a previous comment the Regional District of the East Kootenay (RDEK) has identified a hydraulic connection between the Elko Reservoir and groundwater and surface water in the Elko, Kikomun Creek and Baynes Lake area. Selenium concentrations in some Elko, Kikomun Creek and Baynes Lake area wells are elevated which suggests mixing with mine-affected water. Teck should endeavour to add wells in MU-6 to the RDWMP.		March 11 2022	Waterline-KNC	Teck has reached out to the RDEK to understand what groundwater data are available in the Elko, Baines Lake, Kikumon Creek area. Once available, relevant findings will be incorporated into future investigations in this area, including the forthcoming Regional Groundwater Bypass, Bedrock, and Interbasin Flow Study. Additionally, Teck plans to conduct a 2022 outreach campaign in the Elko and Baynes Lake area in order to expand the spatial extent of the RDWMP.

Permit 107517 Environmental Monitoring Committee Advice/Input - Draft Human Health Risk Assessment Supporting the Elk Valley Water Quality Plan (Permit Section 8.10)						
#	Page and Section	Advice	Rationale	Date Received	EMC Member	Teck Response
ADVICE/INPUT						
W-7	Figure 3-1 Surface Water Sample Locations (p.25)	As discussed in the comment the Regional District of the East Kootenay (RDEK) has identified a hydraulic connection between the Elko Reservoir and groundwater and surface water in the Elko, Kikomun Creek and Baynes Lake area. Kikoman Creek is upstream of RG_KRRRD, therefore RG_KRRRD may be mine-affected		March 11 2022	Waterline-KNC	Please refer to response W-6.
W-8	Table 3-5. Constituents Identified as COPCS in Surface Water (p.40)	Please provide the report that presents the calculation for the reference concentrations used in Table 3-5. The understanding of groundwater surface water interaction in the Designated Area has improved significantly since the monitoring period (2010 to 2015). KNC would like to review the analysis to consider if these reference locations may be mine-influenced through a groundwater pathway.		March 11 2022	Waterline-KNC	Surface water reference concentrations come from the Aquatic Environmental Synthesis Report (Windward Environmental et al. 2014). See Section 3.1.2.1 and Appendix A of that document. Note that the surface water reference concentrations were not the limiting factor in the screening, the risk-based screening levels (RBSLs) ultimately drove the screening results. Constituents in surface water with concentrations greater than RBSLs were also compared to reference concentrations, and if the max concentration of the constituent exceeding the RBSL was lower than the reference concentration, it would have been excluded from further evaluation in the HHRA. However, in all instances where constituents exceeded RBSLs in surface water, the reference concentration was less than the RBSL, meaning the constituent was included for further evaluation in the HHRA. Thus, the surface water reference concentrations had no impact on the screening results.
W-9	Table 3-5. Constituents Identified as COPCS in Surface Water (p.40)	*"c Reference concentration data includes 95th percentile of samples collected between 2010 and 2015, from Elk Valley watershed, Kootenay River, and Lake Koocanusa"* Why would reference concentration data from the Kootenay River and Koocanusa Reservoir be used for comparison with monitoring data from MU-1,2,3,4 or 5? Surface water in the Designated Area upstream of Koocanusa Reservoir are not influenced by the conditions (geology, soil, vegetation, land use, water use etc.) in the Reservoir or the Kootenay River.		March 11 2022	Waterline-KNC	Separate reference concentrations were calculated for the Elk Valley watershed (MUs 1-5) and Lake Koocanusa (MU-6). Data from the Kootenay River and Lake Koocanusa upstream of the confluence with the Elk River were used for MU-6 reference concentrations only. The footnote was clarified.
W-10	4.1 Exposure Point Concentrations (p.46)	*"The EPC is typically represented by the 95th percent upper confidence limit of the mean concentration (UCLM)."* Were the Exposure Point Concentrations (EPCs) for groundwater calculated using the UCLM of the entire Regional Drinking Water Monitoring Program (RDWMP) dataset as presented in Appendix C? If so KNC has concerns that this would result in an unconservative assessment of risk. Although an Elk Valley resident may consume water in more than one location, they will primarily drink water from their home source. The EPC for a single well/source can be determined based on the UCLM of the time series data set for that well/source as constituent concentrations may change seasonally or over time. However, lumping mine-affected and non-mine-affected well/sources together to calculate a Designated Area wide EPC would significantly underestimate the exposure of an individual using a mine-affected well/source at home. Please clarify the methodology used.		March 11 2022	Waterline-KNC	An additional analysis was conducted to estimate risks for individual wells/sources. This evaluation is summarized in the HHRA uncertainty assessment (Section 6.11.4.3) and the appendices (G-1b and H-1b) using de-identified labels for the wells to protect privacy. Briefly, groundwater EPCs were calculated for each COPC detected at each well within MU-4 and MU-5 based on the 95 UCLM of the time series data set for that well. ProUCL was used to calculate well-by-well EPCs, consistent with the EPC calculation methodology described in the HHRA. All groundwater concentrations were below screening levels in MU-3, and no wells were sampled in MUs 1, 2, or 6, so the well-by-well analysis focused on wells in MU-4 and MU-5. HQs for each COPC were calculated by lifestage for each well based on the EPC for that well. Ten wells were found to exceed an HQ of 0.2 (for lithium, manganese, or iron), and two wells were found to exceed an HQ of 1 (for lithium or manganese), when evaluated on a well-by-well basis.
W-11	Section 6.11.5 Toxicity Assessment Uncertainties	Section 6.11.5 Toxicity Assessment Uncertainties presents Ramboll less conservative values for toxicity reference values (TRVs) for Cobalt and Lithium. I think they used their less conservative TRVs in the main assessment although it is not entirely clear in the wording they used. At the end of each section, it says: " It is used as an alternate TRV for cobalt in this HHRA." Table 6-1. COPCs with HQs > 0.2 for Pathways Directly Related to Water Quality (PDF p.156 84-85) does show some areas of concern for both Co and Li so if the alternative TRVs were used it means there would have been more serious concerns if the conventional/conservative TRVs had been used. TRV values are out of my area of expertise so I will not comment on that section but wanted to highlight it for you.		April 7 2022	Waterline-KNC	The USEPA PPRTVs for cobalt and lithium are used in the main assessment. Thus, all risk estimates included in Appendix H and presented in tables and figures in Section 6 are based on the PPRTVs and not the alternate TRVs. This is now clarified in the revised HHRA. A comparison of risk results using the PPRTVs vs the alternate TRVs has been added to the uncertainty assessment.
W-12	Appendix C, Table C-2b	The groundwater quality data for the Fernie James White Park Wells is presented (PDF p.156) and it looks like the selenium concentration in those wells is nearing the 10 ug/L BC Water Quality Guideline for Se. The concentrations measured in 2021 ranged from 4.9 to 9.9 ug/L Se.		April 7 2022	Waterline-KNC	This stated range is correct, the BC Water Quality Guideline for selenium is not exceeded in the Fernie James White Park Wells.

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To: Carla Fraser and Colleen Mooney, Teck Coal

From: Erin Robertson, Team Lead, Mining Oversight, Ktunaxa Nation Council

Date: July 28 2023

Re: Permit 107517 Revised Final Elk Valley Human Health Risk Assessment

On June 7, 2023, Teck shared with KNC the 'Revised Final Human Health Risk Assessment (HHRA) report' provided to the Ministry of the Environment (ENV) to satisfy section 8.10 of Permit 10751 conditions. The HHRA was to determine exposure pathways and potential human health risks from selenium and other mine-related parameters of concern (mercury, cadmium, chromium, copper, manganese, nickel, vanadium and zinc) present in vegetation, fish and wildlife that are potentially used for food or medicinal sources, or present in currently known potable water sources within the designated area in Management Units (MU) 1-6).

Teck's email states that "this revised final report addresses the comments received from the Ktunaxa Nation Council (KNC) and BC Interior Health (IH) following their formal review with ENV of the final report submitted on July 1, 2022".

Our initial technical review of the report leads us to conclude that this most recent version is a major improvement over previous draft versions as the results are now included, and the risk assessors have provided greater clarity. Many of the results, such as the cumulated risks of all consumers and all age groups, were not included in earlier draft versions but are now added in this version. The risk assessors included most of our recommended changes.

In general, we can support the following key findings: 1) Fish, game meat and berries are contaminated with selenium; 2) the high fish consumers (both recreator and Ktunaxa), and Ktunaxa that are sukiɫ ʔiknaɫa (eating good – at the preferred rate) have a higher risk of selenium exposure and 3) the health risk is particularly high for fish and game meat consumers in MU 1-4.

However, there is still a major gap and deficiency in the risk characterization section. Although high-risk groups are identified (Ktunaxa, sports fishers and Ktunaxa that are sukiɫ ʔiknaɫa), there is no clear characterization of the risk of health effects associated with increased Hazard Index among Ktunaxa people with different consumption rates of

ʔa·kpiȼ̓is (favourite food). Also, no ranking of risk or recommended adaptive measures as per the permitting requirement are presented. As discussed in our conference call on July 19th, 2023, we are providing some additional text in the attached language drafted by Dr. Laurie Chan that should be included in the HHRA.

We are also not confident that it is appropriate to combine findings for MU1-6. More evidence is needed about the use of the watershed (do people use the whole area equally or some parts more?) before determining that combining the MUs is appropriate. We were also concerned that respiratory exposure was determined to be outside of the scope of Permit 107517 as it is focused on impacts to water. From our perspective, inclusion of all routes of exposure will provide greater confidence in the HHRA, findings and determination of risk and potential health effects.

It is clear from this report that current mitigations are insufficient to be protective of human health and Ktunaxa rights. The multiple benefits related to the harvest and use of ʔa·kpiȼ̓is (especially local fish), including health, nutrition and food security benefits have been significantly impacted. Mining in the Elk Valley has and continues to directly increase the likelihood of poor health outcomes for Ktunaxa who rely on ʔa·kpiȼ̓is (especially fish) and indirectly increase the likelihood of poor health outcomes for those who are food insecure and for those who no longer have confidence in eating ʔa·kpiȼ̓is because of contamination.

We look forward to seeing a final version of the HHRA that includes our suggested text and comments on risk characterization and risk management.

Dr. Laurie Chan's Proposed Language:

This is stated in the Permit requirement: "*The conclusions and findings of the Human Health Risk Assessment must be risk ranked and prioritized and include recommended risk management controls and other mitigation actions to address human health risks identified in the human health risk assessment for inclusion in the adaptive management plan for the area*". Following our discussion on adding some text to characterize the risk, I suggest the Team can consider expanding the following three paragraphs (*in italic* below) in p. 126 Section 6.10 with the text below:

> *The cumulative risk results suggest that Elk Valley foods are higher in selenium than market basket and reference area foods. Consumption of Elk Valley foods contributes to total risk differently by consumer: the impact of locally harvested foods on average consumers is relatively minor. For example, the average consumer (toddler) has an HI estimate that is 0.7 higher than the background diet (i.e., market basket foods only); the preferred diet consumer (toddler) has a HI estimate that is 5.4 higher than the background diet. Differences in cumulative selenium risk across MUs are mainly due to differences in fish HQs, which are likely attributable to differences in selenium concentration by MU and/or species sampled by MU.*
>
> *The finding of HI estimates above ENV's risk management threshold of 1 indicate the need for ongoing monitoring and adaptive management. In interpreting these cumulative risk estimates for selenium, it is helpful to consider that the TRV of 0.0057 mg/kg-day for selenium used in this assessment (see Section 5.1.1) is based on a NOAEL. No known adverse effects were associated with this intake level. An additional UF of 2 (i.e., protectiveness factor of 2) was applied to the NOAEL before calculating the TRV.*
>
> *The TRV is based on the critical effect of hair and nail brittleness and loss, which are signs and symptoms of selenosis following chronic selenium exposure, as reported in (Yang and Zhou 1994). There is uncertainty in applying the Yang and Zhou findings to children because no children were included in the study. However, IOM (2000) states, "...there is no evidence indicating increased sensitivity to selenium toxicity for any age group." Exposures greater than the 0.0057 mg/kg-day TRV result in HQs greater than ENV's risk management threshold. Section 6.11.5.1 provides additional context regarding selenium intakes potentially associated with adverse health effects.*

Cumulative risks or HIs of different receptors

The cumulative risk results demonstrate that Elk Valley foods are higher in selenium than market basket and reference area foods. Consumption of Elk Valley foods contributes to total risk differently by consumers: the impact of locally harvested foods on average consumers is relatively minor. For example, the average consumer (toddler) has an HI estimate that is 0.7 higher than the background diet (i.e., market basket foods only); the preferred diet consumer (toddler) has a HI estimate that is 5.4 higher than the background diet. Differences in cumulative selenium risk across MUs are mainly due to differences in fish HQs, which are attributable to differences in selenium concentration and/or selenium speciation (which affects bioavailability) by MU and/or species sampled by MU.

The exposure assessment results show that Elk Valley foods such as fish, game meat and berries are higher in selenium than market basket and reference area foods. Therefore, the HI or the cumulated risk of selenium is higher for all Elk-Valley food consumers than the consumers who consume market food only or fish, game meat and berries from reference sites (Figure 6-7 to Figure 6-11). The consumption of Elk Valley foods contributes to the total selenium intake and the risk differently to different consumer groups and life stages. For example, the impact of locally harvested foods on average consumers is relatively minor; the average recreator toddler has an HI estimate of 1.9 which is 0.7 or 58% higher than the HI of 1.2 calculated for the toddlers consuming the background diet (i.e., market basket foods only or consuming fish, game meat and berries from the reference site) (Figure 6-7). In comparison, the Upper Percentile Consumer Recreator toddler has a HI estimate of 2.7 which is more than 2 times higher than the HI for toddlers consuming market foods only or 1.2 or 80% higher than the HI of 1.5 for toddlers consuming fish, game meat and berries from the reference site (Figure 6-9). The Ktunaxa consume more Elk Valley foods and hence have a higher selenium exposure and risk. For example, the Upper Percentile Consumer Ktunaxa toddler has a HI estimate of 3.1 which is more than 2 times higher than the HI of 1.2 for toddlers consuming market foods only or the HI of 1.5 for toddlers consuming fish, game meat and berries from the reference site (Figure 6-10). The Ktunaxa toddler with the preferred diet has the highest exposure and risk of all consumer groups assessed. The HI is 6.6, which is more than 5 times higher than the HI of 1.2 for toddlers consuming market foods only or 3 times higher than the HI of 2.3 calculated for toddlers consuming fish, game meat and berries from the reference site (Figure 6-11).

The HIs for adults are lower (about 50%) than those for toddlers within the same consumer group for all consumer groups that were assessed (Figure 6-7 to Figure 6-11). These results suggest that toddlers have higher selenium exposure after adjusting for body weight and is the more sensitive sub-population. Like the toddler results, the impact of locally harvested foods varies by adult consumer group. For example, even though the HI for the average recreator adult doubled (0.8 vs 0.4) compared to adults consuming the background diet (i.e., market basket foods only or consuming fish, game meat and berries from the reference site) (Figure 6-7), all of them are below the ENV's risk management threshold of 1. In comparison, the Upper Percentile Consumer Ktunaxa adult has a HI of 1.5, which is more than double the HI of 0.4 for adults consuming market foods only or the HI of 0.6 for adults consuming fish, game meat and berries from the reference site and making it exceed the ENV's risk management threshold of 1 (Figure 6-10). The preferred consumer Ktunaxa adult has the highest exposure and risk of all adult consumer groups assessed. Their HI is 3.6, which is 9 times higher than the HI of 0.4 for adults consuming market foods only or more than 3 times higher than the HI of 1.1 for adults consuming fish, game meat and berries from the reference site (Figure 6-11).

There is also a site effect; the HIs for Ktunaxa Upper Percentile Consumer toddlers in MU1, MU-2, MU-3 and MU-4 are around 3 or above, which is higher than the HIs for toddlers in MU-5 and MU-6 at around 2 (Figure 6-12). A similar site pattern is observed among Ktunaxa Upper Percentile Consumer adults; the HIs for adults in MU1, MU-2, MU-3 and MU-4 are around 1.5, which is higher than the HIs for adults in MU-5 and MU-6 at around 0.8 (Figure 6-12). The differences in cumulative selenium risk across MUs are mainly due to differences in fish HQs, which are attributable to differences in selenium concentration by MU and/or species sampled by MU.

Characterizing the health risk indicated by the HI estimate

The HIs for the average adult recreator and average adult Consumer Ktunaxa are below 1 and the HIs for Elk Valley-wide toddlers are all above 1, ranging from 1.7 and 1.9 for average recreator and Ktunaxa toddlers, to 2.7 and 3.1 for the Upper Percentile consumer recreator and Ktunaxa toddlers, to 6.6 for Preferred consumer Ktunaxa toddlers. The HIs for Elk Valley-wide adults are all above 1 for the Upper Percentile Consumer recreator (1.4), the Upper Percentile Consumer Ktunaxa (1.5) and the Preferred Consumer Ktunaxa (3.6).

As per the guidance on human health detailed quantitative assessment for chemicals published by Health Canada, risk assessors can assess the combined risks associated with the site and background sources and compare the resulting HQ or HI with a target value of 1.0 (Health Canada 2010). Therefore, the finding of HI estimates equal to or below the threshold of 1 indicate that the exposure is within the dose at which no non-cancer adverse effects are expected. This means that the risk of selenium exposure from all routes related to the water sources has minimal health risk. When the estimated HIs are above 1, there is no standard approach to use the HIs to characterize the health risk. It is important to note that **the finding of HI estimates above the ENV's risk management threshold of 1 does not mean that there are expected adverse health effects but indicates that action or risk management is required** (Health Canada, 2000). The HI values also do not give a quantification of the probability or severity of adverse health outcomes, and the interpretation must be based on the level of exposure.

The lethal dose of selenium is unknown but is estimated to be 280,000 µg based on animal studies (Morris and Crane 2013). This translates to a HI of 700. In 2008, 201 persons were exposed to acutely toxic levels of selenium from their use of misformulated dietary supplement products ranging from 22,300 to 32,200 µg per day over an approximately 30-day period, which would result in a HI of 56 to 81, leading to selenosis symptoms and adverse health effects, some debilitating, that persist 2.5 years subsequent to the last exposure (Morris and Crane 2013). The highest HI estimated in this study is 6.6, which is about 100 times lower than the lethal dose or 10 times lower than the acute toxicity dose. **Therefore, there is no concern about any acute health effects.**

As discussed in Section 5.1.1, chronic selenium exposure may cause a health condition called selenosis. Symptoms observed include loss of hair and nails, skin lesions, tooth decay, and abnormalities of the nervous system (ENV 2014). The lowest observable adverse effect level (LOAEL) for the onset of selenosis occurs at or above daily selenium intakes of 910 µg/day, and the no adverse effects are expected below 800 µg/day (Yang and Zhou 1994). The 0.0057 mg/kg-day TRV used by Health Canada and this study is based on the NOAEL of 800 µg/day. A UF of 2 was applied to the NOAEL, resulting in a UL of 400 µg/day (Health Canada 2021b).

There was another study of dietary selenium intake in a high-selenium area (western South Dakota and eastern Wyoming) indicated daily intakes of 68 to 724 µg (0.9 to 9.2 µmol) in 142 subjects, and no evidence of selenosis was found, even in the subjects consuming the most selenium (Longnecker et al., 1991). The results of this study further support the NOAEL of 800 ug/day for adults. This evidence suggests that even when the HI is between 1 and 2, or the exposure is below 800 ug/day, there are still no expected observable effects. Therefore, the health risk of selenosis for adults can be considered as low.

The TRV for toddlers and children is more complicated because the Yang and Zhou study did not include children. The Health Canada TRVs for infants and children are based on background dietary intake (i.e., average selenium levels in human breast milk) NOAEL (IOM 2000, Health Canada 2021b). The resulting TRV for infants 0 to less than 6 months of age is 0.0055 mg/kg-day. For all other child and adolescent age ranges, the TRVs are slightly greater than 0.0057 mg/kg-day. Because the TRVs are similar on a body weight basis, therefore, the 0.0057 mg/kg-day TRV is applied to all ages in this assessment. IOM (2000) states, "...there is no evidence indicating increased sensitivity to selenium toxicity for any age group." Therefore, it is assumed that the UL for adults (400 ug/day) can be adjusted for body weight for toddlers (1-3 years old) to 60 ug/day (IOM 2000). Using the same logic, we can assume the no observable adverse effect level (NOAEL) of 800 ug/day and the lowest observable adverse effect level (LOAEL) of 910 ug/day in adults can be adjusted to 120 ug/day and 137 ug/day, respectively, for toddlers and children.

Therefore, HI>1 for toddlers means that the exposure is higher than the background dietary intake level. This also explains the result that the HIs for toddlers consuming the background, i.e. market food only and from fish, game and berries from reference sites, are slightly higher than 1 (ranging from 1.2 to 1.5).

It is common to characterize the hazard level by ranking or classifying the HQ or HI at different levels of risk. However, there is no standard approach. For example, the Centre for Environment, Fisheries, and Aquaculture Science, an Executive Agency of the United Kingdom Government's Department of Environment, Food and Rural Affairs, ranked the levels of risk of different chemicals using a colour banding ranking system according to their calculated Hazard Quotients (HQ); HQ<1=Gold, <30=Silver, <100=White,<300=Blue,<1000=Orange (Hazard Assessment Process - Cefas (Centre for Environment, Fisheries and Aquaculture Science)). Other risk assessors have developed similar ranking systems for HQs (e.g. Benson et al. 2018; Eker, 2020).

Based on the toxicity assessment information discussed above, we propose a 5-level ranking system to classify the level of health risk. There is little information to estimate the dose range for the high risk for chronic effects of selenium exposure. We propose using a cutoff based on the lowest observable acute effects, 22,300 ug per day over 30 day (Morris and Crane 2013). Assuming the cumulated dose is taken over one year or 365 days, the estimated daily dose will be 1833 ug or an HI of 4.6.

Hazarad Index	Classification	Rationale
Equal or less than 1	Minimal	According the the Health Canada Guideline
Above 1 to 2	Low	The dose is below the no observable effect level
Above 2 to 2.2	Moderate	The dose is higher than the no observable effect level but lower than the lowest observable effect level

Above 2.2 to 4.6	High	The dose is higher than the lowest observable effect level and lower than a calculated cutoff using the acute toxic dose of 669,570 ug over 365 days instead of 30 days or a daily dose of 1833 ug or HI=4.6
Above 4.6	Very High	The dose is higher than a calculated cutoff using the acute toxic dose of 669,570 ug over 365 days instead of 30 days or a daily dose of 1833 ug or HI=4.6

Based on this ranking system, **the health risk for the average adult recreator and average adult Consumer Ktunaxa from selenium exposure can be considered as "Minimal".** It is noted that exposure from other sources, such as inhalation of dust, is not included in this HHRA.

The risk for **both the valley-wide Upper Percentile Consumer recreator adult (HI=1.4) and the valley-wide Upper Percentile Consumer Ktunaxa adult (HI=1.5) of developing selenosis can be considered as "Low".**

The valley-wide Preferred Consumer Ktunaxa has an HI of 3.6 or a cumulated intake of Se at 1440 ug/day. This exposure exceeds the lowest observable adverse effect dose of 910 ug/d. Therefore, **the health risk of the Preferred Consumer Ktunaxa adults can be considered as "High".**

The average recreator and Ktunaxa toddlers have HIs of 1.7 and 1.9, respectively. This equals an intake of 102 ug/day and 114 ug/day, respectively. Since they are below the NOAEL of 120 ug/day, **the health risk of selenium exposure for the Elk Valley wide average recreator and Ktunaxa toddlers can be considered as "Low".**

The HIs of the Elk Valley wide Upper Percentile consumer recreator and Ktunaxa toddlers were 2.7 and 3.1, respectively or equal to the daily exposure of 162 ug and 186 ug. Since they are higher than the LOAEL of 137 ug/day, **the health risk of selenium of the Upper Percentile consumer recreator and Ktunaxa toddlers can be considerable as "High".** Finally, the Preferred consumer Ktunaxa toddlers, have the highest HI of 6.6, Therefore, **the health risk of the Preferred consumer Ktunaxa toddlers can be considered as "Very High".**

Table X. Summary of cumulated risk (HI) and risk classification by consumer groups and life stage for Elk Valley wide exposures.

Consumer Groups	Toddlers	Adults
Average Recreator	HI=1.9 LOW	HI=0.8 MNIMAL
Upper Percentile Recreator	HI=2.7 HIGH	HI=1.4 LOW
Average Ktunaxa	HI=1.7 LOW	HI=0.68 MINIMAL
Upper Percentile Ktunaxa	HI=3.1 HIGH	HI=1.5 LOW
Preferred diet Ktunaxa	HI=6.6 VERY HIGH	HI=3.6 HIGH

A similar risk classification approach can be applied to characterize the risk associated with the calculated HIs for different MUs. For example, the HIs for the Ktunaxa Upper Percentile Consumer (Toddler and Adult) are presented in Figure 6-12. (*Please note – we recommend calculating HIs for the different MUs using the same approach used for Figure 6-12 for the other consumer groups).* The risk classification can be summarized in the Table below:

Table Y. Summary of cumulated risk (HI) and risk classification by MUs and life stage.

MU	Toddlers	Adults
1	HI=3.3 HIGH	HI=1.7 LOW
2	HI=3.4 HIGH	HI=1.5 LOW
3	HI=2.7 HIGH	HI=1.4 LOW
4	HI=3.4 HIGH	HI=1.7 LOW
5	HI=2.0 LOW	HI=0.8 MINIMAL
6	HI=2.2 MODERATE	HI=0.9 MINIMAL

In summary, the consumption of fish, game meat and berries in the Elk Valley result in elevated exposure to selenium and increase the risk of adverse health effects among the Upper Percentile consumer recreator and Ktunaxa and the Preferred consumer Ktunaxa toddlers and the Preferred Consumer Ktunaxa adults. Consuming fish, game meat and berries collected in MU1-4 poses higher risk of selenium toxicity. Risk management, including further monitoring and adaptive management measures, are needed to lower the selenium intake of these groups. See Section 7.4 for details.

Many uncertainties are involved in many steps of this quantitative risk assessment which affect the confidence in the findings. They are discussed in the following section (Section 6.11). Section 6.11.5.1 provides additional context regarding the uncertainty associated with characterizing risks of adverse health effects from selenium exposure.

It is important to note that increasing evidence has been accumulated in the scientific literature in recent years, which has not been included yet in the current TRV. This new evidence comes from environmental studies carried out in populations characterized by abnormally high or low selenium intakes and from high-quality and large randomized controlled trials with selenium recently carried out in the US and in other countries. Health conditions significantly associated with excess selenium intake include selenosis, alopecia, dermatitis, non-melanoma skin cancer, increased mortality, type 2 diabetes and increased prostate cancer risk (Rayman 2020). Vinceti et al. (2017) proposed that selenium intake should not exceed 90 µg/day, taking into account the signs of toxicity yielded by the NPC trial (an excess diabetes and skin cancer risk) and by the SELECT trial (an excess incidence of diabetes, advanced prostate cancer, dermatitis and alopecia). In 2023, the European Food Safety Authority (EFSA) established the tolerable upper intake level (UL) for selenium of 255 µg/day for adult men and women (including pregnant and lactating women) based on a lowest-observed-adverse-effect-level (LOAEL) of 330 µg/day identified from the SELECT, a large randomized controlled trial in humans using selenium supplement with an uncertainty factor of 1.3 (EFSA Panel on Nutrition, 2023). Alopecia, or hair loss, was selected as the critical endpoint. This LOAEL is lower than the TRV (400 ug/day) used in Canada and the US and this study. Therefore, it is likely that the TRV used for future HHRAs in the Elk Valley will be lowered. It is reasonable to use a conservative approach for the risk management of selenium to account for the potential error of failing to detect a significant dose effects.

1. *Consider revising the text in P. 132*

6.11.5.1	Selenium Toxicity and Translation to Health Effects	The selenium risk results cannot be directly tied to health effects.	No effect	NA	N

Section		Description	Potential conclusion of uncertainty	Magnitude	Impacts Conclusion?
6.11.5.1	Selenium Toxicity and Translation to Health Effects	The consumption of fish, game meat and berries in the Elk Valley result in elevated exposure to selenium and the associated health effects among the Upper Percentile consumer recreator and Ktunaxa and the Preferred consumer Ktunaxa toddlers and the Preferred Consumer Ktunaxa adults.	Uncertainty on the assumption that the NOAEL and LOAEL for toddlers are the same as adults after adjusting for body weight	Medium to high	Y
	Selenium Toxicity and Translation to Health Effects	The risk of higher dose of Se causing chronic toxicity is estimated based on the acute toxicity of 30 days exposure	Uncertainty in translating the effect observed in the cumulated dose over 30 days to an	Medium to high	Y

			extended exposure of 365 days		
	Selenium Toxicity and Translation to Health Effects	New scientific literature in recent years which has not been included in the current TRV.	The EU has adopted a LOAEL that is lower than the TRV used in Canada and the US and this study (330 ug/day vs. 400 ug/day). Therefore, it is likely that the TRV used for future HHRAs in the Elk Valley will be lowered.	Medium to high	Y

2. Consider adding the following text in Section 7.4

The key findings of this HHRA suggest that the consumption of fish, game meat and berries in the Elk Valley result in elevated exposure to selenium and increase the risk of adverse health effects among the Upper Percentile consumer recreator and Ktunaxa and the Preferred consumer Ktunaxa toddlers and the Preferred Consumer Ktunaxa adults (Section 6.10). Risk management measures are needed to lower the selenium intake of these groups.

There are two options can be considered to lower the selenium intake. 1. To better control the release and bioavailability of selenium to the receiving environment and decrease the concentrations of selenium in the water and eventually lower the concentrations of selenium in the fish. 2. To issue consumption advisory to the Upper Percentile consumer recreator and Ktunaxa toddlers to limit the amount of fish consumed and to encourage the Ktunaxa toddlers and adults NOT to consume fish at their preferred rate.

The advantage of option 1 is that it is a sound and reasonable waste management and social and environmentally responsible action. The disadvantage is that it will take many years to see the effects (design, construction and operation of large treatment facilities in multiple locations – see Teck's Implementation Plan Adjustment for more information). Treatment facilities are already planned and required to meet current permit requirements. Actions such as setting site-specific water criteria and fish tissue concentrations are needed to protect human health and Ktunaxa rights.

The advantage of option 2 is that people can make their own choice to lower their risk. The disadvantage is that the compliance rate to diet advisories can be low. Also, fish is an important source of nutrients and a determinant of food security. Limiting fish consumption will be significant indirect adverse health effects on the people. A complementary nutrition education and intervention program is needed if such an advisory is issued. Finally, the impacts on the cultural identity and rights of the Ktunaxa people must be recognized and mitigated.

Of course, both options can also be pursued in parallel. A consumption advisory could be issued while treatment is brought online until monitoring data confirms that selenium levels in fish have decreased to levels that are safe for all consumer groups. The decision of a consumption advisory lies with governments and not the proponent.

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ENVIRONMENT
& HEALTH

MEMO

To	Erin Robertson, Team Lead, Mining Oversight, Ktunaxa Nation Council
From	Alma Feldpausch, Lisa Yost, Julie Tu, Ramboll Americas Engineering Solutions
Copy to	Carla Fraser and Colleen Mooney, Teck Coal Limited
Subject	**Response to Comments from Erin Robertson, Ktunaxa Nation Council, to Carla Fraser and Colleen Mooney, Teck Coal Ltd. dated July 28, 2023, Regarding Permit 107517 Revised Final Elk Valley Human Health Risk Assessment**

Date October 20, 2023

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On July 28, 2023, Erin Robertson, Ktunaxa Nation Council (KNC) transmitted a memorandum to Carla Fraser and Colleen Mooney, Teck Coal Limited (Teck) which provided advice on the Revised Final Elk Valley Human Health Risk Assessment (HHRA) Supporting the Elk Valley Water Quality Plan.[1] This memorandum provides response to the advice provided in the July 28th memorandum from the KNC ("KNC Comment Memo"), indicating where KNC advice has or has not been incorporated into the Second Revised Final HHRA, to which this letter is appended. This memorandum also provides the rationale for why some advice has not been accepted or where there is disagreement with statements made by the KNC.

This memo is organized according to general comment themes presented in the KNC Comment Memo, beginning with general comments provided in the introductory pages (Section 1), pages 1-2, followed by responses addressing specific KNC comments pertaining to the Revised Final HHRA risk characterization text expansion (Section 2), uncertainty assessment (Section 3), adequacy of the risk characterization (Section 4), linking of hazard indices (HIs) to health effects (Section 5), and risk ranking (Section 6). We also indicate which additional recommended text revisions provided in the KNC Comment Memo have been incorporated into the Second Revised Final HHRA (Section 7) and conclude with statements about how the HHRA results can be used to inform management decisions in the Elk Valley (Section 8).

[1] Ramboll US Consulting. 2023. Revised Final Human Health Risk Assessment Supporting the Elk Valley Water Quality Plan. Prepared on behalf of Teck Coal Limited. June 2023.

1. GENERAL COMMENTS

1.1 General Findings of the HHRA

The KNC Comment Memo notes that:

> "Our initial technical review of the report leads us to conclude that this most recent version is a major improvement over previous draft versions as the results are now included, and the risk assessors have provided greater clarity. Many of the results, such as the cumulated risks of all consumers and all age groups, were not included in earlier draft versions but are now added in this version. The risk assessors included most of our recommended changes." (Page 1)

Response: We appreciate the feedback that the June 2023 Revised Final HHRA provided greater clarity and that it was identified as a major improvement over previous versions.

The following paragraph notes:

> "In general, we can support the following key findings: 1) Fish, game meat and berries are contaminated with selenium; 2) the high fish consumers (both recreator and Ktunaxa), and Ktunaxa that are sukiɬ ʔiknaɬa (eating good – at the preferred rate) have a higher risk of selenium exposure and 3) the health risk is particularly high for fish and game meat consumers in MU 1-4." (Page 1)

Response: In this response we provide additional detail, clarification, and a few corrections regarding these statements.

Regarding the first statement, it is accurate to state that fish, game meat, and berries in some areas within the Designated Area have higher concentrations of selenium than reference areas. Specifically, fish in management units (MUs) 1-5 have selenium concentrations above reference. In contrast, fish in MU-6 (Koocanusa Reservoir) have selenium concentrations consistent with or below reference. The game meat, organ, berry, and rose hip datasets are not as robust as the fish tissue dataset, but the available data for these media indicate selenium concentrations are higher in many MUs than in reference areas.

The second statement is accurate in that higher fish consumers have a higher risk of selenium exposure. Note that the HHRA determined that risks for average and upper percentile fish consumers (recreator and Ktunaxa) in all MUs are acceptable (i.e., do not exceed a hazard quotient (HQ) of 1). Ktunaxa that are sukiɬ ʔiknaɬa (eating good – at the preferred rate) were found to have potential selenium risk (i.e., HQ above 1) in MUs 1-5. Selenium risks were acceptable for sukiɬ ʔiknaɬa (eating good – at the preferred rate) consumers in MU-6 (Koocanusa Reservoir).

The third statement would be more accurately stated as, 'selenium risks are driven by fish consumption in MUs 1-5.' Although consumption of game muscle and organ meat contributes to cumulative selenium risks, it is less than the risk from fish consumption, and selenium risks are below Health Canada and British Columbia Ministry of Environment and Climate Change Strategy (ENV) risk thresholds (i.e., HQ<1). This is true for cumulative selenium risks in MUs 1-5 when evaluated individually and combined as valley-wide exposure.

1.2 Risk Characterization Adequacy

The KNC Comment Memo asserts there is major limitation in the risk characterization provided in the HHRA. The comment states:

> "However, there is still a major gap and deficiency in the risk characterization section. Although high-risk groups are identified (Ktunaxa, sports fishers and Ktunaxa that are sukiɫ ʔiknaɫa), there is no clear characterization of the risk of health effects associated with increased Hazard Index among Ktunaxa people with different consumption rates of ʔa·kpiʞis (favourite food). (Page 2)

Response: The risk characterization in the HHRA meets Health Canada Detailed Quantitative Risk Assessment (DQRA) guidance as described further under Section 4 in this memo. Technical concerns regarding linking risk estimates to health effects are discussed in Section 5 of this memo.

1.3 Permit Requirements Regarding Risk Ranking and Recommendations for Adaptive Measures

Following the assertion that there is a major limitation in the risk characterization identified in Section 1.2, the KNC Comment Memo states:

> "Also, no ranking of risk or recommended adaptive measures as per the permitting requirement are presented." (Page 2)

Response: Section 6 of this memo provides a detailed response regarding prioritization of risks and risk ranking in the Second Revised HHRA. Recommendations and adaptive management measures based on the HHRA findings are provided in Sections 7.3 and 7.4, respectively, of the Second Revised HHRA. Additional response regarding recommendations for adaptive measures is discussed in Section 7 of this memo.

1.4 Combining Risks for MUs

Additionally, the following statement is made in the introductory portion of the KNC Comment Memo:

> "We are also not confident that it is appropriate to combine findings for MUs 1-6." (Page 2)

Response: Risks are evaluated on an individual MU basis and valley-wide basis, as presented in the Executive Summary and throughout the body of the report and appendices. The 'valley-wide' risks presented in the HHRA are for MUs 1-5 combined. The HHRA Workgroup collectively identified a need for, defined, and agreed to "valley-wide" as MUs 1-5 and not MUs 1-6 because inputs to the watershed are predominantly mine-influenced in MUs 1-5, while inputs to MU-6 (Koocanusa Reservoir) include non-mining sources as well as mining influences from the Elk River. Risk results for MUs 1-6 combined were included in the Revised Final HHRA (June 2023) as an additional analysis in the Uncertainty Assessment to provide information for individuals who consume fish from MUs 1-6.

Defining valley-wide as MUs 1-5 is more conservative than combining MUs 1-6 because exposure point concentrations (EPCs) in MUs 1-5 reflect predominantly mine-influenced sources, whereas non-mine influences are also present in MU-6. However, the current definition of valley-wide may not adequately characterize risk for people who regularly consume fish in MU-6 in addition to the rest of the Elk Valley watershed, which is why an additional analysis of selenium risks was completed for people who consume fish in MUs 1-6 in the Uncertainty Assessment (Section 6.11 of the HHRA).

1.5 Inclusion of Risks for Dust

The KNC Comment Memo shares concerns regarding inhalation risks stating:

> "We were also concerned that respiratory exposure was determined to be outside of the scope of Permit 107517 as it is focused on impacts to water. From our perspective, inclusion of all routes of exposure will provide greater confidence in the HHRA, findings and determination of risk and potential health effects." (Page 2)

Response: To satisfy Permit 107517 Section 8.10 and inform the Adaptive Management Plan (AMP) while also addressing questions raised by the HHRA Workgroup, the HHRA evaluated risks directly associated with exposures to surface waters that may receive inputs from the mines and risks indirectly associated with exposures to mine-impacted surface water. Direct exposures to constituents of potential concern (COPCs) in soil and dust, such as via incidental ingestion or inhalation of particulates released to air, are not included in this HHRA because these exposure pathways are not associated with water. These exposure pathways have not been a focus of the HHRA over the last six years. However, potential impacts from mine dust are considered indirectly through evaluation of berries, rose hips, and game. COPC concentrations in berries and rose hips will reflect deposition of dust to vegetation and uptake from soil, if any. Similarly, COPC concentrations in game meat reflect dust that may have been deposited on vegetation, and COPCs taken up into plants from soil, consumed by wildlife.

The focus of the HHRA on risks associated with exposures to water and water-associated media inform water quality management practices, and risks for other media provide additional information informing other potential sources of exposures. Because community concerns have been raised regarding respiratory exposures and dust, these exposure pathways are briefly addressed in the HHRA, discussed in Section 1.2 (Introduction), Section 2.2.2. (Conceptual Site Model), Section 6.11.1 (Uncertainty Assessment), Section 7.2 (Conclusions), and Appendix J (Consideration of Non-Water Quality Pathways Not Evaluated in Permit 107517 HHRA). Section 6.11.1 and Appendix J provide the most detailed discussion of these pathways, wherein Baldy Ridge Extension HHRA results for incidental soil ingestion and inhalation of dust in air are discussed. In the Baldy Ridge Extension HHRA, selenium intakes from soil and air exposure pathways were shown to contribute less than one percent of the total HI for selenium. Although these results demonstrate that soil and air pathways are insignificant contributors to total HI, Section 7.3 (Recommendations) of the HHRA includes a recommendation to address community concerns about dust through collection and analysis of rinsed and unrinsed berry and other vegetation samples.

1.6 Adequacy of Current Mitigations and Protection of Human Health and Ktunaxa Rights

The KNC Comment Memo indicates that:

> "It is clear from this report that current mitigations are insufficient to be protective of human health and Ktunaxa rights. The multiple benefits related to the harvest and use of ʔa·kpiȼis (especially local fish), including health, nutrition and food security benefits have been significantly impacted. Mining in the Elk Valley has and continues to directly increase the likelihood of poor

health outcomes for Ktunaxa who rely on ʔa·kpiʼǂis (especially fish) and indirectly increase the likelihood of poor health outcomes for those who are food insecure and for those who no longer have confidence in eating ʔa·kpiʼǂis because of contamination.” (Page 2)

Response: The HHRA did not nor was intended to evaluate current or planned mitigations. The HHRA evaluated the potential for adverse health risks using approved methodologies and risk management thresholds defined in the British Columbia (BC) Contaminated Sites Regulation (CSR) and Health Canada’s Human Health Risk assessment guides. Risk estimates were ranked consistent with guidance from Health Canada and BC ENV. Hazard quotients (HQs) equal to or less than 0.2 and cancer risks equal to or less than 1 additional cancer case in 100,000 are considered negligible; HQs equal to or less than 1, and HQs and cancer risks consistent with reference areas are considered to have acceptable risks; and HQs greater than 1 and background, and cancer risks greater than 1 in 100,000 and background require further evaluation and may require mitigation.

The HHRA identified selenium and nitrate as the primary risk drivers in the Elk Valley (in MUs 1 to 5). Selenium and nitrate are two of the mining-related constituents of concern addressed in the Elk Valley Water Quality Plan (EVWQP) and Permit 107517, and are the main constituents targeted for mitigation (refer to Section 8.5 of the EVWQP and implementation plan adjustments).

The HHRA used monitoring data obtained from 2015 to 2020. Since 2020, water treatment capacity in the Elk Valley has increased four-fold. Teck’s current water treatment facilities (which have a total treatment capacity of 77.5 million litres per day) are achieving approximately 95% removal of selenium and nitrate from treated water and are improving water quality. Further significant reductions of selenium and nitrate are expected as Teck brings additional facilities online and additional sources are treated. By the end of 2027, water treatment capacity in the Elk Valley is projected to be 142 million litres per day.

In addition to water treatment, Teck’s Research and Development Program is researching and implementing methods to control selenium and nitrate release at the source. These source control measures include geosynthetic covers, water diversions, and nitrate prevention techniques (such as blast-hole liners that prevent the nitrate in explosives from entering the watershed).

The HHRA recommends refining monitoring programs, particularly for wild foods (fish, game, berries), to address some of the uncertainties that underly the risk estimates. The HHRA also recommends developing and implementing a routine health risk-based data screening process to evaluate data as it becomes available. Improved monitoring program data and routine data screening will provide timely information that will help inform if additional risk management actions are required.

2. RISK CHARACTERIZATION TEXT EXPANSION

The suggested text expansion for cumulative noncancer risks under the KNC Comment Memo sub-header *Cumulative risks or HIs of different receptors,* has been added to the Second Revised Final HHRA, Section 6.10 (Risk Characterization).

A new section has been added to the HHRA, Section 6.10.1, *Characterizing Cumulative Selenium Risks*, which includes the first seven paragraphs (with the exception of the paragraph discussing acute toxicity, see Section 5.2 of this memo for explanation) of the suggested text expansion under the KNC Comment Memo sub-header, *Characterizing the health risk indicated by the HI estimate*.

In the redline version of the Second Revised Final HHRA provided to the KNC (October 2023), the suggested text provided in the KNC Comment Memo is shown in *italics* with minor text revisions shown in redline/strike-out font. Additional text regarding the risk prioritization/ranking applied in the HHRA has also been added to Section 6.10.1.

3. UNCERTAINTY ASSESSMENT TEXT EXPANSION

As suggested in the KNC Comment Memo, a brief discussion of the more recent scientific literature on selenium toxicity that is not included in Health Canada's selenium toxicity assessment and derivation of the toxicity reference value (TRV) has been added to Section 6.11.5 (Toxicity Assessment Uncertainties). The revisions include a discussion of the 2023 European Food Safety Authority (EFSA) tolerable upper intake level (UL) for selenium. Additional revisions to the uncertainty assessment discussion relating to proposed risk ranking were not included in the Second Revised Final HHRA for reasons presented in Section 5 and 6 of this memo.

4. THE RISK CHARACTERIZATION SATISFIES GUIDANCE FROM HEALTH CANADA AND ENV

The KNC Comment Memo states that

> "…there is still a major gap and deficiency in the risk characterization section." (Page 1).

The risk characterization presented in the HHRA (Section 6) is consistent with guidance from ENV (2023)[2] and Health Canada (2010)[3] for detailed risk assessment. Health Canada (2010) DQRA guidance states that a risk characterization should:

- Integrate the results of the exposure and toxicity assessments to determine whether a human health risk may be expected;
- Analyze, quantify (where appropriate), and discuss uncertainty in the overall HHRA process, thus providing some indication of the validity or confidence of risk estimates; and
- Describe the risks in terms of magnitude, type, and uncertainty involved. (Page 7-8).

ENV (2023) and Health Canada (2010) require that risk metrics (i.e., hazard quotients, hazard indices, and/or incremental human lifetime cancer risks) be calculated to estimate the magnitude and severity of risks and inform risk management and decision making. Health Canada (2010, 2019)[4] emphasizes the

[2] ENV. 2023. Protocol 1 for Contaminated Sites. Detailed Risk Assessment. Version 4.0. British Columbia Ministry of Environment and Climate Change Strategy. March.

[3] Health Canada. 2010. Federal Contaminated Site Risk Assessment in Canada. Part V: Guidance on Human Health Detailed Quantitative Risk Assessment for Chemicals (DQRAChem). Ottawa, ON: Government of Canada.

[4] Health Canada. 2019. Guidance for Evaluating Human Health Impacts in Environmental Assessment: Human Health Risk Assessment. Ottawa, ON.

importance of incorporating background exposures into the risk estimates, and ENV (2023) requires that background be accounted for in the risk characterization in accordance with BC CSR Section 18(5) (BC 2021).[5] When integrating results of the exposure and toxicity assessments, noncancer risk estimates should be compared to a hazard quotient (HQ) of 1. In Health Canada DQRA and ENV detailed risk assessment, HQs less than 1 represent 'acceptable or negligible risk.' HQs greater than 1 do not necessarily mean that there are expected adverse health effects, but require further evaluation and may require risk management. When HQs greater than 1 are identified, Health Canada recommends reducing uncertainty to allow for refinement and improved accuracy of risk estimates. The HHRA conforms to this guidance, presenting risks in the context of Health Canada's risk management threshold of 1, and providing additional analysis (Section 6.11 of HHRA) and recommendations (Section 7.3) for reducing uncertainty and refining risks.

5. LINKING HIS TO HEALTH EFFECTS

The KNC Comment Memo includes a detailed discussion of health effects reported for varying exposure levels and recommends using available studies to develop a risk ranking system that would assign HIs to classifications ranging from minimal to very high risk. A table is presented wherein the classifications for ranges of HIs are defined by doses associated with the no observable adverse effect level (NOAEL) and lowest observable adverse effect level (LOAEL) for chronic selenium exposure reported by Yang and Zhou (1994),[6] and a calculated cutoff based on the lowest acute toxic dose reported by Morris and Crane (2013)[7] to result in acute health effects averaged over 365 days instead of 30 days. Due to concerns about the technical soundness of applying an acute value to evaluate chronic effects and contradiction with Health Canada guidance on associating HHRA results with health effects, the Second Revised Final HHRA does not directly link specific adverse effects with HQs or HIs. Instead, the HHRA retains the ordinal prioritization of risks to inform recommendations, discussed in Section 6 of this memo and in numerous locations in the Second Revised Final HHRA.

The KNC Comment Memo states that in the HHRA, "…there is no clear characterization of the risk of health effects associated with increased Hazard Index among Ktunaxa people with different consumption rates of ʔa·kpiƛ̓is (favourite food)."

As qualified professionals, we cannot support characterizing HQs or HIs greater than 1 according to the likelihood of health effects. This is consistent and supported by Health Canada risk assessment guidance. When interpreting HQs greater than 1, Health Canada DQRA guidance notes:

> "It is important to note that the magnitude of the HQ does not necessarily correspond to the magnitude of expected health effects. A TDI or RfD [tolerable daily intake or reference dose] does

[5] British Columbia. 2021. Environmental Management Act Contaminated Sites Regulation. B.C. Reg. 375/96 (O.C. 1480/96), deposited December 16, 1996 and effective April 1, 1997. Last amended July 7, 2021 by B.C. Reg. 179/2021. Prepared by Office of Legislative Counsel, Ministry of Attorney General. Victoria, B.C.

[6] Yang, GQ, and Zhou, RH. 1994. Further observations on the human maximum safe dietary selenium intake in a seleniferous area of China. Journal of Trace Elements and Electrolytes in Health and Disease 8(3-4): 159–165

[7] Morris JS, Crane SB. Selenium toxicity from a misformulated dietary supplement, adverse health effects, and the temporal response in the nail biologic monitor. Nutrients. 2013 Mar 28;5(4):1024-57. doi: 10.3390/nu5041024. PMID: 23538937; PMCID: PMC3705333.

not distinguish between health and disease. The TDI represents a conservative estimate of human dose that will be free of health effects in the vast majority of the population. The extent by which a TDI must be exceeded before health effects could occur is not known." (Health Canada 2010, p. 78)

When estimated HQs are above 1, there is no standard approach from Health Canada or ENV to use the HQs to characterize the health risk. To our knowledge, no international risk assessment guidance recommends categorizing risk further when HQs or HIs are above one. This is likely due to the numerous uncertainties in tying toxicological reference points to observed health effects and the conservatism of risk estimates, as described in the HHRA and in Section 5.1, below. In addition to Health Canada and ENV, both the United States Environmental Protection Agency (USEPA; 1989)[8] and EFSA (2019)[9] specify that risk characterization should classify risk as acceptable or unacceptable based on a specified risk threshold (e.g., HQ of 1). If risks are found to be unacceptable, then further evaluation is necessary and risk management may be needed, consistent with the approach and recommendations of the EVWQP HHRA. No categorization of risks above risk management thresholds is recommended. The risk ranking approach proposed in the KNC Comment Memo is not standard in Health Canada or international risk assessment guidance, is not standard practice, and is not technically defensible. However, other methods of risk ranking/ prioritization of risks are appropriate in risk characterization and have been applied in the Permit 107517 HHRA. The risk ranking approach applied in the HHRA is discussed in Section 6 of this memo.

5.1 Risk Assessment Methodology Does Not Constitute Biomonitoring or a Health Study

Human health risk assessment methodology is an empirical model used in decision-making and the model is not adequate to predict actual health effects in individuals or populations. To tie COPC exposures to health effects, biomonitoring data, (i.e., exposure measures based on blood, urine, or other biological samples) and clinical data measuring signs and symptoms in communities are needed. In addition, other exposures or conditions that could be responsible for the observed effects (confounding factors) must also accounted for. The Yang and Zhou (1994) study used by Health Canada as the basis for the selenium TRV evaluated chronic exposure to selenium via diet, conducted biomonitoring, collected clinical health data, and considered potential confounding effects. All of these study elements were needed to determine the no observed adverse effect level for selenium in this population.

Similarly, Morris and Crane (2013) evaluated individuals who had acute overexposure to selenium after taking a selenium supplement that had been formulated incorrectly and had much higher selenium concentrations than the label indicated. Morris and Crane (2013) collected biological samples (toenails) and conducted a health survey, and in this way were able to estimate doses associated with reported health effects. In both the Yang and Zhou (1994) and Morris and Crane (2013) studies, the reported

[8] United States Environmental Protection Agency. 1989. Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A). EPA/540/1-89/002. Office of Emergency and Remedial Response. Washington, D.C. December.

[9] European Food Safety Authority Scientific Committee. 2019. Guidance on harmonised methodologies for human health, animal health and ecological risk assessment of combined exposure to multiple chemicals. EFSA Journal 2019;17(3):5634, 77 pp. https://doi.org/10.2903/j.efsa.2019.5634

health effects and the doses associated with effects varied among the observed population, which is likely due to differences in interindividual susceptibility.

Generally, many studies which include biomonitoring and clinical data are needed to characterize doses associated with adverse effects due to the complexity of these measurements in people and the variability in findings. Human health risk assessments are not designed to predict actual health effects in individuals or populations and should not be interpreted as providing this level of data. Human health risk assessments are useful in identifying a potential for risk associated with exposure to specific chemicals, environmental media, or exposure pathways and in indicating priorities among varying exposure scenarios.

5.2 Use of a Short-term High Dose (Acute) Study to Evaluate Long-term Health Effects

The risk ranking approach proposed in the KNC Comment Memo contradicts toxicological principle by averaging an acute dose over a longer time-period to achieve a "chronic" effective dose. Specifically, the KNC Comment Memo proposes the following:

> "Based on the toxicity assessment information discussed above, we propose a 5-level ranking system to classify the level of health risk. There is little information to estimate the dose range for the high risk for chronic effects of selenium exposure. We propose using a cutoff based on the lowest observable acute effects, 22,300 ug per day over 30 day (Morris and Crane 2013). Assuming the cumulated dose is taken over one year or 365 days, the estimated daily dose will be 1833 ug or an HI of 4.6." (Page 7)

Use of an acute exposure study to estimate chronic effects is highly problematic because high exposures over a short time-period (i.e., acute exposures) can overwhelm clearance and detoxification processes and result in adverse effects that are different and more severe than would occur if the dose was fractionated over a long time-period. For example, consumption of a whole bottle of aspirin in a day could be highly toxic, while exposure over the course of a year can have health benefits. Acute exposure doses cannot be adjusted to HI values using a toxicity value derived to evaluate chronic effects (in this case, the Health Canada TRV for selenium) and compared with the HHRA HIs because the toxicological basis is different. Risk assessment guidance from Health Canada (2010) and USEPA (1989) clearly state that the toxicity criteria should match the exposure period (i.e., acute, sub-chronic, or chronic). During the HHRA Workgroup call on September 14, 2023, Ramboll toxicologists raised concerns regarding the use of acute exposure data and KNC's consultant agreed that the use of an acute study as a basis was not essential in deriving a ranking system.

6. RISK RANKING

The proposed risk ranking in the KNC Comment Memo aligns HI ranges with classifications of risk ranging from minimal to very high. These classifications are then assigned to each receptor evaluated in the HHRA, based on the calculated selenium HIs. In this way, the results of the risk characterization are translated from numerical results (i.e., HIs) to qualitative descriptors (minimal, low, moderate, high, and very high). This translation of results from quantitative to qualitative ranking is overextending what can be learned from the risk assessment model because risk estimates cannot be directly linked to adverse effects as described in Section 5 of this memo.

Responses to specific comments in the KNC Comment Memo on including a risk ranking in the HHRA are presented in this section.

6.1 Guidance on Risk Ranking

As described in Section 5, Health Canada guidance does not provide recommendations for ranking HIs greater than 1. The ranking approach applied in the Second Revised Final HHRA is consistent with guidance from Health Canada (2010, 2019) which emphasizes the importance of baseline conditions (e.g., reference and background diet), the magnitude of risks, and the uncertainties in risk estimates. Attachment 1, Table 7.2 of Health Canada (2019), provides additional guidance regarding the determination and ranking of human health risks.

The references provided in the KNC Comment Memo regarding risk ranking (Cefas 2023; Benson et al. 2018; Saydam Eker 2020) are not relevant for characterizing risks in the HHRA. The risk ranking system referenced from the United Kingdom's Centre for Environment, Fisheries, and Aquaculture Science (Cefas; 2023) is intended for acute hazards, while the HHRA is focused on chronic, lower-level exposures. The Cefas guidance is focused on response actions for offshore chemical spills and specifically notes that inorganic substances (such as selenium) are not amenable to the model. The risk ranking approach used in Benson et al. (2018) and Saydam Eker (2020) is only applicable to ecological risks. Ranking is based on probable effect levels, threshold effect level, and severe effect levels. These are measures of toxicity applied to assess risk for ecological receptors, and not applicable to human health risks. Although Saydam Eker (2020) also evaluates human health risk in their paper, they do not apply a risk ranking to the human health risks.

6.2 Risk Ranking in the Second Revised Final HHRA

Risks are prioritized in the Second Revised Final HHRA consistent with Health Canada and ENV guidance based on comparison with a preliminary risk threshold of HQ of 0.2, and an HQ of 1. Risks related to consumption of fish, game, berries, and rose hips are also compared with HQs derived for reference areas. These assessments are provided throughout the risk characterization section of the HHRA and in detail within the Executive Summary Table ES-3. Health Canada and ENV guidance also note the importance of considering uncertainties in the risk assessment findings and the HHRA has an extensive uncertainty assessment section. Key uncertainties are summarized in Table ES-3.

In interpreting the findings of the HHRA for next steps, the receptor with the highest HI (i.e., Ktunaxa toddler) and the COPCs (i.e., selenium and nitrate), exposure media (i.e., fish and other foods, surface water), and MUs (1-5) associated with the highest HIs are prioritized for further investigation to reduce uncertainties, refine risk, and inform risk management decisions. Receptors and exposure media associated with lower HIs that are greater than 1 are given next priority, and so forth. HIs below 1 are not prioritized.

In the Second Revised Final HHRA, redline text has been provided at numerous locations, as described below, to prioritize risks and to clarify the ranking of risks. New text has been added under "What is Human Health Risk Assessment" within the Executive Summary to state the following:

"Risk estimates are ranked in the HHRA consistent with guidance from Health Canada (2010a, 2019) and ENV (2023). This risk ranking or prioritization of risks can be used to prioritize data gathering and risk management activities to better understand and reduce risks. As indicated in Table ES-1, HQs equal to or less than 0.2 and cancer risks equal to or less than 1 additional cancer case in 100,000 are considered negligible; HQs equal to or less than 1, and HQs and cancer risks consistent with reference areas are considered to have acceptable risks; and HQs greater than 1 and background, and cancer risks greater than 1 in 100,000 and background require further evaluation and may require risk management. Although risk estimates cannot be directly linked to specific health effects, we assume as risk estimates increase the potential for health risk increases. For this reason, exposure pathways and receptors with the highest risk estimates (e.g., fish consumption by toddlers consuming at preferred levels) will be the highest priority for data gathering and risk management, as needed."

New text has also been added in the following locations: the Introduction; in Section 6.1; in new sections 6.1.1, 6.2.1 and 6.10.1; and in Section 7.2.

7. RESPONSE TO SUGGESTED TEXT FOR RISK MANAGEMENT MEASURES (SECTION 7.4)

The KNC Comment Memo asserts that the HHRA does not provide recommended adaptive measures, as required by the permit. Recommendations and adaptive management measures based on the HHRA findings are provided in Sections 7.3 and 7.4 of the HHRA. The recommendations included in the HHRA (Section 7.3) include supporting future risk communication efforts, refining future monitoring efforts to improve human health risk estimates, developing and implementing a health risk-based data evaluation process in sequence with the monitoring data reporting cycle to inform health risks, and purposeful and mindful engagement with Ktunaxa knowledge in future study development.

Adaptive management actions needed to address human health risks described in the HHRA (Section 7.4) include development of a risk-based data evaluation process that can be implemented in synchrony with the completion of each Regional Aquatic Effects Monitoring Program (RAEMP) cycle and associated risk management, along with water treatment as detailed in Teck's 2022 Implementation Plan Adjustment.

The KNC Comment Memo states that risk management measures are needed to reduce selenium intake in the Elk Valley. Two options are presented:

1. To better control the release and bioavailability of selenium to the receiving environment and decrease the concentrations of selenium in the water and eventually lower the concentrations of selenium in the fish.
2. To issue consumption advisory to the Upper Percentile consumer recreator and Ktunaxa toddlers to limit the amount of fish consumed and to encourage the Ktunaxa toddlers and adults NOT to consume fish at their preferred rate.

The first option, to some extent, is already covered in HHRA Section 7.4., Adaptive Management for Human Health (i.e., water treatment as detailed in Teck's 2022 Implementation Plan Adjustment). Additional detail regarding selenium water treatment and associated risk management measures are beyond the scope of the HHRA and will be addressed by a larger group of stakeholders working to maintain and advise on the adaptive management process. The second option, issuing a fish consumption advisory, is the responsibility of the provincial government. It is outside the scope of the HHRA and Teck's authority to recommend a fish consumption advisory.

8. HOW HHRA RESULTS CAN BE USED BY COMMUNITIES

Although it was not part of the formal KNC Comment Memo concerns were raised during the September 14, 2023 HHRA Workgroup call regarding how the HHRA would be used by communities if the proposed ranking was not applied. This section describes edits made to the HHRA to clarify how the HHRA results can be used by communities. The Executive Summary section 'What Are the Next Steps?" has been edited to include the following text (shown here in *italics*):

> **What Are the Next Steps *- How Will the HHRA Be Used?***
>
> The HHRA helps us understand what activities result in negligible or elevated risks in the Elk River watershed and whether water quality is being managed to be protective of human health. *Risk estimates are ranked in the HHRA consistent with guidance from Health Canada (2010a, 2019) and ENV (2023). This risk ranking or prioritization of risks can be used to prioritize data gathering and risk management activities to better understand and reduce risks. Exposure pathways for receptors that result in noncancer risk estimates (i.e., HQs) equal to or less than 0.2 are considered negligible; HQs equal to or less than 1, or consistent with reference areas, are considered to have acceptable risks; and HQs greater than 1 and background require further evaluation and may require risk management. Cancer risks were similarly ranked, by comparison with the ENV risk management threshold. Cancer risks equal to or less than 1 additional cancer case in 100,000 are considered negligible; cancer risks consistent with reference areas are considered to have acceptable risks; and cancer risks greater than 1 in 100,000 and background require further evaluation and risk management.*
>
> *No cancer risks were identified that were greater than 1 in 100,000 and reference, but some HQs were greater than 1 and reference. Although risk estimates cannot be directly linked to specific health effects, we assume that as risk estimates increase the potential for health risk increases. For this reason, exposure pathways and receptors with the highest risk estimates (e.g., fish consumption by toddlers consuming at preferred levels) will be prioritized for data gathering and risk management, as needed.*
>
> Continued monitoring of environmental media and locally harvested foods is important to help us understand potential risks. Ongoing efforts to address releases to surface water are expected to reduce selenium and nitrate concentrations. Continued implementation of the Elk Valley Water Quality Plan (which includes water treatment and source control measures) is expected to improve selenium and nitrate concentrations in the Elk Valley watershed. Ongoing monitoring of selenium in surface water and fish tissue will inform our understanding of selenium uptake in fish and the potential for exposure to people consuming fish.
>
> Looking ahead, a review and possible revision of components of environmental monitoring programs relevant to human exposures will help Teck respond to specific questions such as which specific fish species, game, or berries most influence health risks, and help us identify potential risks associated with specific harvest locations. In addition, continued monitoring and

reporting in association with the environmental monitoring programs and inputs to the adaptive management process will serve as mechanisms for identification of increasing or decreasing chemical constituent concentrations that may affect potential health risks.

Teck will continue working with the HHRA Workgroup to respond to questions about human health risk within the Elk Valley (MUs 1 through 5) and Koocanusa Reservoir (MU-6), and will support the collection of data used to answer the question “Is water quality being managed to be protective of human health” as operations change into the future.

ATTACHMENT 1

TABLE 7.2: DETERMINATION OF HUMAN HEALTH RISKS FROM HEALTH CANADA (2019)

TABLE 7.2: Determination of Human Health Risks

Residual effects criteria	Analysis criteria	Discussion
Context	Comparison of assessment scenarios (e.g., baseline scenario with baseline plus project and future developments)	For each assessment scenario, determine whether risk estimates of the baseline plus project scenario and future development scenario are higher than those of the baseline scenario and by how much.
Magnitude	Identification of key exposure pathways	Identify key pathways that are contributing to the risk estimates and describe relative contributions to help understand the degree of conservatism and uncertainty in the risk estimates.
	Magnitude of risk estimates and cumulative risk estimates in the assessment scenarios (e.g., project alone, baseline plus project, baseline plus project plus any reasonably foreseeable future development)	For each assessment scenario, identify affected receptors and receptor locations, and determine the magnitude of the estimated risk level compared to the baseline level for the COPC in question. Some considerations that may influence the evaluation of the magnitude of an effect include: • natural variability, normal fluctuations or shifts in baseline conditions (e.g., if the population has already been adversely affected by other physical activities or natural change, vulnerable sub-populations) • scale at which magnitude is considered (e.g., the percentage of a population affected may represent 80% at the local level and 5% at the regional level)
Prediction confidence and uncertainty	Conservatism and uncertainty in predictions	Identify the sources of uncertainty related to the predictions and the deposition rates used to predict COPC concentrations (e.g., uncertainty related to emission rates and mitigating factors). Indicate whether the prediction is most likely an overall overestimate, underestimate or reasonable estimate of COPC concentrations.
	Conservatism in the exposure assumptions	Identify the sources of uncertainty in the exposure assumptions used in the exposure dose calculations (e.g., whether an average or a reasonable maximum consumption rate was used in the exposure estimates).
	Conservatism in the TRVs	Identify the sources of uncertainty in the key studies used to derive the TRV and the uncertainty factors that were applied to derive the TRV.
Determination of an overall risk		Provide an overall rating of risks based on the ratings and uncertainties described above (negligible, low, moderate or high), which includes a rationale. Discuss this rating.