KEMESS UNDERGROUND PROJECT

Human Health Follow-up Program

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Human Health Follow-up Program

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GLOSSARY AND ABBREVIATIONS

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

Agency, the	The Canadian Environmental Assessment Agency
AQMP	Air Quality Monitoring Plan
BC	British Columbia
BC MOE	British Columbia Ministry of Environment & Climate Change Strategy
CCME	Canadian Council of Ministers of the Environment
COPC	Contaminant of potential concern
CSF	Cancer slope factor
EAC	Environmental Assessment Certificate
EDI	Estimated daily intake
EEM	Environmental Effects Monitoring
ELDE	Estimated lifetime daily exposure
EMP	Ecosystem Management Plan
FAEMP	Fish and Aquatic Effects Monitoring Plan
FDMP	Fugitive Dust Monitoring Plan
HHFP	Human health follow-up program
HHRA	Human health risk assessment
HQ	Hazard quotient
IBA	Impact Benefits Agreement
ILCR	Incremental lifetime cancer risk
km	Kilometre
KUG	Kemess Underground Project
MA/EMA	*Mines Act/Environmental Management Act*
ML/ARD	Metal leaching/acid rock drainage

MSWMP	Mine Site Water Management Plan
ORAR	Omineca Resource Access Road
Project, the	The Kemess Underground Project
RPD	Relative percent difference
SeMP	Selenium Management Plan
SOP	Standard operating procedure
TKN	Tse Keh Nay
TRV	Toxicity reference value
TSF	Tailings Storage Facility
ww	Wet weight

1. INTRODUCTION

The Canadian Environmental Assessment Agency (the Agency) conducted an environmental assessment of the Kemess Underground Project (KUG; the Project) pursuant to the *Canadian Environmental Assessment Act, 2012* and *the Memorandum of Understanding between the Canadian Environmental Assessment Agency and the B.C. Environmental Assessment Office on the Substitution of Environmental Assessments* (2013). A positive Decision Statement was issued by the Agency on March 9, 2017, with conditions (CEAA 2017). Condition 5 relates to Human Health:

> ***5.1.*** *The Proponent shall develop, prior to construction and in consultation with Indigenous groups and relevant authorities, a follow-up program to verify the accuracy of the environmental assessment as it pertains to adverse effects on the health of Indigenous Peoples caused by changes in concentrations of contaminants of potential concern identified during the environmental assessment in air, soil, water, and sediment. The Proponent shall implement the follow-up program during construction and operation. As part of the development of the follow-up program, the Proponent shall:*
>
> > ***5.1.1.*** *identify levels of environmental change relative to established baseline conditions for contaminants of potential concern that would require the Proponent to implement modified or additional mitigation measure(s) to mitigate increased risks to human health; and*
> >
> > ***5.1.2.*** *if monitoring results demonstrate that concentration levels for contaminants of potential concern are greater than the identified levels of environmental change, update the human health risk assessment for the consumption of traditional foods exposed to these contaminants and communicate the results of the updated human health risk assessment to Indigenous groups.*

This document describes the Human Health Follow-up Program (HHFP) to address the above condition.

1.1 PURPOSE AND OBJECTIVES

The purpose of the HHFP is to mitigate potential adverse effects on the health of Indigenous Peoples as a result of the Project. Objectives of the HHFP are to:

1. Enable the Proponent to verify the accuracy of the environmental assessment as it pertains to adverse effects on the health of Indigenous Peoples caused by changes in concentrations of contaminants of potential concern (COPCs) identified during the environmental assessment.
2. Identify levels of environmental change relative to established baseline conditions for COPC that would require the Proponent to implement modified or additional mitigation measure(s) to mitigate increased risks to human health.

As per Condition 5.1.2, mitigation measures may include an update to the human health risk assessment (HHRA) for the consumption of traditional foods exposed to contaminants exceeding identified levels of environmental change. Thus, a country foods risk assessment is one of the endpoints for the HHFP. Focusing a risk assessment to country foods is justified because food ingestion can be a significant pathway of exposure in humans to contaminants, contaminants can bioaccumulate in the food chain, and animal food (meat or fish) can migrate from high-exposure locations to traditional hunting/fishing areas distant from Project sites, where exposure pathways to Project-related contaminants in air and water are much less significant.

The HHFP contains the following components:

- a review of the COPCs identified for baseline and Project phases;
- a summary or relevant monitoring commitments contained in other Project monitoring and management plans, specifically:
  - Mine Site Water Management Plan (MSWMP),
  - Fish and Aquatic Effects Monitoring Plan (FAEMP),
  - Selenium Management Plan (SeMP), and
  - Ecosystem Management Plan (EMP);
- a sampling plan for supplemental sampling of environmental media necessary for country foods monitoring that are not covered under other monitoring plans;
- identification of levels of environmental change relative to baseline conditions in media that would require the Proponent to implement modified or additional mitigation measure(s) to mitigate increased risks to human health;
- an outline of the country foods risk assessment steps;
- methodology for the derivation of hazard quotients (HQs) and incremental lifetime cancer risks (ILCRs); and
- a data management and reporting framework.

There is limited use of the KUG mine site area by Indigenous peoples and AuRico Metals Inc. (acquired by Centerra Gold Inc.) has agreed to an area of restricted access ("exclusion area") around the mine site through their Impact Benefits Agreement (IBA). The IBA for the Project was established between AuRico Metals Inc. and the Tse Keh Nay (TKN) First Nations in May 2017. The TKN is an alliance of the Takla Lake First Nation, the Tsay Keh Dene Nation, and Kwadacha Nation. Thus, the HHFP is another layer of measures to avoid impacting the health of Indigenous peoples.

1.2 General Approach

As indicated in Condition 5.1, the objective of the HHFP for the Project is to 1) verify the accuracy of the environmental assessment and to 2) identify levels of environmental change at which modified or additional mitigation measure(s), including an update of the country foods risk assessment, to mitigate increased risks to human health may be implemented. The country foods evaluated in the Project's Application for an Environmental Assessment Certificate (EAC Application; AuRico 2016) were:

- berries: crowberry and soapberry (measured COPC tissue concentrations);
- freshwater fish: Bull Trout, Dolly Varden, Whitefish, and Rainbow Trout (measured COPC tissue concentrations);
- moose (COPC tissue concentrations calculated with a food chain model);

- snowshoe hare (COPC tissue concentrations calculated with a food chain model); and
- ruffed grouse (COPC tissue concentrations calculated with a food chain model).

The calculation of COPC tissue concentrations for moose, snowshoe hare, and ruffed grouse using a food chain model (Golder Associates Ltd. 2005) requires the input of measured COPC concentrations in surface water, soil, and diet items (i.e., vegetation). Thus, the environmental media data that would be required for an updated HHRA for country foods includes: surface water, soil, fish tissue, and vegetation tissue (berries for human consumption and vegetation diet items for moose, hare, and grouse) COPC concentrations.

Monitoring of air quality (i.e., dustfall levels and metals in dustfall) is not required for the HHFP as potential COPCs from the Project through atmospheric deposition will be addressed with the monitoring of metal concentrations in soil and vegetation samples. Monitoring of other parameters in air under the HHFP is not required by Condition 5 as criteria air contaminants (CACs), such as NO_2 or particulate matter, were not COPCs in the original EAC Application (i.e., did not meet the criteria to be considered COPCs, see Section 18.5.2.2 of the EAC Application). However, monitoring of some air quality parameters (including NO_2, SO_2, and particulate matter) is included in the Air Quality Monitoring Plan (AQMP; AuRico 2020a) and in the Fugitive Dust Monitoring Plan (FDMP; AuRico 2020c). Results of monitoring under the AQMP will be considered in reporting under the HHFP (Section 8) if exceedances of applicable objectives or standards for these parameters are identified in the AQMP or the FDMP.

Monitoring of relevant environmental media (i.e., surface water, sediment, soil, vegetation, fish tissue) is described in a series of other monitoring and management plans developed for the Project. It is assumed that if there is no change in these environmental media, the quality of country foods will not change and will not require an update to the risk assessment. Therefore, the HHFP relies on commitments and results from the other monitoring plans developed for the Project. Where warranted, the HHFP includes supplemental sampling specifically designed to meet the objectives of the HHFP and needs of a potential future update to the country foods risk assessment. The general adaptive management structure of the HHFP is as follows:

1. Monitoring of surface water, sediment, soil, vegetation, and fish tissues as per the MSWMP, FAEMP, SeMP, and EMP.
2. Should soil or vegetation sampling within the Project footprint under the existing Ecosystem Management Plan indicate increasing COPC concentrations (i.e., above soil metal or vegetation metal concentrations predicted in the EAC Application), additional soil and vegetation samples will be collected from outside of the Project footprint that are accessible to potential country foods consumers (i.e., supplemental sampling).
3. If levels of environmental change (defined in Section 5) are exceeded in environmental media, the combined environmental media sampling results will be used to update the HHRA for country foods and/or will trigger adaptive management actions described in other management plans, such as:
   - alteration of drainage pathways, re-evaluation of the water balance and water quality model, diversion of non-contact water, water treatment options, and re-evaluation of discharge limits (discussed in Sections 5 and 8 of the MSWMP; AuRico 2017c);

  - initiation of additional fish and aquatic habitat Adaptive Management Monitoring Programs and control charting using control datasets (discussed in Section 8.3.7 of the FAEMP; AuRico 2017a);
  - corrective actions to lower selenium concentrations in the environment (discussed in Section 8 of the SeMP; AuRico 2017d); and
  - corrective action or additional control measures to reduce negative effects to soils and vegetation (discussed in Section 6.3.2 of the EMP; AuRico 2020b).
4. The results and uncertainties of the updated HHRA for country foods will be compared to established baseline and predicted Project results to verify the accuracy of the environmental assessment as it pertains to adverse effects on the health of Indigenous Peoples and to indicate whether an increased risk to consumers of country foods exists due to Project activities.
5. Adaptive management/mitigation measures will be reviewed and additional measures will be considered if a significant increase in risk to consumers of country foods due to Project activities is identified.

This phased approach will provide an integrated approach with other ongoing monitoring programs within the Project area, maintains monitoring techniques of historical data collection approaches to allow comparability with previous and ongoing sampling in the Project area, and addresses the requirements of federal HHRA guidelines.

1.3 APPLICABLE GUIDANCE

The HHRA methodology is based on Health Canada's guidelines for HHRAs and environmental assessments (Health Canada 2010a, 2010e, 2010d), which were used in the original EAC Application. Health Canada (2007) also provides a management strategy to reduce the risk of unacceptable exposures to mercury from fish consumption, which is also considered.

2. REVIEW OF CONTAMINANTS OF POTENTIAL CONCERN

The EAC Application (AuRico 2016) identified COPCs for human health under established baseline and predicted Project conditions (i.e., the Construction and Operations phases). Specific contaminants were selected as COPCs if they met at least one of the following five screening criteria:

1. The concentration of metals bound to PM_{10} exceeded (or were predicted to exceed) the Texas Commission on Environmental Quality Effects Screening Levels (Texas CEQ 2014) and the Ontario Ministry of the Environment Ambient Air Quality Criteria (Ontario MOE 2012). However, this COPC screening only applies to the inhalation pathway, which is not considered in the HHFP, as it is of lesser significance than the country foods ingestion pathway.
2. The maximum metal concentrations in soil samples considered in the assessment exceeded (or were predicted to exceed) the Canadian Council of Ministers of the Environment (CCME) Soil Quality Guidelines for Agricultural Land Use (CCME 2013).

3. The maximum metal concentrations in surface water exceeded (or were predicted to exceed) the British Columbia Ministry of Environment and Climate Change (BC MOE) Water Quality Criteria for the drinking water supply or Health Canada Guidelines for Canadian Drinking Water Quality, whichever guideline was lower (BC MOE 2015; Health Canada 2015). However, this COPC screening only applies to the drinking water pathway, which is not considered in the HHFP, as it is of lesser significance than the country foods ingestion pathway.
4. Fish tissue metal concentrations considered in the assessment exceeded (or were predicted to exceed) the fish tissue residue guidelines for mercury and selenium:
    a. The BC MOE (Beatty and Russo 2014) screening value of 1.83 mg selenium/kg wet weight (ww) for a high fish consumption rate of >220 g/day.
    b. The Health Canada fish tissue consumption guideline of 0.5 mg mercury/kg ww (Health Canada 2013).
5. Metals that have a potential to bioaccumulate in organisms or biomagnify in food webs, such that there could be significant transfer of the metal from soil to plants and subsequently into higher trophic levels even at concentrations lower than guidelines. These metals include: arsenic, cadmium, lead, mercury, nickel, selenium, thallium, and zinc.

The Joint *Mines Act/Environmental Management Act* (MA/EMA) Permit Application (AuRico 2017b) also evaluated potential changes in COPCs for human health due to updates to air and water quality modelling associated with waste discharge authorizations for the Project. However, no new COPCs were identified during the Joint MA/EMA Permit Application process, thus it is not discussed further. The results of the COPC selection process for the EAC Application are summarized in Sections 2.1 to 2.3; however, the discussion is limited to the COPC screening applicable to country foods (e.g., does not discuss results of screening metals bound to PM_{10}).

2.1 Contaminants of Potential Concern Identified for Human Health under Baseline Conditions in the Environmental Assessment

No CACs were identified as COPCs in the baseline air quality screening (see Section 4.4.1 and Table 4.4-1 of Appendix 18-A of the EAC Application; AuRico 2016).

The COPCs identified in the baseline soil quality screening (see Section 4.5 and Table 4.5-1 of Appendix 18-A of the EAC Application; AuRico 2016) were: arsenic, barium, boron, cadmium, chromium, copper, lead, molybdenum, nickel, selenium, vanadium, and zinc.

The COPCs identified in the baseline surface water quality screening (see Sections 4.6.1 and 4.6.2, Tables 4.6-1 and 4.6-2 of Appendix 18-A of the EAC Application using drinking water quality guidelines; AuRico 2016) were: dissolved and total aluminum, cadmium, iron, lead, manganese, nitrate, selenium, and sulphate. However, iron was not retained as a COPC as it is an essential element for humans and since environmental exposure to iron from food consumption (the largest source of exposure) is not likely lead to adverse health effects. Furthermore, iron is considered an innocuous substance by Health Canada (2010c).

The COPCs identified in the baseline fish tissue concentrations (see Section 4.7.1.2 and Appendix A of Appendix 18 A of the EAC Application; AuRico 2016) were mercury and selenium.

Thus, with the addition of bioaccumulative contaminants, the COPCs selected for the baseline HHRA included: aluminum, arsenic, barium, boron, cadmium, chromium, copper, lead, manganese, mercury, molybdenum, nickel, nitrate (water only), selenium, sulphate (water only), thallium, vanadium, and zinc.

2.2 CONTAMINANTS OF POTENTIAL CONCERN IDENTIFIED FOR HUMAN HEALTH UNDER PROJECT-RELATED CONDITIONS IN THE ENVIRONMENTAL ASSESSMENT

No CACs were identified as COPCs during the Construction or Operations phases based on screening of air quality predictions (see Section 3.3.1 and Table 3.3-1 of Appendix 18-B of the EAC Application; AuRico 2016).

The soil quality selection identified the following COPCs during the Construction and Operations phases (see Section 3.4 and Table 3.4-2 of Appendix 18-B of the EAC Application; AuRico 2016): arsenic, barium, boron, cadmium, chromium, copper, lead, molybdenum, nickel, selenium, vanadium, and zinc.

The following non-metal COPCs in surface water were screened in (against Canadian Drinking Water Quality Guidelines) during both the Construction and Operations phases (see Section 3.5.1 and Table 3.5-1 of Appendix 18-B of the EAC Application; AuRico 2016): nitrate and sulphate. The surface water quality COPC screening (against Canadian Drinking Water Quality Guidelines) identified the following metal COPCs during both the Construction and Operations phases (see Section 3.5.2 and Table 3.5-2 of Appendix 18-B of the EAC Application; AuRico 2016): total and dissolved aluminum, cadmium, iron, lead, manganese, and selenium. Consistent with the baseline HHRA (Section 4.8 of Appendix 18-A of the EAC Application; AuRico 2016), iron was not retained as a COPC.

Fish tissue selection identified selenium as a COPC during both the Construction and Operations phases (see Section 3.6.1 and Tables 3.6-1 and 3.6-2 of Appendix 18-B of the EAC Application; AuRico 2016).

Thus, with the addition of bioaccumulative contaminants, the COPCs selected for the Project-related HHRA include: aluminum, arsenic, barium, boron, cadmium, chromium, copper, lead, manganese, mercury, molybdenum, nickel, nitrate (water only), selenium, sulphate (water only), thallium, vanadium, and zinc. These COPCs are the same as those selected in the baseline HHRA (Appendix 18-A of the EAC Application; AuRico 2016).

There were no COPCs identified from road dust (Section 3.7 of Appendix 18-B of the EAC Application; AuRico 2016).

2.3 Overall List of Contaminants of Potential Concern Identified for Human Health

The overall list of COPCs identified for human health during the EAC Application (AuRico 2016) were: **aluminum, arsenic, barium, boron, cadmium, chromium, copper, lead, manganese, mercury, molybdenum, nickel, nitrate (water only), selenium, sulphate (water only), thallium, vanadium,** and **zinc**. This list of COPCs is proposed for monitoring in environmental media.

3. RELEVANT MONITORING AND MANAGEMENT PLANS

A series of management and monitoring plans have been developed for the Project. Many of these plans outline monitoring commitments relevant to the HHFP objectives. The HHFP relies on the monitoring and associated results from several of the plans, as described below.

3.1 Mine Site Water Management Plan

Section 6.1.2 of the MSWMP (AuRico 2017c) describes the surface water monitoring in the receiving environment that will be conducted for the Project.

Surface water quality monitoring sites and monitoring frequency under the MSWMP (AuRico 2017c) build on monitoring sites identified in the FAEMP (AuRico 2017a) and have been designed to incorporate the monitoring required under existing permits. Further, the components of the monitoring program are intended to provide sufficient spatial and temporal coverage to collect representative data from the most relevant locations (e.g., downstream of the Project) and time periods (e.g., open water or low flow periods). As applicable, sample and data collection for the separate components of the MSWMP and FAEMP will be coordinated to ensure data are cotemporaneous, which reduces the potential for confounding factors in subsequent analyses.

Surface water quality locations monitored during Construction and Operations phases under the MSWMP include 6 of the 14 surface water quality model node locations (i.e., KN-11b, WQ-01, WQ-14F, WQ-17, WQ-18, and Thutade Lake) that were used in the HHRA presented in the EAC Application (see Section 4.6 of Appendix 18-A). Thus, for the HHFP, water quality samples obtained from these six monitoring locations shown on Figure 4-1 can be compared to the baseline and predicted Project water quality presented in the EAC Application and the Joint MA/EMA Permit Application.

Stream water quality samples will be collected monthly (12 times per year) during pre-Construction, Construction, and Operations, except for sampling at the far-field monitoring site (Thutade Lake), which will be sampled quarterly. The timing of quarterly sampling is designed to capture representative periods during winter low-flow conditions, freshet, summer low flow, and the increased stream flows in fall.

3.2 FISH AND AQUATIC EFFECTS MONITORING PLAN

Monitoring of aquatic resources (i.e., fish, periphyton, and benthic invertebrate communities, and sediment quality) under the FAEMP (AuRico 2017a) will begin during the first year of Construction. There are three sampling locations for aquatic resources proposed under the FAEMP (shown in Figure 4-1): EEM-18 (equivalent to WQ-18), ATT-DIS, and EEM-13 (equivalent to WQ-13).

The monitoring program will occur every few years over a seven-year period, with infill years of slightly reduced monitoring requirements. Kemess South aquatic monitoring plans include: the Provincial Environmental Effects Monitoring (EEM) in Kemess Creek; selenium reporting in Waste Rock Creek; long-term fish monitoring in Attichika/Kemess creeks; and the Federal EEM in Kemess Creek. The KUG aquatic monitoring plan includes: discharge monitoring and adaptive management in Attichika Creek, Waste Rock Creek and the Northern Project Area; and the Federal EEM in Attichika Creek.

As described in Section 8.3.7.2 of the FAEMP (AuRico 2017a), surface water quality in Amazay Lake (which is 1 of the 14 surface water quality model node locations used in the HHRA presented in the EAC Application) will be monitored during the early Construction phase. Thus, water quality samples obtained under the Amazay Lake monitoring component of the FAEMP can also be applied in the HHFP.

Fish monitoring studies are described in Section 8.3.5.7 of the FAEMP (AuRico 2017a). As part of the Adult Fish Monitoring Study, annual non-lethal fish tissue monitoring of adfluvial Bull Trout from Thutade Lake will be conducted. This study will monitor contaminants that can bioaccumulate within fish species, including mercury, and focus specifically on Bull Trout in Thutade Lake, given this population's importance as a food source for Indigenous groups in the area. Sampling will be conducted at three locations in Attichika Creek (Thutade Lake Bull Trout migrate up Attichika Creek to reach spawning habitats), similar to baseline studies presented in Hatfield and Bustard (2015). A target of eight fish will be captured by angling and will be sampled non-lethally using dermal tissue punches. Monitoring will be conducted on an ecologically relevant timeline and will match previous baseline sampling and other ongoing monitoring activities to maximize comparability of data over time.

Biological monitoring in Amazay Lake will only be implemented when routine water quality monitoring from the Amazay Lake Monitoring Plan initiates a trigger response (outlined in Section 8.3.7.1 of the FAEMP). In addition, biological sampling is also proposed in Amazay Lake during the early Construction phase years (either fall 2018 or 2019) as an adaptive management approach and to update baseline information for this lake. Proposed sampling includes Rainbow Trout tissue metal analysis because they are the most abundant fish species in the Lake. Thus, if fish tissue sampling is triggered or fish is collected as an adaptive management approach, samples will also be used in the HHFP.

3.3 SELENIUM MANAGEMENT PLAN

Section 6.1.2 of the SeMP (AuRico 2017d) describes the surface water and sediment monitoring in Waste Rock Creek that will be conducted for the Project. Monitoring will be conducted in accordance with permit PE15335, with sample sites and frequencies specified in the permit.

Section 6.5 of the SeMP (AuRico 2017d) describes the proposed fish tissue sampling. A very small population of adult fish is present in Waste Rock Creek; thus, alternate locations such as the Attichika wetlands will be considered for an annual lethal fish survey. Methodology for fish tissue sampling is provided in the FAEMP (AuRico 2017a). Fish tissue will be analyzed for a full suite of metals.

Surface water quality data, sediment quality data, and fish tissue metal data obtained via monitoring under the SeMP will be used in the HHFP. Should an update of the HHRA for country foods be required, fish tissue monitoring data will be incorporated into the risk assessment for consumers of fish.

3.4 Ecosystem Management Plan

Sections 5.2.2 and 5.2.3 of the EMP (AuRico 2020b) describes the monitoring for trace metal uptake in soil and vegetation that will be conducted for the Project. Under the EMP, vegetation sampling for metals analysis will be co-located with soil sampling, and vegetation samples will be collected with each soil sample (provided relevant vegetation species are present at the sampling site).

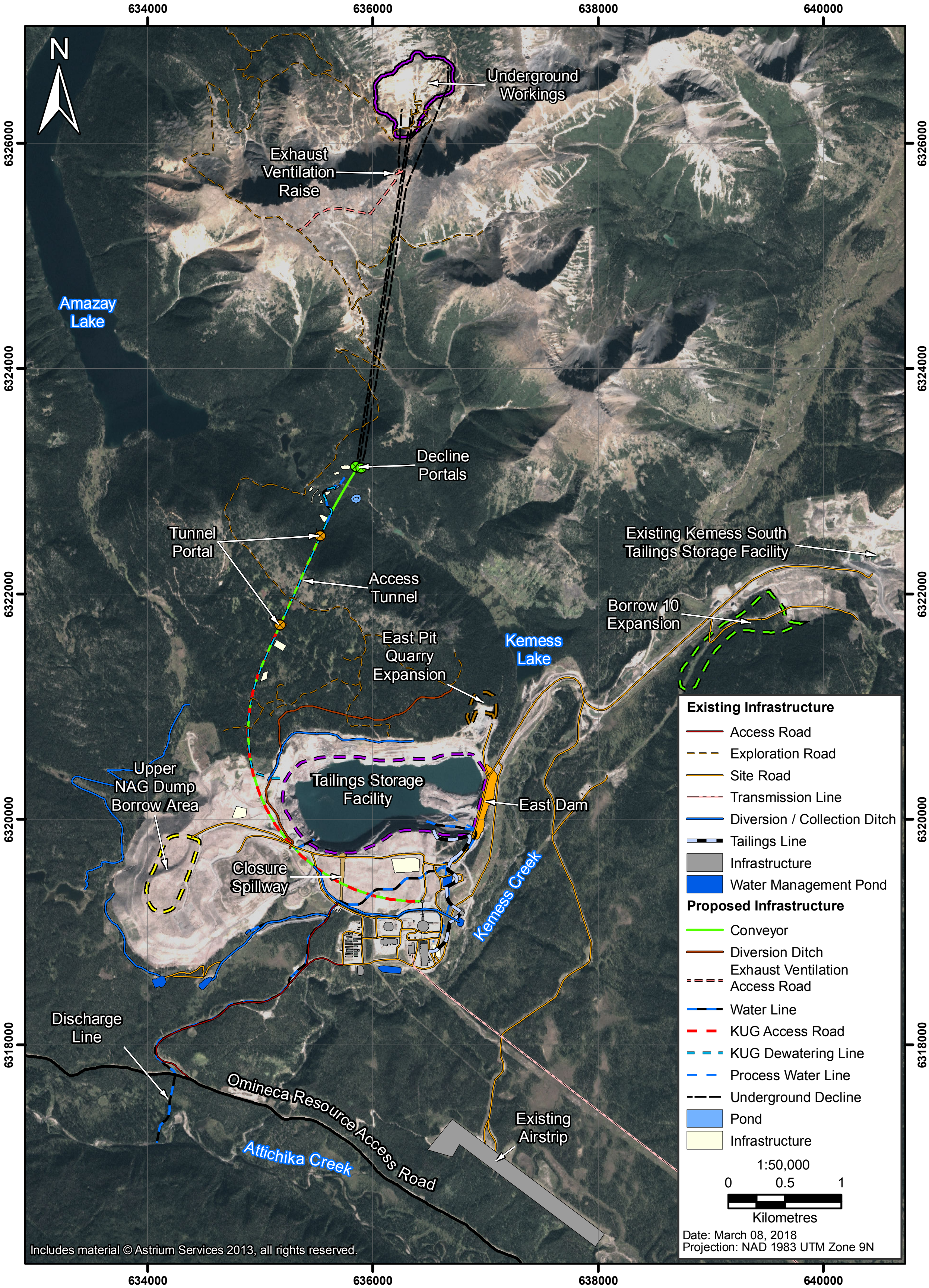
Trace metal concentrations in soil and vegetation will be monitored in samples collected from areas disturbed by the Project (i.e., the Project footprint; Figure 3-1) during the life of mine. Soil and vegetation samples will also be collected from a non-impact control site for comparison. The non-impact control site will be identified at the time of sampling based on accessibility; the preferred location based on air quality modelling is southwest of the mine site, at least 1 km south of the access road.

The frequency of soil and vegetation sampling will be every three to five years to match the frequency of the Reclamation and Closure Plan review/update.

Vegetation sampling will include species identified as country foods and important forage species for wildlife. Vegetation species identified as country foods or important forage species for wildlife include the following:

- Crowberry (*Empetrum nigrum*);
- Soapberry (*Shepherdia canadensis*);
- Water sedge (*Carex aquatilis*);
- Drummond's willow (*Salix drummondiana*);
- Grey-leaved willow (*Salix glauca*);
- Blueberry willow (*Salix myrtillifolia*);
- Tea-leaved willow (*Salix planifolia*);
- Mackenzie's willow (*Salix prolixa*);
- Balsam willow (*Salix pyrifolia*);
- Meadow horsetail (*Equisetum pratense*);
- Marsh cinquefoil (*Comarum palustre*); and
- Fireweed (*Epilobium angustifolium*).

Figure 3-1
Project Footprint



Vegetation samples will be collected in the middle of July, close to the peak summer growth prior to seedset, or at the end of August when berries are ripe. Shrub samples should be collected as a composite from new growth of twigs and leaves from at least three locations on each plant. Sedge and herb samples should be collected as a composite of stems and leaves from each plant. Berries from fruiting shrubs will be collected separately from other plant parts. Composite samples are comprised of clippings from five plants, distributed throughout the sample site, to ensure that the minimum sample weight is collected. Although composite samples have lower variability than individual samples, the results are likely more representative of what would be consumed by browsing wildlife or by humans. Three replicate samples of each composite species should be collected at each sample site.

Soil samples will be analyzed for a comprehensive suite of total metals with detection limits applicable for Agricultural and/or Residential/Parkland use standards. Vegetation samples will be analyzed for a full suite of metals.

4. SAMPLING PLAN

The monitoring locations of environmental media required for the HHFP are shown in Figure 4-1.

4.1 WATER

All of the COPCs listed in Section 2.3 (i.e., aluminum, arsenic, barium, boron, cadmium, chromium, copper, lead, manganese, mercury, molybdenum, nickel, nitrate, selenium, sulphate, thallium, vanadium, and zinc; see Section 3.1) are included in the environmental monitoring programs for water quality under the MSWMP (AuRico 2017c), FAEMP (AuRico 2017a), and SeMP (AuRico 2017d).

Surface water quality monitoring locations that will be used for the HHFP (i.e., KN-11b, WQ-01, WQ-14F, WQ-17, WQ-18, Thutade Lake, and Amazay Lake) are shown on Figure 4-1. The water quality monitoring locations and frequency of monitoring described in the MSWMP (AuRico 2017c), FAEMP (AuRico 2017a), and SeMP (AuRico 2017d) are considered to be sufficient to identify levels of environmental change (described in Section 5.1) for the HHFP. These sites were included in the HHRAs in the EAC Application and are located downstream of the Project in areas where Project-related changes in water quality are most likely to occur, and sampling is already proposed on a regular (monthly or quarterly) basis. Thus, supplemental surface water quality monitoring under the HHFP is not proposed.

4.2 SEDIMENT

All of the COPCs listed in Section 2.3 (i.e., aluminum, arsenic, barium, boron, cadmium, chromium, copper, lead, manganese, mercury, molybdenum, nickel, selenium, thallium, vanadium, and zinc), except for those that only apply to surface water, are proposed for monitoring in sediment under the FAEMP and/or other aquatic monitoring programs ongoing in the Kemess Area (Section 3.2).

Sediment quality sampling locations that will be used for the HHFP are shown on Figure 4-1. The monitoring locations and frequency of monitoring for sediment described in the FAEMP (AuRico 2017a) and SeMP (AuRico 2017d) are considered to be sufficient to identify levels of environmental change (described in Section 5.2) for the HHFP. These locations are downstream of the Project in areas where changes in sediment are most likely to occur and potential changes in sediment concentrations of COPCs typically occur over longer time periods. Thus, supplemental sediment quality monitoring under the HHFP is not proposed.

4.3 FISH

All of the COPCs listed in Section 2.3 (i.e., aluminum, arsenic, barium, boron, cadmium, chromium, copper, lead, manganese, mercury, molybdenum, nickel, selenium, thallium, vanadium, and zinc), except for those that only apply to surface water, are proposed for monitoring under the FAEMP Adult Fish Monitoring Study (Section 3.2) and/or the SeMP (Section 3.3).

Exact locations for fish tissue sampling under the SeMP are currently unknown (potential locations include the Attichika wetlands). Fish tissue sampling locations under the FAEMP are shown on Figure 4.-1. The monitoring locations and frequency of monitoring for fish tissue metals described in the FAEMP (AuRico 2017a) and SeMP (AuRico 2017d) are considered sufficient for fish metal characterization for a potential country foods risk assessment. The sampling sites are located downstream of the Project in areas where changes in tissue concentrations are most likely to occur and where fish populations may support ongoing sampling efforts. Thus, supplemental fish tissue sampling under the HHFP is not proposed.

Inclusion of methylmercury analysis may be considered; however, sample volumes may be too small to allow inclusions (i.e., dermal punch samples). In the event that methylmercury analysis cannot be done, it will be assumed that 100% of the mercury measured in fish tissue is in the methylmercury form, consistent with the approach used in Appendix 18-A and 18-B of the EAC Application (AuRico 2016).

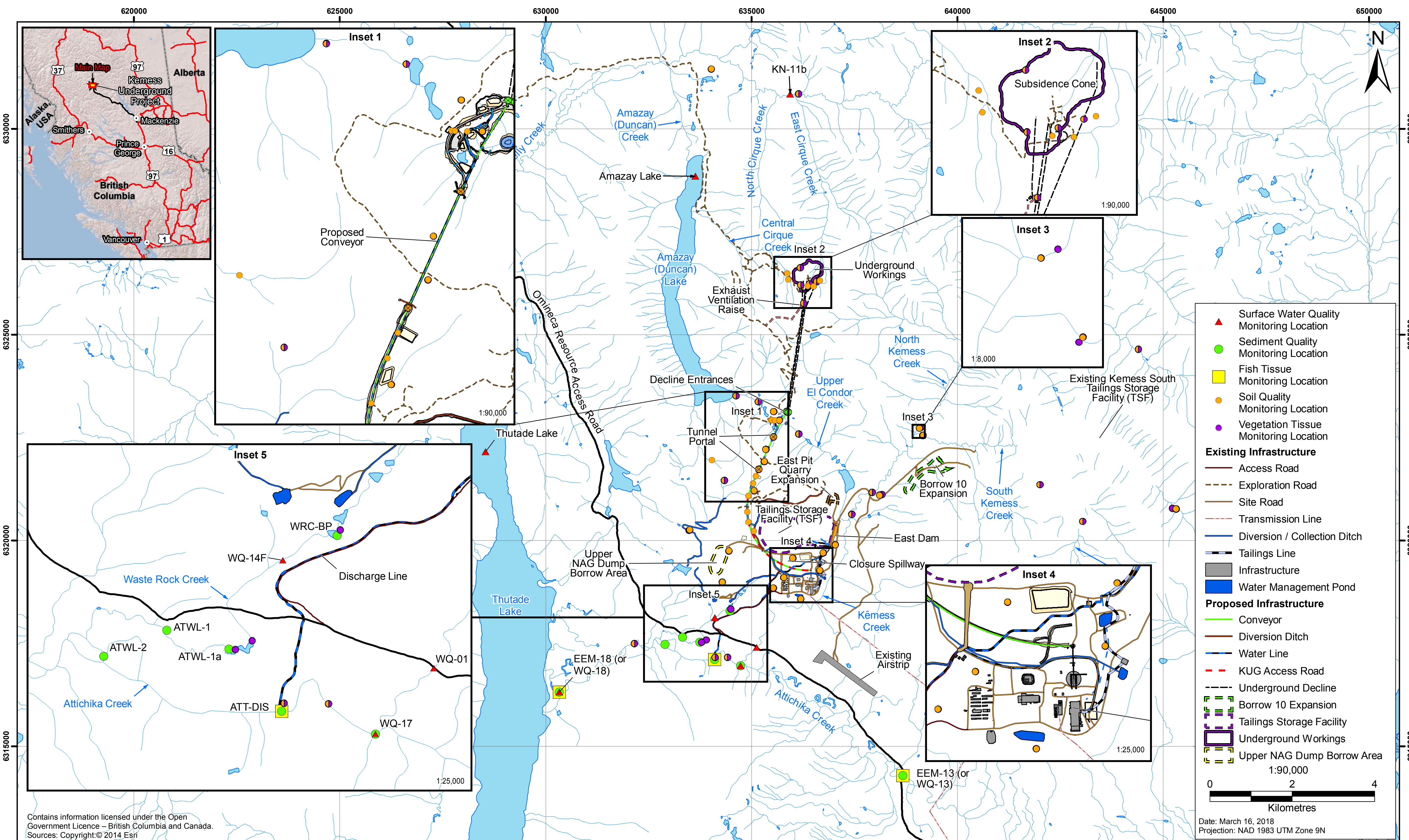
4.4 SOIL AND VEGETATION

Soil and vegetation monitoring done under the EMP (Section 3.4 and AuRico 2020b) will be considered in the HHFP. Soil and vegetation sampling sites will be co-located and samples of both soil and vegetation will be collected at the same time at each site (provided relevant vegetation species are present at the sampling site). The COPCs listed in Section 2.3 (i.e., aluminum, arsenic, barium, boron, cadmium, chromium, copper, lead, manganese, mercury, molybdenum, nickel, selenium, thallium, vanadium, and zinc), except for those that only apply to surface water, are included in the analysis planned under the EMP.

The sampling locations and frequency (every three to five years) of monitoring for soil and vegetation metal concentrations described in the EMP (Section 3.4 and AuRico 2020b) are considered to be sufficient as a starting point to identify levels of environmental change (described in Section 5.3) for soil and vegetation within the Project footprint. These sites within the Project footprint were selected because they are closest to the Project-derived sources of dust and are in the most likely areas to experience the greatest changes in soil or vegetation metal concentrations. The predicted changes in soil and vegetation metal concentrations during Construction and Operations were small (Table 3.4-2, 4.6-1 and 4.6-2 of Appendix 18-B of the EAC Application; AuRico 2016) and potential changes to soil or vegetation tissue metals were predicted to occur over a long time horizon (e.g., several decades). Therefore, initially sampling every three to five years is considered sufficient for the protection of human health.

Figure 4-1

Environmental Media Monitoring Locations for the Human Health Follow-up Program



However, if sampling under the EMP identifies that COPC concentrations in either soils or vegetation within the Project footprint exceed predicted concentrations plus 30% variance (40% for high variability metals, i.e. aluminum, barium, lead, mercury, and molybdenum, see Section 5.0), the sampling frequency for soil and vegetation will be increased to a minimum of every three years.

In addition, if either soil or vegetation sampling under the EMP indicates this trigger for increased sampling frequency has been exceeded within the Project footprint, supplemental soil and vegetation sampling will be added to the program at locations outside of the Project footprint where baseline soil and vegetation sampling was conducted (shown in Figure 4.5-1 of Appendix 18-A of the EAC Application; AuRico 2016). A subset (~10) of sites outside of the Project footprint that were sampled in baseline soil and vegetation quality monitoring programs would require sampling. Sites will be preferentially selected for supplemental sampling if they are downwind of the Project footprint (where dustfall was predicted to be highest during Construction and Operations such as immediately south of the KUG TSF and around the main Mine Site area) or where soil and vegetation samples were co-collected previously.

The soil and vegetation sampling methodology and laboratory analysis described in Section 5.2.2.2 and 5.2.3.2 of the EMP (AuRico 2020b) will be followed in collecting supplemental soil and vegetation samples for the HHFP.

Priority species for supplemental sampling include country foods (i.e., crowberry and soapberry) and diet species for moose, hare, and grouse assessed in the HHRA in the EAC Application to ensure data comparability with baseline studies. Vegetation species identified as country foods or important forage species for wildlife were identified in Section 3.4. Vegetation sampling will be dependent on the types of species present at each supplemental sampling site. Where possible, multiple vegetation species will be co-collected at each sampling location; however, due to the large number of species sampled under baseline programs, not all baseline species need to be sampled in each year of supplemental sampling.

5. LEVELS OF ENVIRONMENTAL CHANGE

Predicted concentrations of COPCs in water, sediment, soil, and vegetation were used to define the acceptable level of change relative to baseline conditions. The predicted concentrations of COPCs were considered to be acceptable because, in the EAC Application, no residual effects to human health were expected based on this level of incremental change relative to baseline concentrations in environmental media (Chapter 18 and Appendix 18-B).

The BC MOE (2013) has defined no change in surface water quality as a difference of no greater than 20% since laboratory precision for measurement of low concentration metals in replicate samples is typically no better than 20% (quantified as the relative percent difference; RPD) and natural variability is often greater than 20%. Changes in concentration below this threshold are not likely to be measurable or statistically different from each other. Therefore, the trigger level to identify concentrations that are measurably different than those used in the EAC Application is predicted concentrations plus 20%.

The issues with laboratory precision and natural variability also apply to sampling other types of environmental media. Natural matrix variability/heterogeneity is generally higher in soils and sediments than in water and higher acceptable RPDs on the order of 30 to 40% are reasonable for these media (Austin 2015). Therefore, a magnitude of 30% change relative to predicted concentrations will be applied to sediment, soil, and dustfall monitoring for most COPCs, and a magnitude of 40% will be applied to high variability metal COPCs (i.e., aluminum, barium, lead, mercury, and molybdenum) as identified in Austin (2015).

5.1 WATER

If the results of surface water quality monitoring at the seven surface water quality model nodes (i.e., KN-11b, WQ-01, WQ-14F, WQ-17, WQ-18, Thutade Lake, and Amazay Lake) indicate that COPC concentrations exceed predicted Project concentrations during the Construction or Operations phases (as described in Appendix 11-D of the EAC Application and Appendix 5-G of the Joint MA/EMA Permit Application) plus 20% for at least three consecutive samples (i.e., for a duration of at least three months except for Thutade Lake, which will be sampled quarterly), a HHRA for country foods will be triggered.

5.2 SEDIMENT

If the results of sediment quality monitoring indicate that COPC concentrations in sediment exceed established baseline concentrations (as described in Section 14.4.3.3 of the EAC Application, since sediment quality is not expected to change from baseline conditions due to the Project) by 30% (40% for high variability metals) for at least three consecutive samples (i.e., for at least three years), a HHRA for country foods will be triggered.

5.3 FISH

A country foods risk assessment for fish will only be triggered by increases in COPC concentrations of substances in water and sediments that are known to bioconcentrate or bioaccumulate in fish above levels of environmental change set out in Sections 5.1 and 5.2. Fish tissue COPC concentrations are generally of higher variability than COPC concentrations in other environmental media due to various factors, including smaller sample size, matrix differences, fish age, developmental stage, life history, habitat, and condition factor. Therefore, fish tissue monitoring data obtained as part of the Adult Fish Monitoring Study of the FAEMP and SeMP will not be used to set trigger levels, but rather to update the country foods risk assessment, if required.

5.4 SOIL AND VEGETATION

If the results of soil quality monitoring indicate that COPC concentrations in soil samples exceed predicted concentrations during the Construction or Operations phases (as shown in Table 3.4-2 of Appendix 18-B of the EAC Application) plus 30% (40% for high variability metals) for at least three consecutive samples (i.e., for at least nine years), a HHRA for country foods will be triggered.

If the results of vegetation tissue metals monitoring indicate that COPC concentrations in vegetation samples exceed predicted concentrations during the Construction or Operations phases (as shown in Tables 4.6-1 and 4.6-2 of Appendix 18-B of the EAC Application) plus 30% (40% for high variability metals) for at least three consecutive samples (i.e., for at least nine years), a HHRA for country foods will be triggered.

6. COUNTRY FOODS RISK ASSESSMENT STEPS

Should monitoring results demonstrate that concentration levels for contaminants of potential concern are greater than the identified levels of environmental change (Section 5), the HHRA for the consumption of country foods exposed to these contaminants will be updated. As with the HHRAs conducted in the EAC Application (Appendices 18-A and 18-B), the HHRA for country foods will be divided into the following six steps based on guidance from Health Canada (2007, 2010a, 2010e, 2010d), and considering any updates to guidance as issued from time to time:

1. Problem Formulation: the conceptual model developed for Project conditions for the EAC Application for conducting the HHRA will be updated in the problem formulation stage. The problem formulation will revisit human receptors and human receptor characteristics, identify the COPCs and media that have triggered the HHRA, and describe food chain and exposure routes considered in the assessment (country foods ingestion only).
2. Exposure Assessment: exposure equations, COPC-specific characteristics, receptor assumptions, and the measured (water, soil, sediment, vegetation) or calculated (country food species) COPC concentrations are presented in this section. An exposure dose is calculated to estimate the daily intake of COPCs for human receptors from the consumption of country foods. For country foods where tissue concentrations were not measured during monitoring studies (i.e., moose, snowshoe hare, and ruffed grouse), food chain modelling will be conducted to estimate tissue concentrations. Food chain modelling of COPC uptake into wildlife tissue is generally highly conservative relative to direct measurement and has the potential to overestimate COPC tissue concentrations by orders of magnitude (Health Canada 2010d). This maintains the conservative nature of the HHRA and ensures with a high degree of certainty that risks will not be under-estimated or overlooked (Health Canada 2010d).
3. Toxicity Assessment: the toxicity reference values for the COPCs (TRVs; levels of daily exposure that can be taken into the body without appreciable health risk) are identified.
4. Risk Characterization: HQs are calculated for threshold chemicals (i.e., non-carcinogens) and ILCRs for non-threshold chemicals (i.e., carcinogens). The exposure and effects assessments are integrated by comparing the estimated exposure dose of COPCs from country foods with TRVs to produce quantitative risk estimates (HQs or ILCRs). Exposure via the country foods pathway is compared to a single TRV for each COPC.
5. Uncertainty Analysis and Data Gaps: the assumptions made throughout the HHRA and their effects on the confidence in the conclusions are evaluated.
6. Conclusions: the potential for risk to human health from country foods consumption is described based on the results of the risk characterization, with qualitative consideration of uncertainties and data gaps that might influence the quantitative assessment.

If additional risk assessment guidance from Health Canada becomes available, it will also be considered for use in the HHRA.

7. METHODOLOGY FOR CALCULATING HAZARD QUOTIENTS AND INCREMENTAL LIFETIME CANCER RISK

Using the results of the exposure assessment and TRV assessment (described in Section 6 above), human health risks are quantified using HQs for non-carcinogens and ILCRs for carcinogens. The HQ is the ratio between the estimated exposure dose and the TRV and provides a measure of the potential risk to a receptor for COPCs ingested from country foods. The ILCR is calculated for COPC(s) that may be associated with carcinogenic potential through ingestion of country foods (i.e., arsenic).

7.1 HAZARD QUOTIENTS

The following equation (Health Canada 2010a) is used to estimate the daily exposure dose for each COPC from the total consumption of country foods:

$$Dose_{CF} = \sum \frac{C_{CF_i} \times IR_{CF_i} \times RAF \times DE}{BW} \quad \text{[Equation 1]}$$

where:

- $Dose_{CF}$ = total estimated daily exposure dose of the COPC from country foods ingestion (mg COPC/kg BW/day)
- IR_{CFi} = ingestion rate for country food *i* (kg/day)
- C_{CFi} = concentration of COPC in country food *i* (mg/kg)
- *RAF* = relative absorption factor from the gastrointestinal tract for the COPC (unitless)
- *DE* = number of days exposed by consuming country food *i* from the area, per 365 days (days/365 days)
- *BW* = body weight (kg BW)

The $Dose_{CF}$ of each COPC from country foods ingestion (in mg/kg BW/day) is divided by the COPC-specific TRV (in mg/kg BW/day) to obtain the HQ (unitless) for each COPC, as follows (Health Canada 2010a):

$$HQ = \frac{Dose_{CF}}{TRV} \quad \text{[Equation 2]}$$

where:

- *HQ* = hazard quotient for the COPC from country foods ingestion (unitless)
- $Dose_{CF}$ = total estimated daily exposure dose of the COPC from country foods ingestion (mg COPC/kg BW/day)
- *TRV* = toxicity reference value for the COPC (mg COPC/kg BW/day)

For non-carcinogenic COPCs, Health Canada (2010a) suggests that an HQ of less than 0.2 indicates that the exposure does not pose a significant health risk to human receptors. An HQ of 0.2 is used as the benchmark (instead of 1.0) because the assessment does not consider intake of contaminants from all potential exposure routes (e.g., from drinking water ingestion, air inhalation, dermal contact, incidental soil ingestion).

An HQ value greater than 0.2 does not necessarily indicate that adverse health effects will occur since the TRVs are conservative (i.e., protect human health by including additional uncertainty factors) and the assumptions made in the assessment are conservative (e.g., 100% of exposure to country foods comes from within the Human Health LSA).

The results for HQ values and uncertainties for country foods consumption during the assessed monitoring period (i.e., Construction, Operations) will be compared qualitatively to established baseline and predicted Project HQ values.

7.2 Incremental Lifetime Cancer Risk

Arsenic is the only potential Project-related COPC that is considered carcinogenic through the ingestion pathway. The following equation is used to calculate the lifetime average daily dose (LADD) from ingestion of arsenic in country foods (Health Canada 2010a):

$$LADD_{CF} = \sum \frac{\mathrm{C}_{CF_i} \times \mathrm{IR}CF_i \times \mathrm{RAF} \times \mathrm{DE} \times \mathrm{YE}}{\mathrm{BW} \times \mathrm{DE} \times \mathrm{LE}} \qquad \text{[Equation 3]}$$

where:

- $LADD_{CF}$ = lifetime average daily dose of arsenic from country foods ingestion (mg/kg BW/day)
- C_{CFi} = concentration of arsenic in country food *i* (mg/kg)
- IR_{CFi} = ingestion rate of country food *i* (kg/day)
- *RAF* = relative absorption factor for arsenic (unitless)
- *DE* = number of days exposed by consuming country food *i* from the area, per 365 days (days/365 days)
- *YE* = number of years exposed by consuming country food *i* from the area (years)
- *BW* = body weight (kg)
- *LE* = life expectancy (years)

Carcinogenic risks due to arsenic exposure are calculated as ILCR estimates according to the following formula (Health Canada 2010a):

$$\mathrm{ILCR} = LADD_{CF} \times \mathrm{Oral\ CSF} \qquad \text{[Equation 4]}$$

where:

- *ILCR* = incremental lifetime cancer risk due to arsenic (unitless)
- $LADD_{CF}$ = lifetime average daily dose of arsenic from country foods ingestion (mg/kg BW/day)
- *Oral CSF* = oral cancer slope factor for arsenic $(\mathrm{mg/kg\ BW/day})^{-1}$

The oral cancer slope factor (CSF) for arsenic is 1.80 $(\mathrm{mg/kg\ BW/day})^{-1}$ (Health Canada 2010b). If the calculated ILCR for arsenic ingestion is less than 1×10^{-5}, it is considered to be of negligible risk (Health Canada 2010a).

The results of the ILCR assessment and uncertainties for country foods consumption during the assessed monitoring period (i.e., Construction, Operation) will be compared qualitatively to established baseline and predicted Project ILCR values.

8. DATA MANAGEMENT AND REPORTING FRAMEWORK

Standard operating procedures (SOPs) will be used for environmental data collection, as referenced in the MSWMP, FAEMP, SeMP, and EMP. SOPs will cover all aspects of data collection, data processing, data quality assurance and control (QA/QC), and data management. SOPs will include duplicate sampling, relevant blanks, chain-of-custody procedures, and recordkeeping. The SOPs will be reassessed and updated when necessary, as part of the iterative QA/QC process conducted under the MSWMP (AuRico 2017c), the FAEMP (AuRico 2017a), the SeMP (AuRico 2017d), and the EMP(AuRico 2020b).

AuRico Metals Inc. will assume the responsibility of data management and record-keeping of monitoring results. Data are entered into suitable electronic databases, checked for QA/QC purposes, and stored. Data are entered in a format and program that allow for comparison over time and storage in a single file format for each type of survey or monitoring activity. Monitoring data will be stored for the life of the mine and be made available for review upon request. Designated personnel will coordinate preparation, review, and distribution of the data and reports required for regulatory purposes.

The environmental media data, including COPC concentrations, gathered during monitoring will be presented annually in monitoring reports for surface water, sediments, fish, soil, and vegetation under the MSWMP (described in Section 7.1 of the MSWMP; AuRico 2017c), FAEMP (described in Section 8.3.6 of the FAEMP; AuRico 2017a), SeMP (described in Section 7.1.1 of the SeMP; AuRico 2017d), and EMP (described in Section 6.2 of the EMP; AuRico 2020b).

Annual HHFP reports will be prepared or reviewed by a person with expertise in HHRA. The annual HHFP report will provide the following:

- summary of environmental media COPC monitoring results for surface water, sediments, fish tissues, soils, and vegetation, including any supplemental sampling results (Section 4), and results of CAC monitoring if results indicate exceedance of objectives or standards (Section 1.2; AuRico 2020a, AuRico 2020c);
- comparison of monitoring results to established baseline and predicted COPC concentration data reported in the EAC Application;
- calculated levels of environmental change in environmental media (Section 5) and interpretation;
- identification of any emerging negative environmental trends likely attributable to the Project identified by monitoring and if supplemental monitoring (i.e., increased sampling frequency or collection of additional soils or vegetation samples outside of the Project footprint) has been triggered; and
- description of proposed mitigation measures, revisions to the management plans to address emerging negative trends, or to update the HHRA for country foods, if required.

If the levels of environmental change exceed the levels described in Section 5, then a HHRA for country foods will be triggered following the steps and methodology described in Sections 6 and 7. The results of the updated HHRA for country foods will be communicated to Indigenous groups.

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Definitions of the acronyms and abbreviations used in this reference list can be found in the Glossary and Abbreviations section.

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